of the trachea (obliquely) and may lie from one half to an inch above the suprasternal notch.

Tracheotomy, under certain conditions, is a very simple procedure. Again it may be difficult to accomplish (emergencies, alarming dyspnea, improper surroundings, poor assistance, etc.).

Types of Operation. High tracheotomy (above the isthmus of the thyroid gland).



Fig. 461

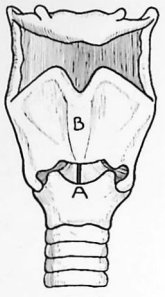


Fig. 462

Fig. 461. Laryngotomy. Infiltration anesthesia for laryngotomy. The circles represent the intracutaneous wheals created by the novocaine solution. The needle and white arrow point in the direction of the needle while making this infiltration. From these points down the tissues between the skin and trachea are infiltrated in the direction indicated by the arrow. The length of the first infiltration is about 3 inches, its highest point being a little below the upper margin of the thyroid cartilage. Hertzler pointed out that theoretically if the needle is passed too deeply there is danger of blocking the pneumogastric nerve. Such danger is negligible since this nerve lies deeply behind the superior thyroid nerve. After incision of the skin, the needle is passed through the cricoid membrane where the mucosa is infiltrated, care being taken not to perforate the mucosa. About 1 cc. of anesthetic is here deposited slowly. A similar deposit is made at the higher point. If the injection is properly performed, no reflexes are excited when the interior of the larynx is exposed. Should a sensitive area be touched, a pledget of cotton moistened with cocaine solution is pressed against it. It is to be hoped that "laryngologists will realize they have here a method that is superior to the hanging method."

Fig. 462. Intercricothyroid laryngotomy (diagrammatic). A. Cricoid cartilage. B. Thyroid cartilage. Between the two a vertical line indicates placements of incision.

Caution. In low tracheotomy the skin incision must be ample in order to avoid subcutaneous emphysema. In making the incision, keep close to the median line. Deviation to one side or the other may cause undesirable bleeding and culminate in an improper opening in the trachea. The trachea must be steadied while being opened. A dry field is essential. A blood clot or mucous plug in the trachea may prevent proper areation. Any tendency to dyspnea must be investigated and the causative factor eliminated.

Complications. 1. Aspiration of blood or mucus causing respiratory embarrassment (bronchopneumonia, tracheobronchitis, etc.).

2. Pressure necrosis from improperly placed tube.

3. Dislodgement of the tube with ensuing threatened suffocation. (Act promptly; remove the tube at once.)

High Tracheotomy

Position of the patient. Place the patient on his back with the shoulders raised on a pillow or sand bag and the head extended. Good illumination is essential.

Anesthesia may be local or general. Palpate the thyroid and cricoid cartilage.

Step 1. From a point below and in the middle of the thyroid cartilage, make an incision exactly in the midline, about 1½ inches in length (Fig. 464 A). The sterno-thyroid and the sterno-hyoid muscles are retracted laterally and the isthmus of the thyroid is pushed downward. Catch all bleeding vessels and ligate them (anterior jugulars). Expose the pretracheal fascia and incise it transversely at the level of the cricoid cartilage (Fig. 464 B). If the isthmus cannot readily be displaced it is best to divide it between two ligatures (Fig. 464 C). The upper three or four tracheal rings are thus exposed.

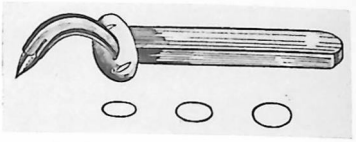


Fig. 463. Butlin's laryngotomy tube with a pilot.

Step 2. Steady the cricoid cartilage with a sharp hook which pulls the cartilage upward (Fig. 464 D). **Incise the trachea from below upward.** Care should be taken not to push the knife so far in as to injure the posterior wall of the trachea. Two or three tracheal rings are divided. The incision in the trachea is about ¾ of an inch in length. A pair of hemostats spreads the opening transversely. Introduce a tracheotomy tube (Fig. 465) or, suture the edges of the tracheal opening to the edges of the skin. One suture on each side suffices to keep the tracheal opening patent.

If a tube is used its size should suit the opening in the trachea (Fig. 466). After the tube is properly placed, it should be secured by a tape around the neck to prevent it slipping out.

Low Tracheotomy

Step 1. The incision in this operation begins near the cricoid cartilage and extends downward for about 2 inches.

Step 2. Divide the fascia and expose the trachea. Ligate and divide vessels as they appear. Vigil is essential to discover any abnormal vessels crossing the operative field. (Fig. 467 A.) If the isthmus of the thyroid interferes with exposure pull it out of the way (upward). A study of Fig. 467A shows why

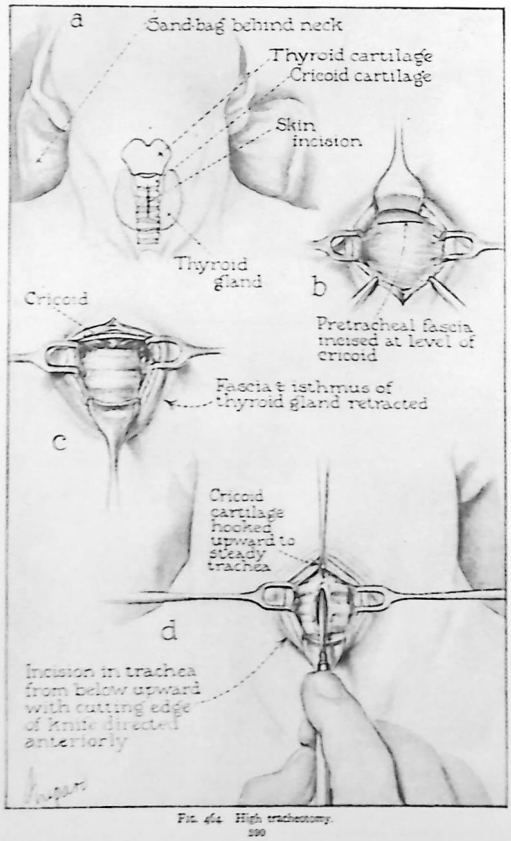


Fig. 464. High tracheotomy.

the low operation should not be used in children (vascular anomalies, deep position of the trachea, short necks, thymus gland).

The trachea is opened in the same manner as in the high operation. (Fig. 467 B.) Some object to high tracheotomy because of the possibility of laryngeal stenosis.

Comment. The inner tracheotomy tube should be frequently removed and cleaned. During the first few days after the operation the outer tube should never be removed except by the surgeon. The nurse or patient should never be permitted to remove the outer tube until the surgeon is satisfied that they are capable of replacing it.



Fig. 465. Tracheotomy tube

DIGBY'S TRACHEOTOMY TECHNIC

Step 1. (Fig. 468) Make an incision in the midline extending from the upper border of the cricoid cartilage and continued downward for about 1½ inches. Divide the cervical fascia longitudinally. Expose the cricoid cartilage.

Step 2. Make a transverse incision into the fascia attached to the lower border of the cricoid cartilage, thus exposing the beginning of the trachea (Fig. 469).

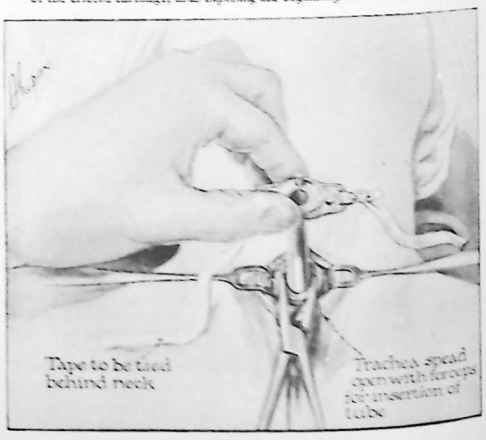


Fig. 466. Insertion of tracheotomy tube.

Step 3. Introduce the point of a closed artery forceps between the trachea and the isthmus of the thyroid gland. A to-and-fro motion of the slightly opened

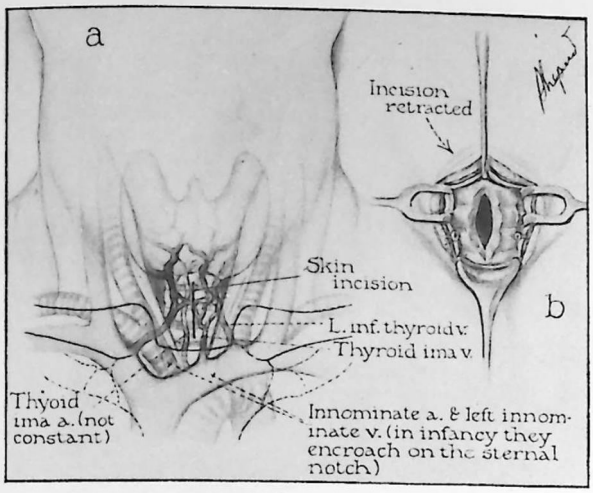


FIG. 467. Low tracheotomy.

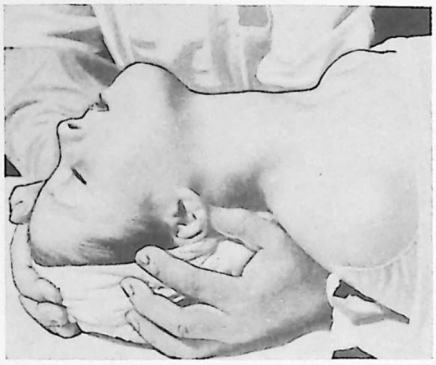


FIG. 468. Tracheotomy. The assistant standing on the patient's left, places his right hand on the forehead and his left on the occiput. He then fully extends the neck, and holds the head firmly in this position until the tracheotomy tube is safely placed. (After Hamilton Bailey.)

forceps will aid in its passage. The isthmic-tissue is raised and the hemostat is kept close to the midline. A second artery forceps is placed parallel to the first (Fig. 470).

Step 4. Divide the isthmus between the artery forceps and rotate these laterally to about 90 degrees; in so doing depress the handles of the forceps somewhat so as to raise the points of the hemostat, thus separating the tissues from the trachea; this is to be aided by a snip of the scalpel where necessary. The first four rings now lie clearly exposed.

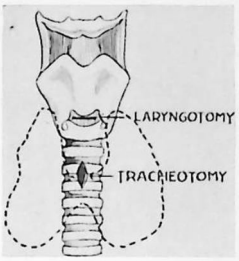


FIG. 469. Emergency openings of the trachea. (Hamilton Bailey.)

Step 5. Now make a vertical incision dividing the second, third and fourth tracheal rings. Pick up one edge of the wound in the trachea with a dissecting forceps, snip off one or two of the tracheal rings and repeat the procedure on the other side—an oval window thus results on the anterior surface of the windpipe. This is preferable to passing the tube through a tight vertical opening.

Step 6. Ligate the divided isthmus. Insert the tracheotomy tube as described above.

Step 7. Close the skin around the tube.

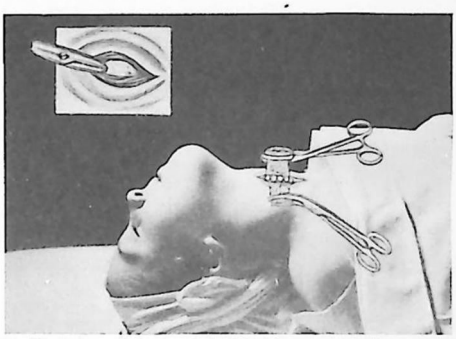


FIG. 470. The isthmus of the thyroid is divided between artery forceps and the trachea is exposed. The insert shows how an artery forceps tunnels the isthmus to separate it from the trachea (Emergency Surgery, Hamilton Bailey, John Wright & Sons, 1936.)

ST. CLAIR THOMSON'S PROCEDURE—(TRANQUIL TRACHEOTOMY)

Sir St. Clair Thomson characterized his procedure in the following terms: "The calm with which this procedure takes place is in striking contrast with the agitated, hurried and often bloody and dangerous operation of former days."

The principal underlying the procedure is based on the elimination of the commotion which attends the first entry of air into the trachea. This is accomplished by the use of intratracheal infusion of cocaine which is accomplished as follows:

Step 1. Fill a hypodermic syringe with 20 drops of a 2½ per cent solution of cocaine for an adult; for a child, 5 drops of a 1 per cent solution.

Step 2. Lay bare the tracheal rings as described above. Grasp the syringe as you would a fountain pen, placing the forefinger about an inch down from the extremity of the needle. The middle, ring and little fingers rest on the patient's neck thus preventing the point of the needle from entering the lumen of the trachea for more than a quarter of an inch.

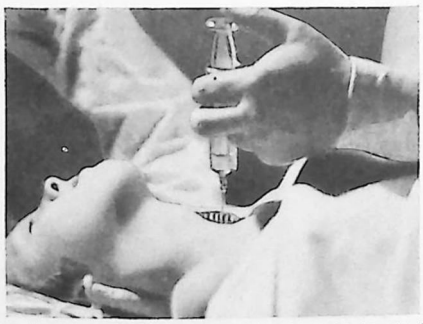


FIG. 471. Tranquil tracheotomy by injecting a solution of cocaine into the lumen of the trachea. (After Sir St. Clair Thomson.)

Step 3. Inject the cocaine solution into the lumen of the trachea (Fig. 471). Withdraw the needle briskly. Immediately upon the solution entering the trachea a slight cough is promptly produced which, however, does not cause much distress. If the condition is not urgent about ten minutes should elapse to allow the cocaine to take full effect. At the end of that period the incision can be made into the trachea and the tube inserted without spasm or cough.

Step 4. Complete the operation as outlined above.

TRACHEOTOMY IN DESPERATE CASES

Step 1. Extend the patient's head. Palpate the cricoid cartilage. Make the skin of the precricoid region tense. (Fig. 472.)

Step 2. Make a longitudinal incision exactly in the midline, about 3 inches in length.

Step 3. Lift up the larynx by placing a sharp hook under the cricoid cartilage which is steadied with the left hand.

Step 4. Direct the cutting edge of a narrow bladed knife toward the patient's

chin and thrust the knife about half an inch below the cricoid cartilage, into the trachea. Extend the incision somewhat upward. Air will now rush into the opened trachea.

Step 5. Guide the point of an artery forceps along the blade of the knife into the opened windpipe. Spread the blades of the hemostat while the scalpel is withdrawn.

Step 6. Insert a tracheotomy tube. Release the sharp hook from under the cricoid cartilage.

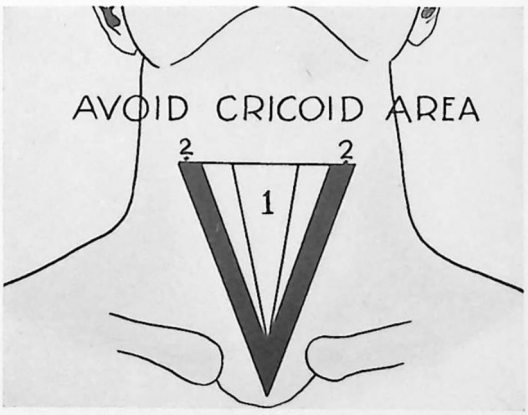


FIG. 472. Jackson's tracheotomy triangle: 1. safety zone, 2. danger zone.

Step 7. Close the wound. Dress.

Comment. In these urgent cases, waste no time in preparations. Procrastination often spells death. Act promptly! On occasion, the resourceful surgeon will have to depend upon a pocket knife and a tube. The desideratum is to get air to the suffocating patient as promptly as possible.

INTUBATION

(Tubage)

This operation was first recommended by Loiseau and Bouchet (France 1880). In England the procedure was championed by Sir W. Macewen and in America by O'Dwyer of New York.

Advantages of intubation.

1. No anesthetic is required.
2. No operation is performed.
3. Performance is rapid.

4. Breathing is continued through natural air passages.
5. Better results are obtained in children under five years of age.
6. Recovery is quicker.

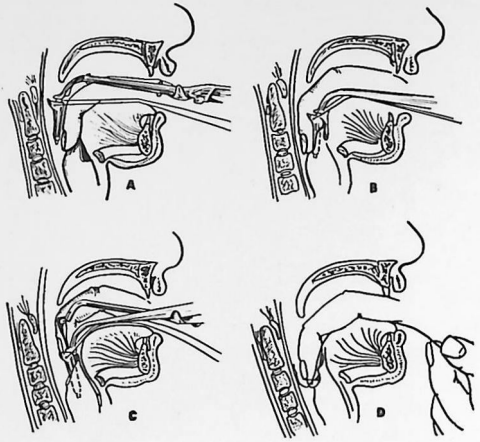


FIG. 473. Intubation. A. Elevate the epiglottis and draw the tongue forward with the finger directing the tube into the larynx; string in the tube. B. The tube is passed under finger. C. The tube is pressed into place with the finger and detached from the obturator. D. The tube is held in place by the finger.

Disadvantages.

1. Requires special training and instruments.
2. Must be performed quickly; respiration is embarrassed during introduction of the tube.
3. The tube may be coughed up or blocked; drainage is inefficient.
4. Complications are frequent (bronchopneumonia, ulceration, stenosis).
5. Exacting after treatment demands constant watchfulness.
6. Secondary tracheotomy is frequently necessary (about 30 per cent).
7. Tube difficult to keep in place.

The choice between tracheotomy and intubation depends upon the experience of the surgeon. Generally it may be stated that in selected cases with an experienced surgeon, the method is valuable.

In this procedure it is necessary that the surgeon's fingers be trained to recognize the epiglottis, the arytenoid cartilages and the laryngeal entrance since the hands place the tube almost entirely without sight.

Step 1. Fix the mouth open. Locate the entrance to the larynx with the left index finger which has been protected by bandages.

Step 2. Now place the left index finger on the posterior surface of the epiglottis to serve as a guide for the tube which is mounted on a special curved instrument and carried into the larynx where it remains in place without aid be-

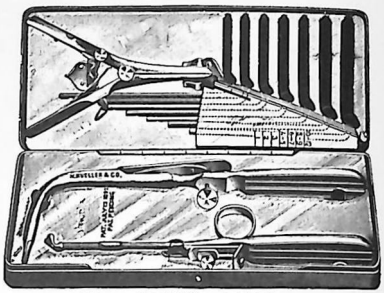


FIG. 474. Ermold-O'Dwyer's intubation set.

cause of its length and shape (Fig. 473 A, B, C and D). The larger part of the tube rests below the cricoid cartilage and its funnel-shaped upper end on the arytenoepiglottidean folds.

The instruments which are absolutely necessary are a mouth gag, an introducer and a laryngeal tube of proper dimensions. (Fig. 474.)

Comment. No anesthesia is employed. An assistant is necessary to help hold the patient and expedite the procedure. The patient is held between the knees of the assistant who sees that the body is kept in an upright position with the head on the assistant's left shoulder; the patient's hands are held firmly by the assistant. The surgeon takes his position on a stool facing the patient. The cannula is inserted alongside of the finger until it reaches the larynx (Fig. 473 A and B). At the first inspiration of the patient the cannula is inserted into the glottis and the carrier withdrawn (Fig. 473 C). The string which has been placed in the cannula need not be removed as it is helpful in removing the tube. In order to be sure the tube is properly placed, insert a finger after the tube has been placed in position; if the larynx can be palpated posteriorly, the tube is correctly placed. If not, the tube must be replaced. If the tube cannot be properly placed in three efforts, do a tracheotomy. It is usually left in about 4 days.

PHARYNGOTOMY

While the patient is lying on his back with his head extending over the operating table and a cushion under his shoulders, locate the hyoid bone and thyroid cartilage with the fingers (Fig. 475).

Step 1. Incise the skin transversely parallel to and directly under the hyoid bone (Fig. 476). An incision 2 inches long is adequate to expose the entrance of the larynx, but if there is a growth in the pharynx or upper larynx, the incision must be longer.



FIG. 475. Subhyoid pharyngotomy. Locating the thyrohyoid space.

Step 2. Incise the platysma myoides, omohyoid, sternohyoid and thyrohyoid muscles near the hyoid bone, permitting enough of their structures to remain so that they may be sutured (Figs. 477-478).

Step 3. With a cutting instrument directed backward and upward, incise the thyrohyoid membrane near the posterior surface of the hyoid, allowing enough of the membrane to remain for resuturing purposes. Check bleeding.

Step 4. While exercising care so that the epiglottis is not injured, grasp the mucosa with a forceps during expiration and incise it. In the upper margin of the incision, place two sutures of catgut to act as guides when the edges of

the wound are being approximated. Place a suture in the epiglottis for the same purpose. Adequate exposure of the upper larynx or lower pharynx is now accomplished. In cases of malignancy of the upper larynx or if undue bleeding is expected, perform a preliminary tracheotomy. A foreign body or a tumor may now be removed, or the latter electrocoagulated.

Step 5. Reunite the incision in the mucous membrane with fine catgut sutures,

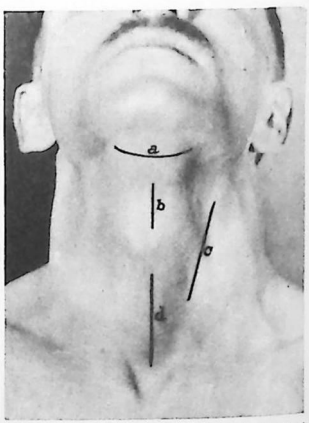


FIG. 476. Incisions used in some operations in the neck. a. Infrahyoid pharyngotomy. b. Cricothyreotomy. c. Lateral esophagotomy. d. Inferior tracheotomy.

uniting the thyrohyoid membrane, muscles and skin separately. Drain through gauze or oiled silk inserted down to the suture-line in the mucous membrane. If most of the pharynx has been dissected, fill the space with gauze and leave the incision partly open. In such cases a tracheotomy becomes imperative.

Transhyoid Pharyngotomy

Vallas advocates mesial division of the pharynx.

Step 1. Incise the skin, subcutaneous tissue and mylohyoid muscles in the midline from a point slightly above the hyoid to the notch of the thyroid.

Step 2. Completely expose a small piece of the hyoid bone in the middle and divide it by means of scissors or forceps.

Step 3. Create a space about 1½ inches wide by retracting the two portions of

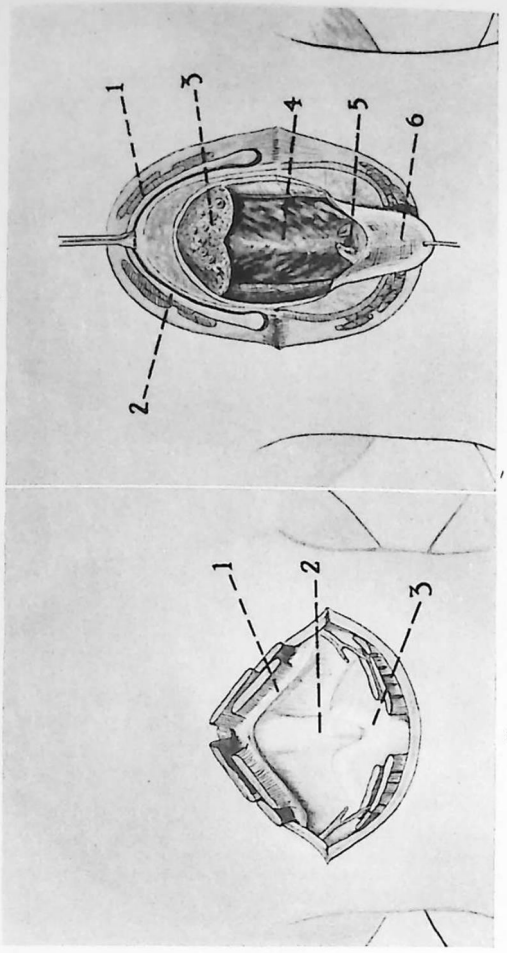


FIG. 478. Median subhyoid pharyngotomy: 1. hyoid bone, 2. thyrohyoid membrane, 3. larynx.
FIG. 477. Median subhyoid pharyngotomy: 1. subhyoid muscles, 2. hyoid bone, 3. base of tongue, 4. posterior wall of pharynx, 5. arytenoid cartilages, 6. epiglottis. (After Doyen.)

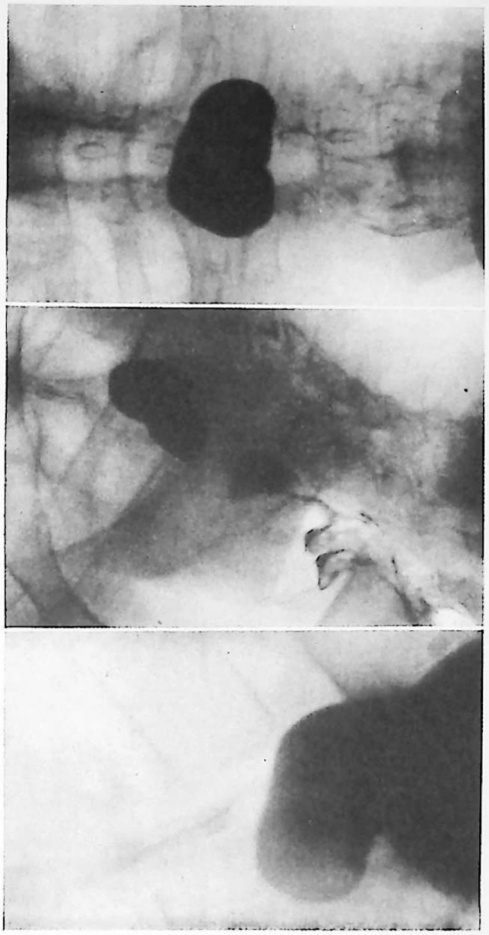


FIG. 479
FIG. 480
FIG. 481

FIG. 479. Diverticulum of the esophagus; front view.
FIG. 480. Diverticulum of the esophagus; lateral view.
FIG. 481. Diverticulum of esophagus; posterior view. (Author's Service, Cook County Hospital.)

the hyoid bone, thus obtaining exposure of the mucosa of the pharynx above and the thyrohyoid membrane below the bone.

Step 4. Incise the pharynx from above downward, being guided by a finger introduced into the pharynx through the mouth.

Step 5. Attend to the corrections which prompted the operation; provide appropriate drainage; suture the tissues in layers. The hyoid bone need not be sutured.

Suprahyoid Pharyngotomy

This operation is recommended by Ermitsch, Grünwald, Federoff and many others when tumors are present, particularly if at the base of the tongue and the epiglottis. No preliminary tracheotomy is required. The patient is placed on his back, his head falling backward over the end of the operating table; a cushion is placed under his shoulders.

Step 1. At a point a quarter of an inch above the hyoid bone make a transverse, concave incision upward including the skin and platysma.

Step 2. The submaxillary gland which now comes into view is drawn back. Protect the insertions of the digastric muscle. Separate the mylohyoids, geniohyoids and hyoglossi muscles by a transverse incision. The pharynx is incised carefully avoiding the epiglottis, and complete exposure of the pharynx, soft palate, tonsils, epiglottis and base of the tongue is accomplished. If it is necessary to operate on the base of the tongue, a sharp tractor is used to draw that organ into the wound.

EXTERNAL ESOPHAGOTOMY

This is indicated in cases of foreign bodies which cannot be attacked otherwise, also in treating strictures which are so situated that dilatation per os is impossible and in certain diverticula (Figs. 479-480-481). Where the indication is the removal of a foreign body, external esophagotomy should be undertaken within 24 hours after other modes of attack have failed. Do this operation where the up and down movement of the foreign body threatens to inflict serious injury or where bleeding forces the surgeon to prompt action. Periesophageal infections and symptoms of mediastinitis indicate immediate operation.

Infiltration, block or general anesthesia may be resorted to in approaching the esophagus in its cervical portion.

Strictures in the neck should be incised longitudinally so that healing takes place transversely thus widening the diameter of the esophagus. In strictures located below the upper thoracic opening the operation is performed for the purpose of permitting dilatation, also for dividing strictures located below the upper opening of the thorax through the esophagotomy opening. External and internal esophagotomy may be combined (see also Surgery of the Esophagus in Chapter on Surgery of the Chest).

Operation. This may be performed on either side of the neck but is usually done on the left side. Guard against injury to the recurrent laryngeal nerve (Fig. 482). If a foreign body is to be removed, its location determines the side to be operated upon.

Step 1. Make an incision along the front margin of the sternocleidomastoid

muscle extending from the hyoid bone to the clavicle. The skin, platysma and superficial fascia are included in the incision.

Step 2. Draw back the sternocleidomastoid muscle laterally and the sternohyoid mesially. Incise the omohyoid muscle mesially to the carotid sheath, exposing the middle layer of deep cervical fascia covering the thyroid gland and permitting access to the esophagus (Figs. 482 and 483 A).

Step 3. Draw the thyroid gland, larynx and trachea to one side and the sternothyroid, sternocleidomastoid, sternohyoid muscles and large vessels to the other, exposing the inferior thyroid artery and the longus colli muscle in the background.

Step 4. Doubly ligate the inferior thyroid artery and divide it between ligatures, exposing the esophagus. Avoid injury to the recurrent laryngeal nerve between the esophagus and trachea; if necessary draw the nerve toward the middle with a hook.

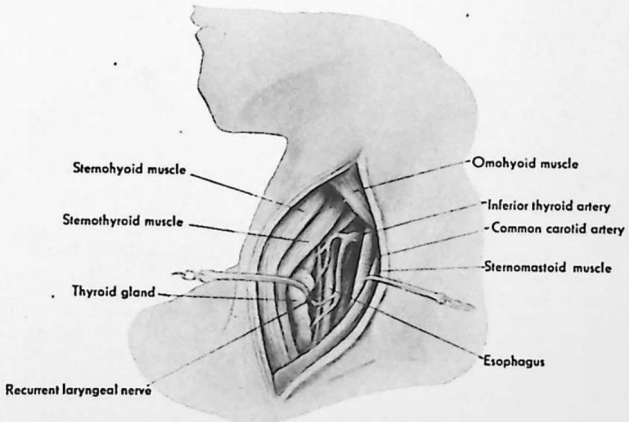


FIG. 482. Exposing the esophagus. (Davis' Applied Anatomy.)

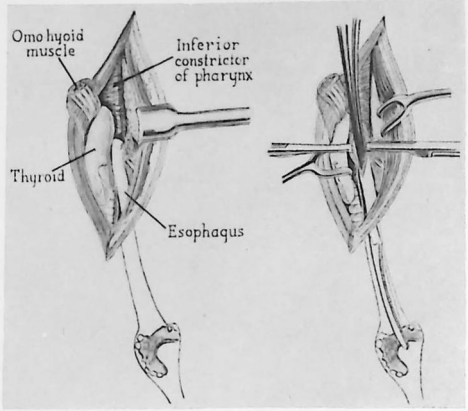
Step 5. Incise the esophagus on its posterolateral aspect. The insertion of a bougie is very helpful. If a foreign body is to be removed, grasp and extract it carefully (Fig. 483 B).

Step 6. Introduce a stomach tube through the esophagotomy incision for feeding purposes. Place one cigarette drain in the esophagus below the tube and another in the direction of the mediastinum. Close the remainder of the wound in the esophagus in two layers. In some cases temporary gastrostomy may be indicated.

Leave the wound entirely open, changing the dressing frequently if symptoms of periesophageal inflammation are present. Remove the tube in about a week.

Apply a gentle compression dressing to the wound for a few days following the removal of the tube.

If during the manipulations little trauma has been inflicted on the esophageal wall, a double row of catgut sutures are used to close the wound. Suturing, however, is generally done under difficulties since only the more serious cases are treated by surgical means. Even though the incision in the esophagus is closed, thorough drainage must be provided for the external incision as well as toward



A B

Fig. 483. External esophagotomy. A. Note the omohyoid muscle has been divided and the inferior constrictor of the pharynx exposed. The thyroid and the sternocleidomastoid muscles have been retracted to expose the esophagus. B. Removal of foreign body from the esophagus by external esophagotomy. Observe v. Graefe's instrument hooked beneath the dental plate pulling it upward (modified after Doyen).

the mediastinum. Hans counsels mesial incision of the esophagus following a median cutaneous incision in cases which can be sutured. He states that this is less difficult and the sutured closure less dangerous by reason of the trachea lying over it.

Dangers. Aspiration pneumonia, the result of anesthesia, swelling of the throat, the result of manipulations, and local inflammation and suppuration as well as mediastinitis may ensue following the operation. Metastatic abscesses or sepsis are possible sequels. Esophageal and mediastinal fistulae often close spontaneously but occasionally they call for surgical repair.

MAJOR LARYNGEAL OPERATIONS

Billroth performed the first laryngectomy for carcinoma of the larynx in 1873 (Fig. 484). Total extirpation of the larynx is usually called for when malignant disease is present to such an extent as to involve both lateral halves of the organ. Although in some technics it may be omitted it is more usual to perform a prior



Fig. 484. Carcinoma of the larynx.

tracheotomy which may be done some days previous to or immediately preceding the main operation. The greatest danger in laryngectomy is not so much the immediate risk of the operation as aspiration pneumonia.

Median Thyrotomy or Laryngofissure

This procedure is indicated for diagnostic purposes, removal of foreign bodies or growths from the larynx or preparatory to some other operation; it is not a serious procedure. Complete exposure is obtained by dividing the anterior aspect of the larynx in the middle and separating it; the larynx is later sutured.

Hemilaryngectomy or Partial Laryngectomy

This procedure holds a median position between laryngofissure and total laryngectomy and may prove more dangerous than either. It is indicated in cases of chondritis accompanied by cartilage necrosis and malignancies which involve the subjacent cartilage. It consists of the removal of a portion of the larynx.

It may be performed under local (infiltration or block) anesthesia.

Total Laryngectomy

Step 1. Make an incision in the median line of the neck starting above the hyoid bone and extending to about an inch above the sternum (Fig. 485 a). The thyroid cartilage and tracheal rings are exposed (Fig. 485 b).

Step 2. Divide the isthmus of the thyroid gland in the midline and ligate the stumps (Fig. 485 c). The infrahyoid muscles are drawn back after being detached from the thyroid cartilage. Retract the sternohyoid and divide the sternothyroid muscles; retract the lobes of the thyroid gland from the larynx and trachea to the desired distance.

Step 3. Ligate the superior and inferior laryngeal arteries and branches as well as their related veins.

Step 4. A single median incision may suffice but it is generally advisable to make additional incisions above and below forming flaps which when drawn back facilitate dissection.

Step 5. Insert two strong silk sutures transversely through the anterolateral aspects of the trachea between the first and second rings of cartilage, then pass one end of each suture through the skin and clamp the loose ends in pairs.

Step 6. Incise the trachea above the sutures between the first tracheal ring and the cricoid cartilage, directing the instrument from the front to the back and from below upward, being careful not to injure the esophagus. The lower end of the trachea is dissected from the esophagus and drawn forward.

Step 7. Make a small transverse incision above the suprasternal notch. Make a tunnel by blunt dissection through the connecting tissue to the main incision.

Step 8. Bring the two pairs of sutures attached to the trachea through the transverse wound by means of an artery clamp, with the end of the trachea following. One suture of each pair is inserted through the adjoining skin on either side and tied to its partner; in like manner a suture is passed above and below. The trachea should be sutured as far down as possible.

Step 9. Insert a tracheotomy tube in the tied end of the trachea and continue anesthesia through it, thus protecting the lungs from aspiration (Fig. 485 d and e).

Step 10. Retract the margins of the wound and subjacent muscles; detach the muscles from the thyroid cartilage; the inferior constrictors to the posterolateral aspects of the larynx are cut; ligate the cricothyroid artery; sever the internal laryngeal nerves where they join the thyrohyoid membrane.

Step 11. If greater exposure is desired the thyrohyoid membrane is incised above the thyroid cartilage. The procedure from here on is determined by the individual involvements. Separation from below is generally preferred.

Step 12. Separate the tracheal stump and larynx from the esophagus by means of blunt dissection accomplished by the use of a forceps, blunt dissector, Mayo scissors and the fingers. This is an exacting part of the operation and should be done very carefully.

Step 13. Sever the inferior constrictors of the pharynx close to the thyroid cartilage. Detach the larynx from the esophagus at the arytenoid cartilages

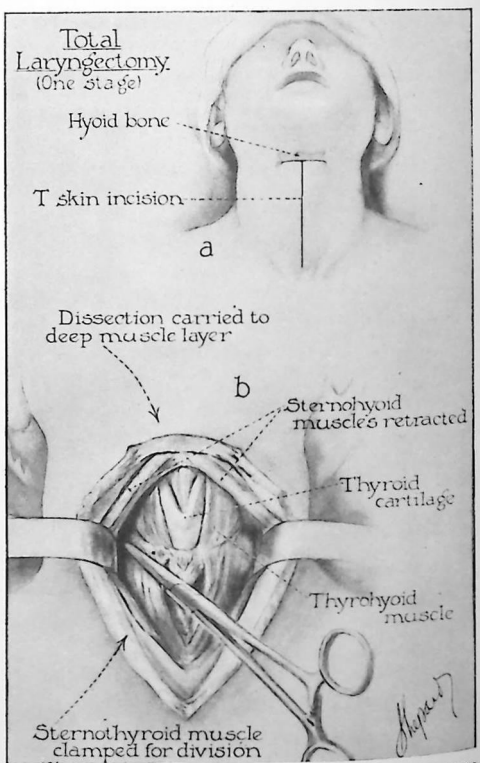


Fig. 485. Total laryngectomy in one step. a. T-skin incision. Note relation of the transverse line of the incision to the hyoid bone and extent of vertical line to the jugulum. b. The superficial tissues have been divided; skeletonization of the larynx has been begun by dissecting the superimposed structures. The illustration depicts the division of the sternothyroid and thyrohyoid muscles.

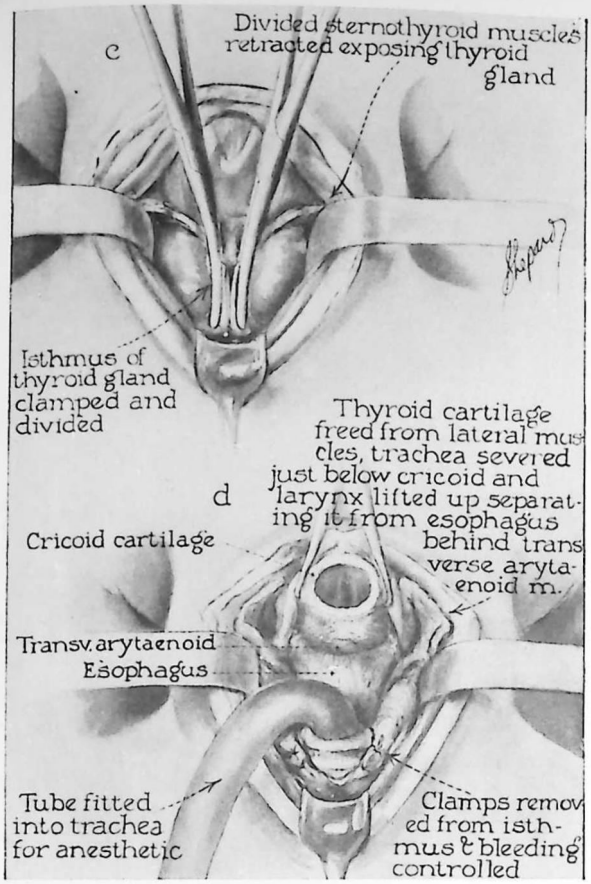


FIG. 485. Total laryngectomy in one step (continued). c. Strap muscles of the neck have been divided and retracted exposing the thyroid gland. Clamping and division of the isthmus of the thyroid. d. The thyroid cartilage has been freed from its muscular attachments. The trachea is severed just below the cricoid cartilage. The larynx is lifted up with hook and forceps and is separated from the esophagus and from the transverse arytenoid muscles in the back. A tube is fitted into the trachea for intratracheal insufflation anesthesia. e. The hypopharynx is opened between the hyoid bone and the attachment of the epiglottis. All arterial trunks have been ligated. The buccal cavity has been packed with iodoform gauze. A nasal tube is introduced for gavage (nasal feeding). Observe that during this step of the operation, the anesthetic is continued by intratracheal insufflation. f. The larynx has been severed from the

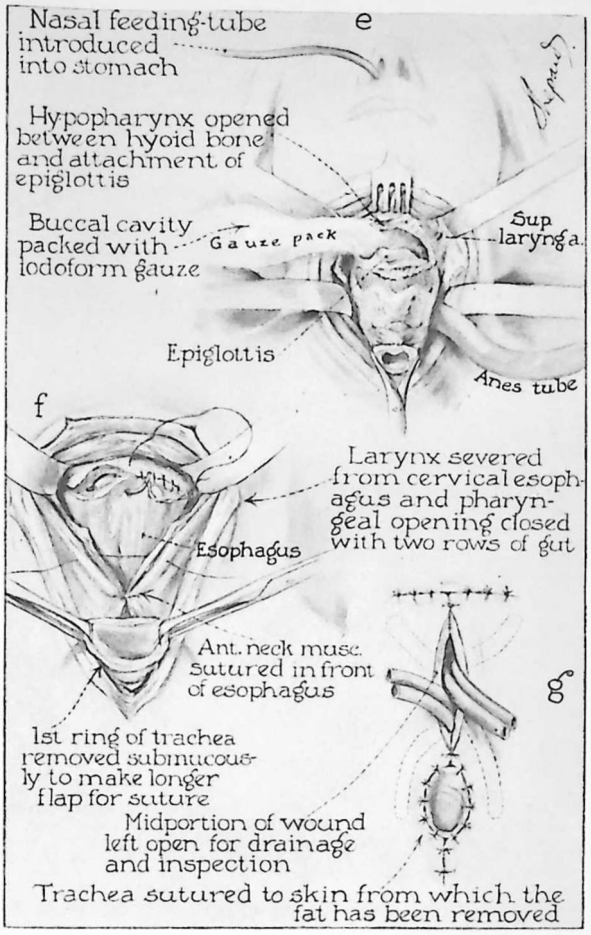


FIG. 485. Total laryngectomy in one step (continued). cervical esophagus. The opening in the pharynx is closed with two rows of interrupted catgut sutures. The strap muscles are reunited in front of the esophagus. The first ring of the trachea has been removed in a submucous manner to afford a longer flap for suture. g. Operation completed. Observe that the midportion of the wound was left open for drainage and dressings. Note the placement of the drainage tubes. The trachea has been sutured to the skin from which the fat has been removed.

(Fig. 485 f). Divide the pharyngeal mucosa transversely a half inch beyond the growth. Divide the thyroid membrane in front transversely.

Step 14. The epiglottis may be removed with the larynx which is dissected leaving the pharyngeal cavity open.

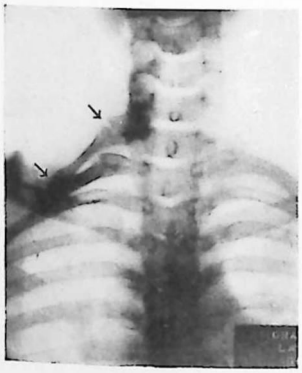


FIG. 486

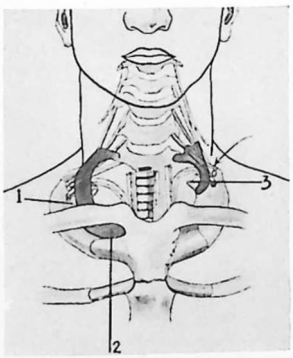


FIG. 487

FIG. 486. Cervical rib.

FIG. 487. Topography of cervical ribs: 1. first rib, 2. (shaded area) servical rib extending to the sternum, 3. scalenus anticus muscle. The arrow points to the direction of the pressure exerted upon the brachial plexus. The shaded area also represents the cervical rib (after Corning).

Step 15. Where it is possible to close the wound by suturing, the trachea is fastened to the lower part of the neck. Temporary drains are inserted (Fig. 485 g).

EXCISION OF CERVICAL RIB

Cervical ribs are unilateral or bilateral and are not of the same size. They are joined to the seventh cervical vertebra and in some instances terminate in the neck tissues; in other instances they are joined anteriorly to the first thoracic rib or sternum (Fig. 486). Ordinarily, there are no symptoms; however, in some cases the rib presses on the vessels or nerve-trunks passing over it (Fig. 487). If pressure symptoms do not respond to simple treatment, surgical intervention becomes necessary. Sometimes the connective tissue which extends beyond the rib is the source of trouble and must be excised.

Anterior Operation

Step 1. Approach:

(a) Make an incision beginning a finger's breadth over the clavicle and extending from the sternomastoid to the trapezius, or

(b) Make an oblique incision along the front edge of the trapezius muscle or slightly in front of it, or

(c) Make a vertical incision over the most prominent part of the swelling.

These incisions possess equal merit provided adequate exposure is obtained; it may be necessary, in some instances, to combine two incisions.

Step 2. Incise the platysma and superficial fascia; ligate the external jugular vein doubly and divide it between ligatures. Incise the deeper tissues so as to obtain exposure of the brachial plexus and large vessels. Carefully draw back the vessels and nerves lying over the cervical rib.

Step 3. Detach the rib from its tissues by means of blunt and sharp dissection; carefully avoid the pleura. Extraperiosteal excision of the rib is more difficult to perform than subperiosteal and seems to be somewhat superior. Expose a small middle part of the rib, divide it near the spine with a bone forceps, carefully cleaning away all sharp spicules adhering to the part left attached to the spine; divide the rib from its frontal attachment and remove it. Only the portion of the bone exerting pressure on the nerves and vessels need be excised, in cases where resection of the entire rib appears too difficult.

Step 4. Check bleeding. Effect closure of the wound by means of deep and superficial sutures.

Posterior Operation (Streissler's Method)

Step 1. Make an incision downward and parallel to the spine, beginning 2 cm. to the side of the spinous processes of the vertebrae and the width of a hand above the vertebra prominens and terminating the width of a hand below the vertebra prominens.

Step 2. Separate the trapezius, both rhomboids, serratus posticus and splenius; the complexus and semispinalis colli are also divided, thus obtaining exposure of the two lower cervical and two upper thoracic vertebrae, as well as the junction of the cervical rib and transverse process of the seventh cervical vertebra.

Step 3. Excise the transverse process exposing the neck of the rib, and divide it with a curved elevator, avoiding the nerve roots immediately in front of it.

Step 4. Grasp the rib with forceps and detach it as far as possible anteriorly by means of sharp and blunt dissection.

If removal of the rib proves too difficult on account of inadequate exposure, finish the operation through a front incision. The results, as a rule, are quite satisfactory.

Comment. Preserve, wherever possible, the posterior supraclavicular nerves; avoid the accessory nerve at the upper end of the wound. When mobilizing the sternomastoid muscle, pull it forward with the external jugular vein. When dividing the deep fascia, secure the transverse cervical vein as it passes over the posterior triangle where it merges with the external jugular vein. Free the posterior belly of the omohyoid muscle, displace it upward. Divide and ligate the transverse cervical artery where it crosses anterior to the brachial plexus. Be sure to identify the plexus at the lateral margin of the scalenus anterior muscle in front of the scalenus medius. In

palpating the cervical rib through the scalenus medius, divide the muscles over the proximal portion of the rib, detaching them entirely from that structure. The rib is usually divided with its periosteum beyond the transverse process of the cervical vertebra. In clearing the rib forward and downward, free a layer corresponding to Sibson's fascia. Avoid injuring the pleura.

The front end of the cervical rib is generally attached to the first thoracic rib in the area of the scalene tubercle by bone or tissue fibers. To obtain exposure of this junction, carefully draw forward the lowest trunk of the brachial plexus and the subclavian artery. Divide the front junction and remove the rib.

In unusual instances where the rib reaches beyond the scalene tubercle, the rib may be excised at the level of the tubercle, since the front portion is harmless. In cases where pressure exists on the lower portion of the brachial plexus near the middle of the first thoracic rib, a similar procedure is followed. Expose the first rib; clear and remove the portion between the neck of the rib and scalene tubercle.

Control hemorrhage and apply a large pad of wool and a bandage to preclude a hematoma.

REMOVAL OF THE CERVICAL SYMPATHETIC

Anatomic and Practical Considerations. The cervical sympathetic is sometimes included in injuries of the neck; it is frequently compressed by a neoplasm, dilatation of an artery or an abscess. Motor fibers of the involuntary muscles of the orbit and eyelids, vasomotor fibers of the face, neck and head, dilator fibers of the pupil, accelerator fibers of the heart and secretory fibers of the salivary glands are furnished by the cervical sympathetic. Irritation of the cervical sympathetic results in the following conditions: wider opening of the palpebral fissure, exophthalmos, dilatation of the pupils, decreased perspiration, saliva and nasal secretion; the face and neck of the patient appears pale and cold. Its obliteration results in symptoms directly opposite those enumerated above.

Epilepsy, glaucoma and exophthalmic goiter have been indications for the removal of the cervical sympathetic. Jonnesco has been very successful in performing this operation in cases of exophthalmic goiter; he recommends it also in cases of hysteria, chorea and brain tumor. The cervical sympathetic is situated on the prevertebral fascia back of the carotid sheath and may be removed through an incision in front of the sternomastoid. Directly opposite the transverse processes of the second and third vertebrae appears the superior cervical ganglion whose branches extend upward near the external and internal carotid arteries, the ascending branch passing through its bony canal along the internal carotid artery in the base of the skull where the carotid and cavernous plexuses develop. The remaining tributaries form a communication with the cranial nerves, the pharyngeal nerves and the superficial cervical cardiac nerve. On the inferior thyroid artery opposite the sixth cervical vertebra appears the middle cervical ganglion; between the neck of the first rib and the transverse process of the seventh cervical vertebra is found the inferior ganglion.

The superior thoracic ganglia of the cervical sympathetic, which are four or five in number, emerge into the thoracic viscera, while the inferior, which are seven or eight in number, make up the splanchnic nerves and supply the abdominal viscera through the solar plexus. It should be remembered that the intercostal nerves originating from the spinal cord which correspond with the splanchnics which emerge from the ganglia and the ilio-hypogastric and ilio-inguinal nerves furnish the motor and sensory supply of the wall of the abdomen. Similarly, the same portions of the spinal cord furnish the abdominal viscera and their coverings of skin and muscle.

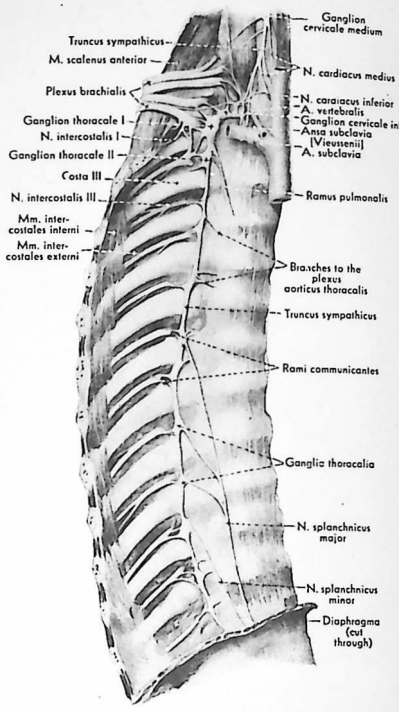


FIG. 488. Right sympathetic trunk in the thoracic cavity, viewed from the right and from in front. (The pleura and fascia endothoracica have been removed. Of the sympathicus only a few branches are drawn.)

The same pattern is followed by the nerves in the joints, the same nerve supplying the skin, joints and muscles, hence the sympathetic action of the joints under certain conditions. When a joint is inflamed in order to protect it, the skin becomes very sensitive, and the muscles stiffen making rest imperative. The abdominal muscles behave in the same way in case of inflamed viscera. (Fig. 488.)

Cervical Sympathectomy

Step 1. Make an incision beginning opposite the posterior margin of the mastoid process and continue it downward along the posterior border of the sternomastoid muscle to a point just below the clavicle. Divide the skin, superficial fascia and platysma. Ligate and divide the external jugular vein. Displace the sternomastoid muscle inward; expose by blunt dissection the common sheath of the exposed vessels (Fig. 520, page 444).

Step 2. Lift the unopened carotid sheath upward and retract it, thus exposing the cervical cord and superior and middle cervical ganglia. Isolate the trunk of the cervical sympathetic near the center of the incision and follow it up to the superior ganglion.

Step 3. Divide the communicating branches of the ganglion with scissors. Remove the ganglion with forceps.

Step 4. By making slight traction upon the distal end of the trunk, the cord is traced down to the middle ganglion; remove it in the same manner. Follow the main trunk of the sympathetic downward behind the clavicle to the inferior ganglion. Remove it. Exercise care not to injure the spinal accessory nerve and other important nerves and vessels in the vicinity.

Step 5. Unite with catgut sutures the separated muscles. Close the superficial wound.

Comment. Isolation and resection of the inferior ganglion is the most difficult step in the operation, as the ganglion lies deeply imbedded in a special pocket at the base of the neck or even in the thorax, behind the clavicle, against the neck and head of the first rib, between the scalenus anticus and longus colli muscles and just above the pleura. The trunk of the nerve should be used as a guide to the ganglion. It lies sometimes internal to, though rarely external to, the vertebral artery. The ganglion is adherent to the artery and enlaces it in a meshwork of its efferent and afferent fibers. To reach it, retract the scalenus anticus, the thyroid axis, and the vertebral artery and vein downward and outward; retract the sternomastoid muscle and the carotid sheath with its contents inward and forward. Divide the cellular and aponeurotic tissues covering the vessels and the ganglion. Isolate the ganglion from the vertebral artery externally and from the rib and spine internally. Isolate and divide the afferent and efferent fibers, and remove the ganglion.

Dangers.

1. Injury to the vertebral artery and vein.
2. Injury to the first intercostal artery or its cervical branch.
3. Injury to the subclavian artery, especially on the left side.
4. Injury to the pleura.
5. Morcellement may become necessary when the ganglion is friable.

6. Intimate union of the inferior cervical and first thoracic ganglia into one mass, from which a portion must be removed.
7. Injury to the retroclavicular venous plexus.

After the patient recovers from the operation performed on one side, the other side is operated on similarly.

TORTICOLLIS (WRY NECK; CAPUT OBSTIPUM)

There are several surgical methods to cope with this condition.

1. **Subcutaneous tenotomy** of the sternal and clavicular portions of the sternomastoid. (Fig. 489.) This operation is not much in vogue at

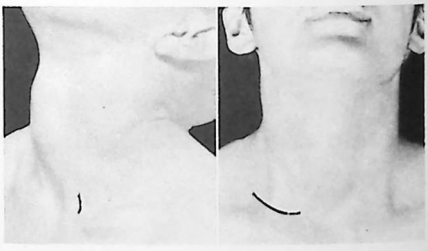


FIG. 489 FIG. 490

FIG. 489. Torticollis. Subcutaneous tenotomy of the sternal and clavicular portions of the sternomastoid.

FIG. 490. Line of incision in open tenotomy of the sternomastoid.

present; in its favor is the absence of scar, while against it appear the inadequacy of the procedure and its accompanying dangers.

2. **Open Operation.** This consists in dividing the constrictions and all fibrous bands which prevent rectification of the torticollis.
3. **Tendon Lengthening.**
4. **Mikulicz' procedure** which consists of excision of the degenerated sternomastoid.

In spasmodic torticollis the following methods may be used:

1. **Multiple myotomy** (Kocher).
2. **Finney's Operation** (see below).

Open Tenotomy of the Sternomastoid Muscle

Step 1. The tendon is divided ½ to ¾ inch above the clavicle; this is best accomplished by an oblique incision (Fig. 490). Begin the incision at the outer edge of the sternal attachment of the sternomastoid; the incision should be 1 to 2 inches in length and should extend upward and outward to the middle of the anterior margin of the clavicular portion of the muscle.

Step 2. Retract the wound thoroughly and expose both portions of the muscle.

Isolate and divide the attachments under visual guidance. The head of the patient should be rotated toward the sound side, thus putting all contracted structures on tension; these should be carefully divided.

Step 3. Attend to hemostasis. Close the wound. Dress.

Comment. Forcible overcorrection is advised by Lorenz before the patient comes out of the anesthesia. Retain the corrected or overcorrected position by an extension apparatus or by means of a proper dressing (plaster of Paris). Later resort to massage, etc.

Muscle Lengthening

This method is recommended by Thelwell Thomas. The object is to dispense with prolonged and tedious after treatment. No retentive apparatus is used.

Step 1. Make a transverse incision over the lower third of the sternomastoid. Expose the sternomastoid muscle and isolate its lower third. Compare for the degree of shortening on the affected side.

Step 2. Split the affected muscle longitudinally for a distance equal to a little more than half the amount of the shortening. Divide the anterior portion of the muscle transversely at the lower end of the vertical incision. At the upper end of the vertical incision divide the posterior portion of the muscle.

Step 3. Unite the ends of the muscle with chromicized catgut.

Step 4. Close the wound.

Comment. Besides lengthening the muscle, restraining bands should be thoroughly divided.

Mikulicz Operation—Myomectomy

In inveterate cases Mikulicz advised excision of the lower two-thirds of the sternomastoid, the upper one-third being preserved to avoid injury to the spinal accessory nerve.

Step 1. Expose and divide the sternal and clavicular portions of the muscle described above under open tenotomy.

Step 2. Grasp the divided ends of the muscle with forceps and pull these downward through the skin wound and while so doing, separate the muscle from its surroundings by thorough, blunt and sharp dissection. Avoid injuring the external jugular vein.

Step 3. When two-thirds of the muscle has been isolated, section and remove it.

Step 4. Attend to hemostasis. Divide all accessible cicatricial bands and close the wound. Dress. There is no need for postoperative orthopedic care.

Comment. Only one-third of the muscle is removed by Bruns. This operation should be reserved for severe or recurrent cases where all other methods have failed. The principle disadvantage of the operation is cosmetic disfiguration of the neck.

SPASMODIC TORTICOLLIS

John M. T. Finney and Walter Hughson made a study of thirty-two cases of spasmodic torticollis.[1] None were the common congenital and other acquired forms.

The disease derives its name from a sudden convulsive movement or spasm

[1] Annals of Surgery, 1925.

of one or more muscles or groups of muscles that move the head on the body. Not infrequently when one muscle or group of muscles—those primarily involved—are put out of commission by operation, the affection immediately manifests itself in an adjacent set of muscles, or may even involve the opposite side. This fact adds greatly to the uncertainty hitherto existing. Either for this reason or because incomplete operations have been performed, a comparatively large proportion of cases have required repeated operations before a cure has been effected. In a fairly large proportion of the cases maximum improvement was not attained for a considerable period—from six months to two or three years.

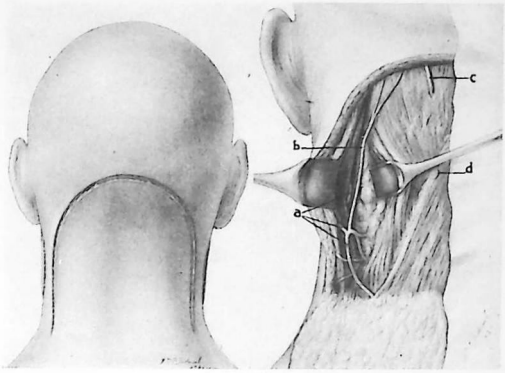


FIG. 491 FIG. 492

FIG. 491. Incision. Lower limit, level of angle of jaw; upper, 1½ cm. below occipital protuberance. (Courtesy of Dr. J. M. T. Finney.)

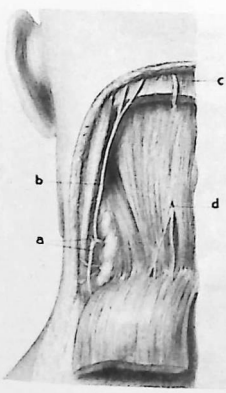
FIG. 492. a. Spinal accessory nerve; b. lesser occipital nerve; c. greater occipital nerve; d. third cervical nerve. View after skin and subcutaneous tissues have been turned back. (Courtesy of Dr. J. M. T. Finney.)

Finney Operation for Spasmodic Torticollis

Step 1. Make an incision along the posterior border of the sternomastoid muscle (Fig. 491), beginning at a point two finger-breadths below the level of the angle of the jaw and continuing upward along the edge of the muscle to a point about the level of the lobe of the ear, then curving over toward the midline to a point about two finger-breadths below the occipital protuberance, thence carried across the midline, following the same general direction as just described, in reverse order. When completed, the incision is in the form of an inverted "U."

Step 2. Reflect the flap of skin and subcutaneous tissue, taking care to identify and avoid the lesser occipital nerve which is quite superficial and lies along the posterior border of the sternomastoid muscle in its upper half. Having exposed and identified this nerve, follow it down to the point where it emerges from behind the posterior border of the sternomastoid muscle (Fig. 492).

Step 3. By retracting the sternomastoid muscle, the anterior divisions of the second, third and fourth cervical nerves now come into view together with the chain of deep cervical lymph nodes.



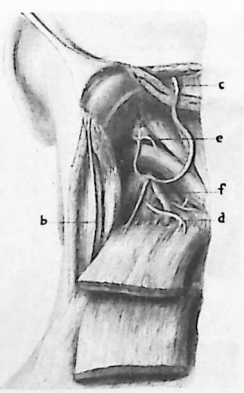


FIG. 493 FIG. 494

FIG. 493. a. Spinal accessory nerve; b. lesser occipital nerve; c. greater occipital nerve; d. third cervical nerve. Splenius and trapezius muscles have been divided and turned back.

FIG. 494. b. Lesser occipital nerve; c. greater occipital nerve; d. third cervical nerve; e. first occipital nerve; f. branch of venous plexus. All posterior muscles have been divided and turned back, exposing the suboccipital triangle. (Courtesy of Dr. J. M. T. Finney.)

Step 4. A little further in front of the nerve plexus, and consequently a little deeper in the wound, will be found the trunk of the spinal accessory nerve at the point where it emerges from the body of the muscle. The nerve having now been definitely identified (and here, as with all other nerve trunks involved, direct stimulation with a bipolar electrode makes the identification absolute) it can be resected at any point desired. No effort should be made to save the sensory branches of these nerves as, in Thomas' opinion, both efferent and afferent pathways should be interrupted.

Step 5. Search should next be made for the great occipital nerve where it emerges through the fibers of the splenius, about one cm. from the midline

and just beneath the skin incision. Having identified this nerve, divide transversely at this point the trapezius and splenius muscles (Fig. 493), exposing the fibers of the complexus which is easily recognized.

Step 6. The fibers of this muscle are divided in turn through its whole thickness in the same planes as the skin incision, and it is then reflected backward in the same way, care being taken all the while to preserve the great occipital nerve which lies immediately below it. This exposes the two recti muscles (major and minor), and the superior and inferior oblique (Fig. 494), each of which can be distinguished by the direction of its fibers and their common point of origin.

Step 7. The trunk of the great occipital nerve should then be traced down to the point where it emerges from the vertebral foramen at the lower border of the inferior oblique muscle. At this point will be found its anastomosis with the suboccipital nerve running across the body of the muscle to the point where it is given off from the first cervical nerve in the suboccipital triangle. The great occipital nerve should be resected below the point of anastomosis with the suboccipital nerve.

Step 8. The suboccipital nerve can be traced out in the suboccipital triangle as it emerges between the vertebral artery lying deep in the triangle and the upper border of the inferior oblique muscle. Its branches to the recti muscles and the superior and inferior oblique muscles are given off here, and the main trunk of the nerve can be readily resected at this point. Care should be taken not to injure the vertebral artery which can be identified as it lies on the floor of the triangle.

Step 9. The splenius and complexus muscles should be reflected sufficiently to allow the exposure of the third cervical nerve where it emerges a finger-breadth below the great occipital. At the level of the second and third cervical nerves is located a venous plexus of considerable size which may give rise to troublesome bleeding if care is not taken to avoid or control it, which, however, can be readily done. The third cervical nerve should be resected where it emerges from the vertebral foramen as it supplies fibers to the overlying muscles (splenius, trapezius and complexus).

Step 10. After the trunks of the upper three cervical nerves have been resected as described, the muscles may be replaced, layer by layer, and held in place by a few stitches, and the wound closed in the usual manner. In the earlier operations, portions of these muscles were excised, but subsequent experience has shown that with complete resection of the nerve-supply this rather mutilating procedure may be omitted. Formerly a drain, consisting of a small piece of protective, was always inserted at each corner of the incision, but with adequate hemostasis this is probably unnecessary.

At one time Finney applied a plaster of Paris bandage reinforced with wooden splints but this added greatly to the patient's discomfort and so was discontinued in favor of the ordinary gauze dressing and soft bandage, reinforced with light wooden coaptation-splints if desired. Notwithstanding the great extent of the wound, he has found the healing to be uniformly satisfactory and the resulting disability surprisingly slight.

The Spurling-Jelsma Technic in Spasmodic Torticollis

R. Glenn Spurling and Franklin Jelsma[1] point out:

While it is true that there are many reports in the literature commending the treatment of psychoanalysis and medical measures, such reports have been, on the whole, unconvincing.

There are cases in which the spasmodic contractures seem to be sharply limited to one sternocleidomastoid muscle or perhaps one sternocleidomastoid and one trapezius muscle. While cases of this sort are rare, yet they do occur, and a unilateral section of the spinal accessory nerve may effect a cure. Judging from the reports of some authors, it would seem that improvement is likely to be temporary because the spasmodic contractures soon develop on the opposite side or in the other muscles of the neck on the same side.

Spurling and Jelsma believe that all of the muscles of the neck are involved in severe cases; and nothing short of the radical intervention will suffice to relieve the symptoms. This attitude is the one held by the majority of surgeons who have written in recent years upon the treatment of this malady. The Keen operation forms the basis of treatment now generally employed. Finney and Hughson in 1925 described an operation which is a great improvement upon the original Keen procedure. It consists of sectioning the first three cervical nerves and the spinal accessory nerve bilaterally, also the division of most of the posterior neck muscles attached to the occipital bone. Their results in a series of thirty-two cases were highly satisfactory.

In 1924, McKenzie, from Cushing's clinic, reported the intradural section of the first, second and third cervical nerves and the spinal accessory nerve on one side for the relief of a severe case of spasmodic torticollis. In this report, a statement by Dr. Cushing indicated that as early as 1902 he had performed an intradural section of the first and second cervical nerves in the treatment of a case of this disease.

Coleman, in 1927, reported the first case in which the first four cervical posterior roots on both sides were sectioned intradurally. He resected the spinal accessory nerves in the neck at the secondary operation. The result in his case was highly satisfactory.

Since McKenzie's report appeared, neurosurgeons generally have adopted the intraspinal operation as the method of choice. The result seems more satisfactory than that by any other procedure heretofore employed.

The only variation in the technic of the intradural operation is that some authors advise cutting the spinal portion of the accessory nerve intradurally, while others prefer to section the nerve in the neck. Spurling and Jelsma believe that the operation can be performed safely by division of all the nerves, viz., the first three cervical anterior and posterior roots and the spinal portion of the accessory nerve intradurally. Thus, the entire procedure can be completed in one session through one operative incision. It is unnecessary to remove a part of the occipital bone as originally advised by McKenzie in order to section the accessory nerve. Inasmuch as

[1] South. Med. Jour., March, 1933.

we are concerned only with the spinal portion of the nerve, it can be divided easily through the dural incision at the level of the foramen magnum. It is unnecessary to section the cerebral portion of the accessory nerve, since it plays no part in the disease.

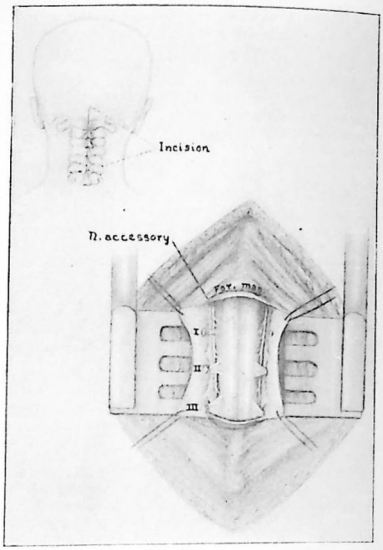


FIG. 495. Spurling-Jelsma operation. First, second and third posterior roots are shown on the left side. On the right side, the first posterior root is absent. The trunk of the spinal portion of the accessory nerve is shown bilaterally. Insert shows line of skin incision.

Step 1. Make a midline incision from the occipital protuberance to the spinous process of the fifth cervical vertebra. Free the muscles and periosteum from the spinous processes and the base of the occipital bone. Remove the laminae of the upper three cervical vertebrae.

Step 2. Open the dura mater in the midline over the first three cervical segments

and extend the incision upward to the rim of the foramen magnum, being careful to avoid the cerebellar dural sinus.

Step 3. Identify and section the posterior and anterior roots of the first three cervical nerves. (Often the posterior root of the first cervical nerve is absent.) Identify the filaments of the spinal portions of the eleventh nerve between the posterior and anterior cervical roots. Where these filaments unite to form the spinal part of the accessory nerve, a small artery is seen. Apply silver clips to include the artery and nerve trunk before cutting the nerve (Fig. 495).

Step 4. Close the dura and neck muscles with layers of interrupted silk sutures. Immobilize the patient's head for the first two days with sandbags. After this the patient should turn his head from side to side, gradually strive to support it while sitting in bed and after two weeks start active motion of the neck muscles.

Spurling and Jelsma comment as follows:

"Convalescence in the two cases which we have treated by this method has been rapid and uneventful. Spasmodic contractures disappeared immediately following the operation. At first, the patient will complain of considerable difficulty in supporting the head. In both instances the patients have been able to walk around with little or no discomfort after four weeks. In the first patient, upon whom we operated eight months ago, the weakness and fatigue of the neck muscles have entirely disappeared, although he still recognizes the fact that movements of the head and neck are limited considerably.

"The choice of which radical operation should be used in the treatment of severe spasmodic torticollis seems to us to be one of individual preference, because both the Finney operation and the intradural operation seek to accomplish the same end. We believe that the intradural operation is by far the simpler procedure, provided the operator is accustomed to intraspinal operations. The mortality for either operation should be practically nil. It seems to us that there is more likelihood of missing important nerve roots by the Finney operation than by the intradural approach. There again, such a contingency would depend largely upon the skill and experience of the individual operator. When the Finney operation is employed, there is always the possibility of regeneration of the nerves after section outside the spinal cord. This possibility does not occur when the nerves are sectioned intradurally."

CYSTS AND TUMORS OF THE NECK

REMOVAL OF TUMORS OF THE NECK IN GENERAL

Removal of tumors of the neck requires mature surgical judgment and experience. It is beset with many pitfalls and dangers. Beginners and those of limited experience tred dangerous ground in undertaking removal of tumors of the neck.

"Block dissection" of the tumor and regional lymph nodes is the goal. In other words, an attempt is made to dissect out the neoplasm and its lymph apparatus en bloc (Fig. 497).

Dangers of the Operation.

1. **Hemorrhage.** Careful dissection and ligation of vessels as encountered will do much to minimize bleeding.
2. **Air Embolism.** We must remember that during inspiration the blood in the cervical veins is under negative pressure and that, under these circumstances, if a vein is injured, air may be sucked into the vessel and through it into the heart with fatal results. This may be obviated by painstak-



FIG. 496. Lymphosarcoma of glands of neck; metastases in the mediastinum. (From Author's Service of Cook County Hospital.)

ing technic and prompt action should the accident occur (salt solution; pressure).

Precautions.

1. Always work with ample exposure and good illumination.
2. Keep the wound moist; should the slightest "hissing" sound be heard, promptly press the finger against the tissue at a point nearer the heart than is the wounded vein. "Hissing" means air has found its way into the vessel, or injury to the pleura; ascertain which. Throw salt solution into the wound.

   The late John B. Murphy placed a small pack of gauze to which a thread was attached to keep it from being lost, under the sternal attachment of the sternomastoid muscle. The object was to exert pressure to keep the cervical veins full, thus making the veins visibly prominent and preventing the danger of negative pressure. This step is of great value.

   Leave inoperable cases alone. (Fig. 496.) (See also air-embolism.)
3. Use blunt dissection in preference to sharp division of the tissues.

4. **Stop! look! and touch!** before you divide any structure about which you are in doubt.
5. Insure hemostasis as you go along. Respect tissues; treat them kindly; don't tear.

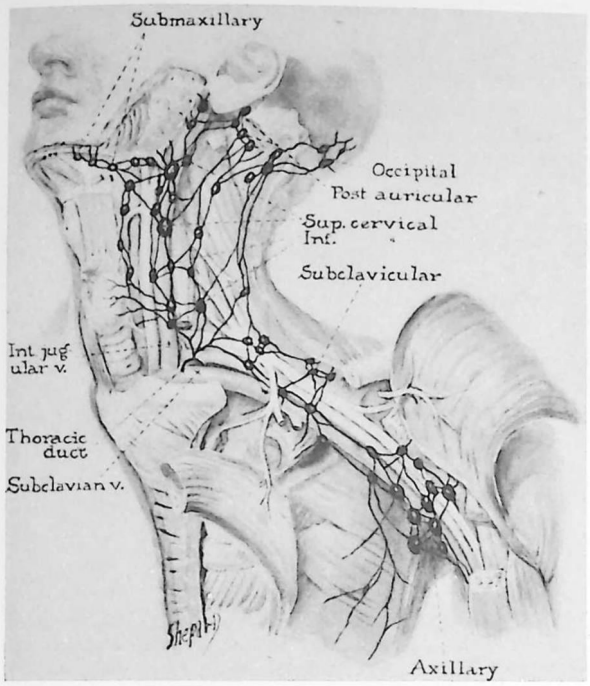


FIG. 497. Distribution of the lymphatics in the neck.

If, in spite of all precautions, air has been sucked into a vein, Binnie advises packing the wound in the neck loosely; do not apply forceps to the vein or forcibly compress the chest during the succeeding expirations; and do not lower the head and shoulders of the patient.

6. **Avoid injury to the thoracic duct.** When the duct has been injured a little clear fluid (chyle) is seen escaping. Usually such mishaps are not

fraught with danger. Lecéne points out that the discharge will continue for about three weeks. It usually yields to compression and proper gauze tamponade. During this period patients lose considerable weight.

7. **Avoid injury to important nerves:** the spinal accessory, vagus, phrenic, recurrent laryngeal or cervical sympathetic nerves.

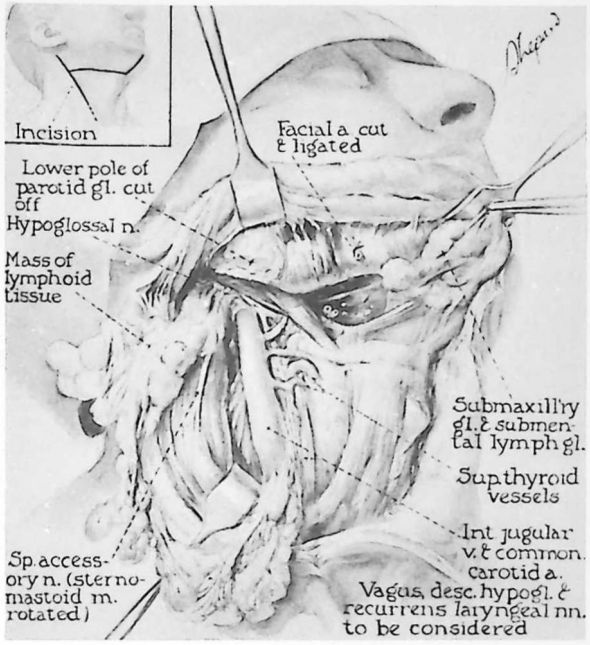


FIG. 498. Block dissection of the lymph nodes of the neck, submaxillary and submental regions.

Where the affected lymph nodes are few or not adherent, the operation is simple. Under such circumstances, make an incision over the tumor and shell it out by blunt dissection through the incision.

Step 1. Drape the scalp with a gauze or rubber cap to keep the hair out of the way. Support the patient's shoulders and turn his head to the opposite side.

Step 2. Make an oblique incision along the sternomastoid muscle beginning at the mastoid process and ending near the sternoclavicular articulation Expose

the external jugular vein and divide it between two ligatures (Fig. 498). Keep the field of operation constantly free from blood.

Step 3. Dissect the skin liberally from the subjacent tissues anterior and posterior to the incision and retract it. If necessary, make another incision beginning at the lower end of the oblique incision and continue it outward, parallel to and close to the clavicle. A variety of incisions have been recommended for block dissections in this region. The resourceful surgeon will plan the incision to meet the requirements of the case.

Lay bare the sternomastoid muscle and liberate it from its surroundings through its entire extent. Divide the deep cervical fascia at the upper border of the clavicle from the symphysis menti to the mastoid process and downward across the hyoid bone to the sternal portion of the sternomastoid muscle; ligate and divide the sternomastoid muscle.

When the internal jugular vein is to be ligated and divided, do so just above the clavicle. Look for the omohyoid muscle which has been exposed and find the internal jugular vein beneath it. Dissect the vein out of its sheath. Do not injure the internal carotid artery or vagus nerve.

Notice the point of exit of the superficial cervical nerves at the posterior edge of the muscle. These nerves are of considerable size and with careful dissection are readily identified. Identify the spinal accessory nerve as it emerges from behind the sternomastoid muscle. This nerve enters the muscle about two inches below the tip of the mastoid process, after passing over the prominent transverse process of the atlas. It is important to preserve this nerve in young individuals. Christian Fenger has shown that if the nerve is severed, drooping of the shoulder and scoliosis result.

Step 4. Dissect out the packet of fascia which enfolds the carotid artery, the internal jugular vein, and the vagus nerve. Once exposed, protection of these important structures from trauma is facilitated. Clear out the supraclavicular space. Ligate the transverse cervical artery here. Look out for the thoracic duct. If divided, no harm will result (see above). Respect the phrenic nerve and cupola of the pleura at the apex of the lung.

Step 5. Systematically remove the diseased lymph nodes. Begin the dissection near the lower end of the wound and by the side of the carotid packet. This is not difficult to accomplish. No blind work is permissible. If these important structures are not carefully exposed and protected at an early stage in the operation, thorough removal of the nodes will become a difficult and dangerous task.

Step 6. Repair the wound in the cervical fascia by suture. Attend to thorough hemostasis. Unite the platysma. In careless suturing of the fascia an ugly scar will result because of stretching of the skin. Drain at the lower angle of the wound.

Step 7. Close the skin wound with interrupted sutures or Michel clips. Apply a voluminous dressing.

Comment. If the operation is performed for tuberculous lymph-nodes some may be ruptured and permit caseous material to escape. In such case, wipe the escaped material away. It is good practice to scrape the remnants of the caseous material from the ruptured gland, subsequently mopping the part scraped with liquid carbolic acid.

In dissecting the nodes for malignant disease look for the external maxillary artery in the upper part of the dissection and identify it where it enters the groove in the submaxillary gland. Clamp and doubly ligate it. Remove the submaxillary gland with its nodes and ligate its duct close to the floor of the mouth. Include the submental nodes in the dissection. When working along the horizontal ramus of the mandible a number of facial veins will also call for division and ligature. Along the submental region great care should be exercised not to leave any nodes behind. Crile insists, and justly so, that complete block dissection of the neck in all cases of carcinoma of the tongue is of cardinal importance. To this must be added complete ablation of the fascial structures surrounding the lymph nodes and complete removal of the sternomastoid muscle. Block dissection is done with greater facility when the sternomastoid is removed together with the anterior jugular vein and lymph structures. In some cases removal of the primary growth with the cautery instead of the scalpel is of distinct value. In working in the submaxillary region, do not injure the hypoglossal nerve.



FIG. 499. Tuberculous lymphoma of the glands of the neck.

HODGKINS DISEASE; MALIGNANT LYMPHOMA; TUBERCULOUS CERVICAL ADENITIS

Much surgery has been done in this class of cases heretofore. At present the scalpel has yielded to x-ray, radium and heliotherapy with much more gratifying results than before; particularly is this true in tuberculous lymphadenitis, while Hodgkins disease is, it needs no emphasis, not amenable to surgical interference (Figs. 499 and 496, p. 423).

The surgeon of today rarely subjects cases of tuberculous lymphadenitis to operation without having first given the measures enumerated above a trial. If a block dissection should, for some reason, be decided upon, the technic of that operation will be found elsewhere in this chapter.

THYROGLOSSAL CYSTS AND SINUSES (FISTULAS)

These congenital conditions are usually found in one of three situations (Fig. 500):

1. Between the foramen cecum of the tongue and the hyoid bone (Fig. 501);
2. Between the hyoid and larynx;
3. Below the larynx overlying the trachea.

The second variety is the most common.. The tumefactions appear as cysts which approach the skin and rupture or are incised so that, as a rule, the surgeon has a sinus rather than a cyst to treat. Suppuration may complicate the condition.

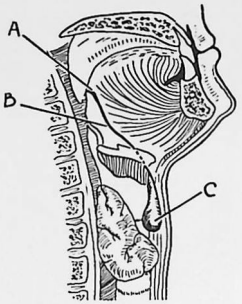


Fig. 500

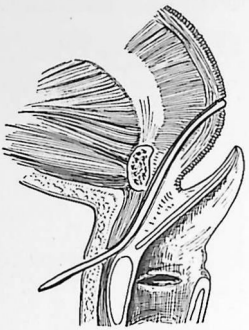


Fig. 501

Fig. 500. Excision of thyroglossal cysts and sinuses (Sistrunk's technic). Lateral view of the remains of the thyroglossal structures: A. foramen cecum, B. thyroglossal duct, C. thyroglossal cyst, showing their embryologic connection with the pyramidal lobe of the thyroid gland.

Fig. 501. Median branchial fistula connected with the foramen cecum of the tongue.

Operation for Second Variety of Thyroglossal Sinus

Step 1. To point the way in exploring the sinus, inject it with a strong methyl blue or brilliant green solution.

Step 2. Circumincise the scar or sinus around a probe introduced into it.

Step 3. Identify the borders of the sternohyoid muscles; retract these. Grasp the sinus with an Allis forceps. Dissect it out by sharp instruments taking care not to sever its superficial part from the deep portion. Follow the course of the sinus which is usually inward, toward the lower edge of the hyoid bone.

Step 4. Cut off the sinus with the lower border of the hyoid bone. As a rule, this is not difficult because most of these operations are on the young when the hyoid is still cartilaginous. Only in so doing can one be sure that the very bottom of the sinus has been removed.

Step 5. Place a small drain at the bottom of the wound.

Median cysts below the larynx and about the sternal notch between the thyroid lobes are very rare. In attacking these, one may shell them out. A pedicle attaches them to the deeper structures (isthmus of thyroid); the pedicle is to be divided.

Cysts below the foramen cecum were referred to by Bland Sutton as "lingual dermoids." Occasionally they are small and are situated just under the foramen cecum producing a tumefaction in this region. Excision is difficult. If they assume considerable proportions, they push the tongue out of the mouth and are palpable between the mandible and the hyoid bone. They must be attacked from below through a midline incision or a curved incision running parallel with the mandible. The latter gives better exposure. Exercise care not to leave any portion of the cyst-wall behind. The attachments are usually to the hyoid bone and foramen cecum.

Excision of Thyroglossal Sinus
(Sistrunk's Technic)

Either local or general anesthesia may be used; general anesthesia is preferable due to the gagging which accompanies the insertion of the finger about the

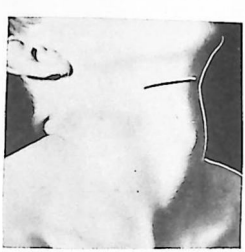


Fig. 502

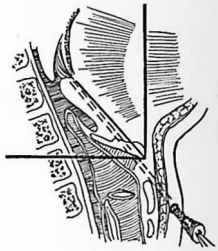


Fig. 503

Fig. 502. Excision of thyroglossal cysts and sinuses (Sistrunk's technic). Line of incision.

Fig. 503. Ascertain the direction of the course of the thyroglossal duct by drawing imaginary lines, one longitudinal and the other perpendicular to the center of the hyoid bone. "Coring out" of the cyst and duct is done along the line represented by the 45 degree bisection of the right angle extending from the distal end of the cyst just below the center of the foramen cecum.

foramen cecum. If a sinus is present, it should be injected with a solution of methylene blue. Place a pillow under the shoulders and head of the patient. Extend the neck in the same way as for thyroidectomy.

Step 1. Make a transverse incision over the cyst about 1 or 1½ inches long, including the skin, subcutaneous tissues and platysma muscle (Figs. 502-503).

Step 2. Divide the raphé joining the sternohyoid muscles in the midline. The cyst is visible immediately under this raphé; dissect it free and in an upward direction toward the hyoid bone. In most instances the tract runs under the hyoid bone making it advisable to remove a small portion from the center of the bone with stout scissors.

Step 3. After introducing a mouth-gag, insert the left index finger into the mouth.

Draw the tongue forward by means of a suture. Direct the finger backward over the tongue thus locating the circumvallate papillae two rows of which form a 'V" near the base. Immediately back of this point the foramen cecum appears. Insert the finger, pressing upward and forward and in this way shorten the distance between it and the hyoid bone. Be mindful of the thyroglossal duct. Core an area about 3 mm. in diameter from the muscles of the tongue with a knife or long-bladed scissors. Make no attempt to isolate the duct; its fragility renders such a step inadvisable.

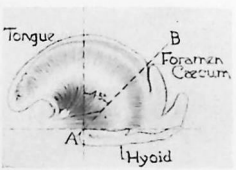


Fig. 504. Sistrunk's operation for the removal of thyroglossal tract. The illustration shows the suprahyoid portion of the thyroglossal tract by "coring out" the tissues along the lines indicated, A-B.

Step 4. With a finger about the foramen cecum acting as a guide, avoid entering the mucosa of the mouth. With a scissors or knife, cut off the cored-out muscles of the tongue when the foramen is reached.

Step 5. Repair the defect in the muscles with a few interrupted catgut sutures; avoid injuring the hypoglossal nerves by placing the sutures superficially.

Step 6. Introduce a small split rubber tube deeply into the muscles of the tongue allowing it to protrude over the hyoid bone. Repair the defect in the bone by approximating the edges with chromic catgut sutures including the periosteum and adjoining tissues. As a rule, two sutures are sufficient. Separate closure is unnecessary for the raphé wound. Close the skin with interrupted sutures of horsehair or any non-absorbable material. Permit the rubber drain to remain in place for four or five days.

Comment. The thyroglossal duct follows a direction in accordance with a line drawn at an angle of 45 degrees backward and downward in the direction of the foramen cecum through the intersection of lines drawn perpendicularly and horizontally toward the center of the hyoid bone (Fig. 504.) An important factor to observe in connection with this operation is the complete disregarding of the duct and the coring out of the tissues through which it passes. A guiding finger in the mouth prevents entering the mouth or pharynx.

Cervical Auricles: Branchial Cysts and Fistulae

The second, third, and fourth branchial clefts have their external orifices along the anterior margin of the sternomastoid muscle. The opening of the second, the one most commonly affected, is situated about the level of the angle of the mandible. It opens into the space in which the tonsil is lodged. If accompanied by a fistula, its dissection with closure of the pharyngeal opening is one of the most difficult things to accomplish. The reason for this is obvious when we recall that the sinus winds its way into the pharynx between the internal and external carotid arteries.

The third and fourth clefts enter the upper part of the larynx; the superior laryngeal nerve is seriously jeopardized if these are attacked.

The cysts of the second cleft are quite common and are distinguished with some difficulty from an enlarged lymph-node in the same situation. Their wall is thick. Their surgical removal does not differ from the operation for a tuberculous lymph-node or other localized tumor (Fig. 505).

Branchial sinuses opening externally are but slightly disfiguring. They require no interference. The scar resulting after their removal will be more conspicuous than the small skin depression in the neck. **"Accessory auricles"** are rare. They consist of tabs of skin and cartilage (termed cervical auricles) found in the neck or just in front of the ear. They are not particularly difficult to remove except when complicated with sinuses.



Fig. 505. Branchial cyst diagnosed as malignant gland of the neck.

Olan R. Hyndman and George Light[1] comment as follows concerning the etiology of branchial cysts:

"1. Branchial cleft anomalies (cysts and fistulas) result from a failure of absorption of the included ectodermal and entodermal epithelium that is buried during the growth and fusion of the branchial arches in early embryonic life. This is most probably the sole explanation, the thymic stalk playing no rôle.

"2. Branchial cysts, in truth, are epidermoid cysts of the neck whose parent epithelium was buried during the development of the branchial apparatus. Their characters are more varied, of course, than those of the commoner epidermoid or inclusion cysts owing to the activity of the entodermal or ectodermal epithelium or both. Many of the submaxillary cysts and so-called granulae are of branchial origin.

[1] Archives of Surgery, September, 1929, Vol. 19.

"3. Branchial fistulas may be familial and hereditary, and they seem to be inherited through the mother only.

"4. More attention should be given to the possibility that a tumor in the neck is of branchial origin, especially in view of their frequent simulation of tuberculous glands and their occurrence in early youth. This is enjoined even more by the fact that results from treatment are in proportion to the completeness with which the epithelial wall is excised.

"5. An adequate and simple classification of the cysts would be (a) branchial cleft epidermoid cysts and (b) branchial cleft mucous cysts."

TUMOR OF THE CAROTID BODY

These tumors are of rare occurrence and are often referred to as paragangliomas or as pheochromoblastomas or chromaffinomas (Fig. 506). They are usually benign and are encountered in the parasympathetic system. While described as a slow-growing, benign neoplasm, recurrences after removal and metastases have been described in about 25 to 30 per cent of cases, the latter reproduce in the main the histologic structure of the carotid gland. These tumors may grow very slowly for many years and ultimately display malignant characteristics. The tumor originates at the bifurcation of the common carotid artery, in the carotid sheath, hence the pneumogastric, hypoglossal and sympathetic nerves are affected early. It tends to displace the pharyngeal wall inward; the opposite is true of lymph-nodes in the same locality. Carotid body tumors when of considerable

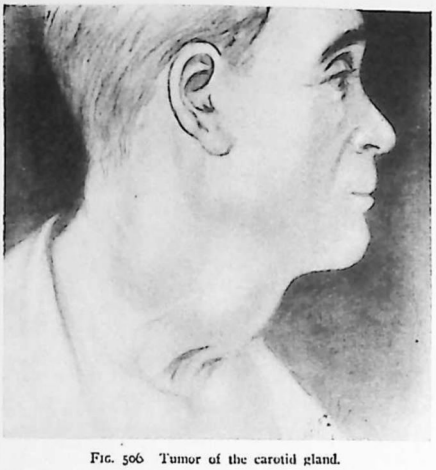


FIG. 506. Tumor of the carotid gland.

size are so vascular that a bruit and expansive pulsation have caused them to be misdiagnosed as aneurysms.

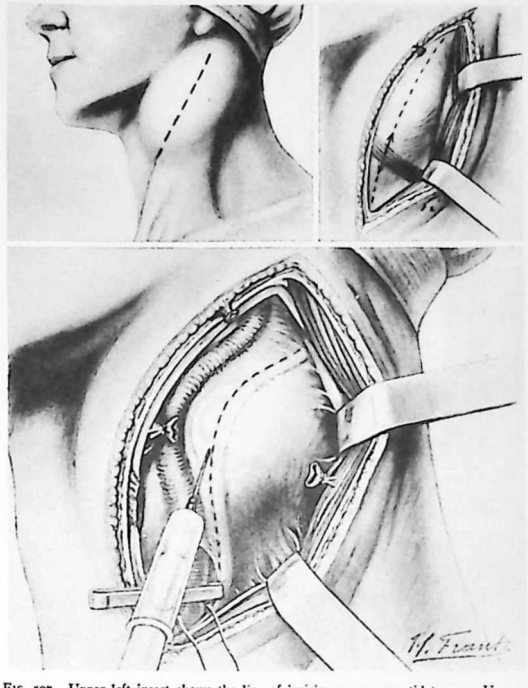


FIG. 507. Upper left insert shows the line of incision over a carotid tumor. Upper right insert depicts the sternomastoid muscle retracted; the omohyoid is seen to traverse the operative field toward the inferior angle. After incising the middle cervical aponeurosis, the omohyoid muscle and the vascular nervous bundle, which is shown ligated in the illustration, the internal jugular vein is retracted together with the sternocleidomastoid muscle. A rubber covered hemostatic clamp is shown compressing the common carotid artery. Observe that the pneumogastric nerve, which passes on the external surface of the tumor, is being injected with an anesthetic.

Step 1. Make an incision along the anterior border of the sternomastoid muscle.

Step 2. As soon as the tumor is exposed, endeavor to determine whether or not it is operable. Often such violent bleeding ensues that ligation of the carotid becomes imperative. In such an emergency, the common carotid artery is

ligated first, then the external, and finally the internal, at the base of the skull. The ligation of the common carotid has, it should be remembered, a high mortality.

Step 3. Remove the tumor. Close the wound.

Dangers of the operation.

1. Immediate high operative mortality.
2. Effects of ligation on the common artery (softening of the brain, hemiplegia, etc.
3. Injury to the hypoglossal, pneumogastric and sympathetic nerves.

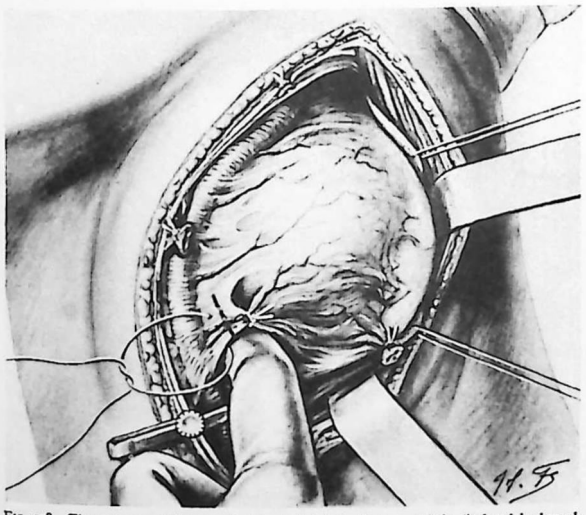


FIG. 508. The pneumogastric nerve is surrounded by a ligature and is displaced backwards. A ligature is placed on the carotid artery near its bifurcation.

Comment. In view of the comparative benignancy of these tumors radium may be tried if danger is sensed should an operation be undertaken. In one of my cases I was able to control bleeding by tamponade (the tumor was not large) after removal of most of the tumor. The patient was then subjected to radium treatment. The tumor diminished in size and at the present writing (3 years after the operation) the patient is at work (housemaid) and enjoys good health.

In the young, therefore, when the tumor is of limited size, radical extirpation should be attempted. In persons of advanced years with atheromatous vessels which would render ligation of the carotid hazardous, it is better to counsel against operation.

P. L. Mirizzi[1] has described a method of removal of a large carotid tumor, the steps of which are illustrated in the subjoined (Figs. 507-508-509).

OPERATIONS ON THE THYROID GLAND

Terminology. One is impressed with the confusion still existing in the denominations of surgical procedures dealing with operations on the thyroid gland. Excision, enucleation, resection, hemithyroidectomy, lobectomy, are terms used frequently and indiscriminately.

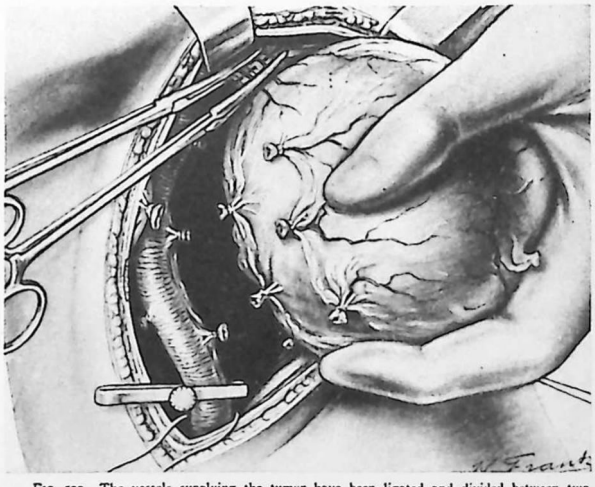


FIG. 509. The vessels supplying the tumor have been ligated and divided between two mosquito forceps. Isolation of the vessels is aided by putting the tumor on traction which exposes the vessels to better advantage (courtesy of Prof. P. L. Mirizzi).

1. Excision (Kocher) refers to a complete removal of one or both lobes. The method is applicable in malignancies of the thyroid only.

2. Resection (Mikulicz) indicates a partial extirpation of one or both lobes of the thyroid.

3. Enucleation (Socin, Billroth) means the removal by separation of one or more nodes or cysts from the thyroid substance.

4. Combined procedures of enucleation and resection are often done. In the majority of cases melon (cuneiform) or marginal resections are performed.

Anatomic Considerations. (Figs. 510-511.) The thyroid gland consists of two lateral lobes and an isthmus. Each lateral lobe is conical in shape with the base directed downward. The superficial surface is slightly convex. It is covered by the

[1] La Presse Medicale, Cordoba, Argentine, No. 92, du 16 Novembre, 1935.

sternohyoid, sternothyroid and the anterior belly of the omohyoid muscles. It is also overlapped by the anterior border of the sternocleidomastoid muscle. Its deep surface is concave and rests upon the lower part of the thyroid cartilage, the side of

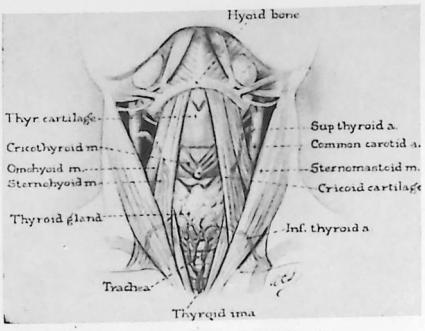


FIG. 510. Anatomy of the anterior thyroid region.

the cricoid cartilage and the sides of the upper five or six rings of the trachea. Its posterior border is rounded and rests upon the pharynx, the esophagus and the prevertebral layer of the deep cervical fascia. If enlarged the lateral lobe may overlie the carotid sheath.

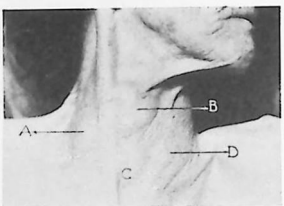


FIG. 511. Surface markings of thyroid gland: A. right lobe, B. pyramidal lobe, C. isthmus, D. left lobe.

The apex of the gland lies upon the inferior constrictor of the pharynx. The isthmus connects the anterior borders of the lateral lobes; it is inconstant, in both

size and position and covers the anterior surface of the second, third and fourth rings of the trachea. The pyramidal lobe, if present, runs upward toward the body of the hyoid bone to which it is attached by a fibro-muscular band.

Rather frequently the lower border of the lobes of the thyroid extend to the superior margin of the sternum. Occasionally they may dip past the clavicle into the superior mediastinum. We then speak of an intrathoracic goiter.

The capsules of the thyroid. For the beginner particularly, these are rather confusing anatomic entities. After dividing the prethyroid muscles a connective tissue layer of variable thickness is encountered. It is a component of the deep cervical fascia. It is known as the external capsule of the thyroid, or prethyroid membrane. (Kocher.) Reverdin called it the "envelope aponeurotique." The best descriptive term, however, adopted by many surgeons is that of the surgical capsule. This capsule is derived from the pretracheal fascia. It is composed of loose connective tissue and is easily detachable. It surrounds the thyroid in all directions and is attached to the trachea and the cricoid cartilage. This membranous structure is of great importance because the parathyroid glands are situated posteriorly on its inner surface. The thyroid gland itself is surrounded by the glandular capsule, often referred to as the capsula interna or capsula propria. It is a peritoneum-like structure through which the large veins are seen coursing on the surface of the thyroid gland. There are three cleavage spaces which are of great importance in operations on the thyroid.

(a) The **sternomastoid space** (deQuervain) between the **sternocleidomastoid muscle** and the prethyroid muscles.

(b) The **musculo-capsular space** between the prethyroid muscles and the surgical capsule, and the

(c) **Intercapsular or surgical space,** located between the glandular capsule and the surgical capsule. This is the most important of the three cleavage spaces. It is composed of loose connective tissue and contains numerous arteries and veins. It surrounds the thyroid gland entirely, extending from one side of the trachea and esophagus to the other side. It is only at the postero-internal surface of the thyroid that they come into more intimate contact. Normally, the relations between the glandular capsule and surgical capsule are very loose. Numerous vessels course here from and out of the thyroid. The surgical space plays an important rôle in operations on the thyroid. The carotid sheath is entirely independent of the spaces described. The inferior thyroid artery passes behind the carotid sheath but does not penetrate it.

Blood Supply. The thyroid gland receives its blood supply from the following sources: superior, inferior thyroid and thyroidea ima. The superior thyroid veins, one or two on each side, leave the upper pole of the thyroid body and ascend to join the internal jugular or common facial vein. A middle thyroid vein in the average case issues from each lateral lobe of the thyroid, crosses the common carotid artery, and enters the internal jugular. This vein is extremely variable in position; moreover, it may be absent or may be represented by several veins. The inferior thyroid veins are of large size; they are formed by branches from the isthmus and lateral lobes of the thyroid. Their course is variable, but in general they descend along the trachea to the innominate trunks. At times they form a plexus on the front of the trachea below the isthmus of the thyroid. All these veins anastomose freely.

The **recurrent (inferior)** laryngeal nerves play an important rôle in operations on the thyroid gland. They are closely related to the lower posterior medial surfaces, (danger zones of Crotti) of the respective thyroid lobes. They course from below upward, lying in the groove between the trachea and esophagus. They pass under the lower border of the inferior constrictor of the pharynx, and enter the larynx behind the articulations of the inferior cornua of the thyroid cartilage with the cricoid. The nerve usually passes behind the inferior thyroid artery. This, however, is not constant; its course varies.

Nerve Supply. The nerves of the thyroid accompany and surround the blood

vessels. They are derived from the superior ganglion of the sympathetic and from the superior and inferior laryngeal branches of the pneumogastric.

The Parathyroids. (Fig. 512.) These bodies which are referred to by Kohn as "epithelial bodies" have their origin in the branchial clefts. They appear as masses of closely connected epithelial cells on either side of the third and fourth branchial clefts. They are generally considered to be four in number although counting them is

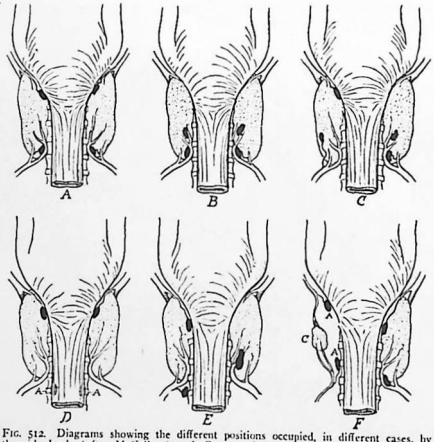


FIG. 512. Diagrams showing the different positions occupied, in different cases, by the parathyroid glands (after McCullum). *A*. Organs of the neck as seen from behind. Four parathyroids—represented as four black oval bodies—are seen in the positions which they commonly occupy. *B*. The two upper parathyroid glands lie close to the lower pair, which are in their usual position. *C*. The left upper and right lower glands are in their most typical position. The right upper gland lies in the region of the inferior thyroid artery; the left lower gland, supplied by a long arterial branch, is imbedded in the posterior surface of the thyroid near its outer margin. *D*. The two upper parathyroid glands are in the common position. The two lower glands AA lie on the anterior surface of the trachea. *E*. On the left side there are two parathyroid glands while on the right only one large gland is to be found. *F*. On the right side the condition of the parts (B) is practically normal; on the left side, however, the thyroid lobe (C) is almost completely atrophied, but the parathyroids (AA) are found about in their usual positions.

difficult because of their small size, inconstant position and resemblance to the surrounding structures. These bodies are enveloped in a capsule made up of thin fibers, have a reticular stroma and are furnished with a generous blood-supply.

These glands generally appear in pairs consisting of a superior (external) and an inferior (internal) body. As a rule, the superior is found close to the thyroid on the middle third of its back surface almost level with the lower margin of the cricoid cartilage. It appears posteriorly and external to the terminal tributaries of the in-

ferior thyroid artery and recurrent laryngeal nerve. The inferior is generally found on the posterior part of the lower third of the thyroid, hence often appearing in front of the recurrent laryngeal nerve and inferior thyroid artery near the thyroid gland at the entrance of the lower arterial branches. It is also found at the inferior pole of the thyroid or immediately under it. Small masses of parathyroid cells have often been found below the thyroid, within the thymus and even within the thyroid (Getzowa).

The parathyroid glands are located external to the thyroid and are separated from it by the external capsule, although one or more may be found under the capsule but are hardly ever found imbedded in the gland itself. Their size averages about 6 to 4 by 2 mm. (Berkeley); however, it varies from 3 mm. to 15 mm. They are round, oval or reniform and generally flat. They have an unusual yellowish brown color.

Preoperative Medication

Emil Goetsch[1] discusses the correct and incorrect use of iodine particularly in preoperative medication and summarizes his observations as follows:

"Iodine has an important relationship to the normal function of the thyroid gland in which it is constantly present and is stored as a normal constituent.

"Simple colloid goiter, the inactive type of parenchymatous goiter, commonly develops whenever there is a deficient intake or a faulty metabolism of iodine in the body. Simple colloid or endemic goiter may be prevented by the prophylactic administration of minute amounts of iodine. Iodine, in small amounts, together with small amounts of thyroid extract is advised in the treatment of simple goiter. This is the only type of goiter in which the therapeutic administration of iodine is indicated. The prolonged administration of iodine to the simple colloid goiter may, however, occasionally stimulate the gland with the consequent production of hyperthyroidism. A correct diagnosis as to the type of goiter is therefore of the greatest importance in order to institute correct therapy.

"A nontoxic goiter may be activated and the symptoms of a toxic goiter may be exacerbated by the indiscriminate administration of iodine.

"The administration of iodine during pregnancy is indicated only in case inactivity of the thyroid gland is present. The physiologically overactive thyroid gland in pregnancy may be stimulated to further activity resulting in a state of true clinical hyperthyroidism.

"The administration of iodine does not prevent the growth and development of true adenoma and has no place in the medical treatment of this condition. Nontoxic adenoma is commonly activated by indiscriminate treatment with iodine and the symptoms of toxic adenoma are exacerbated by its use. The preoperative intensive preparation of the majority of patients with toxic adenoma does not produce improvement comparable to that seen in the case of exophthalmic goiter. The acutely toxic adenomatous goiter particularly when the metabolic rate is high, is often favorably influenced by the use of iodine, whereas those cases of adenoma with lesser degrees of hyperthyroidism may show relatively little improvement. An appreciable number in this group may be made acutely worse.

"The hyperplastic thyroid gland has an extraordinary affinity for iodine which causes the hyperplasia to revert to the colloid or resting state. Accordingly, when iodine is intensively administered to the patient with Graves' disease, previously untreated with iodine, a marked clinical remission in the course of the disease is produced. Operation should be and can be safely performed during this

[1] Amer. Jour. Surgery, 1914.

period of remission. The mortality of resection operations done during the period of remission has been reduced almost to nil, and stage operations are rarely necessary. If thyroid resection is not done at this favorable time of remission, the patient often relapses into a state of clinical exacerbation in the course of one to two or even three months. A condition of uncontrollable hyperthyroidism may thus result. Similarly, exacerbation may follow upon the administration of iodine even in small doses, over a prolonged period.

"The hyperplastic thyroid gland in the phase of reactivation following a previous period of treatment with iodine becomes relatively insensitive or refractive to the further administration of iodine. The preoperative treatment wth iodine



FIG. 513. Pronounced Graves' disease.

does not protect the iodized patient with toxic adenoma or Graves' disease in any way comparable to the protection afforded the patient not previously so treated. The patient suffering with an acute exacerbation following prolonged use of iodine may be a dangerous operative risk whether iodine is given preoperatively or not. It is particularly in these circumstances that recourse must be had to multiple operations such as preliminary ligation and single lobectomies to eliminate the increased risk involved in a primary double lobectomy.

"Iodine has little effect in controlling postoperative hyperthyroidism. There is no evidence that the postoperative administration of iodine reduces the incidence of recurrent hyperthyroidism. The spontaneous hyperthyroid crisis occurring occasionally in the course of severe Graves' disease may be effectively controlled by large doses of iodine given either orally or intravenously. When the crisis occurs

as a result of the incorrect use of iodine, the further administration of iodine, even in large amounts, is ineffectual and a fatal outcome may ensue."

THYROIDECTOMY

"A uniform technic does not exist. Every surgeon puts into his work the seal of his own individuality; consequently, divergence of details will always be found; fundamental differences, however, do not exist any longer." (André Crotti.) (Figs. 513-514-515-516-517.)



FIG. 514 FIG. 515

FIG. 514. Simple adenoma of the thyroid causing tracheal obstruction.
FIG. 515. Same patient after operation. (Author's Service, Cook County Hospital.)

Preanesthetic Medication

One-half to one hour before the operation, administer subcutaneously ¼ gr. of morphine and 1/120 gr. of atropine sulphate.

Local Anesthesia

In selected cases properly executed, local anesthesia is excellent. The advantages of local anesthesia are many. Among these may be mentioned: (a) the deleterious effects of the inhaled anesthetic on the lungs, kidneys and liver are avoided; (b) the recurrent laryngeal nerves are safeguarded; (c) the increased excitement, and consequently added strain, incident to taking and coming out of the anesthetic is avoided; (d) a more leisurely preparation of the field of operation and freedom from worry about the anesthetic during the operation is provided.

Many surgeons prefer this method to others (Kocher, DeQuervain, Socin, Rehn, Jaboulay, Crile). Numerous factors are to be considered in the successful execution of local anesthesia, viz., (a) proper selection of the patient; (b) a thorough knowledge of the surgical anatomy of the parts concerned in the operation; (c) the personality of the surgeon and his ability to quiet the patient (think

of the unstable nervous mechanism of the thyrotoxic patient). We follow the teachings of Crile and "steal" the thyroid from the patient before whom opera-

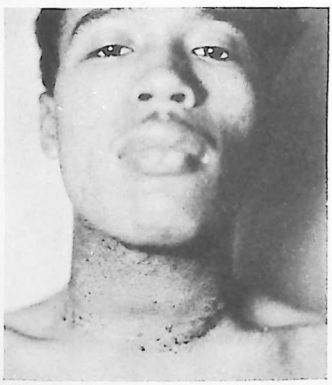


FIG. 516. Patient, from whom thyroid (shown in succeeding illustration) was removed; one week after operation.



FIG. 517. Enormous thyroid fusing both lobes and isthmus into a sausage-shaped mass removed *en bloc*. (Author's Service, Cook County Hospital.)

tion is never discussed and who is unaware of the date set for the ordeal. Each day for a few days prior to the operation, give the patient a hypodermic injection

of sterile water; a little later take him to the operating room where a pretext at anesthesia is made by allowing the patient to inspire a few whiffs of nitrous oxide-oxygen.

I have experimented with other drugs recommended but always returned to novocaine in ½ per cent solution. About 5 ounces can be used with safety, provided the solution is made up fresh and is thoroughly aseptic. Some surgeons add adrenalin to the novocaine solution. Let it be recalled that many thyrotoxic patients are supersensitive to adrenalin (Goetsch test). Yet, from a practical point of view, the amount of adrenalin used is so small that its deleterious effects are negligible. Its advantage is that it delays absorption of the novocaine and hence

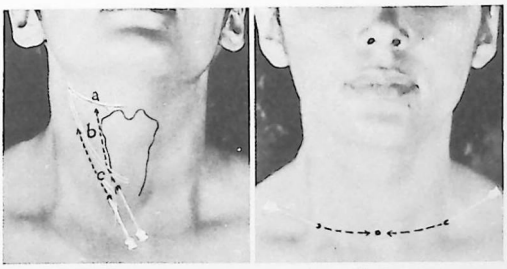


FIG. 518 FIG. 519

FIG. 518. Blocking of the superior laryngeal nerve: a. internal laryngeal branch, b. external laryngeal branch, c. recurrent laryngeal nerve. This nerve does not require infiltration.
FIG. 519. Local anesthesia in thyroidectomy. Line of infiltration in making Kocher's incision in thyroidectomy.

prolongs the time of anesthesia. We add four drops of 1:1000 adrenalin solution to every 100 cc. (3 oz.) of solution. Never exceed 1 Gm. (15 gr.) of novocaine crystals in the course of the operation. This amount of novocaine is present in 200 cc. (about 6 oz.) of the ½ per cent solution.

Precaution: Avoid entering a vein with the injecting needle. After the introduction of the needle into the tissues, draw the piston of the syringe a little back and note if blood is aspirated into the glass barrel of the syringe; if none appears, inject the anesthetic solution.

SUPERFICIAL NERVE BLOCKING

This consists of blocking the cutaneous nerve trunks at their exit at a point corresponding to about the middle of the anterior border of the sternomastoid muscle (Figs. 518-519-520-521).

Ten to twenty cc. of ½ to 1 per cent solution of novocaine are injected on both sides at the point shown in the illustration. (Fig. 519.) Here the cutaneous colli.

the supra-clavicular and great auricular nerves emerge. The skin and subcutaneous tissues become completely anesthetized but the deeper structures remain unaffected.

Raise a wheal first and successively infiltrate the tissues along the line indicated.

Pass the needle vertically through the skin and fascia at the point illustrated; when a sense of release is felt after the point of the needle has penetrated the fascia and the surgeon has assured himself that he did not enter a vein (by withdrawing the piston of the syringe as outlined previously) the injection is made.

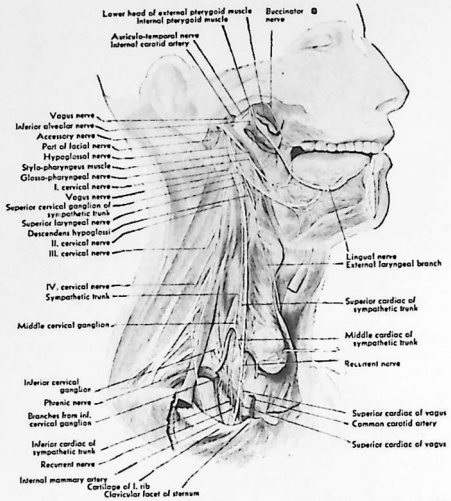


Fig. 520. Deep dissection of right side of head and neck, showing lingual, glosso pharyngeal, vagus and hypoglossal nerves and sympathetic trunk (Piersol).

Do not permit the needle to advance further lest deeper structures be jeopardized. It is for that reason that some surgeons limit the injection to bilateral subcutaneous infiltration in a line along the posterior border of the sternomastoid muscle. This reaches the nerves as they emerge through the fascia, is a simpler procedure, and is preferred by many.

The next step is to inject the subcutaneous and subfascial area of the skin incision (Figs. 522-523-524-525-526).

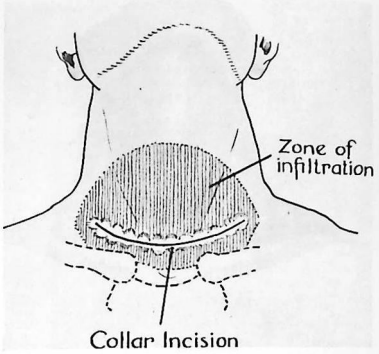


Fig. 521. Infiltration anesthesia in thyroidectomy.

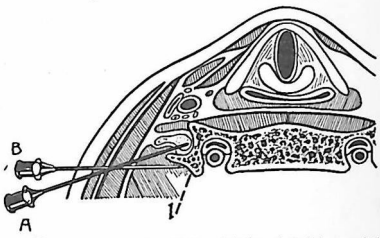


Fig. 522. Nerve blocking in thyroidectomy. Injection of cervical sympathetic nerves. 1. Transverse process of third cervical vertebra; A. needle passed on the posterior aspect of the third cervical vertebra; B. same needle withdrawn and placed about 1 cm. in front where it impinges the nerve supply sought.

Comment. Bilateral injection of the nerve plexus produces the most complete anesthesia, but is attended by the risk of bilateral blocking of the pneumogastric, sympathetic and phrenic nerves. Fatalities have been reported as the result of such accidents.

BLOCKING THE CERVICAL PLEXUS

This consists of injecting the points of junction of the second, third and fourth roots of the cervical nerves at their points of exit from the intervertebral foramina in front of the transverse processes (Figs. 527-528).

Haertel and Geyer's Paravertebral Nerve Block. Braun's modification of this method is as follows:



Fig. 523. Schematic diagram of a cross section of a larynx. The needles are pressed obliquely through the soft parts and through the cricothyroid membrane and the thyroid cartilage. Between these structures and the laryngeal mucous membrane the anesthetic fluid is deposited. The beveled edge of the needle should lie upon the deep surface of the mucous membrane. (After Hertzler.)

Draw a line extending from the anterior border of the mastoid process to the clavicle. This crosses Chassaignac's tubercle. Mark the point of junction of the first 1/3 with the second 1/3 of this line. Practically, this point corresponds to the level of the upper border of the thyroid cartilage. It is at this point that the needle is introduced and passed forward until the transverse process of the third cervical vertebra is felt. Withdraw the needle slightly and reintroduce it about 1 cm. or more in front of the transverse process (Fig. 529). Make sure that no vessel has been entered. Deposit 10 cc. of ½ per cent solution of novocaine. Withdraw the needle again for a short distance and inject the same amount of novocaine in front of the transverse process of the fourth cervical vertebra. DeQuervain admonishes the exercise of the greatest possible care to avoid inadvertently injecting the vertebral artery or vein which when entered

may be followed by serious consequences or even death. If properly performed, complete anesthesia of both superficial and deep tissues result in about ten min-

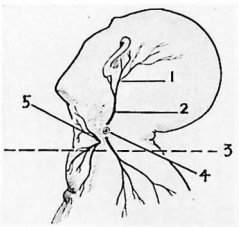


Fig. 524

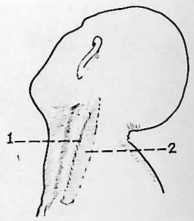


Fig. 525

Fig. 524. Diagram of cutaneous nerves, showing location of point for subfascial injection: 1. lesser occipital, 2. great auricular, 3. midpoint between mastoid and clavicular attachments of sternomastoid muscle, 4 point of insertion of needle, 5. cutaneous colli.
Fig. 525. Diagram of deep subcutaneous infiltration, along posterior border of sternocleidomastoid: 1. posterior border of sternomastoid, 2. zone of deep subcutaneous infiltration.

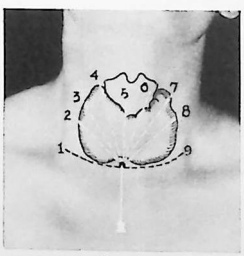


Fig. 526

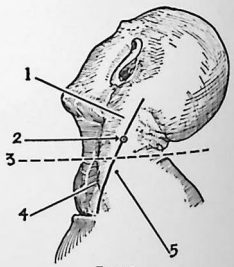


Fig. 527

Fig. 526. Infiltration anesthesia in thyroidectomy (modified from Hertzler). From the primary line of infiltration, the needle is passed between the platysma and the more deeply lying muscles. At 2 and 3 and 7 and 8 the anterior cervical and the supraclavicular nerves are blocked. At 4 and 5 and 6 the paratracheal structures are infiltrated. Line 1 to 9 represents infiltration of line of incision (Kocher).
Fig. 527. Location of point for insertion of needle in cervical plexus block: 1. sternomastoid muscle, 2. point for insertion of needle at junction of upper with middle third of line. 3. midline, 4. external jugular vein, 5. Chassaignac's (carotid) tubercle.

utes. Only one side should be blocked! Anesthesia on the other side is brought about by peripheral blocking.

INJECTION OF THE PARATHYROID SPACES

This is also not free from hazards and should be carried out with extreme caution.

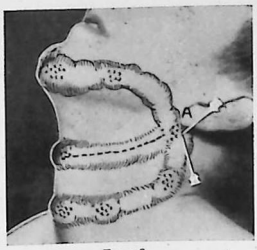


FIG. 528



FIG. 529

FIG. 528. Anesthesia for block dissection of the neck: A. point of entry of needles for blocking the cervical plexus.

FIG. 529. Paraglandular infiltration in thyroidectomy. A needle is passed between the gland and the overlying muscle. According to Hertzler (Local Anesthesia, Mosby, 5th edition) the soft parts over which the needle is passed should be depressed; its point may be made to reach the space between the trachea and superior lobe of the gland. A like maneuver makes it possible to infiltrate the entire paraglandular tissue.

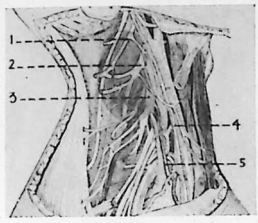


FIG. 530

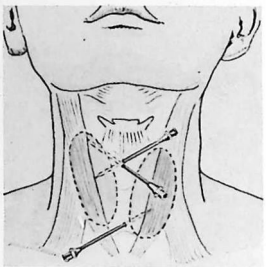


FIG. 531

FIG. 530. Paravertebral injection (after Schultze). 1. Second cervical root. 2. Third cervical root. 3. Fourth cervical root. 4. Pneumogastric nerve. 5. Phrenic nerve.

FIG. 531. Injections of the parathyroid spaces.

In this procedure after the site for the collar incision has been determined and after the tissues have been dissected the parathyroid spaces are infiltrated as shown in Figs. 530-531. No solution is injected into the thyroid itself because it is not sensitive. Some degree of sensitivity is encountered at the upper and lower poles. Painstaking injection is paramount here. Crotti injects some novocaine-adrenalin solution into the surgical capsule of the thyroid before the goiter is luxated since this maneuver is very painful. This holds equally true for the regions about the trachea and esophagus and posterior surface of the thyroid, always keeping in mind the "danger zone." The isthmus is anesthetized by injecting the solution above, below and behind it.

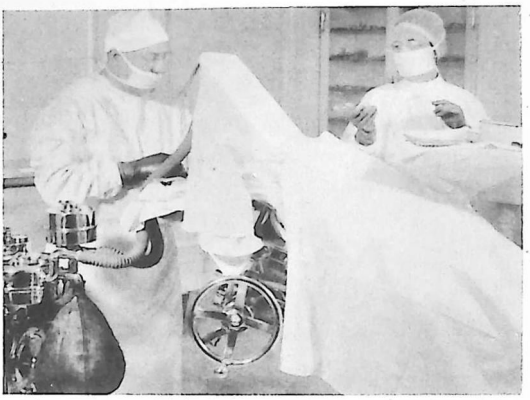


FIG. 532. Thyroidectomy. Arrangement of patient for removal of the thyroid. Observe bridge attachment on operating table which elevates the neck bringing the operative area nearer to the surgeon.

Operation

Do not begin to operate immediately after injection of the anesthetic is made but allow about ten minutes to elapse. Keep within the limits of the infiltrated area where regional infiltration has been resorted to.

Position of the Patient. Adjust the patient on the operating table in such a manner that there is a downward incline from head to foot. This lessens congestion in the field of operation. Elevate the shoulders on a sandbag. Extend the head; this renders the operative field prominent. Separate the face of the patient from the neck by a proper wire screen appropriately draped. (Fig. 532.)

Step 1. (Fig. 533a.) Make a low collar incision (Kocher) slightly curved, its concavity directed upward. It should be 1 or 2 cm. above the manubrium sterni. It varies in length with the size of the goiter. Let the incision correspond to a natural crease of the skin. If you want to avoid ugly scars, dissect the lower skin flap free so that it can be reunited without tension.

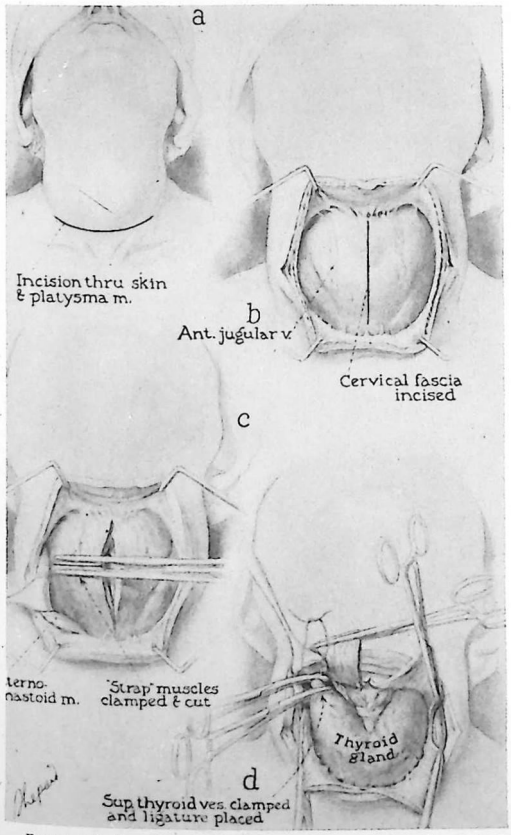


FIG. 533. a. Position of the patient's head. Incision (Kocher's) through skin and platysma. b. Longitudinal division of the cervical fascia. Ligation of the middle and oblique jugular veins. c. Division of the prethyroid ("strap") muscles between clamps. d. Exposure of the superior thyroid pole and vascular pedicle. Ligation of superior thyroid vessels. e. Superior pole freed. Surgical capsule opened and retracted. Glandular capsule clamped at various points, thus outlining the degree of contemplated resection of thyroid tissue. Resection of right lobe begun. f. Diagram showing relative amount of gland tissue removed. Also, protection of recurrent laryngeal nerve and parathyroid bodies afforded by careful operating in

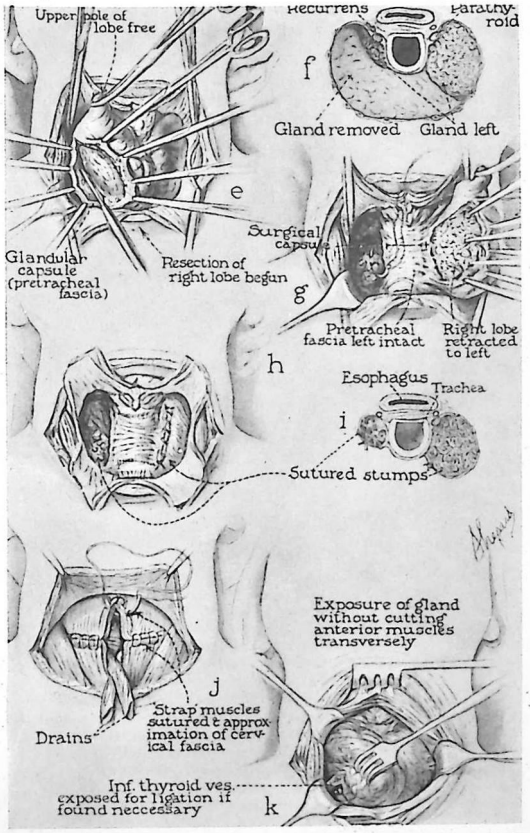


FIG. 533 (continued). the "danger zone" of Crotti. g. Pretracheal fascia left intact. Needle picking up the stump of the thyroid which may be attached to the posterior surface of a prethyroid muscle. (See text.) Right lobe of thyroid retracted outward and resection begun from within outward. h.-i. Sutured stumps and their relation to contiguous structures. j. Suturing of "strap" muscles and cervical fascia. Drains. k. Exposure of thyroid gland without dividing prethyroid muscles, which are forcibly retracted outward. Inferior thyroid vessels exposed for ligation, if found necessary.

Step 2. (Fig. 533b.) Divide and retract the subcutaneous tissues and platysma. Dissect the upper flap as high as the thyroid cartilage, the lower flap as low as the jugulum. Grasp and ligate small vessels as they present themselves. Divide the median and oblique jugular veins and, if necessary, treat the external jugular veins similarly. Drape and retract the flaps.

Step 3. Incise the cervical fascia vertically in the midline from the thyroid cartilage to the episternal notch, dividing the prethyroid muscles longitudinally. Introduce a finger under the muscles and separate them as far as possible in every direction from the subjacent structures. In so doing, direct the dissecting finger against the posterior surface of the muscles. This is for the purpose of avoiding injury to the veins in this situation. We are now in the musculo-capsular space.

Step 4. If the gland to be resected is of moderate size, and no operative difficulties are expected at this stage, the prethyroid muscles are simply separated with the fingers through the longitudinal incision made and are then amply retracted. In most instances this suffices. However, if the surgeon is not very experienced and sufficient space is desirable, it is safest to divide the muscles transversely (Fig. 533c). While it is better to do this step through a longitudinal opening, it is best in most cases to play safe. The muscles are divided at their upper end. The branches of the ansa hypoglossi, which supply the prethyroid muscles, enter the muscles in the lower part of the neck, so that if the nerve supply is to be preserved, the division of the muscles should be as high as possible. Another reason for dividing the muscles high is that after they are united again, the scar lies at a higher level than the scar in the skin. The omohyoid and sternocleidomastoid muscles are incised only when absolutely necessary.

Step 5. The surgical capsule having been divided, the glandular capsule is now in view. It is essential to orient one's self in the proper line of cleavage. The operation must now be continued in the surgical space. If this precaution is not observed, bungling instead of good surgery will result. Separate the lobe to be resected from its connections with the surgical capsule by blunt dissection with the finger. Retract the surgical capsule thoroughly but not too far posteriorly (parathyroid bodies). Respect the "danger zone" (region of the lower pole; parathyroids and recurrent laryngeal nerve). The middle thyroid veins are often encountered now. These must be doubly ligated and divided. Inadvertent tearing of these veins will flood the operative field with blood and will disturb the inexperienced considerably.

Step 6. Delivery of the thyroid lobe. Gently lift the lobe forward with two fingers introduced into the surgical space. Delivery with instruments may injure the large veins under the glandular capsule and cause undesirable bleeding. When by reason of inflammation or preoperative irradiations there are adhesions between the two capsules, luxation of the lobe will be correspondingly difficult. Forcible delivery may result in alarming hemorrhage. Under such conditions it is safer to resect the gland in situ.

Step 7. Free the upper pole from the surrounding structures. Guard the carotid sheath in so doing. Doubly ligate and divide the superior thyroid pedicle carrying the vessels. (Fig. 533d.) For safety, place another ligature above the first. Leave the ends of the ligatures long for the time being. Separate

the superior pole from its attachments to the larynx. Work your way downward toward the (Fig. 533e) inferior pole. Occasionally difficulties are encountered if the upper pole extends high up into the neck or encroaches upon the larynx and esophagus. It must then be carefully and thoroughly resected. Remember it is safer to include in the ligature of the superior thyroid vessels a small knob of thyroid tissue than take a chance of the artery slipping out of the ligature.

Step 8. Ligation of the inferior thyroid artery. This is accomplished at a point internal to the carotid sheath. In so doing displace the thyroid lobe inward and upward and the carotid sheath outward. The inferior thyroid artery will usually be found about the junction of the middle with the lower third of the lateral lobe. Only the anterior branch of the artery is ligated and divided. The posterior branch is left undisturbed for nutrition of the remaining thyroid tissue (Fig. 533k).

Step 9. Map out the degree of resection to be accomplished. (Fig. 533f.) The procedure is a transglandular one and is accomplished from above downward. Apply hemostats to the glandular capsule all along the line of proposed resection. Divide the glandular capsule and resect the lobe until the region of the isthmus is reached. Only a thin layer of thyroid tissue is left along the posterior border of the resected gland. This is to be particularly observed in the "danger zone" (recurrent laryngeal, parathyroid). (Fig. 533h, i.) If a thyroidea ima is present it is ligated. Great care is to be exercised not to disturb the connective tissue covering the larynx and trachea (pretracheal fascia) lest the sensory fibers coursing here be included in ligatures and subjected to undue irritation (Fig. 533g).

Step 10. Resect the isthmus. Introduce a curved artery forceps between the isthmus and the trachea from below upward and separate these structures. The isthmus may now be divided between two clamps. In dividing the isthmus and lower lobe in this situation, bleeding from the superior communicating veins may be encountered. Clamp and ligate these vessels.

Step 11. If both lobes are to be resected the procedure is to be repeated on the opposite side. Resection may proceed from within outward or vice versa. (Fig. 533g.)

Step 12. If a pyramidal lobe be present dissect it out from below upward. Remove it thoroughly. If not, compensatory hypertrophy may ensue and cause a conspicuous bulge in the neck.

Step 13. Survey the field of operation. Hemostasis must be perfect. Redrape. Oozing is usually controlled by hot compresses.

Step 14. Examine the superior mediastinum for the possible presence of an enlarged thymus. If found, remove it (see Thymectomy).

Step 15. Resuture the prethyroid muscles and the cervical fascia (Fig. 533j).

Step 16. In thyrotoxic goiters drain for a day or two with a Penrose drain. Otherwise drainage is unnecessary.

Step 17. Reunite the platysma. If not resutured, spreading of the scar may result by reason of traction of this muscle on the edges of the skin incision.

Before proceeding to close the wound in the neck, flexion of the head will often reveal the presence of bleeding. Again, hemostasis must be perfect. Place the head in the normal position.

If the operation has been performed under local anesthesia, ask the patient to cough or speak. This will disclose whether or not the recurrent nerve has been injured or whether an insecure ligature is present. If the gland surfaces have not been approximated the posterior surface of the strap muscles may be sutured directly to the thyroid tissue.

Step 18. Close the skin with metal clips, Pagenstecher linen or horsehair. A subcuticular suture may also be used.

Intraglandular Enucleation

This consists of the enucleation of one or more nodes or cysts from the thyroid substance (Fig. 534):

Step 1. The extent of the skin incision depends upon the extent of the tumor to be enucleated. Primary ligation of principal vessels is unnecessary.

Step 2. Blunt dissection of the tumor is accomplished with the finger or with the Kocher dissector (Fig. 535) in a cleavage line between the tumor and thyroid tissue.

Step 3. The vessels are ligated as encountered.

Step 4. If a cyst is inadvertently opened during enucleation, grasp the edges of its sac with artery forceps and dissect it out thoroughly.

Step 5. Obliterate the spaces resulting from enucleated masses with interrupted catgut sutures.

Be sure of hemostasis. A hematoma in an incompletely obliterated space may give rise to compression of the trachea and become a source of danger. Should the bleeding become threatening during the enucleation or, by reason of existing adhesions, the enucleation become difficult, proceed at once to resection of the respective lobe.

If, instead of a finger, a cutting instrument is used to remove the intraglandular tumor, intraglandular or intracapsular excision is spoken of.

Resection-Enucleation

If the adenoma is large, or there are multiple adenomas, resection-enucleation is better than simple enucleation. Very large adenomas which occupy the greater part of one lobe are best treated by hemithyroidectomy.

Resection-enucleation is performed as follows:

Step 1. Expose the diseased thyroid.

Step 2. The adenoma to be removed together with about one-quarter to one-half inch of gland tissue surrounding it is outlined with artery forceps and removed (Fig. 536).

Step 3. Fold the remaining thyroid tissue on itself as shown in Fig. 537 and suture it as depicted. Insure hemostasis. Drain for a day or two, if deemed necessary.

Resection

This may be either **frontal (transglandular)** or **cuneiform (melon resection)**. The former is shown in Figs. 538-539. It may be performed on one or both lobes of the thyroid. The raw surfaces may be anchored to the strap muscles.

CUNEIFORM RESECTION (ZOEGE VON MANTEUFFEL) 1898

Step 1. Ligate the blood vessels at their proper site.

Step 2. Dislocate the goiter. Ligate the thyroidea ima.

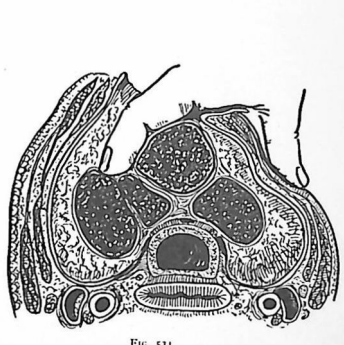


Fig. 534



Fig. 535

Fig. 534. Intraglandular enucleation of cystic goiter.
Fig. 535. Kocher's dissector, for use in goiter and bone work.

Step 3. Resect a wedge-shaped piece of thyroid from the respective lobe or lobes and the isthmus, if indicated. Wedge-shaped portions are removed not unlike slicing a segment out of a watermelon (Figs. 540-541). The "danger zones" must, of course, be scrupulously avoided.

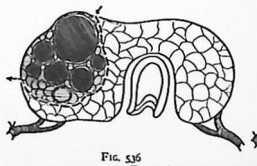


Fig. 536

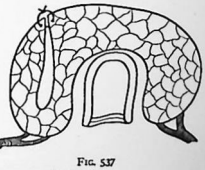


Fig. 537

Fig. 536. Unilateral resection—enucleation.
Fig. 537. Thyroid tissue folded on itself and sutured.

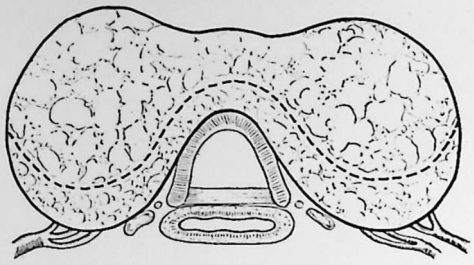


FIG. 538. Transglandular (frontal) resection; outline of line of excision. (After Crotti.)

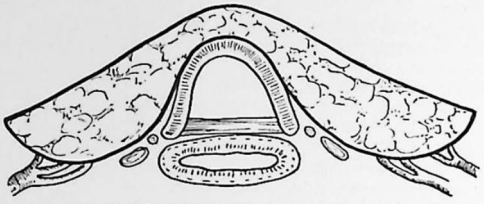


FIG. 539. Transglandular (frontal) resection; the raw surface may be anchored to the strap muscles.

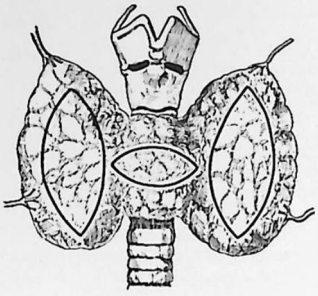


FIG. 540

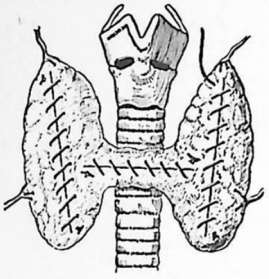


FIG. 541

FIGS. 540-541. Cuneiform resection of the thyroid. Lines of excision and of subsequent suture. (After Crotti.)

Step 4. Reunite the remaining portions of the gland with interrupted catgut sutures (Fig. 541).

Step 5. Insure absolute hemostasis. Reunite the superimposed structures as above.

Intrathoracic (Substernal) Goiter

Thorough anatomic knowledge and considerable technical experience are essential in attacking substernal goiter (Fig. 542).

Step 1. Incision and exposure as before.

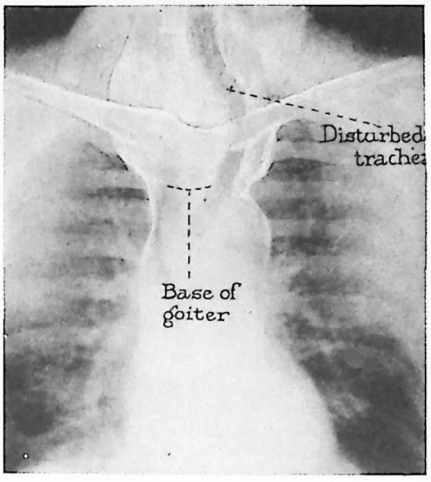


FIG. 542. Displacement of the trachea as a result of substernal goiter.

Step 2. Divide the muscles freely, particularly on the side where the intrathoracic goiter is located or "in cases of extreme gravity," says Joll, "there can be no serious objection to division of part or the whole of the sternomastoid muscle."

Step 3. Free the cervical portion of the goiter as thoroughly as possible.

Step 4. Ligate divided vessels as you go along. Perfect hemostasis is of utmost importance.

Step 5. Separate the substernal portion of the goiter and deliver it using the cervical portion of the thyroid as a tractor. The critical time of the operation is when the thyroid passes the upper opening of the thorax. Alarming hemorrhage and dyspnea may now ensue. The former may be due to injury of

one or other of the large veins (internal jugular, innominate, subclavian); the latter the result of flattening of the trachea from compression, at the moment of delivery.

Step 6. In such case, replace the thyroid and allow the patient to breathe again. Do this a number of times until the goiter is successfully delivered.

Sometimes when the usual methods of delivery of the thyroid fail, recourse to resection of the manubrium sterni as advised by T. P. Dunhill (1922) may be the only avenue of approach. This, of course, is to be looked upon as a last resort and is performed as follows:

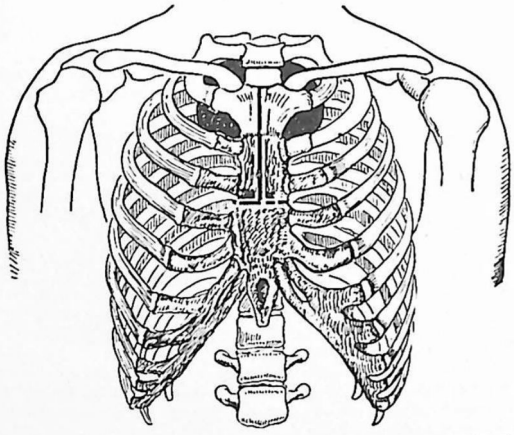


FIG. 543. Dunhill's method of dividing sternum to permit removal of impacted intrathoracic and malignant goiters.

Step 7. The sternum is divided in the median line (Fig. 543) down to or even beyond the junction of the manubrium with the gladiolus.

Step 8. A transverse incision joins the longitudinal thus creating a trap door.

Step 9. Reflect part of the clavicle and the required number of costal cartilages.

Step 10. Control bleeding in the cut surface of the sternum with Horsley's wax or muscle fragments.

Step 11. After removal of the thyroid the divided sternum and ribs are reunited with catgut sutures.

Step 12. The operation is completed in the usual manner.

Comment. Polycystic retrosternal goiter may be handled as illustrated in Figs. 544-545.

Operation for Malignancies of the Thyroid

The operation may be performed uni- or bilaterally.

Step 1. Make a collar incision a little higher than usual. After dividing the platysma, direct the cutting instrument toward the sternomastoid freeing its insertion over the sternum or resecting it if it is attached to the goiter.

Step 2. Divide the prethyroid muscles above and below, leaving them in contact with the goiter.

Step 3. Doubly ligate the superior thyroid vessels on the upper pole and divide them between ligatures.

Step 4. Raise the growth up; ascertain the location of the inferior thyroid artery; ignore the parathyroids and recurrent nerve if hopelessly fused with the growth.

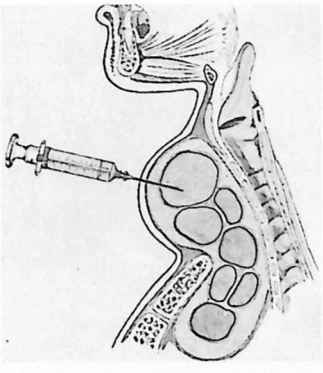


FIG. 544

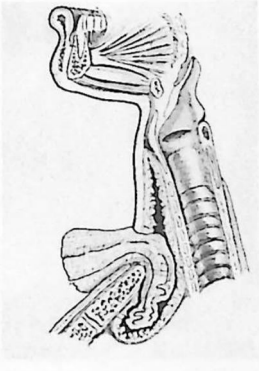


FIG. 545

FIG. 544. Evacuation of cysts in retrosternal goiter.
FIG. 545. Tamponing of cavity following evacuation of polycystic retrosternal goiter.

Step 5. If the internal jugular vein is attached to the growth, resect it, after ligating it; this, to preclude air embolism. If in patients under forty years of age, the carotid is adherent to the growth, resect it; in older patients detach it carefully.

Step 6. Elevate the lower pole of the gland; doubly ligate the inferior thyroid vessels and divide them between the ligatures. Free the goiter toward the middle; separate it from the trachea and resect it. Ligate the antero-internal branch of the superior thyroid artery before the isthmus is dissected.

Comment. Where the tumor involves both lobes, the procedure requires careful study as to whether partial or complete removal of the thyroid should be done. In some instances the superior thyroid artery cannot be

reached at first; this necessitates approaching the tumor either through the isthmus or by detaching first the lower pole. The growth appears much more mobile before the operation than during it. A tumor fixed in the upper aperture of the thorax should not be interfered with. In fixation caused by neoplastic infiltration, the surgeon should hesitate before undertaking an operation. In some types of thyroid tumor where the growth is enclosed in the upper opening of the thorax chances of a successful operation may be very good, provided the tumor is not fixed.

It is sometimes difficult to distinguish between a malignant goiter and thyroiditis.

Stenosis of the trachea is treated in the same way as in non-malignant goiter; however, tracheotomy is performed more often for malignant goiter than for the innocent variety.

The after treatment in this type of case consists generally of radiation, arsenic and morphia in case of recurrence.

Injections of Boiling Water

In this procedure (Wyeth's operation) the blood and albuminoids of the tissues are coagulated by injections of hot water kept at the boiling point by using a Bunsen burner; the injections are made with a needle and syringe. The temperature of the water should range from 190° to 212° F.

Step 1. Prepare the skin as usual. Anesthetize the patient. Determine beforehand the temperature of the water to be injected into the growth as well as the amount and speed with which it is to be injected.

Step 2. When treating arterial and venous angiomas insert the needle deeply into the growth, injecting 30 to 60 minims of water at one location; withdraw the needle from ½ to 1 inch and repeat the injection. Continue this procedure until the entire tumor is made firm. Exercise care in using the needle so that the surrounding parts do not slough. Do not inject more than two ounces of water at one sitting.

Step 3. Dress and keep the parts quiet. If necessary, repeat the injection after 7 or 10 days.

Comment. Based on his thorough researches and careful scrutiny De Quervain concludes his observations as follows:[1]

The best immediate and lasting results are obtained in malignancies of the thyroid by early radical operation (calculated to protect the air passages), supplemented by radium.

Cases best yielding to treatment as shown by all statistics are those of the proliferating type of struma of Langhans (proliferating adenoma), papilloma and hemangio-endothelioma. The worst results are obtained in cases of sarcoma.

Irradiations supplementing incompletely operated cases prolong life and require further development of technic with reference to higher dosage.

Better results are obtained when patients are referred to the surgeon early in the disease at a time when there is a suspicion of malignancy. Some improvement may result from radiation-methods.

[1] Bull. Schweiz. ver. f. Krebs Forsch. No. 4, 1934.

Removal of benign goiters and efforts directed toward the systematic eradication of endemic goiters constitute prophylactic measures.

Electrosurgical Thyroidectomy

Advantages:

1. The radio knife is time-saving.
2. Hemostasis is better; fewer forceps are used.
3. In bad-risk cases the reduction in time and the facilitating of the operation are contributing factors in lowering mortality.
4. More thyroid tissue can be removed with less danger to the recurrent laryngeal nerves and the parathyroid glands than with the scalpel.
5. Less catgut is used, resulting in improved wound healing.
6. The radio knife is superior to either the scalpel or the cautery in the treatment of malignancy of the thyroid.
7. It is of particular value in resecting the hyperplastic or exophthalmic type of goiter.

Disadvantages:

1. The radio knife is not satisfactory for skin incision.
2. Occasional skin burns have resulted from coagulation too near the surface of the skin.
3. All important vessels must be ligated.
4. There is a tendency to postoperative hemorrhage.

Full cooperation of the nursing staff is necessary when the surgeon is using the radio knife. It would facilitate matters greatly in the operating room if a unit were available which could be manipulated entirely by the surgeon; there is need for much improvement on the present apparatus.

The technic may be summarized as follows:*

Step 1. The usual transverse incision is made either with a scalpel or a fine, purely cutting current, and the bleeders clamped and coagulated, avoiding damage to the skin margin. The scalpel gives a nicer scar.

Step 2. The usual exposure is made by dissecting the skin-platysma flaps downward and upward.

Step 3. The cervical fascia is incised in the midline, freed from the capsule by blunt dissection, and retracted laterally along with the sternohyoid muscles.

Step 4. The gland is gently mobilized with a finger and clamps are placed on the superior and inferior thyroid arteries.

Step 5. The gland is attacked in its superiolateral aspect with the combined coagulating and cutting current instead of with the scalpel and hemostats. The current is a valuable adjutant in cutting across the thyroid tissue, by controlling bleeding and lessening the toxic substances liberated into the blood and lymph streams.

Step 6. An occasional bleeding vessel will require clamping, but usually not more than four or five are needed on each lobe, and these, with the exception of the superior thyroid artery, are sealed by clamp coagulation. So small

* A. S. Jackson, Annals of Surgery, June, 1931. Martin B. Tinker, S.G., O Iii, 2. A. 1931; Kelly & Ward, Electrosurgery, 1932.

is the amount of current necessary, that these vessels are sealed with but little destruction of tissue.

Step 7. The wound is closed in the usual manner.

PROTECTION OF THE RECURRENT LARYNGEAL NERVE

The points at which the nerve may be most easily injured are (a) where it crosses the inferior thyroid artery and where it penetrates under the cricopharyngeal muscle; (b) at the upper or lower pole. De Quervain says: "No surgeon has succeeded in avoiding these perils completely . . . The proposals made for safeguarding the nerve are diametrically opposed to one another. Payr, Hildebrand, Stierlin, Enderlen, and others deliberately expose the nerve. This anatomical dissection presupposes previous dislodgment of the goiter—a manipu-

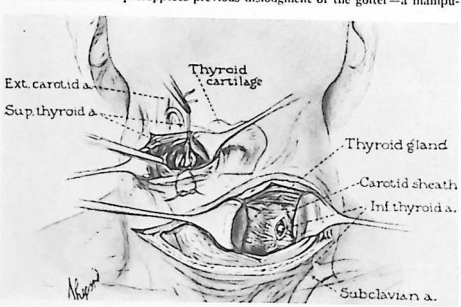


Fig. 546. Ligation of thyroid vessels, superior and inferior thyroid artery. Small collar incision. Carotid sheath retracted outward, thyroid lobe inward. Fascia overlying artery has been incised (see text). Incision of skin, platysma and deep cervical fascia along inner border of sternocleidomastoid muscle. Artery located in region of Chassaignac's tubercle. Another ligature placed around upper pole of the thyroid gland.

lation which the most expert cannot perform without the risk of injuring the nerve by dragging on it. This anatomical dissection is, therefore, no absolute guarantee of immunity—although it saves the nerve from injury by forceps, or from being included in a ligature, or from an inadvertent cut with scissors. Personally, we think that the remedy is worse than the disease, because the nerve is exceedingly sensitive, and practical experience supports this view. It is hardly necessary to mention the risk to the parathyroids involved in such a dissection of the retrothyroid region."

LIGATION OF THE THYROID ARTERIES

Ligation of the Superior Thyroid Artery

Step 1. Make an incision about 1 inch in length along the inner border of the sternocleidomastoid muscle below the point where the hyoid bone crosses that

muscle. Divide the platysma. Divide the deep cervical fascia vertically. Retract the sternocleidomastoid muscle laterally and the omohyoid muscle toward the midline. Palpate for pulsations and identify the vessel (Fig. 546). If there are difficulties encountered expose the superior pole of the thyroid. Ligate the artery with a blunt ligature carrier or with the author's olive-pointed needle (Fig. 547).

Step 2. Avoid injury to the vessel. Apply a second ligature around the upper pole of the thyroid gland. An additional ligature or two at the upper pole is effective in preventing return circulation through one of the anastomosing branches, as well as cutting off the superior thyroid lymphatics and sympathetic nerve fibers.

Step 3. Close the wound.

Ligation of the Inferior Thyroid Artery

This vessel is usually ligated between the carotid sheath and the sympathetic trunk externally and the thyroid gland and the recurrent laryngeal nerve medially.

Step 1. Make a small collar incision dividing the skin, fascia and platysma. Retract the sternocleidomastoid outward.

Step 2. Incise vertically the fascia covering the sternohyoid muscle. Expose the carotid sheath. Ligate and divide any veins crossing the field. Displace the carotid artery laterally and the thyroid medially.



Fig. 547. Author's olive-pointed needles for ligating poles in thyroidectomy or in ligation of individual thyroid vessels.

Step 3. Locate the carotid tubercle (Chassaignac's) on the transverse process of the sixth cervical vertebra. The inferior thyroid artery can be palpated immediately below this and to the inner side of the thyroid. Free the artery. Ligate it doubly. Occasionally, anomalies are encountered (direction, number of arteries).

Step 4. Close the wound.

Comment: Should the condition of the patient become alarming during a thyroid operation do not continue to operate. Leave hemostats on the vessels, pack the wound with gauze, apply a retentive dressing to the neck and return the patient to bed promptly. To persist in operating on a patient who is apparently succumbing on the table is foolhardiness. The operation may be continued, if deemed advisable, a few days later. Many a calamity may be averted by adopting this rule.

Ligation of vessels first, prevents entrance of gland secretions into the general circulation. Particularly is this of value in dealing with carcinoma of the thyroid. Another reason for such ligating is that as the operation proceeds the weight of a multitude of hemostats tugs at the trachea and thus often embarrasses respiration.

In exposing the large veins think of the possibility of air embolism. To avoid this divide the veins promptly after first doubly ligating them.

Practice ligations of the external carotid on the cadaver; it will fortify your confidence in doing thyroid surgery.

Avoid injuring the trachea during the separation of the thyroid from it. If the trachea is opened inadvertently, repair it at once. A thin layer of thyroid tissue left on the trachea insures against its accidental opening. A collapsed trachea must be combated promptly with tracheotomy.



Fig. 548. Postoperative cachexia strumipriva after removal of thyroid. Patient aged 26. (Courtesy of Prof. de Quervain.)

If hoarseness develops on the day following thyroidectomy, do not conclude that there is an injury to the recurrent laryngeal nerve. Postoperative edema is usually responsible for hoarseness. With the recession of the edema, the patient's voice will return.

It is better not to remove the isthmus completely, unless it causes definite symptoms of compression of the trachea. Have a competent laryngologist ascertain the condition of the vocal cords prior to thyroidectomy. This is good insurance to your reputation and the patient's welfare. Unilateral or bilateral operation? The consensus of opinion is in favor of the latter. How much thyroid should be removed? That depends upon the case. Too little is just as bad as too much (hypothyroidism, myxedema, etc., Fig. 548).

In hyperthyroidism only an amount of thyroid tissue sufficient to carry on normal function should be left behind.

It is safer to resect from the inside outward (less danger of injuring the parathyroids).

Asepsis in thyroid operations is of vital importance. Do not be alarmed by a transitory rise in temperature following thyroidectomy. It is a common occurrence. In preparing thyrotoxic patients for thyroidectomy do not use iodine on the skin.

Complications Arising During Thyroidectomy

Dyspnea. If threatening, ascertain its cause promptly; in desperate cases tracheotomize at once.

Hemorrhage from the Superior Thyroid Artery. I have learned to leave a rather small button of superior pole tissue embraced by the ligature and place another ligature above it instead of depending upon the latter alone for security.

Commenting on this precaution De Quervain says: "Slipping of this artery should never occur if the precaution is taken of preserving a small tip of the upper pole."

Hemorrhage from the Inferior Thyroid Artery. Displace the carotid artery outward, press the lobe of the thyroid against the trachea and, simultaneously pulling it upward, locate the bleeding vessel and ligate it. Be cool! If a surgeon loses his head at this point, he will lose his patient. Pack the bleeding area for about five or ten minutes—look for the vessel again—you will find it!

Hemorrhage from the Middle Thyroid Veins. This should also be treated by compression and ligature. If the bleeding comes from the capsular veins or from those of the upper or lower pole, quick dislodgment of the respective lobe will tend to arrest the bleeding; greater opportunity is thus offered the surgeon to search for the bleeding point and control it. If the field of operation is suddenly flooded with blood, pack promptly and properly; wait a few minutes and proceed as suggested above.

Injury to the Esophagus. While rare, I have injured the esophagus once in extirpating a large goiter which embraced the retrotracheal space for a considerable distance. Fortunately, the opening was small and in the upper part of the esophagus. The patient was fed through a tube for a fortnight and the fistulous tract closed spontaneously.

Perithyroiditis Causing Adhesions. These often render the operation difficult and usually result from previously given x-ray or radium treatments or antecedent operations on the thyroid. Radium and x-ray-therapy obliterates the cleavage planes, and only meticulous and painstaking work will circumvent the constantly lurking dangers in these cases.

Should drainage be instituted after thyroidectomy? I always drain every toxic goiter. I never drain goiters of the non-toxic variety provided the operation has proceeded smoothly with no operative complications and one is reasonably sure of thorough hemostasis.

Tracheal Collapse and Conditions Which Simulate It. According to Cecil A. Joll[1] the term tracheal collapse is used to describe certain rare cases of acute respiratory distress occurring during or immediately after thyroidectomy. The theories advanced to explain its production are: (1) that the walls of the trachea are softened by the long-continued pressure of the goiter and, the latter being removed, there is not sufficient rigidity remaining in the tracheal wall which is therefore sucked in at each inspiratory movement and acts as an obstructive valve; (2) that although there is no actual softening of the wall of the trachea (a point emphasized by Berry), the peculiar physical characters of the cartilage-ringed walls of the trachea render it liable to collapse after removal of the tissues which surround its walls and, to some extent, hold them apart.

The difficulty Joll finds in accepting either of these explanations as invariably applicable is that he has met with three cases in which sudden respiratory distress occurred during thyroidectomy, the whole length of the cervical trachea being under direct observation, yet no trace of collapse of its walls or of any serious kink or stenosis was visible. The passage of a large intratracheal tube from above temporarily overcame the respiratory difficulty, but as soon as the tube was removed the dyspnea recurred. In each case tracheotomy cured the condition. It is difficult to resist the conclusion that some of the cases designated

[1] Diseases of the Thyroid. Wm. Heinemann, London, 1932.

tracheal collapse may be due to laryngeal spasm. It has been suggested that sudden onset of dyspnea during thyroid operations is due to bilateral injuries to the recurrent nerves; but in the cases to which Joll referred, the fact that the tracheotomy tube was removed within a week and that no subsequent trace of laryngeal paralysis could be found makes this explanation untenable.

Air Embolism in Thyroidectomy was first seen by Donald Guthrie* in 1907, while he was an assistant at the Mayo Clinic. A. Kocher was present and assured Guthrie that no ill effects would ensue. Kocher was right. Guthrie points out that arterial air embolism which may occur in any thoracic operation, beginning with pleural paracenthesis, is far more dangerous than the venous type, because it can lead to embolism to the brain or coronary arteries. He considers "pleural epilepsy" not as a pleural reflex, but as a consequence of arterial embolism. The entrance of larger amounts of air into the veins leads to exitus. In the seventeenth century, horses and cattle were killed by blowing air into their veins. The first case in the literature of a fatal air embolism in man was reported in 1818. In abortions and confinements, air embolism can lead to death, especially in placenta praevia. Postmortem examinations in these cases show foamy blood in a dilated right ventricle and in the large veins. Death occurs only if the amount of air reaches a certain maximum. Death is caused by mechanical and biologic changes. Anemia of the center of the fourth ventricle through primary cessation of breathing leads to death. Timely artificial respiration may sustain life. If after the heart has continued to function for a certain length of time, and breathing has stopped a second time, death will result. Small amounts of air compressed into the circulation cause shortness of breath and lower blood pressure; injection of large amounts can also result in heart palpitation. Patients having hyperthyroidism, with resultant cardiac changes, are in greater peril if an air embolus occurs than are patients with other diseases. Because of the typical hissing noise, followed by "bruit de soufflement" of the French, a whirring, splashing sound which can be heard even at a distance of 1 or 2 meters from the operating table, diagnosis is not difficult. Sometimes vision is impaired; in some instances one may even see gas bubbles in the retinal vessels. Guthrie has seen, since 1932, four air emboli in goiter cases, three being secondary operations, one of which was fatal. In one case, the patient developed a postoperative paralysis on one leg without losing sensibility. The best method of prophylaxis consists of curtailing the collection of too many clamps in the thyroid bed before ligation. In shock, resort to artificial respiration supplemented by the administration of salt solution because heart-paralysis precedes paralysis of respiration; intracardiac injection of adrenalin should be used.

Denk reported one fatal and two mild air embolisms in 378 goiter cases during the last four years and believes they can be prevented by ligation of the veins before separating them and that air embolism may occur even after closure of the wound. It is recognized by the cessation of breathing. The suggestion of Claremont to draw out the foamy blood may perhaps succeed by introduction of a urethral catheter into the right ventricle through the cubital vein. A research worker demonstrated the possibility of reaching the right ventricle by a catheter introduced into the cubital vein on his own person. Von Eiselsberg believes that with accurate hemostasis, air embolus, of which he has seen a great number as a student, has become much more rare. He has observed, during a secondary lami-

* Guthrie, Donald: Wiener klinische Wochenschrift, Vienna, 50:1667 (Dec. 10) 1937.

nectomy, a fatal air embolus, into the coronary artery as a result of a congenital communication of both ventricles in a case of a war injury. Finsterer (1914) observed an air embolism in a sixty year old woman, in two separate instances. At first, during the development of a retrosternal struma, a hissing noise was heard for a minute or two from which the patient recovered quickly. That same afternoon she vomited, became cyanotic and unconscious. The chest was opened, and the heart incised. Artificial respiration brought relief after several minutes. Since that time, Finsterer operates goiters in Trendelenburg's position, which he considers the best preventive. Sternberg saw embolism twice. The vein was immediately compressed with the finger. Ranzi calls attention to the fact that most of the emboli are not fatal. He saw an exitus only once. Since the air enters in consequence of negative pressure the patient should immediately have the head lowered and the field of operation covered with moist gauze. In severe goiter cases the positive pressure apparatus should be ready, because positive pressure prevents entrance of air into the veins, while Schnitzler emphasizes that the lowering of the head diminishes the danger, but does not prevent it, especially in tracheal stenosis. Albert in all his lectures advises removal of blood from the heart by suction. Werkgartner examined the records of the Institute of Forensic Medicine since 1919 and found fifty cases of death from air embolism, more than half of these followed operation. Next in frequency to this, are abortions and puncture wounds. Several times emboli occurred in operations for injuries, four times in goiters, once in an operation for lymphoma. At postmortem the point of entrance is hard to find. One would have to fill the pericardium with salt solution, puncture the right ventricle and, if necessary, press out the blood from the pulmonary veins. Radical procedures should be used, because these cases invariably terminate fatally when less radical measures are employed.

COMPLICATIONS FOLLOWING THYROIDECTOMY

Hyperthyroidism

Comment: My experiences coincide with the subjoined conclusions of Donald Guthrie who emphasizes that:

Severe postoperative hyperthyroidism may be largely prevented by the proper preoperative treatment. It is important to consider each patient with hyperthyroidism as a separate problem and not to apply set rules or standardized methods of preparation. The cooperation of an experienced internist is invaluable in this work.

It is important to appreciate the disturbed psychic state of the patient and to understand how proper forms of suggestion will be of benefit. It is equally important to appreciate the deleterious effects of fear upon bodily physiology and to understand how easily disturbed mental states will aggravate toxic symptoms.

Anoci-association and general anesthesia are both important safeguards against the development of severe postoperative hyperthyroid reactions.

Safe thyroid surgery demands the services of a skilled anesthetist and of a well-trained goiter team.

The condition of a large group of former hyperthyroid patients, not weeks or months, but years after operation, should be the gauge by which a

method of preparing and operating upon these patients should be judged.

No set rules can be applied to suit all cases. Every patient is a separate problem.

Crotti uses, with success, diasporal, a colloidal iodine preparation, pre- and postoperatively in hyperthyroid states and to frustrate postoperative thyrotoxic crises. Cole uses sodium iodide, intravenously, for the same purpose.

MORTALITY FOLLOWING THYROIDECTOMY

Emil Goetsch,[1] analyzing 3,610 operations on 3,321 patients performed between 1920 and 1934, found that there were forty-two fatalities: operative mortality, 1.16 per cent; patient mortality, 1.26 per cent. Of these fatalities, seventeen (40 per cent) were due to postoperative crisis with secondary cardiac failure and seven (17 per cent) to primary cardiac failure unassociated with severe postoperative crisis. Five were due to pneumonia, five to embolism, and one to tetany which could have been obviated. The remaining seven fatalities were mostly accidental, of the type which do not now occur with refinement in technic.

TRANSPLANTATION OF THYROID TISSUE

Historical Notes. To Schiff is given credit for first transplanting the thyroid in animals; Kocher receives credit for the first attempt in man in a case of cachexia strumipriva in 1883. In both cases, the functional results were only temporary. Bircher and others met with the same results when attempting transplantation of the thyroid for myxedema. v. Eiselsberg and Christiani seem to have met with the first success with this operation both as regards life and function of the transplanted thyroid tissue. Unusual results have been reported by Payr in both animal and human experiments. A large piece of thyroid tissue from a mother was transplanted into the spleen of her child, who was a victim of congenital myxedema, with very favorable results.

Serge Voronoff* describes his results followed up twenty years after grafting thyroid tissue in cases of myxedema.

Kocher met with a certain degree of success by transplanting thyroid tissue into the medulla of the tibia. He employed the following procedure.

Step 1. Form an osteoperiosteal flap in the diaphysis of the tibia. Make a pocket near the epiphyseal line where the blood supply is adequate, and in the medulla.

Step 2. Introduce into the opening a silver ball about 1 cm. in diameter and close the bone and skin flap over it.

Step 3. A few days later reopen the incision after granulation has taken place, remove the ball, irrigate the wound with normal saline solution and place the implant, which is of the same size as the ball, in the blood-free pocket. Use normal or hyperplastic thyroid tissue from which the capsule has been dissected.

ANCILLARY THYROID OPERATIONS

The Surgical Relief of Progressive Exophthalmos

NAFFZIGER OPERATION

While, after thyroidectomy, exophthalmos usually recedes, in certain individuals the exophthalmos not only does not recede but becomes progressively

[1] Criteria of Operability for Goiter, Minnesota Medicine, Oct., 1935.
* Bull. Soc. Path. Comp. No. 492. Oct. 1937.

pronounced. If not relieved, the symptoms (lacrimation, epiphora, corneal ulcerations and ophthalmitis) may become so marked that only enucleation or death relieves the patient from a pitiable existence. The disease is one of mechanical origin, viz., the result of a pronounced swelling of the extra-ocular muscles (often to 10 times their normal size). H. C. Naffziger devised an ingenious operation for the relief of this condition which is indicated in progressive exophthalmos following thyroidectomy and which has yielded him and others gratifying results.

The rationale of the operation is a decompression of the orbit and the optic foramen to afford adequate space for the increased orbital content and constricted optic nerve brought about by reflecting bilateral frontal flaps, elevating the dura of the frontal lobe, unroofing the orbit and removing the upper portion of the optic foramen, wide exposure of the orbital fascia and the ring of Zinn (Fig. 549).

Before operating, x-ray studies are to be made to show (a) the height and extent of the frontal sinuses; (b) the projection of the frontal and ethmoid sinuses into the orbital plate and (c) views of the optic foramen showing the immediate relationship of the sphenoid sinus to it. These roentgenologic studies will point the way to avoid opening into spaces and sinuses during the operation.

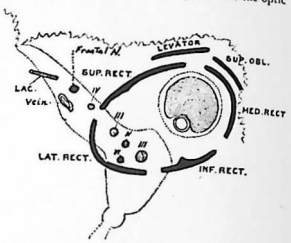


Fig. 549. Scheme to show the position of the annulus of Zinn and its relation to the structures in the apex of the orbit (after S. Whitnall).

Anesthesia. Avertin 85 mgm. per kgm. of body weight and 0.5 per cent procaine hydrochloride for local anesthesia.

Step 1. Expose the frontal bone by a transverse incision from the temporal fossa on one side, across the frontoparietal region, immediately behind the hair line, to the temporal fossa on the other side. (Fig. 550.) Dissect the scalp from the pericranium and reflect it forward thus exposing the frontal bone on both sides down to the frontal sinus. Bilateral frontal flaps are fashioned, the hinge of each being the temporal muscle. A small ridge of bone is left in the midline for the purpose of stabilizing these flaps when replaced.

Step 2. Separate the dura from the floor of the anterior fossa. Carry this stripping of the dura back to the sphenoid ridge and the base of the anterior clinoid process. Mesially, it is continued almost to the cribriform plate. The roof of the orbit is then opened (Fig. 551). Carefully separate the orbital fascia.

Step 3. Remove the roof of the orbit with rongeur forceps. Carry the opening in the bone forward, anteriorly, to the frontal sinus and laterally to a point where the orbital roof merges into the lateral wall of the skull and posteriorly to the sphenoidal ridge. Leave only a thin line of bone attached to the small sinus which is to be found in the dural reflection. Remove the roof of the

optic foramen and its superolateral margin (Fig. 552). X-rays of the optic foramen will show its relation to the sphenoidal sinus. The orbital contents will bulge into the opening as it is enlarged.

Step 4. Open the orbital fascia. Avoid the frontal branches of the fifth nerve, working by blunt dissection. Expose the levator superioris and superior rectus muscles. Avoid the nerve supply, which enters from below.

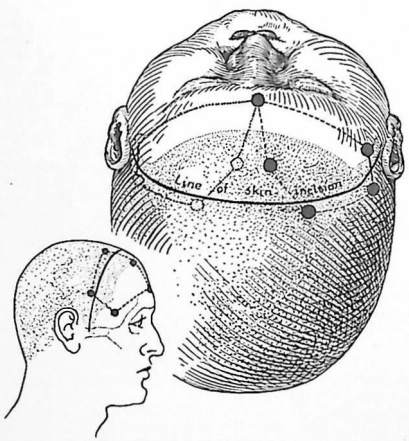


Fig. 550. Incision used. The solid black line indicates the coronal incision; the dotted lines, the two osteoplastic flaps. (Courtesy of Dr. Howard C. Naffziger.)

Step 5. Expose the internal and external recti similarly. The muscles are usually enormously enlarged (Fig. 553). In some patients, Naffziger carried the dissection down to expose the capsule of Tenon and the optic nerve as it enters the globe. Ordinarily this is unnecessary, the orbital fascia being open in all directions. The zonule of Zinn surrounding the orbital fissure and the optic foramen may be slit, usually at the outer margin of the superior rectus muscle.

Step 6. Hemostasis. Allow the dura to come down and rest directly on the orbital content. Carry out a similar procedure on the opposite side. Replace the bone flaps and fasten them together across the ridge of bone in the midline. Replace and suture the scalp in position. Suture the galea and skin separately. Fill the openings in the bone with bone dust. Protect the cornea carefully.

OPERATIONS ON THE PARATHYROID GLANDS

"Hyperparathyroidism" is a distinct disease-entity associated with a definite train of symptoms and a characteristic disturbance of calcium and phosphorus metabolism. It is constantly associated with a demonstrable adenoma usually of

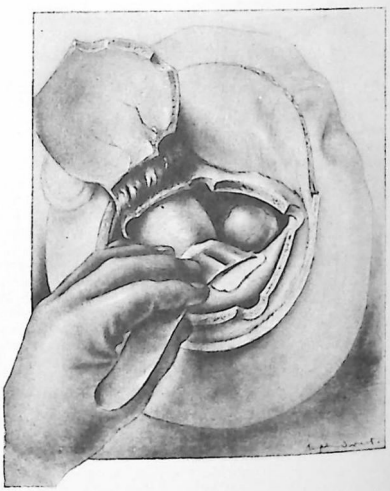


Fig. 551. Intracranial approach to the orbit. Part of the orbital plate is removed, exposing the fascia of the orbit. (Courtesy of Dr. Howard C. Naffziger.)

gross size of one or more parathyroid bodies. Following the total or subtotal resection of the tumor the calcium and phosphorus metabolism returns to normal, usually after a more or less prolonged period of tetany.

"The beneficial effects said to follow the removal of one or more normal parathyroids in certain cases of arthritis or in Paget's disease are, to say the least, viewed with skepticism. . . .

"The removal of normal parathyroid bodies or interference with their blood

[1] Churchill, E. D., and O. Cope, Surg. Gynec. and Obst., 58:255, 1934.

supply when operating with a definite diagnosis of hyperparathyroidism is absolutely contra-indicated.

"Subtotal resection of a parathyroid tumor is advisable when normal glands have been removed or damaged at a previous operation. Subtotal resection may also prove to be the operation of election in a very sick patient to lessen the

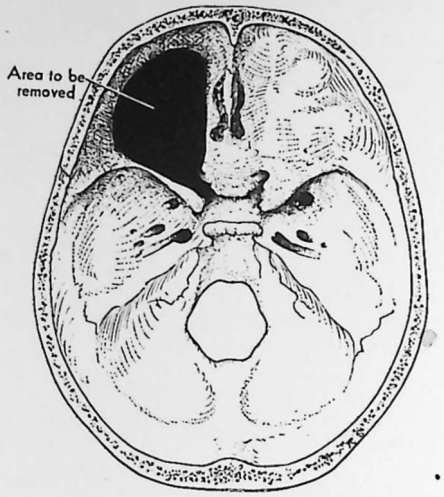


Fig. 552. Naffziger operation. The base of the skull showing the area of bone removed from the orbital plate and from the optic canal. (Courtesy Dr. Howard C. Naffziger.)

dangers of severe tetany. It has been done in one such case. The fate of the residual tissue being unknown at the present time, complete resection is the operation of choice.

Felix Mandl pioneered, in 1926, in parathyroidectomy as a means of cure in von Recklinghausen's disease. Others verified Mandl's findings.*

PARATHYROIDECTOMY

Removal of a parathyroid tumor is sometimes called for in cases of generalized osteitis fibrosa. Parathyroids are seldom palpable; therefore, free excision is essential.

Step 1. Make a wide collar incision as for thyroidectomy. Divide the depressor muscles transversely.

Step 2. Expose the whole thyroid gland thoroughly. Incise the thyroid sheath over each lobe.

* M. Chifo'iau and A. Amdire, Jour. Chir. 38, Nov. 1931.

Step 3. After ligating and dividing the middle thyroid vein, rotate the corresponding lobe mesially and complete the separation of the thyroid fascia from the capsule covering the posterior surface of the lobe. The existing tumor of the superior or inferior parathyroid body is now exposed. The tumor may be found on either side of the trachea or in the superior mediastinum.

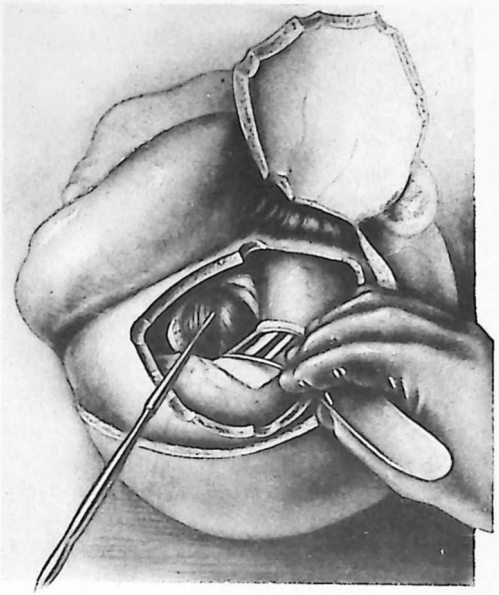


Fig. 553. Naffziger operation. Enlarged levator superioris and superior oblique muscles. (Courtesy Dr. Howard C. Naffziger.)

Step 4. Remove the tumor. This is usually not difficult. Walton calls attention to the fact that when the parathyroid tumor cannot be found in any of these situations it is probable that it involves one or other of the inferior parathyroid glands which may lie behind the thyroid sheath. It is necessary, therefore, in such instances to incise the thyroid sheath on one or both sides immediately above the level of the inferior thyroid artery and to search for the tumor alongside the esophagus, or within the thorax, where it may have passed down behind the esophagus to rest upon the bodies of the upper thoracic vertebrae.

Churchill's and Cope's Operation for Parathyroid Tumors Associated with Hyperparathyroidism

It is best to locate a small parathyroid adenoma in the first surgical exploration of the neck. Strict attention should be paid to hemostasis, as the staining of the tissue with blood makes it difficult to identify the parathyroid tissue. Doubly ligate even the smallest vessels before sectioning. It is imperative that all tissues be carefully handled by sharp dissection, as a hematoma may quickly develop

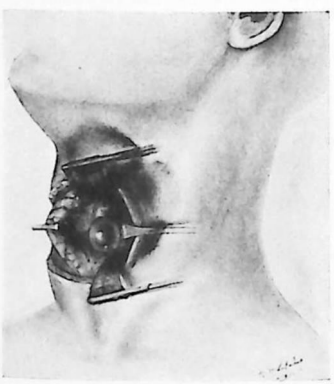


Fig. 554

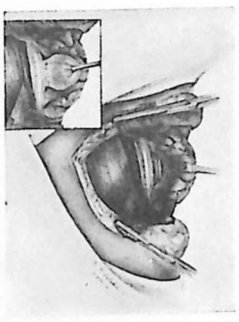


Fig. 555

Fig. 554. Parathyroid tumors associated with hyperparathyroidism. A parathyroid tumor exposed by elevating lobe of thyroid. The inferior thyroid artery formed a sling which may have prevented this tumor from descending into the posterior mediastinum, as it lay on the deep cervical fascia. Only the upper third of the tumor is shown in the cut.

Fig. 555. Parathyroid tumor situated between trachea and esophagus posterior to the recurrent nerve. Insert shows the tumor when delivered. (Courtesy of Drs. Edward D. Churchill and Oliver Cope and Surgery, Gynecology and Obstetrics.)

following an injury to the parathyroid body. A parathyroid with a hemorrhage in its tissue resembles a ripe currant. If this is present there is danger of postoperative tetany.

Do not cut into the thyroid gland, as the resultant hemorrhage will obscure the operative field. Use traction stitches of fine silk instead of double hooks to retract the thyroid. After hyperparathyroidism has been established proceed as follows:

Step 1. Try to locate the tumor by means of an x-ray. Take films to outline the trachea and penetrate the superior mediastinum. Look for a calcified capsule or displaced trachea. Use a swallow of thick barium to outline the esophagus in both anterior and lateral views. A filling defect or displacement of the esophagus may indicate the position of the tumor.

Step 2. After anesthetizing the patient, preferably with ether, make a wide

collar incision; section the pretracheal muscles and dissect the middle cervical fascia from the surface of the thyroid. Look for any indications of tumor behind the thyroid.

Step 3. Identify the carotid sheaths and cut the lateral thyroid veins between ligatures. Palpate the posterolateral aspects of the thyroid and examine them directly. Continue the dissection downward on one side until the recurrent laryngeal nerve is identified and the region of the terminal divisions of the inferior thyroid artery exposed. Repeat this on the opposite side.

Step 4. Expose the trachea and esophagus and carry dissection upward to the larynx and downward into the superior mediastinum (Figs 554-555). Sever the branches of the inferior thyroid artery individually as they enter the capsule of the thyroid, making sure the blood supply of any normal parathyroid body is left intact (Fig. 556).

Step 5. Insert the finger back of the sternal notch deep to the middle cervical fascia; explore the anterior mediastinum. Insert the finger into the posterior mediastinum behind the trachea and esophagus. At the same time introduce a finger of the other hand into the posterior mediastinum on the other side. Palpate the structures of the mediastinum between the two fingers. If a substernal tumor is identified, deliver it into the operating-field with gentle traction. **Do not remove normal parathyroid bodies if no tumor is found.**



Fig. 556. Parathyroid tumors associated with hyperparathyroidism. Sketch from actual autopsy dissection (by R. R. Linton). The inferior thyroid artery may be divided at a point between the artery to the parathyroid and the capsule of the thyroid gland. This technic has been useful in complete thyroidectomy. A second parathyroid body is shown on the lateral aspect of the trachea. (Courtesy of Drs. Edward D. Churchill and Oliver Cope, and Surgery, Gynecology and Obstetrics.)

If no tumor is found after complete dissection of the neck and palpation of the mediastinal structures, recheck the diagnosis during convalescence. At the conclusion of an unsuccessful operation remove a small button of bone from the sternum if that has not already been done. If the diagnosis is confirmed, explore the mediastinum under direct vision by section of the sternum. Under positive pressure-anesthesia make a midline incision downward from the sternal notch sweeping to the right at the level of the third costal cartilage. Insert a finger into the mediastinum and direct it upward behind the sternum pushing the great vessels backward to avoid injury. Split the sternum with a Lebsche sternum knife and retract the two halves bringing the anterior mediastinum into view (Figs. 557-558-559-560).

In a final attempt to locate a tumor undertake block dissection of the neck above the larynx.

SECONDARY OPERATION

Churchill follows the principles of Clute for secondary operations on the parathyroid (Fig. 561).



FIG. 557. Parathyroid tumors associated with hyperparathyroidism. First step in anterior mediastinotomy (after Sauerbruch). (Courtesy of Drs. Edward D. Churchill and Oliver Cope and Surgery, Gynecology and Obstetrics.)



FIG. 558. Parathyroid tumor exposed by retraction of the two halves of the sternum. The vascular pedicle extended downward from the neck, the tumor lying below the left innominate vein. (Courtesy of Drs. Edward D. Churchill and Oliver Cope and Surgery, Gynecology and Obstetrics.)

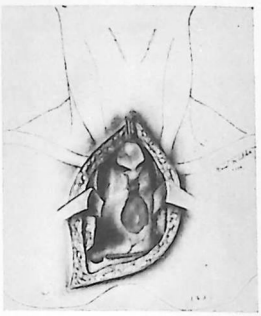


FIG. 559. Subtotal resection of the tumor because of the fact that at least two normal parathyroids had been previously removed. (Courtesy of Drs. Edward D. Churchill and Oliver Cope and Surgery, Gynecology and Obstetrics.)



FIG. 560. Fixation of residual tumor tissue in the sternal notch with vascular pedicle intact. (Courtesy of Drs. Edward D. Churchill and Oliver Cope and Surgery, Gynecology and Obstetrics.)

Step 1. Section the pretracheal muscles; enter the deep areas of the neck on both sides through the carotid sheaths.

Step 2. Identify and retract the great vessels and the vagus nerves laterally; find the trunks of the cervical sympathetics marking the deep cervical fascia. Isolate the recurrent nerves as low as possible and trace these upward toward the larynx. Identify the thoracic duct.

Step 3. Explore the scar-tissue around the thyroid only after the exploration has been carried "far afield." Normal parathyroids or their vascular pedicles may be injured here, but a tumor would likely have been identified by the first surgeon.

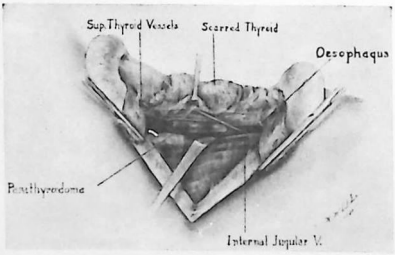


FIG. 561. Parathyroid tumors associated with hyperparathyroidism. Parathyroid lying behind the esophagus discovered at secondary operation. (Courtesy of Drs. Edward D. Churchill and Oliver Cope and Surgery, Gynecology and Obstetrics.)

SUBTOTAL PARATHYROIDECTOMY

This operation is indicated where damage has been done to normal glands or their blood supply. The capsule is resutured to form a compact body and its location clearly marked. In the case of mediastinal tumors, transfer the residual tissue, with its vascular pedicle intact, to the neck. The cases operated on showed marked tetany even with subtotal resection.

In some advanced cases accompanied by extensive decalcification of the bones, subtotal resection is indicated even if the normal parathyroids are intact. Severe tetany sometimes follows the removal of a large adenoma even when a limited dissection made damage to other parathyroids impossible. Death has been known to follow from uncontrollable metabolic disturbance caused by total resection of a tumor.

Comment. In speaking of the results of the operation, Churchill and Cope state: "The immediate result in the cases from which a parathyroid tumor has been removed either completely or by subtotal resection, has been a correction of the disturbance in calcium and phosphorus metabolism. In fact, postoperative studies showing the return to normal constitute the final step in establishing the diagnosis and efficacy of the treatment. They are

notably lacking in the reported cases of Paget's disease and arthritis. Following removal of the tumor in true hyperparathyroidism the serum-calcium values fall with dramatic rapidity. Symptoms and signs of tetany may appear even with a serum-calcium above the normal level when hypercalcemia has been present for a long time. The tetany is controlled by high calcium diet, administration of calcium gluconate, irradiated ergosterol and parathormone.

Improvement in many of the symptoms of hyperparathyroidism may be expected within a few days. In several instances the patient has only been made conscious of certain long standing but ill defined symptoms such as loss of energy, constipation or fatigue by their abrupt cessation following operation. These symptoms are then recognized in retrospect as manifestations of the disease. The muscle and joint pains as well as bony tenderness are promptly relieved. The replacement of calcium in the bones takes a longer time and many months may elapse before any change becomes apparent by x-ray. The bone tumors being osteoclastomata, may be expected to disappear, but the bone cysts formed by fibrous replacement of bone substance persist.

"How far the kidney damage may be repaired is not known. In certain cases some improvement in renal function has been observed. The only fatality in the 11 cases here presented occurred following the removal of a ureteral stone several weeks after the resection of a parathyroid adenoma."

PARATHYROID TRANSPLANTATION

In discussing Transplantation of Living Grafts of Thyroid and Parathyroid Glands Harvey B. Stone[1] concludes:

"In dogs, certain endocrine tissues may be transplanted successfully from one individual to another. Factors of success in such transplants include the choice of a proper site for the graft, proper size and form of the graft, and biochemical adaptation of the graft to the host. The axilla and groin are proper sites. The grafts should be tiny fragments or tissue cultures. The grafts should be grown in culture in a medium containing the blood fluids of the host to adapt it before implantation.

"In human beings, ten cases have been submitted to grafting treatments, using the methods developed by experiments on dogs. Five of these were grafts of thyroid tissue and five were grafts of parathyroid tissue. Of these ten cases, only two are of sufficiently long standing to permit an opinion as to the success of the experiment—both of them being parathyroid tetany cases. In both of them we believe we are justified in assuming that the grafts were successful."

Tissues chosen to receive this implant should have a generous blood and lymph supply; the subcutaneous tissues, properitoneal tissue, omentum, spleen and bone marrow have all been recommended.

Step 1. Select a parathyroid in a location free from blood in a patient who is undergoing a goiter operation but is otherwise healthy. The surgeon should make sure that the patient will suffer no ill effects from parting with a parathyroid. The removed parathyroid is placed in Locke's solution and kept at body temperature until implantation takes place; implantation immediately upon removal is to be preferred.

Step 2. Anesthetize the patient and form a properitoneal pocket free from blood

[1] Annals of Surgery, October, 1934.

under the rectus abdominis muscle. Local anesthesia is best avoided as it may interfere with the transplant.

Step 3. Split the parathyroid without taking it out of the solution or incise it so that there are two raw surfaces; the procedure varies according to the size of the organ. Place the implant in the pocket made for it with as little han-

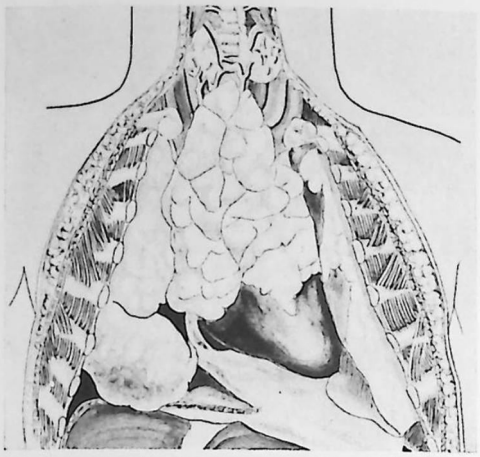


Fig. 562. Thymus of newborn baby (natural size). Note that the thymus fills almost the entire mediastinum and extends upward as far as the thyroid gland. The figure illustrates very well what is called the "cervical" and the "intrathoracic" portions of the thymus. Note, too, the vessels extending from the thyroid to the thymus (after Crotti).

dling and exposure to the air as possible. Check bleeding and close the incision without drainage.

Frugoni and Binde reported a case (Il Policlinico, Sezione Pratica, 44, 1937) in which a graft from a simian gland persisted for eight years in a patient twenty-one years of age. The operation was performed by Serge Voronoff.

OPERATIONS ON THE THYMUS

THYMECTOMY

Anatomic Considerations. To all appearances, the thymus seems to be associated with the nourishment of the unborn child and infant (Fig. 562). It increases in size in proportion to the rest of the body until the child is about two years old. After that it grows larger in some parts, diminishes in other parts, adipose formations appear followed by degeneration of the gland. Before degeneration takes place, it is firm and pink in color; later it is similar in appearance to adipose and areolar tissue and is very easily torn.

The thymus is enveloped in a capsule of fibers from which branches project

among the lobules. It is found behind the upper part of the sternum and when it reaches its greatest size it projects for a short distance into the neck and extends down to about the fourth costal cartilage and in unusual cases as far as the diaphragm. The thickest part of the thymus rests on the pericardium, emerging from here into two flat lobes which become thinner and more divergent as they descend. The left lobe overlaps the right and is separated by a tissue of fibers. The left lobe is generally the larger of the two. Irregularities of the fibrous septa sometimes result in the fusion of the two lobes so that a third one appears between them.

The thymus is in touch with most of the aortic arch while the innominate veins and superior vena cava form a furrow on its posterior surface. It extends into the

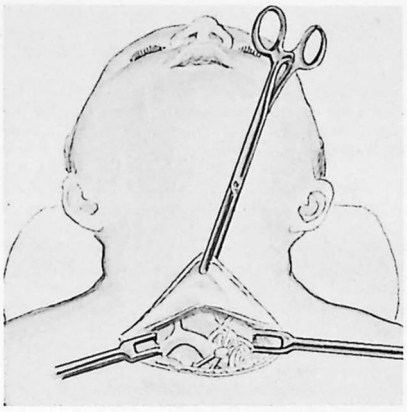


Fig. 563. Thymectomy. Transverse incision over manubrium. The superficial fascia of the neck is shown divided. The veins overlying this fascia are ligated.

space between the pericardium and pleura on either side. Before atrophy takes place, the thymus resembles a thick crescent. The suspensory ligaments connect the thymus capsule to the thyroid. The internal mammary vessels follow their course in front of it. Authorities differ widely concerning the weight of this body at birth; 3 gm., 5 gm. and 13.75 gm. being given as average figures. It is heaviest at puberty after which it becomes thinner and softer being replaced by fat and areolar tissue but rarely disappears completely although after 20 years of age it is not easily discerned as a rule. The internal mammary, thyroid and pericardial arteries furnish the blood supply for the thymus through capillaries at the junction of the medulla and cortex. The veins join together forming larger trunks, the left innominate being the most important. There are many large lymphatics which empty into the nodes behind the sternum and form a plexus around the lobes.

Anesthesia. Crotti admonishes that "in children, especially in the newborn, the dyspnea may be so intense that anesthesia, no matter what form, may only increase the dyspnea, consequently in such conditions the operation may have to be performed under local anesthesia or with no anesthesia at all as in

the newborn for instance. . . . In small children chloroform seems to be preferable to ether."

The patient's position is the same as in classical thyroidectomy.

Step 1. Make a transverse incision above the manubrium of the sternum. Retract the lips of the wound. Divide the cervical fascia in the median line (Fig. 563).

Step. 2. Separate the prethyroid-muscles in the midline. Retract them laterally. Look for the upper limit of the thymus, which will ascend and descend during the respiratory excursions.

Step 3. Deliver the thymus into the wound by gentle traction on its upper pole. Attend to hemostasis during delivery (Fig. 564).

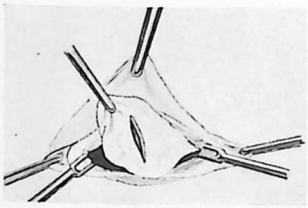


Fig. 564

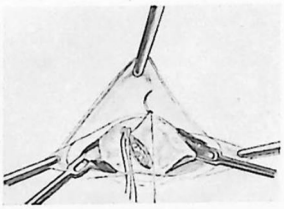


Fig. 565

Fig. 564. Thymectomy. The capsule of the thymus is grasped with a pair of forceps, pulled upward, forward, and incised.

Fig. 565. Thymectomy. The thymus has been removed. The capsule of the thymus is sutured to the fascia and sternum.

Step 4. Crotti counsels extracapsular resection of the thymus, stating that "usually the thymus is easily loosened from the surrounding structures. Whenever, however, there is some perithyroiditis and consequently there is some difficulty in getting the thymus up, it is better then to perform an intracapsular thymectomy." Under such circumstances the capsule of the thymus is opened, permitting the parenchyma of the gland to protrude during the respiratory excursions (expiration). Shell out the gland digitally with care (Fig. 565).

Step 5. Ligate the base of the thymus snugly. Ablate it sufficiently above the ligated base to avoid slipping of the ligature. In an emergency (hemorrhage) tight packing should be resorted to.

Step 6. Attend to hemostasis. Reunite the prethyroid muscles. Suture the platysma. Close the skin. Dress.

TUMORS OF THE THYMUS

This surgery is of a very different type.

Lilienthal says: "Greater progress would be made if it were possible to perform more exploratory operations for suspected tumors in this region before such proportions have been reached that a transpleural operation with its added dangers has become necessary. Also, there would be less embarrassment from the greatly dilated veins which are present later on in the disease. The method of approach

when the tumor does not extend too far beyond the borders of the sternum is by Milton's operation (Chap. 29) or one of its modifications. The thymic arteries are small in size and should not add greatly to the dangers, but means for differential pressure must be ready with an anesthetist skilled in their use in case one or both pleurae are wounded. When it is obvious that we are dealing with an inoperable condition some relief may be secured by the decompression afforded by a longitudinal division of the sternum and its posterior periosteum. Large mediastinal tumors spreading laterally need not of necessity cause distress by pressure upon the trachea as do those confined to the mediastinum itself."

CHAPTER 18

PRINCIPLES OF PLASTIC SURGERY AND SKIN GRAFTING

Historical Notes. The Hindus practiced skin grafting and plastic surgery two thousand years ago. A customary form of punishment was cutting off the nose; men belonging to the tile-maker's caste consequently became skilled in grafting on noses formed from the skin of the gluteal region. It is doubtful if similar operations could be done so successfully today, since there is no record of the exact technic employed by these operators. It was believed at that time that the graft atrophied or grew healthy in accordance with the state of health of the original donor.

There is very little recorded concerning the progress of this art during the middle ages. Toward the end of the eighteenth century Indian methods of grafting were introduced into Europe. At about this time Tagliacozza, a famous Bologna surgeon, is given credit for some very fine work in rhinoplasty.

RECONSTRUCTIVE AND AESTHETIC PLASTIC SURGERY

Plastic surgery designates that branch of general surgery which deals particularly with repair and reconstruction in connection with defects and malformations, whether these may be congenital or acquired; it includes not only the improvement of appearance but, so far as possible, the restoration of function. Plastic reconstructive work may, and generally does, consist in building up local defects with tissue obtained from the immediate vicinity or even from a considerable distance from the defect; but it also often includes removal of the localized redundant tissues and remodeling what is left so as to produce a normal or approximately normal appearance. This type of plastic reconstructive work and all operations which are undertaken principally for the removal of unsightly disfigurements may in a general sense be described as **aesthetic plastic surgery**; but many of these operations have not merely an aesthetic but also an economic and therapeutic value. (See Surgery of the Breast, etc.) Aesthetic plastic work, at present, is to a great extent confined to the facial and other exposed regions, but in the case of women, it may include the breasts, abdomen and other parts which have become unsightly and burdensome. General plastic work not only includes the aesthetic type but also work on bones, joints, tendons, etc., so as to eliminate pain and restore function. This type of plastic work may be called for in any region of the body following the healing of traumatisms or to remedy such congenital defects as webbed fingers, deformed feet or the like. The plastic work may require manipulation of bone, muscle, fascia, fat and skin, either in situ or transposed from a distance. By the term "take" we mean that the entire graft has healed in its new position. By a "partial take" we mean that the tissue transplanted has only partially healed.

The surgeon who undertakes plastic work should, therefore, be thoroughly familiar with the behavior of such tissues under all conditions and very particularly with their mode of healing when traumatized. He should also be conversant

with the possibilities of tissue-transplantation and the use of free and pedicled flaps and grafts. By a "flap" is meant a segment of tissue detached from its natural bed for the greater part of its extent. The part by which it is left attached to its original surroundings (pedicle) carries blood vessels, thus supplying nourishment to the detached part of the flap. The detached part may be applied to a raw, granulating surface and, if this latter is well vascularized, the flap will, as a general rule, soon become itself vascularized and when this occurs, the flap may be entirely detached from its nutrient base. A "graft" may be entirely detached from its surroundings and connections and transferred to the place for which it is intended, where in due time it may become vascularized and live incorporated in its new surroundings. Bone, cartilage, skin and perhaps other tissues may be freely grafted or transplanted and under certain conditions will permanently live in the new site; other tissues and even parts of internal organs can be transplanted, become vascularized and live for a greater or lesser time in their new environment (Alexis Carrel). The free ends of the same or different tendons may be sutured together and will in time become integrate.

It will be seen that the operations of plastic surgery are manifold and the knowledge of technic demanded from the plastic surgeon is extensive if he covers all the fields embraced in this type of surgical work. Many procedures, such for instance as arthroplasty, are undertaken by the general surgeon as a part of his general work.

TWO MAIN PRINCIPLES OF PLASTIC REPAIR

1. The proper preparation or vivification of the surface or site of the plastic work;

2. Complete absence of tension when and after flaps or grafts are applied.

These principles are perhaps more applicable to superficial than to deep plastic work and in this chapter, we will confine our attention principally to superficial plastic work.

The first of the main principles just referred to must of necessity presuppose some general conditions in regard to the patient; he should be free from all active disease such as syphilis, tuberculosis or suppurative disease of any kind; he should not be aged or feeble and his general health should be good. In the case where a plastic operation is being performed to remedy defects due to traumatism, such as a burn, the healing process should be complete and the patient in good general condition. All scar tissues must be completely removed from the superficies and all bleeding arrested before a flap or graft is applied to it.

METHODS OF PLASTIC REPAIR

When a superficial defect has to be repaired by a plastic operation which includes a skin covering, the following methods may be employed: (a) Skin grafting; (b) The French Method (gliding the edges together and suturing). This method was originally devised by Celsus. In such cases of tension, the skin may be mobilized to a great extent by undercutting; in this manner large areas of skin may be shifted without impairing the vitality of the transplant. (c) The Indian Method, which consists of using pedunculated flaps from tissue in the immediate neighborhood with more or less torsion of the pedicle. (d) The Italian or Tagliacotian Method: the use of pedunculated flaps from distant parts, as

for instance when a nasal defect is to be repaired by a flap of tissue from the arm. While the method is inconvenient for the patient requiring immobilization of the arm for a long period, the procedure assures nourishment of the flap. (e) The Gillies Tubed-Pedicle Flap: In treating soldiers who had been wounded during the World War, it often happened that no local flaps were available to fill in defects where something more than epithelial covering was needed and it became necessary to obtain flaps from a distance; thus Gillies tubed-pedicle flap was

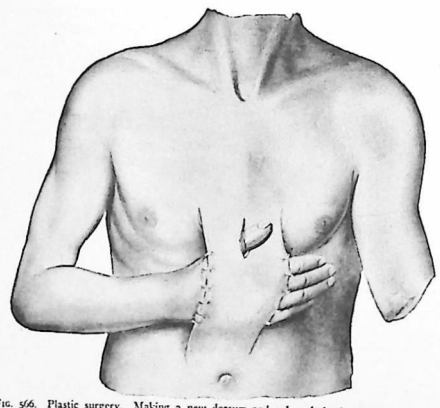


Fig. 566. Plastic surgery. Making a new dorsum and palm of the hand through a bridge flap taken from the abdominal wall.

developed. It is an excellent way to transfer whole skin together with the necessary amount of subcutaneous tissue from one part of the body to another. The wall of the abdomen usually furnishes this flap. The accompanying illustrations describe better than words the method of procedure (Fig. 566). The flap may be used for repairing various defects.

Flaps

Flaps for plastic work are usually thick and include the subcutaneous tissue which contains the blood vessels supplying the skin, so that vitality is not impaired. The deep fascia is not, as a rule, included in the flap. In some cases, as in certain kinds of rhinoplasties a flap may be cut containing bone and periosteum.

It is not within the province of this chapter to describe the many types of defects for which flaps may be employed nor the manner in which they may be utilized. Each type of defect will have to be handled according to its own particular circumstances and the judgment of the surgeon. There are, however, certain generalities which apply to flaps of all kinds. When a flap is obtained from the vicinity of a defect it may be glided into its new position and fixed there by sutures. In the case, for instance, of an external wound left following amputation of the breast, when the edges cannot be approximated, a flap may be obtained from the axillary or shoulder region and slid into the defect (sliding flaps). There is more danger of necrosis when such a flap is transplanted.

Davis and Traut have ably illustrated and described the various types of flaps used in modern plastic work. A study of the illustrations and legends (Figs. 567-587 incl.) will do more to elucidate the factors under consideration than any amount of text.

According to circumstances, a flap in plastic work may be used in different ways. There is the reversed flap in which the cuticle is directed inward, the outer surface being later covered by a skin graft. This may be indicated in repairing defects in the cheek or other regions having a mucous lining. In the superimposed flap, the first reversed flap is itself covered by a second flap with its cuticle outward, or the first reversed flap may be folded on itself. A granulating flap is a double pedicled one in which the superficial tissues are dissected up but the extremities left intact. The isolated part forms a kind of bridge, the undersurface of which is prevented from uniting to its surroundings by some protective material and then allowed to granulate for from ten to fourteen days. Experience has shown that the vitality of such a flap in its new position is

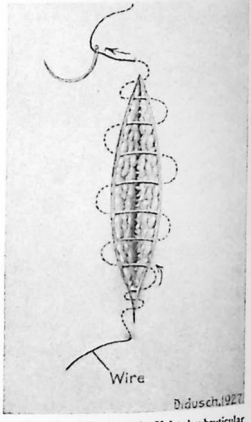


Fig. 567. Illustrating the Halsted subcuticular suture. This suture was first used by Dr. W. S. Halsted in closing hernia wounds; and when properly inserted in closing a straight incision gives the minimum skin scar. A small curved needle is used, and this penetrates the epithelial layer of the skin only at its point of entrance at one end of the wound and of emergence at the other. The skin edges are brought together by drawing the suture snug after taking short lateral bites on each side through the deeper layers of the corium. Although any suture material may be used, silver wire is the most satisfactory, as it has enough rigidity to splint the coapted edges. Care must be taken not to kink the wire while making the closure and also the wire must be freely loosened as the stitch is being placed so that it will slide through the skin after the suture is completed; otherwise it may be difficult to remove and may even break off and remain in the skin. The wire is usually removed after ten days. (Davis and Traut in Lewis' Practice of Surgery.)

more assured after the pedicles have been divided if the deeper parts are granulated. Moreover, such a flap can be cut much longer in proportion to its width than a free flap without fear of sloughing; the length may be three times the breadth.

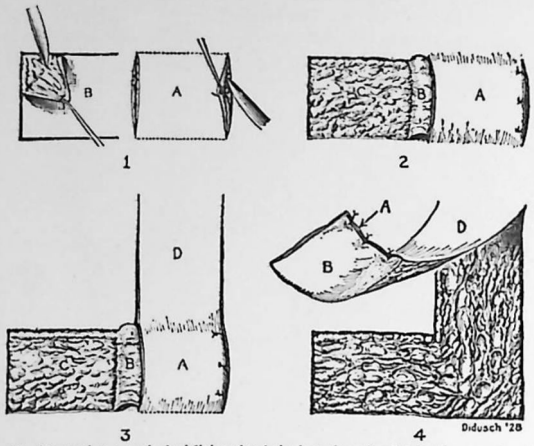


FIG. 568. Illustrating a method of lining the desired portion of a flap by the use of a lateral flap adjacent to the lower pedicle (Lauenstein).

1. The dotted lines and incisions in A mark out what will eventually be the lower end of the pedunculated flap which is to be lined. This area is completely undercut. B indicates the lateral flap which is raised with its pedicle adjacent to A and which will be turned over and drawn under A to line it. A long lateral flap whose pedicle is at a greater distance from A and in which delayed transfer has been used might be more sure of success in certain situations.

2. Shows the lateral flap B drawn under the undercut area A and sutured so that the raw surface of B is in close contact with the raw surface of A.

3. After healing is complete between A and B, the length of the future shank D is outlined with incisions and may be undercut, leaving it attached at each end, and either be replaced for delayed transfer or tubed. The pedicle of B is then divided and the raw margins of B and A on that side are sutured. The desired portion of the flap is now lined and consists of a double thickness of subcutaneous tissue with whole-thickness skin on both sides. After gradual division of the lower pedicle of A, this lined area can be shifted into any position to which the length of its pedicle will carry it.

4. Shows the lined portion of the flap after division of the lower pedicle has been completed. After the lined portion has been grown into its new position, the pedicle is either divided close and the shank returned to its bed, or the shank may be utilized. The defects left by the removal of the flap should be grafted with skin. This suggestion may be very advantageous in various ways. (Davis and Traut in Lewis' Practice of Surgery.)

When a flap has been used for filling up a defect or other plastic procedure, it will, of course, be necessary to fit and trim it so as to leave no projections over the contiguous tissues. When its exact figuration has been accomplished, it should be sutured in place. The suturing of a plastic flap in place is a most important procedure. Silkworm gut or fine linen is commonly used, every effort being

made to obtain good apposition between the edges of the flap and those of the prepared bed. Catgut may be used for buried sutures if they are necessary, or for the union of mucous surfaces. Fine horse-hair is employed where the situation calls for the avoidance of stitch marks.

The management of tension is a delicate matter; there should be enough but not too much; the condition of the sutured edges should be constantly inspected and any dragging stitches removed. Usually after suturing there is always some swelling of the flap and of the tissues surrounding it; a stitch, there-

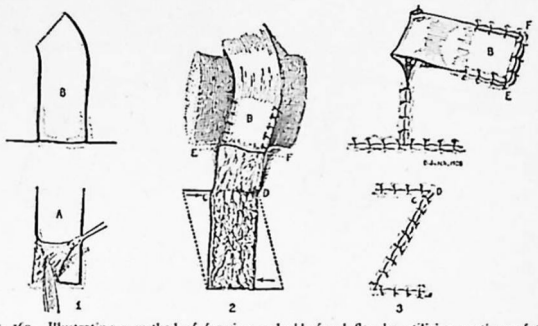


FIG. 569. Illustrating a method of forming a double-faced flap by utilizing portions of two pedunculated flaps.

1. A and B show the outlines of the two flaps of the same width and of the required length, both having their pedicles above.

2. Shows the flap A raised and turned upward and its lower third placed under the lower third of flap B and sutured raw surface to raw surface. Note the roll of gauze to prevent kinking of the pedicle of flap A. Also note the outline of the lateral triangular flaps which will be advanced to close the defect made by raising flap A.

3. After healing has taken place the double-faced portion is separated from flap A, and on the pedicle of flap B is shifted where necessary. Note the closure of the defect left by raising the flaps. This procedure may be used very advantageously in certain situations and has been utilized in making compound flaps, for instance, when including a portion of the clavicle in the section to be lined. (Davis and Traut in Lewis' Practice of Surgery.)

fore, that may when put in appear slack, will soon tighten up; too much tension may occur with the appearance of a zone of inflammation which, if not corrected in time, may be followed by sloughing.

Different modes have been devised for the closure or filling of deformity gaps of varying shapes. Triangular-shaped gaps, if small, may have the edges brought into apposition by simple undermining of the subcutaneous tissues and suturing the skin edges together. When such gaps are of a larger size, an incision is made continuous with one side of the triangle; the subcutaneous tissues beneath the edge of this incision and of the side of the triangle next to it are undermined by dissection; the loosened-up skin may then be sutured over the defect. If necessary, the original incision may be continued on both sides continuous with one side of the triangular gap and the same procedure followed on each side. Quad-

rilateral and elliptical gaps may be dealt with in a similar manner by undermining the subcutaneous tissues around them.

The most satisfactory method of suturing skin edges in plastic work is the single on-end or vertical mattress suture as it prevents overlapping of the edges. This suture may also be used for coapting mucous membranes. A continuous mattress suture may also be employed.

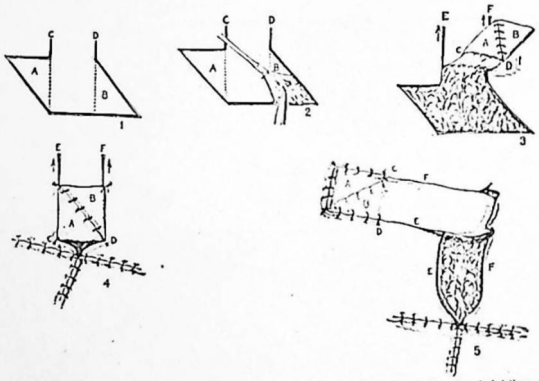


FIG. 570. Illustrating a method of lining a portion of a pedunculated flap by infolding two lateral triangular sections (after Cole).

1. The dotted lines indicate the width of the flap to be lined. The incisions show the shape of the flap to be raised. The triangles A and B are to be turned under for lining.

2. The flap being raised.

3. The flap raised and the triangles A and B folded backward and sutured, thus lining the selected portion of the flap. Note the diagonal suture line.

4. The lined portion is laid back against the underlying tissues and kept stretched by sutures. The defect from which the flap came should be closed by sutures if possible, but where this cannot be done skin grafting is required.

5. After healing is complete, the pedicle of the flap is gradually lengthened and the lined portion of the flap is shifted wherever desired. The shank of the pedicle is returned to its original position after it is finally separated from the lined portion. This is a more complicated method than we usually employ, but is illustrated to show the idea, which may be modified to suit conditions. (Davis and Traut in Lewis' Practice of Surgery.)

In the French method of cutting flaps for plastic work the skin edges, both of the flap and its bed, are undermined and the subcutaneous tissue pads removed. This enables the surgeon to bring the skin edges into better apposition and to avoid undue tension. Another method is to incise the edge of the flap on the slant so as to produce a bevel edge. This appears to give a larger area of epithelial surface for union, while the thin edge having the character of an epithelial graft tends to fuse with the opposite skin and to produce a rapidly fading scar. If this method be employed, it seems best to use a semi-subcutaneous mattress suture with a few interrupted edge-to-edge sutures. Tension sutures may be inserted occasionally along the united edges, care being taken to prevent cutting by tying them over strips of rubber.

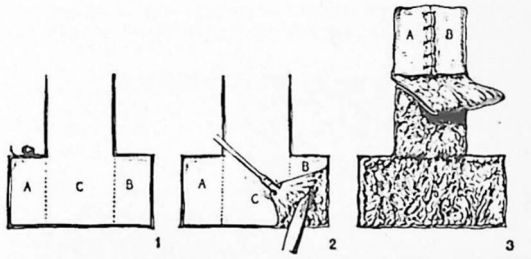
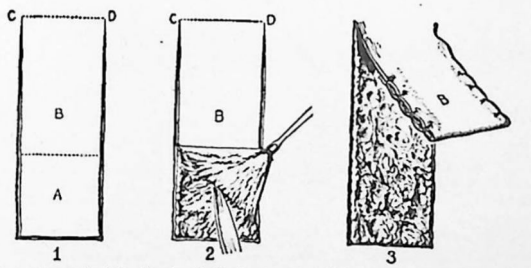


FIG. 571. Illustrating a method of lining the lower portion of a pedunculated flap by infolding two lateral rectangular sections (after Cole).

1. Shows the outline of the flap cut in the shape of a T. The dotted lines indicate the width of the portion C to be lined. The sections A and B are each one-half the width of the flap itself.

2. The entire flap is then undercut and raised.

3. The sections A and B are turned inward and the margins are sutured thus lining the section C. It is advisable for healing to be complete before attempting to shift the flap thus lined to its new location. The unused portion of the pedicle should be returned to its bed, and the rest of the defect left by raising the flap should be skin grafted. (Davis and Traut in Lewis' Practice of Surgery.)



Suggestive methods for forming double-faced or lined flaps, in other words, flaps with skin on both sides. Many modifications may be made in carrying out the procedures, depending on the situation of the defect and the tissues available.

FIG. 572. Illustrating a method of lining a flap by folding it on itself.

1. Note the outline of the flap. The section A is the portion to be turned under to line a similar sized section of B. The dotted line CD indicates the extent of the undercut.

2. The flap being raised.

3. The section A has been folded under B and sutured so that raw surface is to raw surface. When healing is complete, the flap may be shifted as far as its primary pedicle will allow, or the pedicle may be gradually lengthened to give greater distance. Should the flap be on the arm, it may be carried to the face or elsewhere by the Italian method. The area from which the flap was raised may be snugged by sutures and skin grafted. (Davis and Traut in Lewis' Practice of Surgery.)

ANCHORING OF FLAPS

Some surgeons doing plastic work have found it advantageous to approximate divided edges without suturing them together. This is accomplished in different ways. Strips of muslin to which hooks have been sewn may be glued

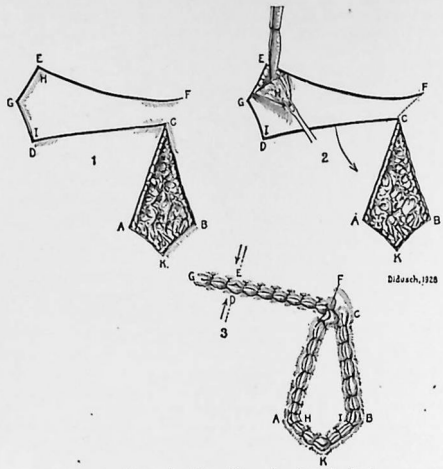


FIG. 573. Illustrating the closure of a defect with a pedunculated flap having a very narrow pedicle.

1. The defect with the outline of the measured flap. It will be noted that the pedicle is very narrow and the flap is long. A pedicle as narrow as this must carry an artery to nourish the flap, otherwise necrosis would surely take place, at least in part, even though delayed transfer was resorted to.

2. The flap being raised. Note the direction of the twist of the pedicle. Before inserting the flap the tissues adjacent to point C were undercut.

3. The flap sutured into the defect. The area from which it was raised was closed by sutures. Note the position of the points F and C as compared with that in 2. (Davis and Traut in Lewis' Practice of Surgery.)

to the shaved and cleaned skin-surfaces and the edges of the gap approximated by lacing up the hooks. Huessner's glue is one of the many similar preparations used for keeping the strips in place. It is composed of resin, 25 Gm.; alcohol (90%) 25 cc.; Venetian turpentine, 0.5 cc.; benzene 5.0 cc. There are various other non-suture methods such as the use of metal clips (Michel).

One thing to be borne in mind in connection with plastic work is that infinite patience both on the part of the operator and patient is called for. There must be no hurry and numerous operations may be required before a satisfactory result is obtained.

After-Care

Where there are no infective complications, the part should be immobilized and soft, non-irritant, dressings applied with even pressure. If the dressings are tight, the blood supply may be interfered with and a slough result.

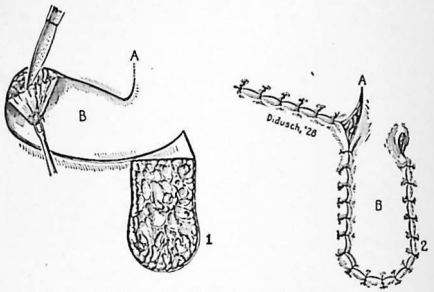


FIG. 574. Illustrating the closing of a defect with a single pedunculated flap from adjacent tissue with twisting of the pedicle by the Indian method.

1. The defect with the measured flap outlined. Note the triangle of skin between the pedicle of the flap and the upper end of the defect. In this instance it is advisable to remove this area in order to make a better closure.

2. The flap turned down with a partial twist of the pedicle and sutured into position. Note the closure of the area from which the flap was raised. When closure cannot be made, it is advisable to skin graft the defect. The pouting point caused by the twist of the pedicle can be removed later should it be objectionable. (Davis and Traut in Lewis' Practice of Surgery.)

Massage, or passive movement, is of great value both before and after operation. Before operation, scars may be made movable and the circulation in the region improved. Following operation, massage helps in restoring lost function; areas that have been grafted may be loosened up a bit and the color and circulation in the grafts improved. But massage should not be commenced until at least three weeks following operation.

In speaking of the Treatment of Superficial Granulating Wounds, John E. Cannaday[1] points out that Sir Walter Scott tells of the old belief among the Highland clansmen that a wound heals better if the first dressing is not changed for a long time and that the dried blood in the dressing was beneficial and promoted healing. Chutro, of Buenos Aires, in dealing with war wounded in Paris

[1] Am. Jour. Surg., Vol. XXV, No. 2, 1934.

during the World War, strongly stressed the great value of infrequent dressings and non-interference with wounds during the process of healing. He did not dis-

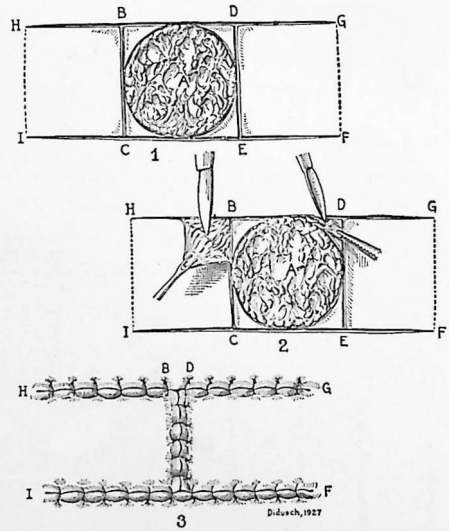


FIG. 575. Illustrating a method of closing a circular-shaped defect by the removal of four triangles of skin, thus changing the defect from a circle into a square. Lateral square flaps are undercut and advanced, and the closure is in the shape of an H (Szymanowski).

1. Shows the circular defect with the triangles outlined and the incisions made to form the lateral flaps.

2. Shows the removal of the triangles converting the circle into a square. Also the raising of the lateral flaps.

3. The lateral flaps have been advanced to meet each other and have been sutured. Szymanowski based the closure of all of these circular defects on Burow's method of excising triangles of tissue, combined with other well known procedures used for closing an ellipse, a triangle and a square. In other words, he used combinations of different procedures. In plastic surgery combinations must be frequently made in order to meet situations which unexpectedly arise. For this reason, it is essential for the operator to have mastered the methods of closing defects of various shapes. (Davis and Traut in Lewis' Practice of Surgery.)

turb the dressing for from two to three weeks or longer. Orr popularized a somewhat similar method. He packs the wound with vaseline gauze, applies a plaster

cast over this and not infrequently does not disturb the dressing for a full month, the odor often being the indication for a change of dressing.

Wounds of the face that have not been dressed, apparently heal in a much more kindly and prompt manner than those that are covered with dressings. As far as the wound's healing is concerned, dressings are, as a rule, of no value

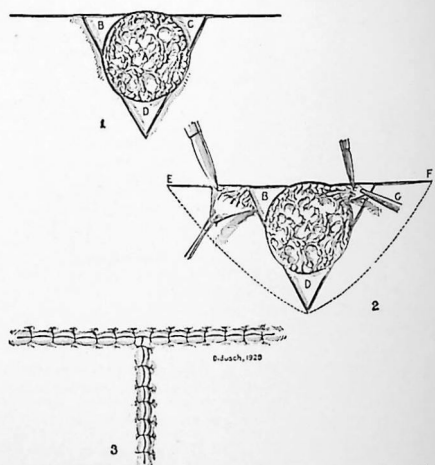


FIG. 576. Illustrating a method of closing a circular defect by the removal of three triangles of skin, thus changing the defect from a circle to a triangle. Lateral triangular flaps are formed and the closure is in the shape of a T (Szymanowski).

1. Shows the defect and the incisions outlining the three triangles, B, C, D, which are all to be removed. The incisions, E and F, on each side are continuous with the base of the large triangle and form the shorter side of the lateral flaps after they are undercut and raised.

2. Shows the process of removing the triangles of skin and raising the flaps which are undercut as far as the dotted lines.

3. Result obtained by sliding the flaps together and suturing the margins. (Davis and Traut in Lewis' Practice of Surgery.)

whatever. In some cases, they may protect tender, unhealed areas from contact with clothing. On a raw surface frequent application and subsequent removal of dressings or the more or less constant traumatism brought about by their presence, does a very great deal of harm: first, by keeping the skin edges in a moist, macerated and water-logged condition; second, by tearing away the epithelial new

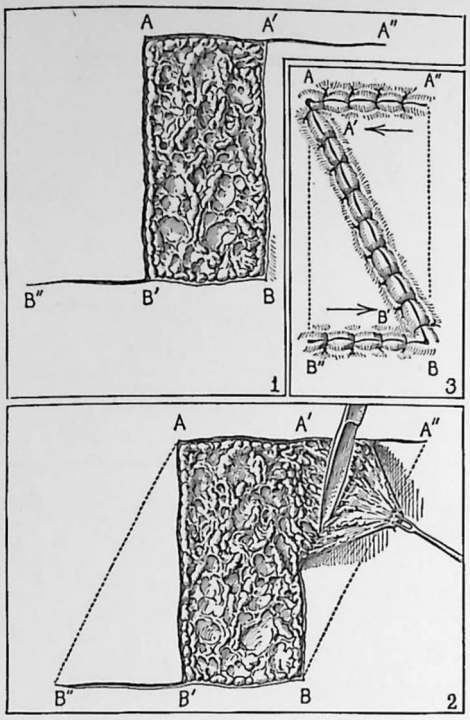


FIG. 577. Illustrating a method of closing either a large or a small rectangular defect by means of triangular flaps raised from opposite sides of the defect and advanced to meet each other.

1. Shows flaps formed by two incisions carried outward from diagonal corners of the shorter ends of the rectangle. Each of these incisions should equal in length the shorter side of the rectangle.

2. Shows the raising of a flap. The dotted lines indicate the size of each flap when completed.

3. Shows the flaps shifted inward and sutured, the final closure being in the shape of a reversed Z. This is an old procedure and a useful one. (Davis and Traut in Lewis' Practice of Surgery.)

growth thrown out for repair. Granulation tissue constituting the ulcer base becomes infiltrated with fibrous scar tissue, circulation suffers and the processes of repair are put to disadvantage.

Cannaday treats certain types of wounds, particularly those of a superficial nature, showing a tendency to delay in healing, by exposure to open air and sunlight; and, if the latter was not available, to the various types of electric light.

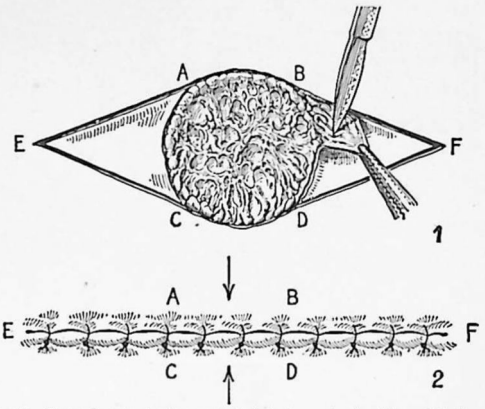


FIG. 578. Illustrating the simplest method of closing a circular defect which is too large to be drawn together by a purse-string suture. Two triangles of skin are removed and the defect is thus changed from a circle into an ellipse. The closure is in a line (after Szymanowski).

1. Shows the defect and the outline of the triangles of skin on each side which are to be excised.

2. The line closure made possible by the removal of the triangles. It may be necessary to undercut the margins considerably before the edges can be approximated if the defect is large or if the tissues are not freely movable. (Davis and Traut in Lewis' Practice of Surgery.)

He points out that the contact of dressings of the usual type with any granulating surface causes a free outpouring of serum, the so-called foreign-body reaction. This reaction is most strikingly seen in the response caused by a drain; the profuse discharge provoked usually disappears for the most part soon after the removal of the offending body.

Mouse-proof mesh and adhesive plaster is used to construct a screen or framework to be applied about the wound. The screen-wire is cut to the requisite size necessary to make an adequate shield over the wound. The edges are bound with strips of adhesive plaster and shaped so as to fit about the wound. (Fig. 588.) In many instances raw areas thus treated will heal in contradistinction to others that have been assiduously dressed day after day without apparent diminution in the size of the wound. If the wound is deep, as a rule, this form of treatment is supplemented by the application of heat, as by sunshine or lamp,

which promotes healing by improvement of circulation as well as by the drying of the skin.

The position of the part involved often plays an important part in the healing process. If the wound is deep this form of treatment is not begun until the granulations are nearly flush with the surface. If the wound is superficial, such

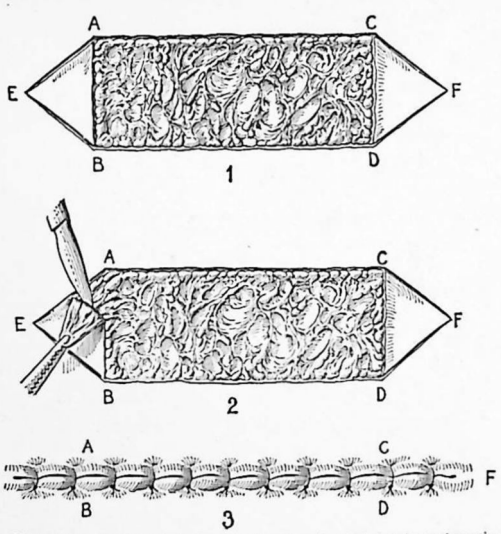


FIG. 579. Illustrating a method of closing a rectangular shaped defect by undercutting the margins, removing a triangle of tissue from each end and closing with sutures (v. Ammon).

1. Shows the defect with the two triangles of tissue to be removed marked out by incisions.

2. Shows the removal of the triangles on each end.

3. Shows the approximation of the edges and the closure in a straight line. This method can be used for closing larger defects than it would be possible to do with simple undercutting and suturing. (Davis and Traut in Lewis' Practice of Surgery.)

as that produced by removal of skin grafts for use elsewhere, the treatment can well be begun at once.

Skin Grafting

Skin grafting consists in completely removing a portion of skin or epithelium from one part of the body and transferring it to another part to correct a defect. It differs from plastic surgery in that the transplant used in plastic work is furnished with a pedicle through which it is nourished while uniting with the surrounding structures.

Skin grafting is often called "transplantation." The term "implantation"

signifies the use of dead organic or inorganic substances. The word "graft" should be used in describing transplantation procedures while the word "flap" should be used in connection with plastic surgery.

Epidermal grafts are made up of epithelium alone in either large or small pieces; dermo-epidermal grafts consist of epidermis and a part of the true derm; total cutaneous or whole-thickness grafts are made up of the whole thickness of the skin and in some instances including the subcutaneous connective tissue.

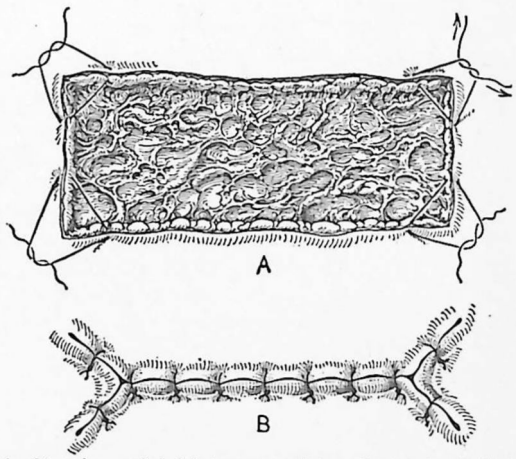


FIG. 580. Illustrating a method of closing a comparatively small rectangular defect by undercutting the margins and approximating the edges with sutures.

A. Shows the defect with the sutures which are first placed in the four corners.

B. After these are tied, the other sutures are inserted in such a way as to entirely close the defect in the shape of a double Y. This is a useful procedure and can often be advantageously employed. (Davis and Traut in Lewis' Practice of Surgery.)

Vegetable grafting although appearing somewhat similar to skin grafting is really quite different. Vegetable grafts grow more as parasites while skin grafts become a part of the tissue into which they are transplanted.

Autodermic grafts are those obtained from the patient himself. Those obtained from another individual are called hetero-, homo-, or isodermic; zoodermic is the term applied to grafts taken from animals.

If **zoodermic grafts** were successful, they would be classed as the favorite method. However, results are rather uncertain following this procedure. Reclus classes it as a "laboratory experiment." Colrat contends they are absorbed and that even though they appear to be successful at first, granulations are sure to appear later. Nevertheless many cases have been reported where the procedure was followed by gratifying results.

Out of 165 transplantations obtained from frogs, chickens, guinea pigs and rabbits, Cousin had 15 successes; out of 122 human grafts he reports successful results in 115 cases.

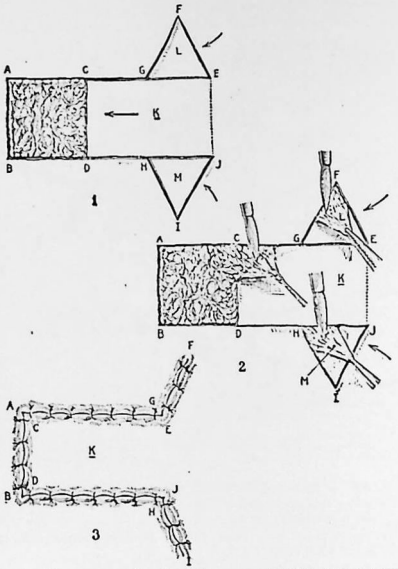


FIG. 581. Illustrates a procedure for closing a square defect by means of advancing a lateral flap and at the same time removing two triangles of tissue to facilitate the advancement, according to Burow's method.

1. Shows the defect and the outline of the flap, also the position of the triangles.
2. Shows the flap being raised and the triangles being excised.
3. Shows the closure. This is a more complicated method but is often useful in relaxing the shank of the flap. (Davis and Traut in Lewis' Practice of Surgery.)

There is a wide variation in the results obtained by the different surgeons in their experiments—some laud it highly; others condemn it.

Medieval history records an instance concerning the transplanting of a graft from an animal to man which is quite remarkable. During the seventeenth century a surgeon placed a skin-periosteum-bone graft from a dog in a defect in the scalp and skull of a human; after it had grown in place, he was forced to remove it, under threat of excommunciation from the Church.

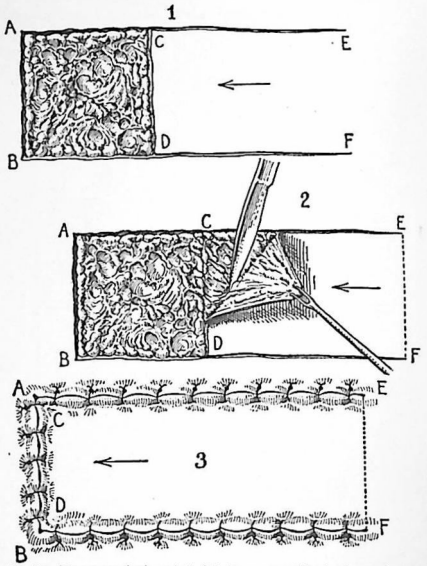


FIG. 582. Illustrates a simple method of closing a square defect by the use of a lateral flap which is advanced and sutured. This is typical of the French method and there are many modifications used, depending on the condition of the surrounding skin and on the situation of the lesion.

1. The defect with the flap outlined.
2. The flap partially raised. The dotted line indicates the outer limit of the flap.
3. The flap advanced in the direction of the arrow and sutured. (Davis and Traut in Lewis' Practice of Surgery.)

Skin from the frog furnishes perhaps the most successful zoograft. The skin from any portion of the frog's body may be used although that from the abdomen is usually employed. In 1884, Allen performed operations using this kind of graft; Baratoux and Dubousquet-Laborderie employed the method a few years later.

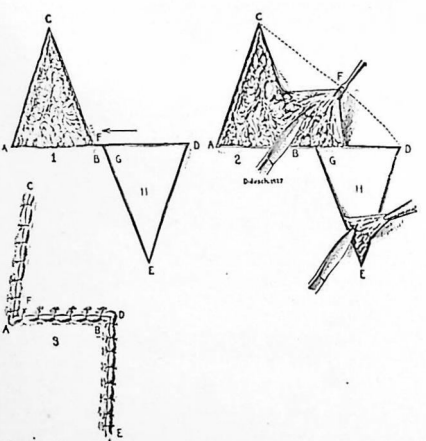


FIG. 583. Illustrating a method of closing a triangular defect of considerable size by the removal of a triangle of skin equal in size to the original defect. A triangular flap is then formed adjacent to the lesion and is advanced to fill it (after Burow).

1. Shows the defect and the outline of the triangle of skin, H, which is to be removed.
2. Note the formation of the triangular flap FCD. Also the removal of the triangle of skin H.
3. The point F of the flap FCD is advanced and sutured to the point A and the point B to the point D. This is rather an extensive procedure which is utilized only in situations in which for one reason or another other simpler methods cannot be used. However, the excision of triangles of tissues in the necessary situations, as first suggested by Burow, is most effective in aiding the closure of defects of various shapes found in everyday work and we frequently use the procedure. (Davis and Traut in Lewis' Practice of Surgery.)

The frog is prepared as follows: after scrubbing it is immersed as far as the neck for five minutes in a solution of corrosive sublimate or permitted to swim in a boric acid solution for some time.

Grafts may be wrapped in waterproof tissue with moist gauze and preserved for several hours.

The new skin becomes translucent and pink, appearing as a film through which the red surface beneath can be discerned. The pigmentation disappears in a few days but the new skin still seems to be slightly darker than the surrounding skin.

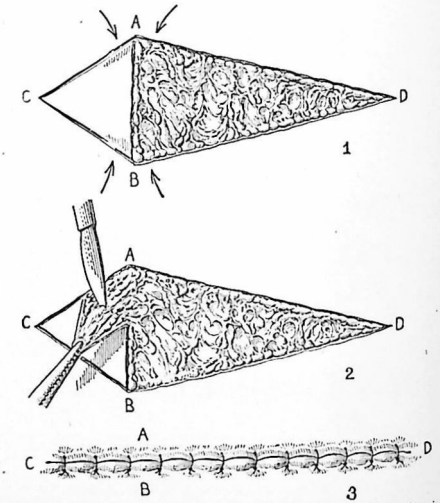


FIG. 584. Illustrating the closure of a larger triangular defect by the removal of a triangle of skin at the base of the triangular defect, undercutting the margins and approximating the edges with sutures (v. Ammon).

1. The defect with the outline of the triangle of skin which is to be removed.
2. Removal of the triangle of skin, which changes the shape of the defect from a triangle into a kite shape. The margins are undercut.
3. Shows the edges closed in a straight line. (Davis and Traut in Lewis' Practice of Surgery.)

Frog's skin must be given careful attention for at least three months, for although it makes a soft, pliable covering, it has a tendency to ulcerate and vanish.

A certain degree of success was attained by Redard by using the skin from the undersurface of a chicken's wing.

An ulcer was successfully grafted with pieces of cock's wattle by Altamirano.

Miles of Edinburgh grafted successfully the skin of a greyhound while Van Meter of Colorado employed the cuticle from a Mexican hairless puppy. The skin of a young pig was satisfactorily used by Raven and Hübscher.

Miles also used the skin of rabbits and kittens, after shaving the abdomen or flanks of the animals, he removed the skin in strips ranging from 1 to 6 inches long and from one-half to one inch wide. The edges of the grafts were placed

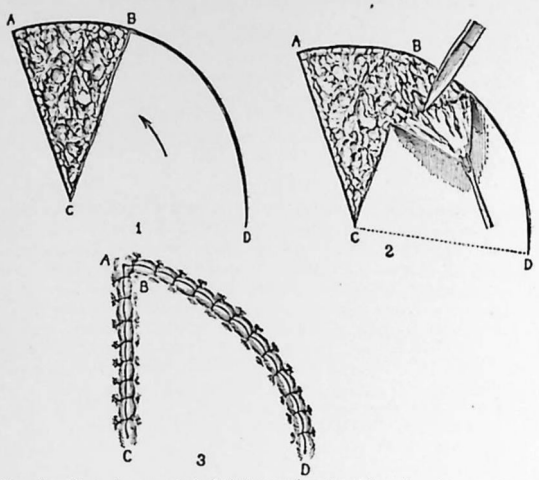


FIG. 585. Illustrating a method of closing a triangular defect of considerable size by the use of a unilateral flap which is advanced over the defect and sutured (after Jasche).
1. Shows the defect with the outline of the flap made by the curved incision BD.
2. Shows the flap being raised. Note the width of the pedicle CD.
3. The closure after sliding the flap over the defect. Smaller bilateral flaps can be used to accomplish the same purpose. (Davis and Traut in Lewis' Practice of Surgery.)

together and pressed down firmly being held in place by a dressing for forty-eight to seventy-two hours, after which it was carefully removed. If pustules have formed they should be opened. Granulations growing through the new skin which would seem to injure or destroy it should be removed with a sharp spoon. Out of 10 cases Miles reports 4 successes; only 2 were complete failures.

Based upon the idea that the testicle possesses a greater degree of cellular activity than other parts of the body, E. Aievoli used thin pieces of the testes of rabbits for grafting purposes with good results.

The lining membrane of an egg has been used advantageously for grafting purposes in the case of extensive burns, injuries to the tympanum, conjunctiva or pterygium.

Venable has reported excellent results using thin layers of skin from the shaved thigh of a young pig. Usually the skin is taken above the bristle layer; should a few bristles appear they are of no consequence, since the follicles in the graft soon atrophy. He reports 85 to 100 per cent of takes as against 30 to 75 per cent with other heterografts.

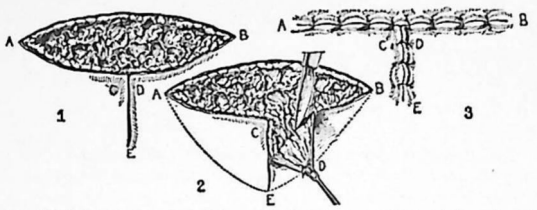


FIG. 586 I. Illustrating a method of closing an elliptical-shaped defect by the formation of two triangular flaps from the same side which are advanced and sutured (Lisfranc).
1. The defect. Note the vertical incision made from the central portion of the defect margin on the selected side.
2. Shows the formation and extent of the flaps which extend outward to the dotted line.
3. The closure in the shape of a flattened T. The principle of this procedure will be found helpful in many instances.

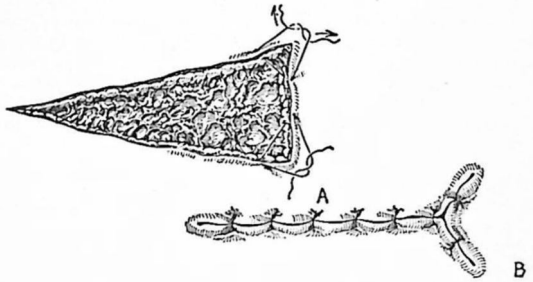


FIG. 586 II. Illustrates the simplest method of closing a small triangular defect by undercutting the margins and approximating the edges with sutures.
A. The defect, with the sutures which are first placed across the corners of the base of the triangle.
B. The closure in the shape of an elongated Y. (Davis and Traut in Lewis' Practice of Surgery.)

Transmission of Disease

Diseases of different varieties may be transmitted in skin grafting from one person to another. Syphilis, tuberculosis, small pox and even cancer are said to have been transmitted in this manner.

General Condition of the Patient

It is not necessary for the patient to be in an extremely vigorous state of health before a skin graft is applied but he should be free from toxicity.

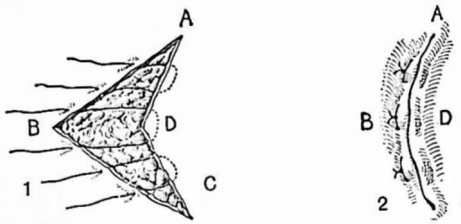


FIG. 587 I. Illustrating a method of closing an angled wound. 1. Note the modified mattress type of sutures which penetrates the full thickness of the skin on the side to which the tissue is to be drawn and loops through the deeper portion of the corium on the other side without penetrating the epithelial layer. 2. Sutures drawn snug and tied. This is a helpful type of stitch and can be used to advantage in many situations.

Where the patient has been suffering from erysipelas, grafts should not be undertaken until the disease has disappeared at least six weeks, for the streptococci

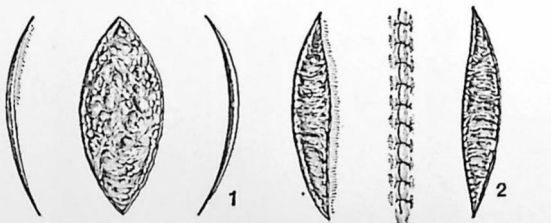


FIG. 587 II. Illustrating a method of closing an elliptical-shaped defect by means of bilateral relaxation incisions and approximation of the edges with sutures (Celsus).
1. Shows the defect with the bilateral curved relaxation incisions. When the defect is not too wide, the relaxation incisions will allow closure without extensive undercutting. In wider defects, the tissues must be undercut between the defect and the incisions in order to approximate the edges.
2. Shows the relaxation incisions gaping widely and the defect closed. These lateral defects may be allowed to heal by granulation or may be immediately skin grafted. A unilateral relaxation incision is sometimes sufficient. This is one of the oldest procedures in plastic surgery and the principle is very useful in everyday work. (Davis and Traut in Lewis' Practice of Surgery.)

are likely to cause dissolution of the grafts before or even after adhesions have taken place.

Successful grafts have been made in the presence of nephritis and diabetes although they exert an unfavorable influence.

Surgeons do not agree as to whether grafts can be satisfactorily implanted in the presence of syphilis. A great deal depends on the stage of the disease and whether the area to receive the graft is syphilitic. A skin graft should not be placed over a syphilitic ulcer. There are cases recorded where grafts have been known to grow and heal where the patient was afflicted with syphilis.

REVERDIN GRAFTS

When J. L. Reverdin, an intern of La Charité, in Paris, on Dec. 8, 1869, made his famous report on the subject of skingrafting to the Société de Chirurgie, he instigated new interest in this phase of surgery when he informed his hearers that

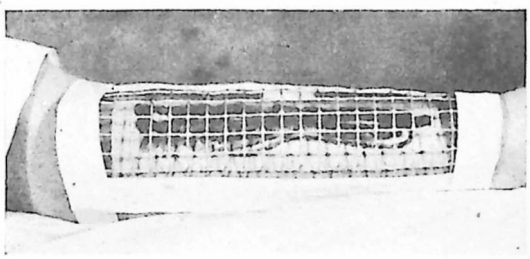


FIG. 588. Wire mesh and adhesive plaster used as a protection for wound. (Courtesy Dr. John E. Cannady.)

pieces of skin, removed from their original connections would adhere and grow on granulating surfaces.

Preparation of the Surface to be Grafted

When the granulating surface is healthy and the wounds fresh, little preparation is necessary. If, however, conditions are not so favorable more precautions should be taken.

It is quite possible for epithelium to grow on an unhealthy granulating surface, according to Bryant; many Reverdin grafts are applied in the presence of pus and some have been known to grow on cancerous surfaces. Naturally, a healthy granulating surface is to be preferred.

Granulations should be of medium size, vascular, and of a fresh red color; not large and flabby. One of the best indications of fitness for the reception of grafts is the formation of a pellicle of new skin around the borders of an ulcer.

Excavated ulcers should be curetted. Cicatricial tissue often surrounds the margins of old ulcers, interfering with the vascular supply and rendering skin grafting difficult if not impossible.

If the circulation is impaired by varicosities or scar tissue, or if inflammations or complications are present, the patient should remain in bed a few days or weeks until the part returns to normal. Moderate pressure, evenly applied with a sea-sponge, is of great value.

When acute inflammation has been allayed, the granulations should be prepared for reception of the grafts. This may be accomplished by cauterization and compression (stick nitrate of silver or tincture of iodine). Cauterization should be done every two or three days. Iodoform gauze saturated with balsam of Peru sometimes does good service (Freeman).

Induration and fibrous thickening of the borders are treated by making a few radiating incisions through the ring of callus down to the softer tissues; this relieves tension and promotes vascularity. Heliotherapy is sometimes of value.

In order not to injure the vitality of the grafts, any strong antiseptics which have been used for cleansing should be washed away before transplantation is done.

Grafts

The inside of the arm or thigh, or the side of the chest or bend of the elbow is considered best. In these situations the skin is thin and soft and comparatively free from hairs or glands.

Lucas considers that "the prepuce of a child possesses a germinal vitality which renders it peculiarly serviceable for grafting," in addition to suppleness, thinness, and vascularity. He claims that preputial grafts will adhere when those from other parts fail, even on unhealthy granulating surfaces.

Reverdin recommended originally that the grafts should be small, that is, about the size of a grain of wheat, thus reducing to a minimum the pain and the scars occasioned.

The removal of grafts from the donor is most easily done by raising a small fold of skin with a pair of mousetooth forceps and dividing it with a scissors, knife or razor. Iridectomy scissors are useful. Obtain all of the epithelium and part of the corium. Include no subcutaneous cellular tissue or fat. The epidermis is all that is really necessary although it is well to include part of the corium. Reverdin employed the term "greffe dermique," which Poncet changed to "greffe dermoepidermique" thus more correctly expressing what is really meant. A small amount of blood issues.

The skin may be partially frozen with ethyl chloride or anesthetized with novocaine, although the pain is very slight. In case the skin is partly frozen, the grafts may be all cut at once and placed in warm salt solution until required; or they may be preserved on a warm piece of glass, raw side down. The small elliptical wounds heal quickly. No sutures are necessary. An ordinary aseptic or antiseptic dressing may be applied, dry or moist, which serves to prevent the development of infections.

Marcy has shown that satisfactory grafts may often be cut by pressing a pair of curved scissors firmly against the skin and snipping off the portion which protrudes between the blades. Some prefer to elevate a fold of skin by transfixion with a fine needle, but this offers no advantage over forceps.

Souchon has recently emphasized an old and useful method of obtaining small grafts by cutting them with scissors from the thin, new epithelium as it "floats" out from the skin-edges of a healthy granulating surface which is beginning to heal.

Grafting

After being cut the grafts are immediately placed upon the surface to be grafted with a forceps or needle with their raw sides down. Curled edges are carefully straightened with a probe. If no blood or other fluid is present, attachment immediately takes place; slight pressure with a dampened gauze pledget is helpful. Roberts and others claim that exposure of the ulcer to the atmosphere before and after operating is helpful by causing it to become sticky, thus facilitating adherence.

Each graft is capable of some expansion but it cannot stimulate the borders of the ulcer effectually farther than half an inch. If a single graft is placed in the center of a very large ulcer it will form an island of skin only. Therefore, the transplants should not be more than half an inch apart. They need not be placed in rows or geometrical figures. If only a few grafts are available it is better thoroughly to cover a small area than to scatter the pieces too far apart. (Figs. 589, 590, 591.)

DRESSINGS

Place rubber protective next to the grafts, thus preventing their adherence and displacement when the dressings are changed. This should be cut in strips half an inch wide which are placed side by side, or criss-crossed, like basket-work, or punched full of holes which serve as outlets for secretions. Strips of transparent gutta-percha are useful here; their ends should project onto the sound skin; adhesion will take place if they are dampened with chloroform. If the gutta-percha is not available, gold-beater's skin, oiled silk, isinglass plaster, tin or silver foil, etc., may be used. Ordinary adhesive plaster is preferred by Marcy.

Any of the above methods may jeopardize the vitality of the new skin by causing maceration. A superior method which is much simpler consists in spreading a single layer of gauze over the grafted surface and fastening it to the skin with collodion. This is recommended by McCarthy and Freeman.

If a dusting powder is used, care must be taken that it does not form a crust, beneath which pus may accumulate and destroy the grafts. If a wet dressing is used, omit the powder or salve; use a pad saturated with boric acid solution or normal salt solution (warm) instead. If a covering of oiled silk is placed over the dressing, it will be unnecessary to moisten it oftener than once every twenty-four hours.

It would be unnecessary to change the dressing during the healing process if the operative field were always aseptic. Since there is always a certain amount of suppuration, it is advisable to change the dressing every 24 to 48 hours. The wound may be gently irrigated but never rubbed for fear of injuring the transplanted skin.

If the discharge has been profuse and protective has been used it should also be frequently changed; if little suppuration is present, however, it may be left in place for 5 or 10 days.

Bacillus pyocyaneus sometimes causes the dressings to become green; this, combined with the unpleasant odor which is often present may needlessly occasion some alarm.

The "open method" may be used in place of the different dressings. This

consists in exposing the graft to the air beneath a protecting wire-gauze cage. If a great deal of suppuration is present, the formation of thick crusts is likely to render this procedure unsatisfactory.

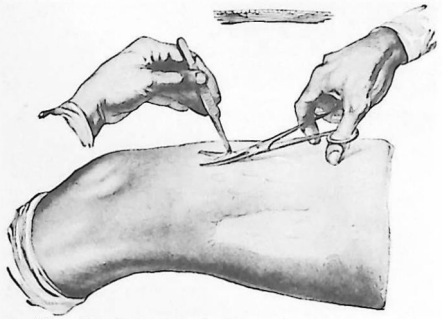


FIG. 589. Skin grafting with Reverdin grafts, which are obtained with curved scissors and tissue forceps. (Kirschner, Operative Surgery.)

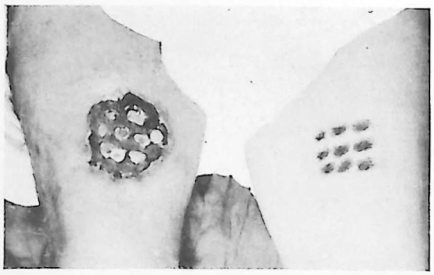


FIG. 590. Reverdin pinch grafts.

When grafting is done near a joint, especially in children, the part should be immobilized by the application of a splint. The lower extremity should be elevated to promote circulation.

Process of Healing

The grafts appear to swell, becoming whiter, thicker and softer during the first 24 hours; in two or three days those which adhere become pink and surrounded by a reddish areola. Following this a gray epithelial pellicle emerges from their margins and the connecting borders of the ulcer. The pieces of skin which turn brown are dead while those which turn a yellowish white lose their superficial layers of epidermis; as the deeper layers remain that which is lost is soon reproduced.

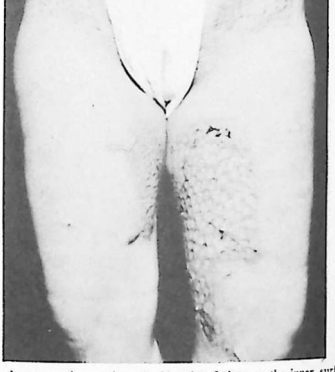


FIG. 591. A woman who was burned with a hot flatiron on the inner surfaces of both thighs. Skin pinch grafts were taken from the abdomen and transplanted over the affected area. Condition one week after transplantation.

At first, the new epithelial pellicle is not fastened to the granulations; it simply rests like tissue-paper upon the surface from which it may be raised. After a time roots grow down into the granulations, securing the epithelium and connecting the grafts together and to the edges of the ulcer.

The part must be carefully protected for several weeks after cicatrization until a certain amount of resistance has been attained, as ulcers thus treated have

a tendency to break down upon the slightest provocation. A soothing ointment may be used to combat any tendency to dryness or exfoliation.

The new skin is quite inferior to normal skin although it is better than scar tissue. It is without hair bulbs, sweat glands or sebaceous follicles. In time a certain amount of sensation is regained.

THIERSCH GRAFTS

As regards priority, Ollier[1] was in the habit of cutting grafts 10 to 15 mm. wide and 2 to 4 cm. long, resembling in every way Thiersch grafts; but unlike Thiersch, he did not scrape away the granulations before making the transplantation. Fischer[2] also shaved from the surface of a limb, thin strips of skin identical with those used by Thiersch.

This superior method of skin grafting has never received the recognition to which it is entitled. Fresh wounds or granulating surfaces of almost any size may be covered with epithelium in from ten days to three weeks; scar contractions are prevented; infections are avoided and the cosmetic result cannot be too highly praised.

Preparation of the Surface to be Grafted

Scrub the skin. Remove the débris (crusts) and surrounding hairs and irrigate with normal salt solution. Anesthetize the patient. Curet the surface. Check oozing with firm pressure.

Grafts

The grafts are best obtained from the anterior surface of the thigh. Cut them with a sharp razor. An assistant renders the surface tense by means of a hand on each side of the limb or by grasping the thigh from below, while the surgeon, taking his position with his back to the patient's feet, cuts toward himself while his left hand is used to stretch the skin in front of the razor toward the knee. Pieces of gauze beneath the hand help in obtaining a firm grip. Thin pieces of epidermis are removed by means of a side-to-side sawing motion. The pieces may be several inches long and range from one-half to one inch wide. Keep the skin and razor wet with salt solution. (Fig. 592).

It is unnecessary to remove the whole thickness of skin; all that is required is a paper-like layer with several bleeding points caused by dividing the capillary vessels in the papillary ends. Beginners will do well to practice skin grafting on the cadaver first, before attempting it on a patient.

As the strips of skin are cut they fold up on the razor and when sufficient length has been obtained, slightly incline the instrument away from the thigh thus severing the graft from its connection.

Grafting

Place the grafts on the surface prepared for them shingle-wise—that is, overlapping each other as well as the wound edges. If the pieces are large they may be buttonholed with a scissors or perforated with a punch for drainage purposes. If there is a redundancy of skin the extra portions may be replaced upon the surface from which they were taken.

[1] Bull. de l'acad. de Med., 1872.
[2] Zeit. f. Chir. Bd. 13, 1880, p. 193.

BLEEDING

In controlling the bleeding which often follows the curetting, Thiersch first used an Esmarch constrictor, leaving it in situ until grafts and dressings were applied, but later considered this procedure injurious. Others, however, have used it extensively. There seems to be no logical objection to the use of a constrictor although its removal is usually followed by an undesirable oozing.

Pressure with gauze pledgets moistened with peroxide of hydrogen or adrenalin solution is useful for controlling bleeding, particularly if the part is elevated; or pressure is applied over a piece of rubber protective thus avoiding tearing the clots from the mouths of the small vessels when the dressing is removed. Rushmore recommended the use of a high-frequency electric current for coagulating the blood and promoting the adherence of the graft; this has not proved very popular, however. It is better to twist a vessel than to ligate it. A dry surface should be maintained in order to promote the growth of the new skin.

CURETTING

Curetting was one of the principal features of Thiersch's original procedure. It was his idea that the large, soft, superficial granulations, during their transformation into connective tissues, were the cause of scar contraction which could be avoided by curetting down to the firmer tissue. Schmitzler and Ewald proved it was unnecessary to remove healthy granulations and that the graft may be placed on the unaltered surfaces without fear of any great amount of contraction. Reliable results have been obtained without curetting but diseased tissues should always be removed. In any case, results are likely better when the granulations are removed.

Sick rubs the granulations away with gauze instead of using a curet. Halsted, McBurney and others preferred to shave the surface with a scalpel or an amputating knife. In this way a smoother surface is obtained thus promoting the vitality of the transplant.

Irrigations of warm salt solution or sterilized water are advisable during and following the operation.

Thiersch and others advise against using antiseptics after curetting, stating that the resulting necrosis interferes greatly with the anchoring of the grafts; however, they may be used both before and after curetting if they are washed away with a neutral solution. Their value is doubtful.

After-Treatment

Grafts become firmly fixed in from 7 to 10 days. The lowermost layer of dressing material may be left in place for two weeks under ordinary conditions. The coverings should be soaked off with warm salt solution to avoid injuring the grafts, although in some instances this is not necessary as the dressings slide off very easily.

The part receiving the graft should be protected from injury and sudden temperature changes for several weeks, especially in the case of ulcers which have a tendency to recur after grafting. Some mild soothing ointment should be applied to the part to prevent dryness and cracking.

In many cases, especially where wet dressings are employed, the external

layers of epidermis atrophy and become macerated and seem to come away with the dressing when it is removed leaving a grayish, sodden surface behind. This is not always indicative of failure for in a short time the epithelium will be replaced from the remaining rete Malpighii.

Schmieden and others are of the opinion that scarlet-red ointment promotes the growth of epithelium greatly. It may be employed advantageously in Thiersch grafting where the whole area has not been covered by skin. It is recommended that the ointment does not come in contact with the graft unnecessarily as it is likely to destroy it.

THE WOLFE-KRAUSE METHOD

J. R. Wolfe, an oculist of Glasgow, introduced the method of using grafts to fill the entire defect in the skin including the whole thickness of the skin but without adipose or cellular tissue (Figs. 593-594). He first experimented with the conjunctiva, shifting parts of it from one part of the eye to the other without pedicles. Later (1872) he employed the conjunctiva of rabbits in treating defects in the human eye. Three years later he made public his experiments in skin grafting for ectropion. In a short time Wadsworth introduced the method in America. Von Esmarch was the first to use the procedure extensively in general surgery.

Grafts comprising the whole thickness of skin had been used often before the time of Wolfe but in nearly all instances, the subcutaneous tissues were also included. Jacenko may have been the first to use grafts without fat satisfactorily; in 1872 Le Fort reported success in treating a case of ectropion.

Wolfe contended that the fat should not be included in the graft on the basis that it was likely to undergo necrosis and interfere with nutrition, and he was doubtless correct. Hirschberg and Taylor as well as many others do not conform with this belief since transplants of fat alone have been grafted from one place to another to fill in depressions or as a substitute for the mammary gland. The original method of Wolfe has been modified and improved upon by Fedor Krause to such an extent that it is generally called the Wolfe-Krause method.

Grafts

The grafts may be cut in the form of an oval or round so that the defect left may be closed by suture. The arm, thigh or buttocks may be chosen. It is of little moment where the grafts are obtained. Davis suggests using skin from the abdomen in the course of a laparotomy.

Outline the graft by an incision. Dissect the whole flap with a knife, the edge of which is turned toward the surface so as to remove the fat. Allow at least one-third for shrinkage; this is always great (elasticity of the skin).

Young advocates the removal of the subcutaneous fat with the grafts, trimming it off later with curved scissors while the flap is spread on the palm of the hand or is curled over a finger. He contends this is a quicker, easier method and the remaining defect is more readily closed.

According to Krause, absolute dryness is an important factor in promoting quick healing. The hands and instruments should be kept dry and no irrigations should be done. Others do not agree with him.

The entire wound should be completely covered with as large sections of skin as it is possible to obtain, because where there is an open space a scar

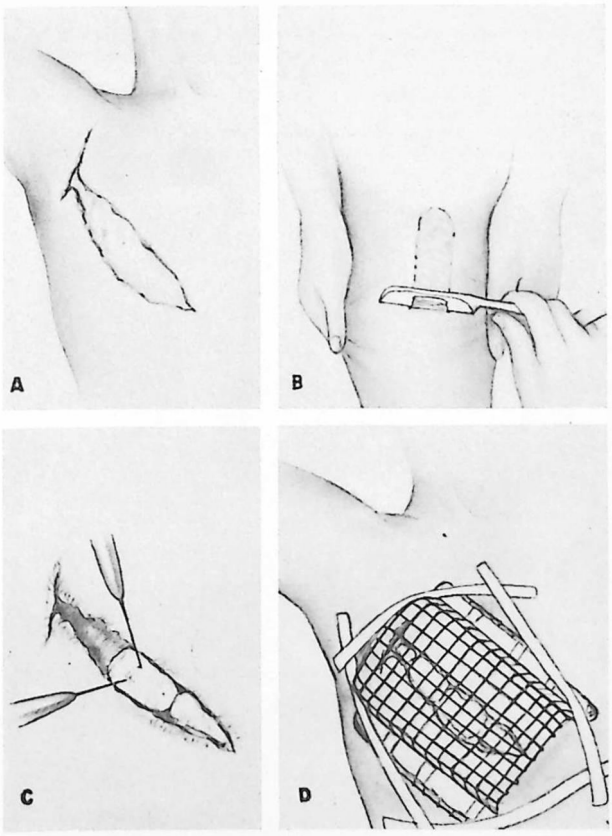


Fig. 592. Thiersch graft: A, granulation tissue formed in scar after breast amputation, B, thin layer of skin removed from thigh, C, placing the graft in wound, D, wire basket protects wound.

results. It may be necessary to complete the operation with Thiersch grafts.

Originally, artificial heat was used to keep the new skin warm; this was discontinued when it was found to promote decomposition.

A dry gauze dressing is applied.

After three or four days it is advisable to soak the gauze off with boric acid solution, examine the graft and open any blisters which may be present. Apply sterilized borated vaseline.

SIEVE GRAFT

Beverly Douglas describes a "sieve graft" for covering large skin defects[1] as follows:

"This large graft has been called the 'sieve graft method' because the graft is uniformly perforated with small round openings. The method provides firm, safe healing without contracture in a defect upon any portion of the body. The cosmetic result accomplished is very nearly as good as that obtained by the Wolfe-Krause graft."



FIG. 593



FIG. 594

FIG. 593. Fibroma of plantar fascia.

FIG. 594. Skin grafting (Wolfe-Krause method) following removal of tumor of foot. Oval homo-transplant taken from buttock of daughter of the patient. Excellent final result.

Prepare the wound to be grafted in accordance with Blair's method.[2] Outline a pattern on transparent cellophane with a pen on the day before the operation. This should be about one-fourth larger than the wound to be covered; transfer to tinfoil and punch the letter "E" near the lower border for the purpose of orientation. The usual antiseptic preparation is made at time of the operation. General anesthesia is recommended although local analgesia may be employed. As a rule, four lines of intradermal infiltration are made enclosing the pattern; this is supplemented by an injection of 3 cc. of the anesthetizing solution subcutaneously at eight points equally spaced within the area to be lifted. In the presence of small varicose venules, more infiltration is necessary.

The "sieve graft" technic takes no longer than an ordinary full thickness graft, if the closure of the excision wound is included with which the "sieve" method entirely dispenses.

Step 1. Place the foil pattern upon the donor skin site. Follow its periphery with a scalpel cutting through the skin just to the fat. Use a steel die similar to that illustrated in Fig. 595.

[1] S. G. O., June, 1930, Vol. 50.
[2] V. P. Blair, Ann. Surg., 1924.

Step 2. Twist the steel die with the thumb and index finger boring out islands of skin equidistant from each other over the graft area. The die is one-fourth of an inch in diameter and its flange is one-sixteenth of an inch deep. The surrounding skin is tensed while each island is being bored. Make the openings one and one-half cm. apart.

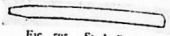


FIG. 595. Steel die used in sieve graft. (Courtesy, Surg., Gynec. and Obst., vol. 50, 1930.)

Step 3. Insert the point of a sharp pointed narrow bladed scalpel into the incision made by the punch for each island (Fig. 596), a, keeping just the full thickness of the skin until its point comes out through the punch incision to the left of it but over the top of the corresponding island, b. With a sawing motion it is advanced to islands, c and d, the skin surrounding which is similarly undercut. Reverse the blade and complete the 180 degrees of the circle from b to e to d in the same way. As the scalpel enters each circular punch incision, have an assistant depress each island with a knife handle or other suitable instrument to prevent its injury. When each opening is undermined, undermine the peripheral edges of the graft in the usual manner and cut through a few strands of tissue previously overlooked, thus liberating the entire sieve graft. The donor site will still possess small islands of skin spaced within the fat and fascia (Fig. 597). Apply vaseline gauze over which dry gauze is strapped with adhesive.

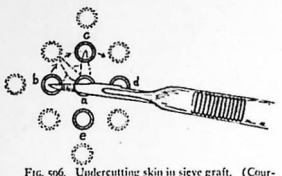


FIG. 596. Undercutting skin in sieve graft. (Courtesy, Surg., Gynec. and Obst., vol. 50, 1930.)

Step 4. Remove all fat from the graft with curved scissors and suture it into the wound with interrupted stitches of silkworm-gut or horsehair. Approximate the edges accurately (Fig. 598). Dress the grafted area in accordance with Blair's sea sponge technic. Press the graft into contact thus expressing all serum and blood clot. Cover with a layer of xeroform vaselin gauze-mesh or ordinary vaselin gauze wiped until very little vaselin remains on it. Over four layers of dry flat gauze apply large, flat sea sponges which have been sterilized in bichloride and wrung out in dry towels just before using. If possible, one sponge should cover the entire area extending well over the suture lines, thus

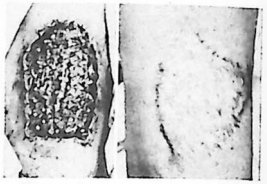


FIG. 597. Small islands of skin left on the donor site; and healed. (Courtesy, Surg., Gynec. and Obst., vol. 50, 1930.)

even pressure will be exerted. If only part of the wound has been grafted, treat the other part with the Carrel technic 48 hours later without fear of injury.

Douglas removes the sponge only after ten days, provided infection is not indicated by local signs or fever. At this time he inspects the graft, removes stitches, trims away any necrotic portions and reapplies the pressure dressings. Within 12 to 18 days the perforations will have been found to be epithelialized and pressure may be discontinued.

A longer time is required by the islands for healing but they heal with certainty and a pigmented epithelium will result. These islands have the appearance of small deep grafts but should not be confused with them, as they have not been



A B C

FIG. 598. The ulcer prepared; the graft in place; and the graft healed. (Courtesy, Surg., Gynec. and Obst., vol. 50, 1930.)

undercut and hold their position strongly. The epithelium from them has great healing power. It is not necessary to attempt closure by undermining the edges of the wound, etc., as satisfactory healing with almost full pigmentation is bound to take place.

Comment. According to Douglas, the ideal graft for filling large skin defects must possess the following properties:

1. It must be capable of being so cut that its removal will leave behind a wound which will heal rapidly without further grafting and with only slight scarring.
2. It must be able to take hold and grow upon a moderately infected surface.
3. It must provide complete healing in a reasonably short time.
4. It must inhibit scar formation and subsequent contracture—a point especially important in defects over joints.
5. It must produce a skin surface so pliable that healing is stable and resistant to minor injuries.

6. It must effect a good, though not necessarily an excellent, cosmetic result.

Weighing each of the types of grafts in general on the basis of these points, Douglas' experience is as follows:

1. The Ollier-Thiersch graft fails from the standpoint of resisting infection and of preventing contracture, and the surface healed by its employment is easily eroded.
2. The small deep graft is ideal from every standpoint but two, viz.: it fails to prevent contracture and often fails to give a good cosmetic effect.
3. The Wolfe-Krause or full thickness grafts are excellent from the standpoints of stable healing, cosmetic effect, and prevention of contracture. However, if the graft is large, a defect is left behind at the donor-site which will require further grafting—a distinct disadvantage. Furthermore, infection may readily cause its total loss.

The sieve graft satisfied all of the demands enumerated. Two valuable properties possessed by none of the above varieties deserve especial mention: (1) the perforations, by providing adequate drainage, make it resistant to infection, thus insuring a very high percentage of takes; (b) the donor site requires no further grafting and heals with a good cosmetic result.

Dragstedt and Wilson's Modification of the Douglas Sieve Graft

L. R. Dragstedt and H. Wilson* point out that the Douglas method of placing the graft was so devised as to leave behind numerous small islands of skin from which regeneration could occur making it unnecessary to treat further the donor-site. In other words, it retained the advantages of the Wolfe-Krause full thickness graft in preventing contracture and providing a new skin surface resistant to minor injuries while also affording a higher incidence of takes, especially in the presence of mild infections.

The Dragstedt and Wilson procedure retains the advantages of the perforated full thickness graft of Douglas while it greatly facilitates healing of the donor-site. Besides, the graft is easier to prepare, does not require any special instruments and the procedure consumes much less time.

Step 1. Prepare the wound to be grafted in the usual manner.

Step 2. Secure an oval shaped transplant (Fig. 599) the full thickness of the skin with none of the subcutaneous fat. The long axis of the graft should be about one-third longer than the long axis of the wound to be covered. The graft is taken from the lax skin of the abdomen wall. No undercutting is usually necessary.

Step 3. Place the graft, dermal side down, on a smooth towel moistened with physiological salt solution.

Step 4. With a sharp scalpel make numerous short longitudinal incisions (Fig. 600). These incisions should be overlapping. When this step is completed it permits the graft to be stretched into any desired shape. (Fig. 601.) Practically, the graft need not be more than one-third to one-half the width of the defect to be covered.

* Surg., Gyn. & Obst., Vol. 65, No. 1, July, 1937.

Step 5. Suture the transplant into place and press it firmly in contact with the underlying raw surface. (Fig. 602.)

Step 6. Cover the graft with vaselinized gauze which is covered with flat gauze and sea sponges. (Blair's method of sea-sponge compression.)

Comment. Remove the sponges on the seventh day. Inspect the graft. Remove the stitches. Reapply the compression dressing for another week. Follow this by ordinary dressings. The donor-site usually heals within a week or ten days.

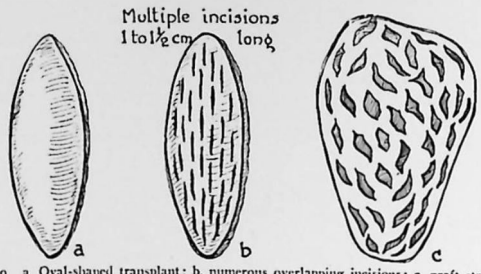


FIG. 599. a. Oval-shaped transplant; b, numerous overlapping incisions; c, graft stretched to shape of area to be covered. (Courtesy of Dr. Lester R. Dragstedt.)

SKIN-PERIOSTEUM-BONE GRAFTS (HIRSCHBERG)

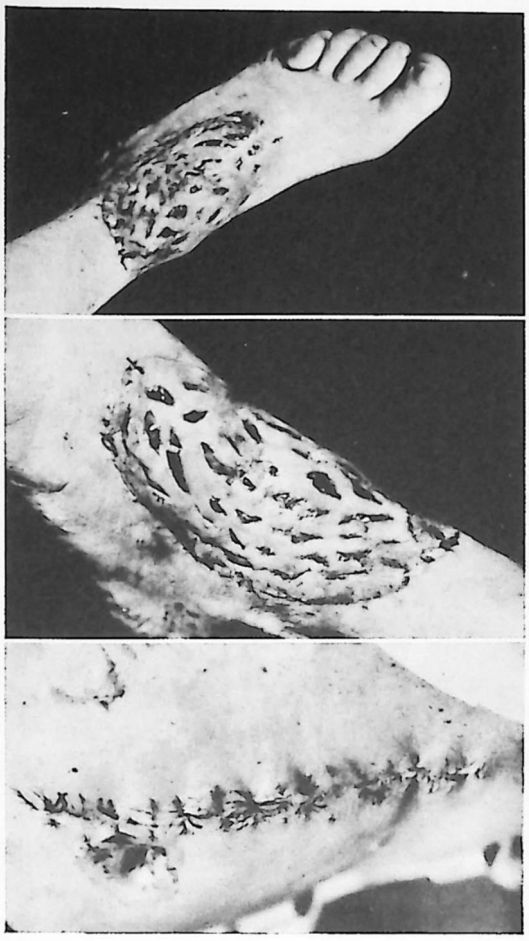
In employing grafts which include the skin, subcutaneous tissues, periosteum and bone, strict asepsis is imperative. There are not many conditions calling for this type of grafting; it is generally used in connection with filling in defects of the skull and scalp and in certain rhinoplastic operations.

The graft is usually obtained from the front surface of the tibia; the incision is made down to the bone, a thin layer of which is removed with a sharp chisel without interfering with its connection with the periosteum and skin lying over it. The remaining wound is closed by undermining and suturing the integument around it. Success is usually more certain when a portion of bone is included than when the periosteum alone is used.

MUCOUS MEMBRANE (WÖLFLER) GRAFTS

Wölfler was the first to methodically graft mucous membrane other than the conjunctiva; he grafted urethras, after removing strictures, with sections of mucosa from a prolapsed rectum, from the cervix of a prolapsed uterus or a uterus which was excised. He performed successful experiments later, using the stomach of a frog, esophagus of a rabbit, etc. An autopsy, made 6 months after his operation on a patient, revealed the new urethra in perfect condition. Beigel did some very fine work in this line; Fenwick repaired a defect in a human urethra with a section of sheep's urethra.

Recently the urethra has been successfully replaced with parts of the internal



FIGS. 600-601-602. Condition of transplant and donor site 10 days after operation. (Courtesy of Dr. Lester R. Dragstedt.)

saphenous vein as well as the ureter and the vermiform appendix removed from other patients.

According to Wölfler, mucous membrane adheres as well as skin; others do not agree with this idea. It may be shaved off or stripped.

In 1874, Hirschberg made the first buccal mucous membrane transplantation to the conjunctiva. This has been done repeatedly since. In 1872 Wolfe transplanted the conjunctiva of animals to man thus popularizing the procedure.

Czerny demonstrated that mucous membrane from the mouth with flat epithelium, and from the nose with cylindrical or ciliated epithelium readily takes on the appearance of epidermis when grafted on a raw skin surface. Sick noted that this also occurred in connection with vaginal mucosa.

Virchow and his followers maintain that skin grafted on a mucous surface turns into mucous membrane. It is true that in most cases the skin conforms to its surroundings. Thiersch claims this is not pure and backs his statement up by citing a case where a skin flap was used in repairing a soft palate and so much hair grew that the patient had to shave the inside of his mouth.

Thiersch grafts have been successfully employed in operations for hypospadias. They are used to line the new urethra by wrapping them around a catheter which is left in place until adhesion takes place. They have also been used within the larynx after excision of a stricture.

GRAFTING IN X-RAY BURNS

X-ray burns cause a stubborn form of chronic dermatitis where different components of the true derm atrophy and is often characterized by areas of epithelial proliferation having a tendency to ulceration, infection and malignancy. Spontaneous healing hardly ever takes place and in case a malignancy is suspected the area should be excised. Skin grafting by either the Thiersch or Wolfe-Krause method may then be necessary. Transplantation including the whole thickness of skin seems to be advisable. Wolfe-Krause grafts are preferable around the knuckles, wrists and fingertips. All of the burned area should be removed so that recurrence will not take place.

According to Porter, hemostasis should be absolute, moderate pressure should be employed in applying the dressing and the affected part (usually the hand) is kept raised. The borders of the wound should be beveled and cut to fit the defect exactly—the edges should be thinner than the centers to correspond to the bevel.

Rubber protective, when employed, should be removed in from 24 to 36 hours; if serum or blood is present the grafts should be incised and the fluid expressed; lanolin is then applied to the edges of the graft.

It is doubtful if this procedure has any advantages over the others. If the affected area is completely removed, as it should be, the transplanted surface is the same as an ordinary wound. It is difficult to check oozing about the hands. In this case the grafts are preserved on a rubber protective in an aseptic jar containing a piece of moist gauze and applied the following day with no antiseptic. If there is very little oozing, it may be checked by placing the grafts in position and applying slight pressure.

TREATMENT OF BURNS

The causes of fatalities in burns and scalds are:

(1) **Shock** which is often accompanied by pulmonary congestion and suffocation resulting from exposure to the smoke of the fire.

(2) **Collapse** which may prove fatal and

(3) **Toxemia** resulting from sepsis.

Collapse becomes manifest very rapidly. It is due partly to absorption of histamine bodies from the damaged tissues, but largely, in the earlier stages particularly, to loss of serum from the burnt surface. In order to give some idea of the amount of fluid lost, where in a man weighing 65 kilograms one-sixth of the body surface is burnt, it is estimated that in the first twelve hours after injury he will lose 3,500 c.c. serum from a total blood volume of 5,000 c.c.! (Mitchiner). This loss must be replaced promptly by giving fluids in large quantities. We must prevent this drain by coagulation of the damaged vessels and their contents. The coagulant must be capable of penetration through all damaged tissues and not only the surface of the injured area. Tannic acid in weak solution is ideal as a penetrating coagulant (Mitchiner). The coagulant must be applied at once as a first-aid measure. The patient must be kept warm and fluids administered.

Toxic Symptoms occurring from forty-eight hours to ten days later, usually are the result of septic absorption.

While scarring cannot be entirely prevented in deep burns, the prevention of sepsis does much to diminish the amount of scar tissue; prompt suitable splinting is also helpful. Thorough preliminary cleansing of the burn and surrounding tissues is essential. In cases of severe scarring (see chapter on Neck) plastic surgery, radium or x-ray may be used.

First Aid

Wrap the patient in a blanket. Immediately thereafter apply a coagulant to the burnt area to stop collapse and to relieve pain. According to Mitchiner, by far the best solution to use is 2 to 2½ per cent tannic acid in sterile water. Strong solutions of tannic acid or tannic-acid powder at once coagulate only the surface protein; thus the deeper parts of the injured area are not penetrated or coagulated. Absorption of histamine and loss of fluid will, therefore, continue and produce collapse in spite of the surface coagulation. Administer morphine to relieve the pain.

Scalds are treated similarly. Before applying the tannic-acid solution to a greasy surface, the latter must be removed. Efficient cleaning of the affected area must be done under an anesthetic. General anesthesia, however, is not without risk (pulmonary complications). "Twilight sleep" (scopolamine-morphine anesthesia, which see) serves here well. Upon thorough cleansing of the area depends the whole success of the coagulative treatment and the prevention of future sepsis. (Mitchiner). Open all blisters. Remove dead skin and charred tissue thoroughly. Wash the area and surrounding skin with soap and warm water. Dry with a sterile towel. Sponge with ether. Apply coagulant dressing.

In case of sepsis, anesthetize the patient, remove the dressing, reclean the area and reapply the coagulant dressing. Exsanguination transfusion is valuable where a measured quantity of the patient's toxic blood is withdrawn and

replaced by double the amount of a donor's blood. Venoclysis of normal saline and hot drinks are also a great aid.

Coagulant

Mitchiner advises in order to prevent the growth of molds in the tannic-acid solution, to add very weak perchloride of mercury; the molds then gradually decompose to oxide of mercury. No solution should be more than two months old.

Tannic acid powder is only slightly antiseptic. It will not deteriorate if kept in the dark. In watery solutions molds rapidly appear unless an antiseptic be added to the solutions. The antiseptic used must be nontoxic and produce no pain to the patient; it must not interfere with the coagulative action of the tannic acid but must stop the growth of the mold. Mitchiner states:*

"Many antiseptics have been tried, and personally we favour perchloride of mercury, in itself a coagulant and used in treating burns by Lord Lister. Added in such a strength as to give a solution of 1/2,000 it is harmless to the patient, and allows solutions of tannic acid to keep free from moulds for at least two months, and usually three; the perchloride slowly decomposes to yellow oxide of mercury, which is deposited out of solution. In conjunction with tannic acid powder the perchloride of mercury keeps indefinitely. Many coal-tar antiseptics have been tried, but most of these are painful to the patient in a greater or less degree, and in addition may interfere with the formation of a firm coagulum. Acriflavine and dettol have both been used successfully, though in both cases slight pain is often experienced. A new compound combining euflavine and zinc phenolsulphonate is, however, quite painless and gives a good coagulum; it has, however, the disadvantage of all flavine compounds that it stains everything bright yellow. These solutions appear to keep indefinitely and are quite harmless. Tannic acid should, therefore, be combined with an antiseptic, and may be kept in a solid form or in solution."

The Tannic Acid Compress

Five or six layers of sterile gauze are cut to the required size and should overlap the apparent limits of the burn by at least 3 inches. If the burn involves flexures between fingers, etc., the dressing must be shaped carefully to fit closely to these.

Soak the dressing in a 2 per cent tannic acid solution. Apply the dripping dressing evenly to the whole affected area, great care being taken to see that accurate apposition is accomplished. Fixation is now applied; bandage the dressings gently but firmly into position. Put a cradle over the burnt area; an electric lamp will assist drying. Keep the temperature of the room around 105° F. or 40° C. The dressing should be hard in 24 hours. Inspect the dressing but do not touch it unless indicated (pyrexia, toxemia, etc.), then reclean and redress the affected area. Slight exudation of serum or sero-pus around the edges of the dressing is no indication for redressing. The dressing is not to be touched until the coagulum separates from the injured area. This usually takes about 12 days in small burns and 28 in large ones.

Most persons suffering from severe burns are in a state of shock which should be combated first.

* *Modern Treatment of Burns*, Wm. Wood, 1935.

Intravenous injections of saline are often effectual in counteracting the toxemia caused by burns. Sponge the uninjured skin with cold water. Give per os, alkaline preparations to relieve acidity which often accompanies severe burns.

In the extreme cases where it becomes imperative immediately to neutralize the toxin in the blood stream, exsanguination-transfusion is resorted to. This procedure consists of first bleeding the patient and then performing a transfusion from a donor correctly typed. The quantity of blood withdrawn varies from 120 cc. in infants to ¾ pint in adults; while the amount of blood transfused ranges from 150 cc. in the infant to a pint in the adult.

Tannic acid has been widely used for the local treatment of burns since its introduction in 1925 by E. C. Davidson. It forms a very fine protection for the injured area and prevents toxemia. The coagulum covers the exposed nerve ends, thus preventing pain. Tannic acid fixes proteins and their metabolites thus locking in the coagulum those which would otherwise find their way into the circulation. In other words toxemia, the "bête noir" of burns, is much less likely to take place when tannic acid treatment is instituted. This treatment may be begun as late as seventy-two hours after the burn has been sustained.

It is important that no water comes in contact with the tanned (leathery) coagulum which forms when tannic acid is applied to the burned area. If this precaution is not observed, toxins will be liberated which may result in death. Bailey records such a catastrophe.

To prevent sepsis and scarring, the affected region should be thoroughly cleansed under a general anesthetic.

PREPARATION OF THE TANNIC ACID SOLUTION

A 4 per cent solution of tannic acid in 1:1000 acriflavine seems to be best. Dissolve about a teaspoonful (2 ounces) of tannic acid in five ounces of 1:000 acriflavine in water.

The Tannic Acid Treatment is carried out as follows:

Step 1. Puncture the blisters and trim away the loose epithelium.

Step 2. Render the burnt area aseptic by scrubbing it as well as the adjacent region with liquid green soap.

Step 3. After applying some good antiseptic to the burnt area, dry it with sponges soaked in ether.

Step 4. With a sponge or brush apply the 4 per cent tannic acid solution; dry it by fanning. An electric hair drier may be useful here.

Step 5. Cease giving the anesthetic after the injured region turns a golden brown. However, apply three or four more coats after this, drying each one separately.

The patient is now placed in bed on a sterile sheet and the burnt area is covered with a sterile towel over which a cradle is placed. Great care should be taken to see that the area is kept dry at all times.

Further coats of tannic acid are applied daily until the coagulum becomes hard and black. Dressings are then discontinued. Healing takes place under these coats of tannic acid and they are left in place until they peel off spontaneously which in the usual case is from 10 to 14 days. After the covering is removed, apply vaselinized gauze and bandage. Skin grafting is necessary in some cases.

Figures 603-604 depict the treatment of an extensive burn of the shoulder treated by skin grafting with superimposed pressure and body cast spica.

Comment. Donald B. Wells[1] submerges the burned patient in a large tub of tannic acid solution which is renewed when fouled; it is kept at a temperature comfortable to the patient. All débris, blisters, etc., are carefully washed away, the analgesic effects of the tannic acid rendering this painless. After about three hours, when the entire burned area is clean and a slight tan has already formed, the patient is transferred to bed and kept absolutely dry by the air from one or more large, commercial hair



FIG. 603



FIG. 604

FIG. 603. Extensive burn of the shoulder and back treated by skin grafting with superimposed pressure and body cast spica. Plaster of Paris immobilization for purposes of rest and prevention of scar contraction.

FIG. 604. Same as preceding, posterior view. Note that the scar is not pigmented. Center granulating. (Surgical Service, Cook County Hospital.)

driers. A 2 to 5 per cent solution of tannic acid is now sprayed on, a small area at a time so that each is dry before another is started. All blisters are broken. After a thick coagulum is formed the spraying is stopped, but the driers are continued so that not even perspiration can soften the precipitate. The author has never had to follow this treatment by skin grafting nor has he had any infection as long as the coagulum was kept perfectly dry.

In the treatment of burns about the head and face, evipan (see under anesthesia) or ether may be advantageously used. Eye pads and nasal plugs of cotton soaked with saline are employed and the face is rendered antiseptic in the manner described above.

[1] Wells, Donald B., Jour. Amer. Med. Asso., 101:1136, 1931.

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VOLUME II

Part III

SURGERY OF THE NERVES, VESSELS AND BONES

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ORIENTATION

The absorbing field of surgery of the peripheral nerves and the engaging problems of the surgery of the sympathetic nervous system are taken up in Chapters 19 and 20, respectively. In the latter particularly many obscure problems are gradually being clarified. Notable advances have been made, the result of the impetus given by Royle, Jonnesco, Lériche, Adson, Cannon and others. The surgery of the blood and lymph vascular system are discussed in Chapter 21 beginning with Lambert's arteriorrhaphy (1750) to G. Ménégaux's analysis of the work of Rudolph Matas and that of Pierre Delbet; this, in order to evaluate the methods used in the past in the surgery of aneurysmal dilatations and the conclusions arrived at after many decades, yea, centuries of surgical endeavor. The conclusions here are interesting and instructive. It is regrettable to note the paucity of information accorded in some textbooks on surgery to the subject of ligation of arteries.

Orthopedic surgery is taken up in Chapters 22, 23 and 24. No attempt has been made here to present a one-sided opinion on the methods used for the correction of muscular defects, congenital anomalies, tendon transplantation, etc. In passing I wish to recall that if success is to be attained in tendon transplantation, reduction of the deformity with over-correction must be accomplished first. Many a surgeon has suffered a blow to his reputation and many a patient has paid with permanent deformity or incapacity, the price of improper management of fractures. It is, therefore, imperative that the general surgeon be conversant with modern methods in vogue in the treatment of fractures and dislocations. Never trust to the fluoroscopic image to make a diagnosis! It is misleading. The greatest pitfalls lurk in green stick fractures and subperiosteal fractures and in so-called "sprains" which upon close examination are found to cloak unrevealed fractures.

The unrivaled use of Roentgen's discovery has revolutionized diagnosis. It has made obscure conditions simple but it also tempts the young surgeon to place too much confidence in the x-ray, often to the neglect of developing his own diagnostic acumen and of his special senses. This is regrettable. The x-ray, while having brought about greater success in the recognition of fractures and dislocations has also taught us that many methods of treatment heretofore resorted to were inadequate or imperfectly understood. Nevertheless, too many fractures are being operated upon where proper conservative management would yield better anatomic and functional results.

In Chapter 23 amputations and disarticulations are discussed. The modern views and methods of amputations and exarticulations have been pointed out while the time-honored methods of ablating portions or all of an extremity, which originated in the days before anesthesia and Listerism, have been given historical consideration. Some old operations (Chopart's, Faraboeuf's, Pirogoff's, Gritti-Stokes and others) have stood the test of time and are still resorted to by some excellent surgeons—hence they may be still considered modern.

CHAPTER 19

SURGERY OF THE PERIPHERAL NERVES

Exploration of peripheral nerves is of greatest importance to determine the extent of injury or degeneration of a nerve and define indications for the proper treatment in a given case. Various tests (motor and sensory by means of electrical currents) are used for the purpose. The function of a peripheral nerve may be seriously interfered with or completely suspended by compression from cicatrices, exuberant callus formations in fractures and various adhesive processes. Such suspensions may be temporary (physiologic) or permanent (anatomic); in the latter case the nerve has been divided.

OPERATIONS ON THE NERVES

NEUROLYSIS

This operation was first performed by Busch and by Ollier in 1863. The former liberated a nerve, compressed by scar tissue, the latter freed the nerve from compression of a callus.

The operative procedures consist of liberating a compressed or adherent nerve and of providing a new bed for the freed nerve; and often of surrounding it with some material for the purpose of preventing reformation of scar tissue.

Capsulectomy

When the thickened sheath of a nerve is dissected free with its scar encasement, capsulectomy is spoken of. The operation consists of (Fig. 605):

Step 1. Exposure of the affected nerve above and below the point of compression.

Step 2. Careful dissection and liberation of the affected segment of the nerve. Avoid injury to the nerve during the performance of this step of the operation.

Step 3. Place the liberated nerve in a newly prepared vascular bed, preferably an intermuscular plane. If the nerve has been compressed against a bone a layer of muscle or other soft structure is interposed between the nerve and the bone. Some surgeons surround the nerve with avascular tissue such as Cargile membrane, fat, blood vessels hardened in formalin (Foramitis method). This is undesirable (Babcock). "Uninjured neighboring muscle forms the best bed for a liberated nerve and should be used whenever possible" (Dean Lewis). Fat, when transplanted, is said to be replaced by connective tissue that may interfere with vascularization of the nerve. On the other hand, Rehn's experiments tend to prove the value of transplanted fat.

Step 4. Suture of the wound. No drainage.

Perineurolysis

Perineurolysis consists of dissecting the nerve from and removing the cicatricial tissue surrounding it (Fig. 606).

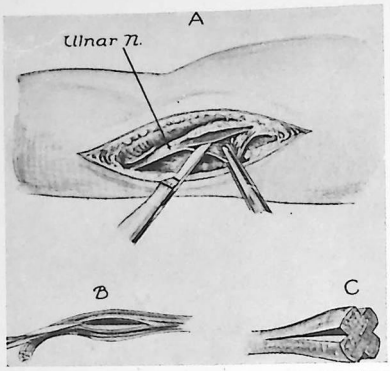


FIG. 605. Capsulectomy: A. removal of thickened sheath of nerve with adherent scar tissue, B. parallel incision of thickened epineurium in cases with a spindle-shaped enlargement without interruption of continuity, C. appearance on cross-section after epineural incisions have been made. (After Dean Lewis.)

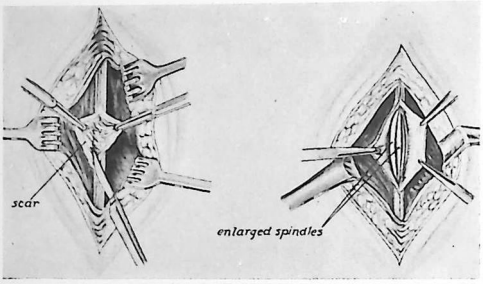


FIG. 606 FIG. 607

FIG. 606. Perineurolysis. The scar tissue around the nerve is removed exposing the epineurium. The nerve is placed on a new bed and hemorrhage controlled to prevent formation of scar tissue. Dissection should be made along the intermuscular septa when possible so that a new blood-free bed is provided for the nerve.

FIG. 607. When the scar is endoneural, the epineurium is opened and the funiculi liberated from scar tissue. This procedure is called endoneural neurolysis or hersage. (After Dean Lewis.)

Comment. Strict asepsis is essential for success in this form of surgical procedure.

Nerve suture done within one or two months after the initial injury offers the best prognosis (according to some authors close to 100 per cent). After six months the prognosis is much less favorable; after a year about 25 per cent of good results may be expected; after that period the chances for success are slight.

Individual nerves differ in their power of regeneration; thus suture of the brachial plexus and of the radial nerve should, according to Kirschner, give an average of 70 per cent good results, the median nerve 50 per cent, the ulnar nerve 30 per cent, the sciatic and tibial nerves 40 per cent, the peroneal 20 per cent. Return of function may be early (usually after about three months). If after two years there is no return of function the prognosis is bad.

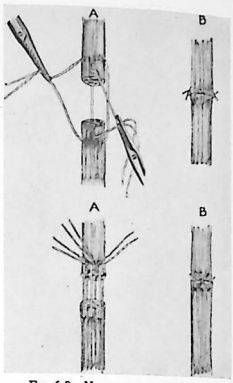


FIG. 608. Nerve suture: A. manner of inserting tension sutures, B. approximation of epineurium by fine catgut or silk, precluding neurofibrillae from digressing into the adjacent tissues. (After Dean Lewis.)

Endoneurolysis Hersage (Babcock)

This consists of a combing or the dissociation of the fibers of the peripheral nerves. This procedure was introduced by Babcock in 1907. It is used when nerve-conduction is interrupted by conditions within the nerve sheath not sufficiently severe to require the excision of the diseased segment with end-to-end suture. It finds its greatest field of usefulness in thickenings of the nerve sheath, intraneural exudates, limited fibrosis and in partial neuromas. The term is applied to a variety of operations ranging from longitudinal splitting of the epineural sheath to dissociation of its fibers so that finally the rounded nerve is transposed into a ribbon of free fibers in the nerve trunk.

Dean Lewis found simple longitudinal incision of the thickened epineurium sufficient in most of the cases in which this procedure is indicated. From three to six longitudinal incisions may be needed, depending on the size of the nerve (Fig. 607). Incise the thickened epineurium longitudinally at different points and thus obtain a decompression of the nerve. The fibers may be dissociated when needed. In most cases longitudinal incision of the thickened epineurium will suffice.

NEURORRHAPHY

This consists of suturing divided nerves and may be primary or secondary (Fig. 608).

Primary Neurorrhaphy

A divided nerve should be united as promptly as possible. Fine chromicized catgut or linen sutures are best suited for the purpose. End-to-end suture is the method par excellence; substitute methods are doomed to failure.

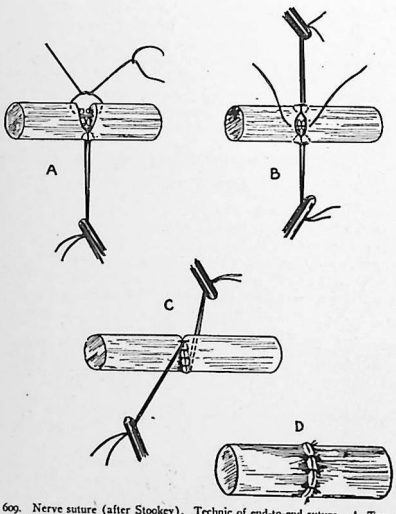


FIG. 609. Nerve suture (after Stookey). Technic of end-to-end suture. A. Two 000 plain catgut sutures on fine rounded needles are passed through the nerve at opposite points, taking a bite a little deeper than the epineurium. The sutures are then tied and the ends clamped without cutting. These sutures serve to bring the ends in alignment and act as stay sutures. B. The two stay sutures are held to steady the nerve while the fine epineural sutures are passed. Black Corticelli AAA silk is split into three strands, waxed and then used for the epineural sutures. Each suture is cut and tied after it is passed. For accurate approximation of the epineural edges the sutures must be tied with forceps. C. The upper surfaces have been sutured and the stay sutures are now reversed, the lower one passed beneath the nerve and the upper one over the nerve so as to expose the under surface. The under surfaces are then sutured in the same manner as the upper. D. The ends have been brought together, the sutures cut after being tied so as to evert slightly the epineural edges.

Step 1. Make a free incision over the injured nerve.

Step 2. Expose healthy surrounding structures above and below the injured point. Use a fine cambric needle to avoid injury to the nerve itself. Remove

the contused parts of the nerve. Approximate only healthy neurofibrillae. In primary suture No. 000 catgut is used by preference. These are used as epineural sutures (4 to 6) (Fig. 609).

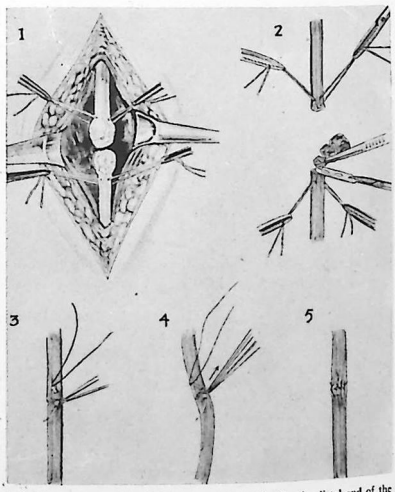


FIG. 610. Nerve suture. The divided nerve is exposed. On the distal end of the proximal segment a neuroma is noted. The proximal end of the distal segment is embedded in a scar. 1. When the ends are exposed two sutures are applied one on each side so that rotation will be as little as possible and which are used for traction when suturing is performed. In 2, successive pieces of the bulbous end of the proximal segment are removed until normal funiculi are seen. The silk or catgut suture is passed through the epineurium. The ends of the nerve should be approximated, not crushed together. 3. The ends of the funiculi should not be retracted. A blood clot between the ends interferes seriously with repair. The sutures are left long when applied so that the nerve can be rotated to permit of the insertion of sutures posteriorly. 4. The epineurium must be closed, for regenerating nerve fibers passing into surrounding tissues will produce a dense scar about the nerve. 5. Suture completed. It may be difficult to approximate the ends at times because of extensive reactions. (After Dean Lewis.)

Step 3. Two transfixion tension sutures of fine linen are introduced; they avoid dead spaces which when not guarded against will permit a blood clot to form which will interfere with primary union. Approximation without strangulation of the nerve-ends should be aimed at.

Step 4. Close the superimposed structures.

Comment. Place the limb in such position as to relax the united nerve ends. A cast to the limb will act admirably (median or ulnar nerve-fixation about 6 weeks, sciatic nerve about 2 months).

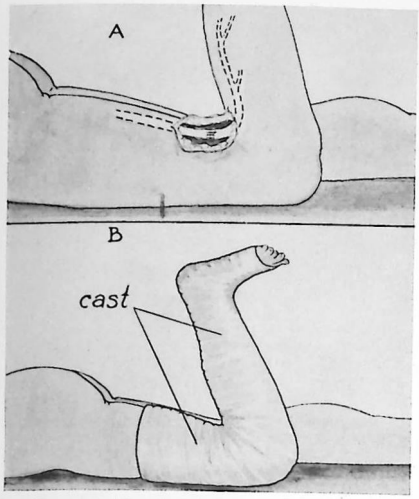


FIG. 611. Nerve suture. Illustration depicts suture of the sciatic nerve accompanied by approximating the ends made secure by mobilizing the nerve segments and bending the knee to a right angle. Maintain cast fixation for six to eight weeks after the sciatic is sutured. Cast fixation is required for about four weeks where the ulnar or median nerve is involved.

Secondary Neurorrhaphy

This operation varies in technical details depending upon the pathologic conditions present. Neuromas are usually present.

Step 1. Prepare as above. Be certain that the exposed nerve segments are not rotated during the dissection or the suture of the nerve (Stoffel).

Step 2. Resect the neuroma or scar with a sharp scalpel. Blunt instruments contuse the nerve-ends. Healthy neurofibrillae should be seen protruding from the cut ends (Fig. 610). Mobilize the nerve-ends to assure approximation without tension. This should be aided by flexion of the corresponding limb (Fig. 611).

Step 3. Suturing is accomplished as in the previous procedure (*vide supra*). All manipulations must be gentle.

Step 4. Surround the sutured area, whenever possible, with healthy tissue. Kirschner advises pedunculated muscle flaps from the vicinity; free fat transplants may be used.

Step 5. Unite the superimposed structures. Relax. Cast.

POSITIONS AFFORDING MAXIMUM RELAXATION OF INDIVIDUAL NERVE TRUNKS

Median Nerve. Place upper arm close to chest; flex elbow and wrist.

Musculo-spiral Nerve. Place upper arm close to chest; flex elbow fully; dorsiflex wrist.

Ulnar Nerve. If nerve is left behind the internal epicondyle—place upper arm close to chest; extend elbow; flex wrist.

Ulnar Nerve. If nerve is displaced in front of the epicondyle, place upper arm close to chest; completely flex elbow and wrist.

Brachial Plexus. Approximate head to shoulder; elevate arm or place it close to the chest.

Sciatic Nerve and Its Main Divisions. Hyperextend hip; completely flex knee.

Comment. Babcock estimates that the following lengths of gap may be overcome by changes in the position of the different joints. Flexion in the wrist alone will overcome a gap of 4 cm. in the median and ulnar nerves; flexion of the elbow, a gap of 5 cm. in the musculospiral or median nerves. Acute flexion of the knee will overcome a gap of 8 cm. in the sciatic or popliteal nerves; dorsiflexion of the foot, 4 cm. in the anterior tibial nerve. Extension of the elbow adds 1 to 2 cm. to the ulnar nerve; hyperextension of the thigh 2 cm. to the sciatic nerve; extension and adduction of the foot, 4 cm. to the posterior tibial nerve. Babcock also found that adduction of the shoulder alone gives sufficient slack to enable one to overcome a gap of 7 cm. in the musculospiral nerve and somewhat shorter gaps in other branches of the brachial plexus. Rotation of the head to the opposite side gives 1 to 2 cm. additional slack in cords of the brachial plexus. This may be increased by raising the shoulder on the side of the operation.

Additional lengths may be gained in cases of the musculo-spiral nerve by dissecting the nerve free and changing its course to the anterior surface of the arm beneath the muscles. The ulnar nerve may be dissected out of its groove and placed anteriorly, increased length being then given by flexion of the elbow joint. Additional lengths may be gained in cases of the median nerve by dissecting it from its deep position, placing it more superficial and then flexing the wrist and elbow.

NERVE ANASTOMOSIS

Nerve Implantation

It has been shown that spontaneous regeneration of a nerve may ensue across a gap without artificial intervention provided the distance to be bridged is not too great (¾ inch). So-called autocable nerve transplants (Huber) are often of use. A cutaneous nerve is usually mustered into service to accomplish the desired end

(internal cutaneous, radial (superficial branch), external cutaneous, in the upper limb). Auto and homotransplants of nerves may be resorted to.

Nageotte's method of neurotransplantation while devotedly championed by some is energetically opposed by others. It consists of bridging the defect with

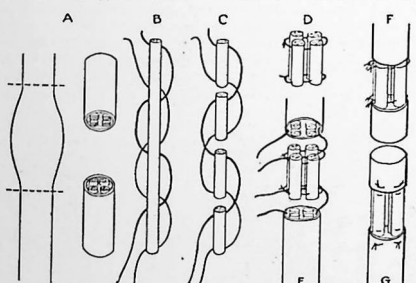


FIG. 612. The cable graft: A. ends of the nerves are exposed by resecting bulb, B. sutures inserted through the cutaneous nerve utilized from the cable graft, C. division of the nerve into segments, D. the cable graft prepared for transplanting, E. insertion of the sutures through the ends of the cable graft and nerve ends, F. the tied sutures, G. tying of perineural sutures. (After Elsberg, J.A.M.A.)

a segment of sciatic nerve of a calf embryo, the tissue having been treated with 50 per cent alcohol. Figures 612-613 illustrate the use of the autocable transplant and nerve grafting.

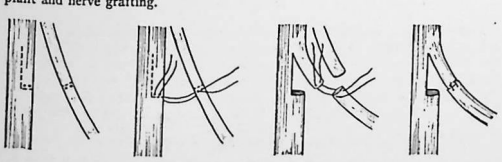


FIG. 613. Diagrammatic illustration of partial nerve crossing. When the point at which the nerve is to be cut is determined and the length of the flap estimated, the sutures are passed before making the flap or cutting the nerve to be neuroticized. Thus sutures are placed without manipulating the nerve ends and crushing them with forceps. (After Stookey.)

It has been shown experimentally and clinically by previous authors that by implanting the central end of a motor nerve into a denervated muscle, motor endplates will be formed and motor function will be restored. This can be done when the nerve branch is large enough so that an adequate nerve supply may be established.

METHOD OF NERVE IMPLANTATION

Step 1. Freshen the central end of the nerve that is to be implanted.

Step 2. Place two epineural sutures at opposite points 2 mm. from the end of the nerve.

Step 3. Make a longitudinal incision in the muscle at a point most suited for the implantation, considering the movements of that muscle during function.

Step 4. Obtain complete hemostasis.

Step 5. Pass both ends of the epineural sutures in the muscle, at the same time pointing the end of the nerve downward in the direction of the muscle fibers.

Step 6. Close the muscular incision.

Step 7. Place two extra epineural sutures in such a way as to prevent nerve angulation.

Anastomosis Between the Facial and Spinal Accessory Nerve for Facial Paralysis

(See Nerve Anastomosis for Facial Paralysis, Chapter 14, p. 297.)

Duchenne-Erb Paralysis—Obstetrical Palsy

This type of paralysis is usually attributed to an injury such as tearing or stretching or pressure on the fifth and sixth cervical nerves, during childbirth. The muscles affected are the deltoid, spinati, biceps, brachialis anticus, supinator longus and brevis and the teres minor. This results in loss of the power of abduction of the arm, inability of flexion at the elbow, the forearm is pronated, and the arm is in a position of outward rotation. Sensation in the limb is only slightly involved. Turner Thomas states that during childbirth, pressure on the front of the shoulder resulting in a bending down of the acromium process and a posterior subluxation of the head of the humerus is the cause of most cases of Duchenne-Erb paralysis.

Reduction of the subluxation is relatively simple soon after birth, but becomes difficult later on.

If injury to the brachial plexus is considered to be the cause of the paralysis, several months of electrical treatment, massage, etc., may be tried. However, if no improvement occurs, and if the reaction of degeneration appears in due course, operation is desirable.

There are two types of surgical procedure which may be performed:

(1) Nerve anastomosis.

(2) Muscle transplantation.

Operations On the Brachial Plexus

Injuries of the brachial plexus may either be infra- or supra-clavicular. The extent of the injury should be determined by painstaking neurological examination. The degree of injury may be from a simple stretching of one of the nerves to complete rupture of the plexus (Fig. 614).

(a) **Where the Whole Plexus is Paralyzed.**—All the muscles of the forearm and hand are involved. The serratus magnus and rhomboid muscles usually

escape. Occasionally, the pectoralis major, the supra- and infraspinatus remain unaffected. The site of the lesion may be traced by the loss of sensation and extent of the paralysis.

(b) **Where the Inner Cord is Paralyzed.**—Paralysis of the muscles supplied by the ulnar nerve and of the intrinsic muscles of the hand will be observed.

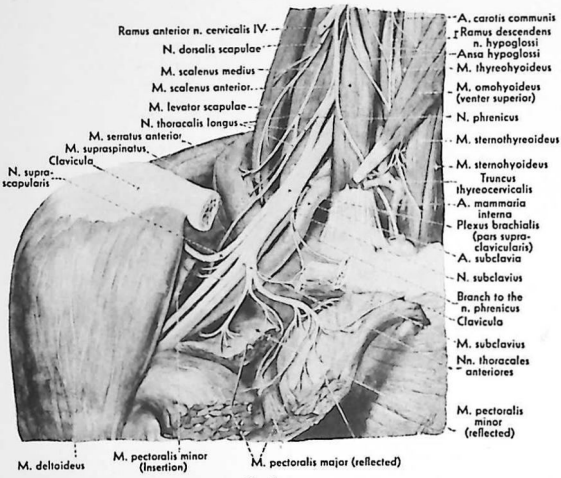


FIG. 614

(c) **Upper Arm Paralysis (Erb-Duchenne Type).**—This usually results from injury of the fifth cervical anterior or primary division or a combination of the fifth and sixth. The paralysis affects the deltoid, biceps, supra- and infraspinatus, brachialis anticus and the supinators.

(d) **Lower Arm Paralysis.**—Here the lesion involves the first dorsal anterior primary divisinn and affects all of the intrinsic muscles of the hand.

TREATMENT

No definite rules can be given. Many patients recover or greatly improve under rest, massage and electrical stimulation. Any lesion causing pressure in the infraclavicular cases should be subjected to prompt surgical treatment. Also

where a complete supraclavicular lesion follows direct injury, early exploration is strongly indicated.

Step 1. Make an incision extending from the junction of the lower and middle thirds of the sternocleidomastoid muscle to the outer end of the clavicle. Wherever necessary, divide the clavicle.

Step 2. Endeavor to identify the nerves; this is sometimes very difficult. Suture of roots may be impossible owing to the proximity of the intervertebral foramina.

Step 3. Attempt end-to-end suture and if that is impossible, resort to nerve-anastomosis.

Step 4. Immobilize the arm in a position free from strain.

DIRECT METHOD—NERVE ANASTOMOSIS (ROBERT KENNEDY'S OPERATION)

Step 1. The patient is placed on his back with a support under his shoulders. Rotate the head and face toward the opposite side.

Step 2. Make an incision beginning at the junction of the middle and lower thirds of the outer margin of the sternomastoid, passing outward and downward and ending at the junction of the outer and middle thirds of the clavicle. The fascia between the trapezius and sternomastoid is then divided.

Step 3. Expose the omohyoid, and then above it, the scalenus anticus. The nerve trunks are seen coming out from beneath it. Follow them outward to the junction of the fifth and sixth nerves and separate them from adhesions.

Step 4. The isolated nerve usually consists of scar tissue. Sever the fifth and sixth nerves above the affected area. Then the three peripheral divisions of the nerve are severed beyond the diseased portion.

Fine chromicized catgut is used to suture the three peripheral divisions to the two central stumps. To relieve tension before suturing elevate the shoulder and bend the head to the side of the operation. Place the muscle or fascia over the nerve suture line.

Step 5. Close the wound and dress. Keep the shoulder elevated and the head inclined toward the operative side by means of a suitable apparatus, and prevent motion of the head on the shoulders.

Remove the fixed dressings after two weeks. Kennedy advises no special after-treatment. Some surgeons institute electrical stimulation and massage. Harris and Low advise using electrical tests previous to excising parts of the nerve to prevent destruction of healthy nerve tissue.

MUSCLE TRANSPLANTATION (TUBBY'S OPERATION)

This operation is done in two stages.

Stage 1. **Restoring Flexion of Elbow.**

Step 1. An incision is made from the center of the posterior aspect of the upper arm downward and forward, for about five inches, toward the anterior aspect of the elbow, following the musculospiral groove. The musculospiral nerve is exposed and drawn aside.

Step 2. Separate a wide strip of the external portion of the triceps muscle from its tendon, leaving its upper portion attached to the rest of the muscle. Using

the same incision, expose the inferior end of the biceps muscle. Make a tunnel through the muscle from behind forward, two inches above the elbow.

Step 3. Relieve tension by flexing the elbow. Pull the end of the triceps flap through the tunnel in the biceps and suture it there.

Close the wound and apply dressings. Immobilize the elbow in flexion. Allow no movements for four weeks.

Stage 2. **Restoring Abduction of the Shoulder.**

Step 1. Make an incision laterally beginning about an inch below the center of the clavicle, to the tip of the acromion and then extending it downward for several inches. Detach the clavicular part of the pectoralis major muscle from the rest of the muscle and divide its insertion into the humerus. This forms a muscular flap attached to the clavicle. The insertion of the trapezius muscle into the clavicle is divided. Then the corresponding portion of the muscle is separated from the rest of the trapezius by splitting it in the course of the fibers. This forms a second muscular flap.

Step 2. The free end of the pectoralis major flap is brought upwards over the acromion process and fixed into the deltoid muscle. To avoid slipping, suture several of the pectoral fibers to the tip of the acromion. Suture the end of the trapezius-flap to the lateral part of the pectoral-flap. Close the wound and apply dressings. Immobilize the arm in abduction without motion for four weeks, and then slowly begin exercises.

Tubulizations

This consists of encouraging nerve regeneration to progress between the ends of a nerve, along a tube, along which the neurofibrillae may grow. Materials used for this are fascia and veins turned inside out to avoid the regenerating endothelium from interfering with nerve regeneration and function. The usefulness of the method is still sub judice.

OPERATIONS FOR CAUSALGIA

Injection, Freezing, Crushing, Chordotomy

Weir Mitchell studied causalgia during the Civil War. He pointed out that nerve pains may be relieved by injecting the nerve above the site of injury with alcohol (70 to 95 per cent). The injection of 1 to 3 cc. alcohol blocks afferent impulses for months. Some surgeons prefer the injection of absolute alcohol (Frazier). Lesser strengths (Figs. 615-616-617-618) abolish sensory conduction and affect the motor paths only slightly (this is important in the treatment of mixed nerves).

For temporary interruption of pain in a given nerve the Trendelenburg-Perthes method for freezing the nerve is of advantage. Ethyl chloride—15°—is used in this method. Kirschner advocated exposing the nerve and placing it between two cakes of carbon dioxide snow (80°) from 2 to 20 minutes.

Nerve crushing with an angiotribe is used by some.

Fœrster's operation for the relief of pain consists of interrupting nerve conduction at the spinal cord (laminectomy; exposure and division of the posterior roots of the spinal cord).

SPASTICITY (FŒRSTER'S OPERATION)

According to Frazier, "if we admit that spasticity or spastic muscular contractures are reflex disturbances, unrestrained by cortical impulses, one way, but not the only way of controlling them, is to remove at least one link in the chain of the reflex arc. Naturally the motor portion of the arc, the anterior horns, the roots, or the peripheral nerves cannot be broken, otherwise the limb would be hopelessly paralyzed; for the same reason the sensory nerves, many of which are mixed nerves, must be left intact, so that by a process of exclusion there remain the sensory roots." (See Fig. 631A, page 558.)

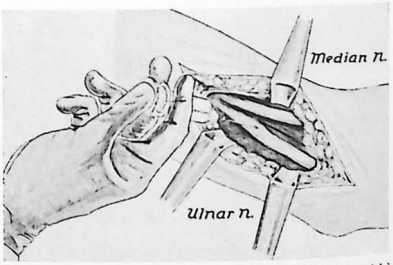


FIG. 615. Injection of median and ulnar nerves with 60 per cent of alcohol (causalgia). (After Dean Lewis.)

This operation is indicated in stubborn cases of radiculitis and is often performed in two stages. First, a laminectomy is performed and several days later the dura is opened and the work completed. Ample exposure of the posterior surface of the cord is necessary so that the posterior roots may be recognized. Blood should be removed by irrigation with warm salt solution as sponges are likely to injure the delicate nerves. The number of nerve roots removed varies.

Hoffman's Method of Performing Fœrster's Operation

Step 1. Make an incision over the spinous processes of the vertebrae to be reflected and free the muscle-structures from the spinous processes and laminae on both sides, by blunt dissection. Control hemorrhage by means of gauze pressure.

Step 2. With an osteotome held in a horizontal position, divide the laminae on either side.

Step 3. Make a transverse incision in the interspinous ligament either above or below the selected vertebrae in accordance with the direction the bone flap is to be turned back. Incise any remaining connecting structures either upward or downward. The dura is now exposed, but if more ample exposure is desired, pieces of bone are removed with a rongeur forceps.

Step 4. Make an incision in the dura longitudinally; divide the posterior spinal roots involved.

Step 5. The edges of the dural wound are united by continuous suture.

Step 6. The bone flap is replaced, the muscles and fascia over the spinous processes are sutured and the skin incision closed.

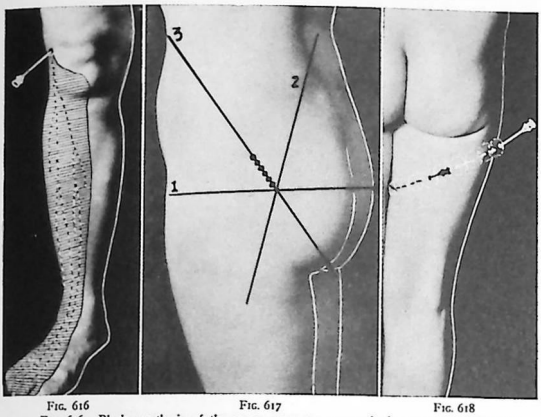


FIG. 616 FIG. 617 FIG. 618

FIG. 616. Block anesthesia of the nervus peroneus communis for purposes of blocking the external popliteal nerve. Ascertain the position of the nerve by palpating the point where it crosses the head of the fibula. Shaded area shows approximate extent of anesthesia resulting from blocking this nerve.

FIG. 617. Blocking of the sciatic nerve. Line 1 traverses the proximal point of the greater trochanter of the femur, line 2, the posterior superior spine of the ilium external to the tuberosity of the ischium, line 3 intersects lines 1 and 2 in their relation to the gluteal tubercle on the crest of the ilium. The six dots indicate where the injections are to be made to reach the sciatic nerve.

FIG. 618. Posterior view.

Stoffel's Operation

When a certain set of affected muscles is ascertained, the nerve supply to the particular group is surgically exposed, its identity ascertained by electrical stimulation and the nerve bundle supplying a given muscular group is either divided or a portion of it resected (several cm.) (Fig. 619. See also p. 555, Ramicotomy.).

NERVE STRETCHING

This is indicated in cases of sciatica brought about by exposure to cold and dampness and in which the pain radiates along the nerve route.

Sciatic Nerve

Step 1. Place the patient in the prone position. From a point midway between the tuber ischii and the great trochanter make a longitudinal incision about 4 inches long, beginning at the gluteal fold and extending downward.

Step 2. Incise the fascia. Retract the gluteus maximus muscle upward. Retract the hamstring muscles outward after bending the knee to relax them.

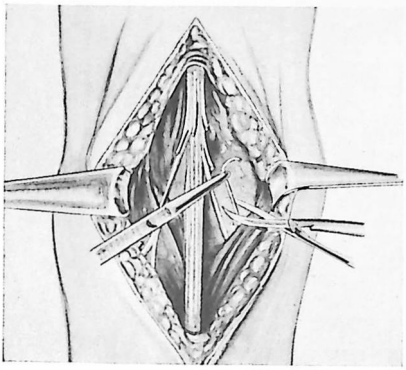


FIG. 619. Stoffel's operation for relieving spasticity. Individual nerve tracts are exposed as shown in the illustration and divided, thus cutting off the innervation of certain muscles.

Step 3. Hook up the nerve which is now exposed with the finger and retract it upward and downward with a strong, steady pull.

Step 4. Replace the nerve. Close the wound.

Exposure of Internal Popliteal Nerve (Tibial Nerve)

Step 1. Make an incision over the space between the two heads of the gastrocnemius muscle extending downward 3½ inches from the middle of the popliteal space.

Step 2. Draw back the short saphenous nerve and vein and incise the deep fascia.

Step 3. Bend the knee for purposes of relaxation and separate the two heads of the gastrocnemius muscle. The short saphenous vein upon its return to the popliteal space goes directly to the popliteal vessels over which the nerve lies.

Step 4. Stretch the nerve by hooking it over the finger and applying traction upward and downward.

Exposure of External Popliteal Nerve (Peroneal)

A method of exposing this nerve is described by Treves as follows:

"**Anatomy.** The external popliteal or peroneal nerve follows the outer side of the popliteal space, lying close to the biceps. Passing over the outer head of the gastrocnemius, between it and the biceps, the nerve reaches the neck of the fibula, and crosses that bone beneath the fibers of the peroneus longus muscle. The nerve may be easily felt, when the knee is a little flexed, as a loose rounded cord, lying just behind the biceps, as it nears the head of the fibula.

"**Operation.** The patient lies upon the sound side, with a sufficient tending to the prone position to well expose the outer aspect of the knee. The knee-joint is extended. An incision, one inch and a half in length, is made parallel with and immediately posterior to the tendon of the biceps. The cut should be so placed that its

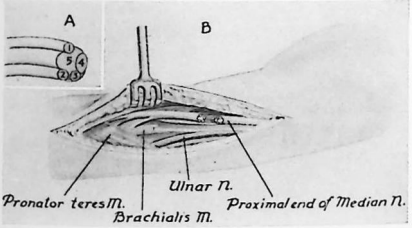


FIG. 620. A. Exposure and topography of the median nerve: 1, channel for pronator radii teres, flexor carpi radialis and palmaris longus, 2 and 3, channels for the flexor sublimis digitorum, 4, channel for the flexor profundus digitorum and flexor longus pollicis, 5, muscle and sensory tracts of the thenar eminence and first and second lumbricales. (After Vulpius and Stoffel.

upper half is in relation with the tendon while its lower half is over the fibula. The skin and deep fascia having been divided, the biceps tendon is exposed. The knee should now be a little flexed and the nerve sought, close to the joint at which the tendon reaches the head of the fibula. A narrow and unduly prominent ilio-tibial band has been mistaken for the biceps tendon."

Facial Nerve

Satisfactory results have followed the stretching of this nerve in cases of spasmodic tic. Kocher recommends this procedure highly. The operation for exposing this nerve is described elsewhere.

Exposure of Musculospiral (Radial) Nerve

Injury or pressure caused by a fractured humerus are the chief reasons for exposing and treating this nerve (see also Fractures of Humerus).

METHOD OF EXPOSING NERVE IN LOWER PART OF ARM

Step 1. Make an oblique incision about 3 inches long between the supinator longus and the brachialis anticus muscle. The incision is confined to the lower third of the arm.

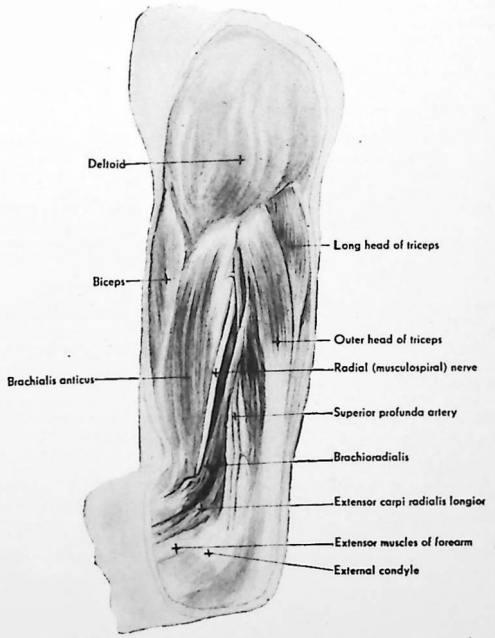


FIG. 621. The radial (musculospiral) nerve and outer side of arm.

Step 2. Incise the deep fascia; expose the nerve which lies between the supinator longus and the brachialis anticus, by separating these muscles (Fig. 621).

Step 3. Pursue the nerve in an upward direction to the point of injury; avoid

puncturing its accompanying artery. If exposure of the nerve cannot be obtained below the site of injury, expose it above.

EXPOSURE OF THE NERVE IN THE UPPER OR MIDDLE PART OF ARM

An incision is made between the long head and the external head of the triceps beginning a little below the posterior axillary fold and extending downward. By blunt dissection divide the two heads of the muscle down to the bone, thus exposing the nerve and profunda artery.

Schwarz and Kuss recommend the following procedure for exposing this nerve[1]:

Step 1. Place the patient in the dorsal position; hold the arm vertical but incline it slightly toward the center; hold the forearm at right angles to the arm resting the hand on the chest inside the opposite axilla.

Step 2. Make a skin incision along an imaginary line drawn from the tip of the olecranon exactly in the midline of the posterior surface of the arm to the prominent posterior border of the deltoid. Begin the incision about 4 finger-breadths below the tip of the olecranon and extend it downward to the nerve lesion—usually from 12 to 18 cm.

Step 3. Incise the subcutaneous tissue exposing the deep fascia.

Step 4. Retract the borders of the aponeurotic wound after incising the brachial aponeurosis for the entire length of the wound. The V-shaped tendon of the long triceps can be seen on the ulnar side of the midline in the distal portion of the wound.

Step 5. Divide the fibrous tissues along the radial border of the V-shaped tendon between it and the tendon of the external head of the triceps. This incision reveals a muscular space between the external head of the triceps on the radial side and the long head of the triceps on the ulnar side. The incision of the triceps, if kept strictly to the midline, presents a yellowish-white fascia, varying in thickness and consistency. The musculospiral nerve and its accompanying vessels are bound to the humerus by this fascia.

Step 6. Incise the fascia exposing the nerve from the axilla to the point where it enters the external intermuscular septum.

In some cases the terminals of the divided nerves cannot be found. For instance, after an external condyle has been fractured, there may be a quantity of callus which presses on the nerve rendering the restoration of conduction out of the question. Tendon transplantation is then resorted to.

ANTERIOR TRANS-EPITROCHLEO-MUSCULAR DISPLACEMENT OF THE CUBITAL NERVE (GUTIERREZ TECHNIC)[2]

In traumatisms about the region of the elbow the cubital nerve is frequently injured resulting in late paralyses which often call for subsequent operations. Gutierrez has evolved a method of transposing the nerve which he claims is free from certain disadvantages observed in other current procedures for the transposition of the nerve.

Step 1. The arm is put in abduction and the forearm flexed in external rotation. Make a curved incision about 18 to 20 cm. over the epitrochlea-olecranon canal; about 10 to 12 cm. of the incision is on the arm (Fig. 622).

[1] "Revue de Chir.," No. 6, 1912.
[2] Revist. de cirug. Buenos Aires, 4:No. 3, Aug., 1925.



Fig. 622. Cutaneous incision. Exposure of cubital nerve. (Gutierrez.)



Fig. 623. Pushing backward the epitrocleo-olecranon canal; about 10 to 12 cm. of the incision is on the arm (Fig. 622).

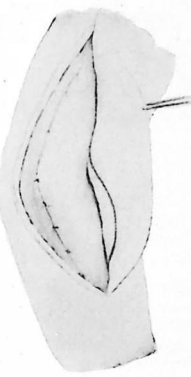


Fig. 624. Termino-terminal approximation of the ulnar nerve.



Fig. 625. Epitrocleomuscular reposition and aponeuroticomuscular suture.

Gutierrez technic for anterior trans-epitrocleomuscular displacement of the ulnar nerve.

Step 2. Expose the lower part of the epitrochlea. Some fibers of the internal cutaneous brachial nerve and the cubital vein are exposed. The continuation of the cubital nerve is exposed throughout all the length of the incision from one extremity to the other. In its inferior extremity it is necessary to section the antebrachial aponeurosis and the anterior cubital muscle for some 8 cm., taking care not to injure nerve fibers in the lower segment (Fig. 623).

Step 3. The epitrochlea is mobilized in its most superficial part and the insertions of the epitrochlear mass in the humerus sectioned with chisel and mallet.

Step 4. The epitrochlea and its inserted muscles are lifted partly from the deep muscle-plane and pushed backward. In the depth the median nerve is seen reposing on the internal part of the anterior brachial muscle. In its lower segment it traverses the round pronator muscle.

Step 5. The cubital nerve is easily isolated, especially in its superior part, and is transplanted to the anterior muscle-plane. In order that the nerve should not be displaced posteriorly above the epitrochlea, a couple of catgut sutures are passed through the deeper part of the mobilized muscles and the superficial flexor muscle outside the nerve (Fig. 624).

Step 6. The fragment of mobilized epitrochlea is replaced in position and fixed and the wound closed (Fig. 625).

Note. If the loss of cubital nerve is so great that termino-terminal anastomosis of its ends is impossible the proximate situation of the median nerve allows an easy implantation of the cubital into it.

METHOD OF EXPOSING THE POSTERIOR INTEROSSEOUS BRANCH OF THE RADIAL NERVE (GUTIERREZ TECHNIC)[1]

Step 1. Separate the arm about 45 degrees from the thorax. The forearm is in about 95 degrees of flexion with the arm and rests upon a table by its cubital edge.

Step 2. Make a vertical incision extending from about a couple of finger widths below the epicondyle to about one or two finger widths above the styloid apophysis (Fig. 626). Incise the skin and subjacent tissues exposing some veins and nerve-fibers. The aponeurosis is cut about the lower half of the incision, thus exposing the large abductor and the short extensor muscles of the wrist. The plane of separation between the second external radial and the common extensor of the fingers is exposed above the superior border of the large abductor. The short supinator muscle is seen above the large abductor of the wrist (Fig. 627).

Step 3. The posterior branch of the radial nerve runs at some three finger widths beneath the epicondyle, deeply situated and running between the short supinator, the large abductor and short and large extensors of the wrist. By sectioning the short supinator superficially, the intramuscular part of the radial nerve is exposed. The articulation of the elbow, in its humeroradial segment, can, if necessary, be exposed by prolonging the incision in its upper part to a little above the epicondyle and by separating the muscle (Fig. 628).

[1] Revist. de Cirug. (Buenos Aires), Aug. 1925.



Fig. 626. Cutaneous incision.

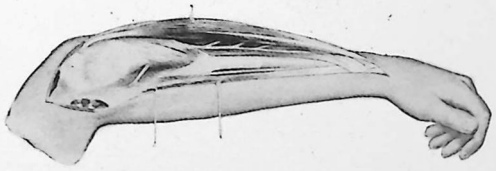


Fig. 627. Exposure of deeper strictures.

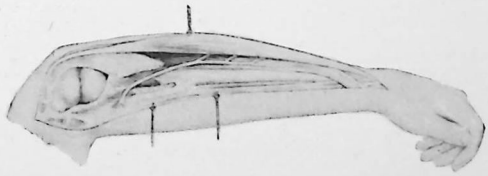


Fig. 628. Gutierrez technic of exposure of the posterior branch of the radial nerve.

CHAPTER 20

SURGERY OF THE SYMPATHETIC NERVOUS SYSTEM

Anatomic Considerations. The nerve structures of the ganglion-chain-system are generally described as "sympathetic" while the nerve elements of the visceral, cranial and pelvic region are referred to as "parasympathetic" or "autonomic."

The ciliary, otic and sphenopalatine ganglia belong to the cranial autonomic system which is connected to the midbrain; the nervi erigentes, the hypogastric plexus and the pelvic ganglia belong to the pelvic autonomic system. Two ganglionated trunks comprise the sympathetic system proper; these trunks extend vertically through the neck, thorax and abdomen, one on each side of the vertebral column. White and gray rami communicantes connect the ganglions in the thoracic, lumbar and sacral regions to the corresponding spinal nerve. There are only three sympathetic ganglia in the cervical region; their white communicantes emerge from the first and second dorsal nerve. The white rami are medullated, mostly efferent and visceromotor in function. They originate from the cells in the lateral horns of the gray matter of the cord and make their exit through the anterior nerve roots from the first dorsal to the second lumbar inclusive, ending in their corresponding ganglion from where a postganglionic fiber sends the nervous impulse to the involuntary muscle or gland involved. Afferent viscerosensory fibers are contained in the white rami. These are connected to the cells of the posterior root ganglion.

The gray rami communicantes emerge from their corresponding ganglia and continue uninterruptedly to the corresponding spinal nerves in the cervical, dorsal, lumbar and sacral regions. These rami are mostly nonmedullated, running through the spinal nerves furnishing vasomotor and vasoinhibitory fibers to the arteries and secretory fibers to the skin. The plexus formed by the vasomotor fibers to the large arteries of the limbs seem to arise from two sources; those located proximally seem to arise from the sympathetic plexus around the aorta, continuing along the adventitia; those located distally seem to be derived from the peripheral nerves and branch off at different planes along the limb.

The Cervical Sympathetic Trunk appears back of the carotid sheath and has three ganglia. It proceeds inferiorly into the thoracic part of the sympathetic trunk forming an intricate plexus around the internal carotid artery at the base of the skull. In the thoracic part of the sympathetic trunk, each ganglion sends to the respective intercostal nerve a gray ramus communicans and receives from the corresponding spinal segment a white ramus communicans (the first dorsal is an exception). There are no white rami in the cervical sympathetic trunk, the spinal fibers being derived from the upper thoracic ganglia. Terminal branches of the cervical sympathetic furnish motor fibers to the pupil, accelerator fibers to the heart, secretory fibers to the salivary glands, vasodilator fibers to the arteries of the head, neck and upper limbs, and pilomotor fibers to the integument of the scalp, face and neck.

Tumors in the neck or upper part of the mediastinum may compress the sympathetic trunk; irritation or stimulation is characterized by a widened palpebral fissure, dilated pupil and exophthalmos; the secretory functions of the sweat and salivary glands are increased. An opposite effect follows cutting of the sympathetic.

EXCISION OF THE SYMPATHETIC NERVES

PERIARTERIAL SYMPATHECTOMY

René Leriche enriched the literature with his valuable contributions on surgery of the sympathetic nervous system.

When the adventitia of an artery is excised for a considerable distance for

syringomyelia, vasomotor diseases such as Raynaud's disease, acrocyanosis and acroparesthesia, erythromelalgia, scleroderma, edemas and elephantiasis.

Leriche's Technic

Step 1. Expose the artery to be operated upon under local anesthesia. Incise the common vascular sheath. Dissect it free from adjacent veins and nerves.

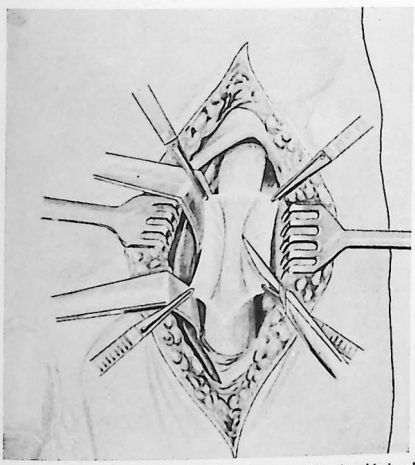


Fig. 629. Periarterial sympathectomy of the femoral artery. The adventitia is split longitudinally and after being carefully dissected away from the media, it is ablated. During this maneuver, it will be observed, the vessel contracts. (After Kirschner.)

Step 2. Grasp the artery with a smooth forceps. Release the resistant part of the wall of the vessel in the grasp of the forceps leaving only the adventitia in its bite. Elevate the adventitia as high as possible.

Step 3. With a sharp pointed scalpel make an incision for the whole length of the desired sympathectomy. With the point of the instrument draw a semicircular mark at the beginning and the end of the incision.

Step 4. With a blunt instrument grasp one of the lips of the wound in the adventitia and retract it as far as possible. Repeat the same procedure on the opposite side (Figs. 629-630).

Step 5. In order to clear the posterior wall of the vessel, push the artery aside

with a small blunt curved instrument. Continue the detachment and complete it by stripping the thin tissues from the artery by cautious snipping with a scissors, if necessary. If small arteries are encountered, exercise your skill by stripping the adventitia with a pair of blunt-pointed scissors from around the media without injuring them. If these smaller vessels are accidentally ruptured, ligate them with fine catgut. Should bleeding take place from the vasa-vasorum compression will stop it. Only rarely may the

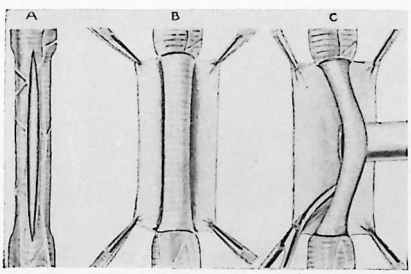


Fig. 630. Periarterial sympathectomy. Steps in removing the adventitia. (After Leriche.)

adventitia be detached in one piece; usually it is lacerated and removed in fragments.

Step 6. Irrigate the wound with warm normal saline solution to eliminate cellular débris.

The operation is considered finished when all that is detachable from the media has been removed and when the artery has become visibly contracted. Curettage of the media, as practiced by some, is unnecessary.

CERVICOTHORACIC SYMPATHECTOMY*

Step 1. Make a skin incision parallel to the posterior border of the sternomastoid muscle and extending from the tip of the mastoid process to the lower border of the clavicle.

Step 2. Divide the external jugular vein between ligatures. Avoid injury to the spinal accessory nerve. Split the muscle longitudinally near to its posterior border thus minimizing the danger of injuring the eleventh nerve.

Step 3. Liberate the carotid-jugular-vagus bundle without opening its sheath and retract it mesially along with the sternomastoid muscle. Follow the normal cleavage planes; the sympathetic trunk which is on the prevertebral fascia, back of the neurovascular bundle, will not then be disturbed. If it is not found here, relax on the retractor and look along the posterior wall

* Lewis Pract. Surg. W. F. Prior Co. 1932.

of the neurovascular sheath as it may possibly be caught up by the retractor. It is smaller than the vagus nerve, rather flat and its diameter is unequal. **Do not confuse the sympathetic with the pneumogastric, the descending branch of the hypoglossal and the phrenic nerves.** The phrenic nerve courses over the scalenus muscle and is usually far lateral to the position of the sympathetic. Having once successfully identified the cervical sympathetic chain, the surgeon experiences no doubt in subsequent operations. At first, however, it is well to identify absolutely the nerve before cutting it by following it up to the fusiform superior cervical ganglion.

Step 4. After positive identification, liberate as much of the trunk as is necessary for the completion of the operation. If the entire cervical chain and stellate ganglion are to be removed, free the superior cervical ganglion and dissect downward, using the freed part of the chain for traction. After cutting its lateral branches, either sever or avulse the superior ganglion from its cranial attachments. The cervical chain may appear in front of or behind or may surround the inferior thyroid artery. Continuing downward, the inferior cervical ganglion is usually found against the neck and head of the first rib between the scalenus anticus and longus colli muscles and just above the pleura. It is in intimate contact with the vertebral artery which is usually enlaced in a meshwork of sympathetic branches.

Step 5. Carefully free the vertebral artery, then retract downward and outward the thyroid axis, vertebral and subclavian vessels, the scalenus anticus muscle and the pleura and the sternomastoid muscle and the carotid sheath with its contents. Divide the lateral branches of this ganglion and follow the sympathetic trunk upward to the first thoracic ganglion. These two ganglions lie very close together and may appear almost fused. On occasion a small ganglion appears in what Jonnesco has termed the "Scaleno-pleuro-vertebral well" which rests posterially against the transverse process of the seventh cervical vertebra and the first and second ribs. It is important, while dissecting, not to break the cervical chain which acts as a valuable guide to the inferior cervical and first thoracic ganglion which often are in their cervical position. Besides, it acts as a tractor to deliver these ganglia from the thorax.

Step 6. Hemostasis. Close the wound with fine silk; this is also employed for ligatures.

Comment.* **General anesthesia, local anesthesia or a combination of both may be used. The principal dangers of the procedure are injuries to the following structures; vertebral artery and vein; the first intercostal artery or its cervical branch; the subclavian vessels; the pleura; the retroclavicular venous-plexus and the thoracic duct on the left side.**

To remove only the superior cervical ganglion many use an incision anterior to the sternocleidomastoid muscle, opposite the bifurcation of the common carotid artery. This incision may be transverse. The sternomastoid is displaced with a retractor outward, the neurovascular bundle toward the midline, the connecting branches of the ganglion are divided and the ganglion is severed or avulsed from its attachments.

* Consult, in this connection, ligation of the vertebral artery, p. 599, and consult Figs. 667 and 668.

In cervicothoracic sympathectomy it is not difficult to lift the trachea and esophagus forward and divide the sympathetic nerve on the opposite side.

RAMICOTOMY

(See also p. 542, Stoffel's operation)

Ramicotomy was introduced in 1924 by Hunter and Royle for treating spastic paralysis; Gaza employed it for the relief of gastric pains (tabetic crisis) and René Leriche resorted to its use in painful conditions of the extremities. According to Leriche, ramicotomy may be performed in the (a) cervical, (b) dorsal, (c) lumbar or (d) sacral region.

CERVICAL RAMICOTOMY

The superior branches in the cervical region may be exposed by making an incision along the posterior margin of the sternomastoid muscle. Care should be taken not to go beyond the prominence of the external jugular vein, below, which indicates the direction taken by the spinal accessory nerve.

If it is desired to expose the inferior nerve, the following technic has proved successful:

Step 1. Make an oblique incision 6 cm. long between the two bellies of the sternocleidomastoid and in the direction of its fibers, terminating on the superior margin of the clavicle. Retract the tissues.

Step 2. The plane of the intermediate aponeurosis is uninterrupted and isolates the sternocleidomastoid bed. The omohyoid muscle is seen beneath the sheath of the aponeurosis; a fat-pad protrudes below it. Make an incision beginning at the omohyoid muscle. Divide the muscle a short distance from the intersection of its fibers. If a small artery is divided on the upper surface, ligate it. Completely divide the aponeurosis. The incision should extend anteriorly to the neuro-vascular bundle in the neck; posteriorly, it should extend to the scalenus muscle and the phrenic nerve and below to the subclavian artery. If the incision is directed toward the thorax, the thyroid artery, the vertebral artery and the sympathetic nerve will be exposed.

Step 3. Expose the prevertebral space. Dissect the adipose tissue from it, thus exposing anteriorly the internal jugular vein, the common carotid artery and the pneumogastric nerve which are drawn to one side with a blunt retractor. Posteriorly, the phrenic nerve crosses the surface of the scalenus. Direct the point of the instrument by visual guidance. Small tampons immersed in normal salt solution and a blunt instrument like a Kocher's director facilitate the manipulations. One retractor pulls the structures gently outward and the other inward.

Step 4. Isolate the inferior thyroid artery. The vessel varies in size; it is well exposed from the subclavian artery to the thyroid. The anterior branch of the sympathetic and the loop of Vieussens are exposed. The latter does not always appear where it is expected. Insert a thread under these branches and retract them. Draw the thyroid artery outward by means of a retractor.

Step 5. Expose the vertebral artery which lies deeper and farther back than the thyroid (see also ligation of vertebral artery, p. 598). It may be located, unless the patient is very fat, by pressing a damp sponge on the deep layer.

Step 6. Exposure of the ganglion and its branches is accomplished by dissecting the deep tissues and connecting branches under visual guidance. Bleeding rarely follows. The subclavian artery is barely visible.

If complete section of the second cervical and first dorsal is aimed at, they will be found coursing from above downward.

CERVICAL RAMISECTION*

In this operation only the rami communicantes are divided. Only in approaching the first thoracic nerve does the sympathetic trunk come into the operative field. The first thoracic nerve itself usually has both a white and gray ramus while the rami above it have postganglionic fibers. As a rule, the sympathetic rami join the nerve roots of the brachial plexus after they leave the intervertebral foramina, although sometimes they enter the nerve roots within the foramina. The normal site for the nerve roots of the brachial plexus is between the scalenus anterior and scalenus medius muscles, according to anatomists. However, it is much more common to find the fifth and sixth roots penetrating the scalenus anterior: many times these roots appear in front of the muscle. A bundle of muscle fibers often divides the seventh and eighth nerves. The eighth cervical and first thoracic nerves usually appear back of the scalenus anterior. The operation is simple if the nerves form a regular plexus; the emergence of each nerve root separately through the scalenus anterior renders the procedure much more complicated. (Fig. 631.)

Step 1. Place the patient on his back, turn his chin away from the site of operation and put a pillow under his shoulders. Make an incision from the clavicular insertion of the sternomastoid backward and upward across the posterior triangle. It may be necessary in some instances to make a second small incision, directing it upward along the posterior border of the sternomastoid so as to be sure of reaching the fibers connecting the fifth and sixth nerves.

Step 2. Divide the platysma and secure the external jugular vein in the line of the original incision. Divide the front layer of cervical fascia and by means of blunt dissection expose the deep layer of fascia which covers the brachial plexus and the scalenus muscle; the superficial cervical artery is often encountered between the two layers; the transversus coli artery often appears in a deeper plane between the seventh and eighth nerve-roots; ligate and divide this artery. Retract the omohyoid muscle downward.

Step 3. Identify the phrenic nerve in the upper part of the plexus. Expose the nerve-roots to the intervertebral foramina. Draw the subclavian artery forward exposing the eighth cervical and first thoracic nerve. The rami communicantes are difficult to identify; those connected with the fifth and sixth nerves may traverse the scalenus anterior in front or they may penetrate the muscle itself. There may be two or more branches making it necessary to exercise care to see that all of the nerve roots and their anterior connections are separated up to the intervertebral foramina. In some cases gray rami are joined to the nerve roots on their antero-inferior aspects. Medullated muscular branches appearing on the front surface of the nerve

* After Royle.

roots may be confused with the sympathetic; if there is any doubt concerning their identity, they should be removed. If the phrenic nerve is connected to the fifth cervical nerve, retract it. Great difficulty is likely to be experienced with the eighth cervical and first thoracic nerves. The latter should be looked for across the neck of the first rib; the nerve trunk may be traced into the thorax. The cervical sympathetic trunk is usually located

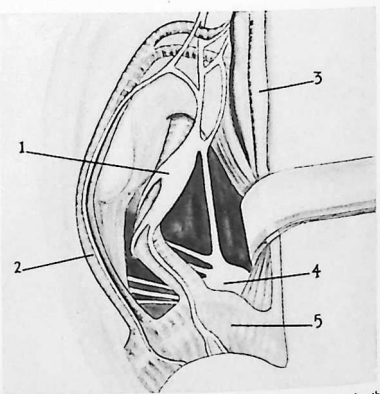


FIG. 631. 1. Here the intermediate ganglion is seen. This is often mistaken for the stellate ganglion, 2. inferior thyroid artery, 3. common carotid, 4. stellate ganglion, 5. subclavian artery.

behind the subclavian artery thus facilitating the identification of the communicating rami to the eighth nerve. From here on this trunk tends to follow a medial course into the neck, but may sometimes be found on the eighth nerve-root. Avoid, if possible, the gray ramus of the first thoracic nerve which is found on its superior surface medial to the white ramus. Use a small strabismus hook to divide the rami in this operation.

Step 4. Close the wound by approximating the edges of the platysma and suturing the skin. Drainage is unnecessary.

DORSAL RAMICOTOMY

Ramicotomy is a rather difficult task to accomplish. Gaza recommends approaching the dorsal nerve in the deepest part of the intercostal space which is made larger by resecting the corresponding transverse process. The connecting branch is approached where it ends on the intercostal branch of the dorsal nerve.

Step 1. Make a vertical incision starting 4 cm. above the highest of the intervertebral spaces to be reached and extending two finger breadths from the line of the spines.

Step 2. Detach the vertical muscles from the grooves where necessary about 3 cm. outward from the costal tuberosities.

Step 3. Resect the transverse processes and search for the nerve in the intercostal space. Retraction of the soft parts with a moist tampon is helpful. If the nerve cannot be seen, incise the muscle fibers perpendicularly. The endothoracic fascia will be seen to form a bed for the nerve.

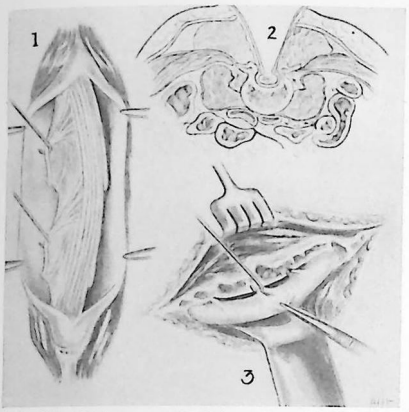


FIG. 631A. Dorsal Ramicotomy. 1. Foerster's operation. Lateral exposure of dorsal roots. Tension on the two dorsal roots by means of delicate hooks, exposes the dentate ligaments. Observe that the anterior motor roots are visible through the dentate ligaments. 2. Semidiagrammatic cross-section through the lumbar spine showing opened dura and topographic anatomy in performing Foerster's operation. 3. Guleke's modification of Foerster's operation. The osseous structures have been removed exposing the dura mater which is picked up with a delicate tissue forceps and pulled to the side. This maneuver enables the surgeon to expose the nerve roots on the corresponding side. In the illustration the uppermost dorsal nerve roots are shown divided, the next root to undergo division is seen on a hook. (After Victor Schmieden.)

Step 4. With a hook, grasp the nerve trunk, drawing it outward, backward and upward, thus liberating the inferior connecting branches. After incising the branch, lower the intercostal to make sure there is no superior connecting branch as sometimes happens. (Fig. 631A.)

LUMBAR RAMICOTOMY

The best method for doing a unilateral ramisection is the procedure known as lateral subperitoneal laparotomy.

Step 1. Make a vertical incision beginning at the front end of the eleventh rib and extending downward to 2 cm. above the anterior superior iliac spine, then turn making the incision parallel with the crural arch 3 cm. over it, as far as the margin of the rectus muscle. In cases where the costo-iliac space is extremely narrow it may be advisable to make a superior transverse incision beginning at the apex of the eleventh rib about 8 to 16 cm. long. The intercostal, iliohypogastric and ilio-inguinal nerves are not divided. The muscles are incised in layers. It is hardly ever necessary to incise the major oblique but the minor oblique and transversalis are cut transversely.

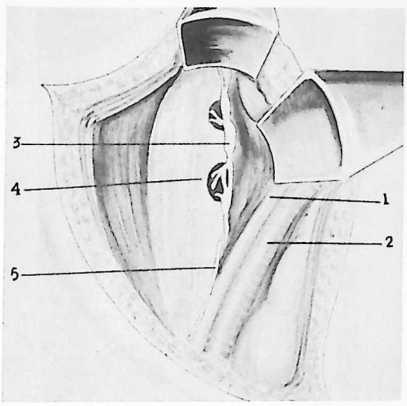


FIG. 632. The second and third lumbar ganglia are seen with their rami communicantes. The fourth lumbar ganglion is behind the iliac vessels. Its ramus communicans is situated beside the genitofemoral nerve. 1. Common iliac vein, 2. common iliac artery, 3. second lumbar ganglion, 4. psoas muscle, 5. genitofemoral nerve.

Step 2. Incise the transversalis fascia thus opening the subperitoneal space.

Step 3. Liberate the peritoneum by pushing the intestines inward with a sponge, thus exposing the psoas and surrounding area as far as the iliac vessels and spinal column.

Step 4. With a large valve retractor, force the intestine inward toward the midline. With another retractor displace the structures upward and outward exposing the common iliac vessels, the origin of the vena cava or the aorta (depending on the side involved) and the lateral aspect of the lumbar column (Fig. 632). The sympathetic is found lying on the prominence of the psoas in front of the vertebral column. The lymphatic vessels and

nodes are seen across to the midline. The nerve-chain is generally observed on a level with the third lumbar ganglion from whence it is easily followed.

Step 5. Exert force on the upper retractor to expose the second ganglion from which branches emerge and disappear under the arch of the psoas muscle.

Step 6. After incising the first four branches, expose the fifth by detaching the iliac vessels from the deep layer and elevating them. The sacral communicating vessels are sometimes difficult to locate but should be searched for on the internal aspect of the common iliac vessels above the hypogastric artery.

Comment. There seems to be a tendency toward the formation of a neuroma on the divided sympathetic nerves. René Leriche is inclined toward the belief that the reported failures of sympathetic nerve surgery are due to the formation of such neuromas.

Ramicotomy is indicated in spastic paralysis, angina pectoris, bronchial asthma, abdominal visceral discomfort and painful conditions in the extremities as well as abnormalities of the vasomotor system.



FIG. 632A. Ramicotomy. The fifth lumbar nerve root is seen retracted on a hook. The dorsolateral sensory root is separated by means of another hook from the ventromedial motor root. (After Küttner.)

PRESACRAL NERVE RESECTION

Anatomic Considerations. (Fig. 633.)[1] (1) The plexus submesentericus of Winslow; (2) the nervus uterinus magnus of Tiedemann; (3) the plexus uterinus magnus of Frankenhauser; (4) the presacral nerve of Latarjet and Bonnet; (5) the prelumbar nerve of De Rouville; (6) the superior hypogastric plexus of Hovelacque is, according to Elaut, made up about as follows: Beginning in the plexus situated between the superior and inferior mesenteric arteries, to these nerve-elements are added the intermesenteric nerves of Petit-Dutaillis and Flandrin, also lumbar sympathetic fibers from both sides, so that at the level of the inferior mesenteric artery these nerves divide into two distinct bundles—the inferior mesenteric plexus and the superior hypogastric plexus.

According to Hovelacque, the superior hypogastric plexus is essentially a continuation of the inferior mesenteric plexus below the inferior mesenteric artery and includes the part of the plexus that extends from the superior part of the fourth lumbar vertebra to the middle of the first sacral vertebra, where it divides into two terminal plexuses called the right and left inferior hypogastric plexuses.

Important branches to this plexus come from the lumbar sympathetic chains. Delmas and Laux found that branches come from the first and second lumbar ganglia, also from the third and fourth, and that the superior mesenteric plexus is made up in similar fashion to the splanchnic nerves and consequently these branches are often referred to as the pelvic splanchnic nerves. About one inch below the origin of the inferior mesenteric artery the superior hypogastric plexus begins. The plexus enters the pelvis over the bifurcation of the aorta, crosses the left iliac vein, passes over the sacral promontory and on down over its anterior surface. According to the studies of Elaut, also Dobrzaniecki and Serafin, the arrangement of the plexus is quite irregular

[1] John E. Cannaday, Annals of Surgery, 1936.

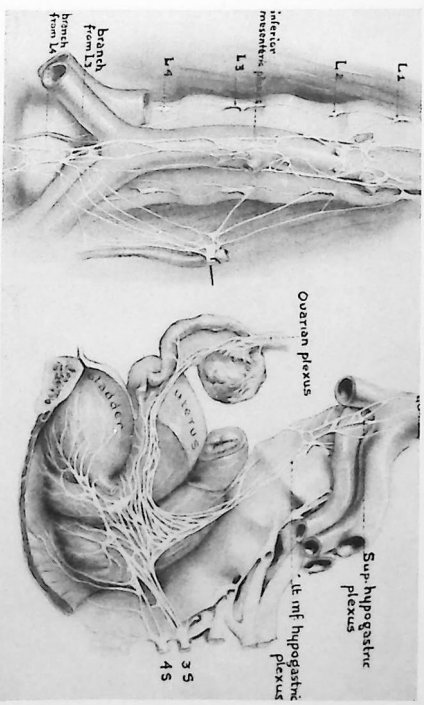


FIG. 633. Showing the origin of the superior hypogastric plexus as a continuation of the inferior mesenteric plexus, and the important branches to it from the first, second, third and fourth lumbar ganglia. (Courtesy of John E. Cannaday.)

FIG. 634. Showing the division of the superior hypogastric plexus into its two terminal plexuses, the right and left inferior hypogastric and the distribution of the fibers from these to the uterus, ovary and bladder. Fibers from the 3, 4 and 5 will also be noted.

and variable, sometimes approaching a definite band and again spreading out fanwise in several branches. Generally speaking, the lower end of the superior hypogastric plexus is about on the level of the bifurcation of the common iliac artery. Segond has shown the plexus to consist of a network of nerve-fibers closely united by anastomosing branches and connective tissue. It extends from the upper part of the lumbar to the middle of the first sacral vertebra. Elaborate histologic studies of the pelvic sympathetics and their ultimate distribution have been made by Kuntz, also by Dahl.

Indications. This procedure is indicated in cases of dysmenorrhea where there is no organic lesion; in cases of inoperable carcinoma of the pelvis not associated with bony metastases or ureteral blockage. It may in some instances be indicated in cases of dyspareunia, vaginismus and pruritus vulvae.

This operation is recommended by Kindel and others in cases where there is a dull, deep ache in the pelvis during and just before the menstrual period, especially if the pain extends toward the coccyx, the rectum and inner part of the thighs.

Rozemon, Lambret and others are of the opinion that presacral nerve resection has a tendency to regularize the menstrual function, cause the absorption of pelvic adhesions and to do away with parametritis and inflammatory lesions in the pouch of Douglas.

This operation may be accomplished by resecting the superior hypogastric plexus alone, or by resecting the inferior mesenteric ganglia, or resecting or dividing the lumosacral sympathetic on both sides, or it may be a combination of all the above-mentioned procedures. In most cases a left rectus incision is made which extends a little above the umbilicus although a Pfannenstiel incision may also be employed. Many surgeons recommend the resection of the plexus above and direct the dissection of the nerve fibers downward, but Cannaday prefers to start below. (Fig. 634.)

Dangers of Operation. In some instances the inferior mesenteric vessels are directly connected with the presacral nerve, especially when the pelvic mesocolon is centrally implanted and overlaps the left iliac vessels. According to Elaut this occurs in about 8 per cent of cases and complicates the resection of the nerve fibers without injuring important blood vessels. In some cases the fibers of the plexus project outward under a long loosely mobile mesocolon instead of across the trigone, bounded by the iliac vessels. A case was recorded in which there was a large anomalous vein which passed across the interiliac trigone draining into the common iliac vein.

Results. From a total of 85 presacral neurectomies, Cannaday concludes that the most favorable results have been with the primary type of dysmenorrhea. There have been a few recurrences among the first apparently successful cases. Two of the recurrent cases have been re-operated on and in both instances it was discovered that neuromas had formed on the divided ends of some of the nerve-fibers which probably caused the pain. Other failures were attributed to incomplete operations, abnormal distribution of nerve fibers and to improper selection of cases.

Many of the cases operated upon were of the most severe type, and were associated with nausea and vomiting as well as pains radiating down the thighs at the menstrual period so excruciating as to cause the patient to remain in bed for several days as well as receive hypodermic injections of morphine. Many of these patients stated that the operation had relieved them more than could be imagined, giving them a new outlook on life.

Intercurrent infections, such as tubo-ovarian inflammation of venereal origin is sometimes the reason for the patient's failure to obtain lasting relief.

According to Craig there will probably always be as much as 10 per cent of poor results in cases of dysmenorrhea, due to the borderline type of case, some of them being the victims of a constitutional biologic inferiority.

SURGICAL EXPOSURE OF THE LUMBAR SYMPATHETIC TRUNKS BY MOBILIZATION OF THE ROOT OF THE MESENTERY

Albert Gutierrez points out that in the adult the root of the mesentery represents the termination of the process of coalescence downward of the primary meso with the intestinal tract. In these zones of peritoneal fusion the coalescence-

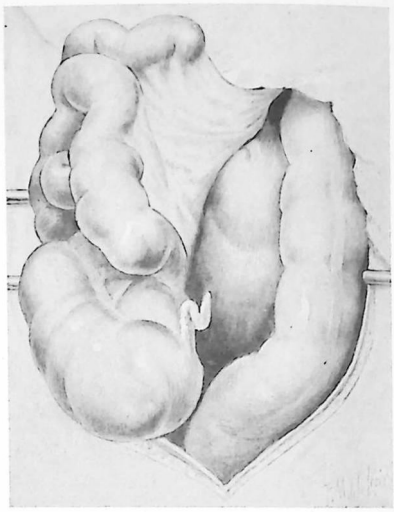


FIG. 635. The mass of the small intestine is pulled downward and to the right, bringing into view the left surface of the mesentery and its zone of parietal fixation. (Gutierrez.)

laminae are formed of loose connective tissue which permit easy separation of the fused elements. Gutierrez' method of mobilization of the root of the mesentery is based on the existence of these laminae.

Step 1. Place the patient in the Trendelenburg position; open the abdomen.

Step 2. Displace and pack away the intestines to the right. The left surface of the mesentery is thus exposed (Fig. 635).

Step 3. Trace a rectilinear incision varying in length, a little beneath and to the left of the root of the mesentery (Fig. 636).

Step 4. Grasp the mesentery with a Kocher forceps, pull it downward and to the right. More or less abundant loose connective tissue will be found here



FIG. 636. Following incision of the peritoneum and pulling the mesentery downward, the aorta, vena cava, ureter and spermatic vessels are seen. (Gutierrez.)

covering the terminal portion of the aorta and vena cava, the right common iliac artery, the ureter and genital vessels (Figs. 637-638).

Step 5. With a Farabeuf separator the right border of the inferior vena cava, is displaced toward the median line; the right lumbar sympathetic is now seen and by prolonging the incision a little more toward the left and pulling the aorta toward the right, the left lumbar sympathetic is brought into view (Figs. 637-640).

Step 6. Close the peritoneum (Fig. 641).

LUMBAR SYMPATHETIC RAMISECTION

The technic of the extraperitoneal operation as described by Royle* is as follows:

"The patient should be made to lie on the side opposite to that of operation and shou'd be inclined slightly toward the surgeon who faces the patient's back.

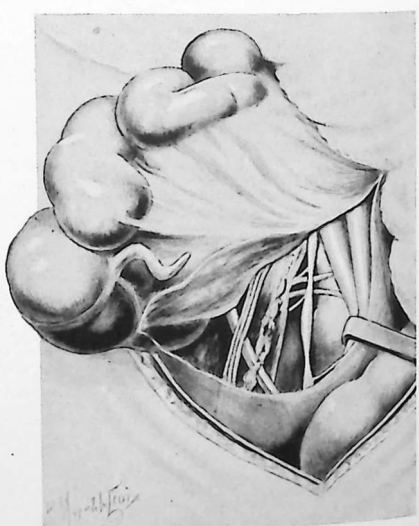


FIG. 637. A retractor pulls the descending vena cava out of the way, exposing the lumbar sympathetic and its communicating branches. (Gutierrez.)

The space between the ribs and the crest of the ilium should be made as wide as possible by placing a sandbag beneath the patient or better still by using the adjustable support devised for operations on the kidney.

"**Step 1.** The incision is made from the last rib to the crest of the ilium and thence forward to the anterior superior spine of the ilium. If the quadratus lumborum muscle can be palpated, the downwardly directed part of the incision should follow its lateral margin, but if not, the lateral margin of the

*N. D. Royle Med. J. Anat. 1924, p. 77.

sacro-spinalis should serve as a guide. The forwardly directed part of the incision should lie about one centimeter below the actual crest of the ilium. This enables the attachment of the external oblique muscle to be exposed. The flap of skin and fascia outlined by this incision is reflected forward to expose the attachments of the latissimus dorsi to the lumbodorsal fascia and of the external oblique muscle to the crest of the ilium.

"Step 2. The trigonum lumbale Petit is next defined and from this point forward the oblique muscles are freed from the crest of the ilium to within six or eight centimeters of the antero-superior spine of the ilium. In doing this



FIG. 638



FIG. 639

FIG. 638. Exposure of the right sympathetic; in the upper part the third portion of the duodenum is seen.

FIG. 639. Exposure of the left sympathetic; above are seen the third portion of the duodenum and the beginning of the fourth.

it is possible in most subjects to divide the external oblique through definite tendinous tissue close to its insertion and to avoid cutting the actual muscle fibers. This gives a decided advantage in closing the wound. The internal oblique and transversus abdominis muscles are divided through the muscle fibers close to their attachment. The dissection is then carried upward and the lumbodorsal fascia is divided at the lateral border of the quadratus lumborum. In doing this it may be necessary to cut through the fibers of the latissimus dorsi.

"Step 3. The abdominal wall is now free to be thrown forward and after dividing the fascia transversalis the hand can be passed in front of the quadratus lumborum and the psoas muscles until the medial border of the psoas is palpated. Suitable retractors are then placed in position. Care should be taken not to disturb the fascia covering the quadratus lumborum and fascia covering the psoas muscle.

"In a very fat subject, however, the approach to the sympathetic trunk may be rendered more easy by leaving the transversalis fascia intact except at the medial border of the psoas muscle where it must be pierced to reach

the sympathetic trunk. The ganglionated sympathetic trunk can often definitely be palpated where it lies at the medial border of the psoas muscle before it can be seen. The psoas itself sometimes constitutes a difficulty in the adult subject by obscuring the trunk from view and a suitable retractor is necessary to flatten the muscle. In children and poorly developed subjects this difficulty is not great.

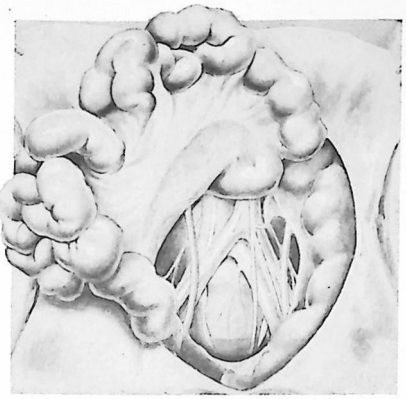


FIG. 640. View of the retroperitoneal organs exposed by means of mesenteric mobilization. (Gutierrez.)

"The ganglionated sympathetic trunk will be found lying on the bodies of the lumbar vertebrae near the medial border of the psoas muscle. The abdominal sympathetic trunk on the left side is easy to define, if the medial border of the psoas is sought. In this situation a thin layer of connective tissue passes from the psoas muscles across the sympathetic trunk and great vessels to the region of the psoas on the opposite side. This is easily slit with a blunt dissector and the sympathetic trunk comes into view. On the right side the trunk lies under the lateral margin of the inferior vena cava and is usually placed anteriorly to the lumbar vessels. On the left side this complication has not been met, but in young subjects the lumbar arteries can be mistaken for rami communicantes which they sometimes resemble in size and direction.

"In defining the sympathetic trunk long blunt dissectors are necessary. A long probe with a flat handle and curved on its end like a strabismus hook is useful for lifting the sympathetic trunk when defining its branches. Long

straight or slightly curved artery forceps, 20 centimeters long, are also essential and four should be provided. The structure of the abdominal wall and abdominal viscera demand a large, broad and deep retractor. The sympathetic trunk and the rami communicantes should be clearly defined before section. The method of dividing the rami communicantes is usually by



FIG. 641. Approximation of the peritoneal edges at the termination of the operation. (Gutierrez.)

avulsion. Each ramus may be seized by a pair of artery forceps and drawn away from its lateral connections, though in many instances it is necessary to divide a big ramus with a long pair of blunt-pointed scissors. When ramisection of the second, third, and fourth lumbar nerves has been effected, the ganglionated cord is then divided at a level corresponding in position to the fourth lumbar nerve. The operation is then completed. The edges of the lumbodorsal fascia are first sutured in the region of the trigonum lumbale. The oblique muscles are then sutured to the crest of the ilium and a special

point is made of suturing the tendinous portion of the external oblique to its original attachment and to the adjacent fascia lata. When this is done carefully the raw area on the crest of the ilium comes in contact with a raw area of considerable width on the under surface of the external oblique tendon and this facilitates adhesion. The lumbodorsal fascia and the latissimus dorsi muscles are then sutured. The skin is closed without drainage."

SINGLE TRANSABDOMINAL INCISION FOR THE EXTRAPERITONEAL APPROACH TO THE LUMBAR GANGLIA

C. E. Rees[1] approaches the lumbar ganglia through a single transabdominal extraperitoneal incision as follows:

Step 1. Make a midline incision through skin and fat extending from the symphysis pubis to one inch below the umbilicus.

Step 2. Develop the incision into a Y with its upper limbs extending on each side of the umbilicus over the inner one-third of the rectus muscle to a point midway between the xyphoid and the umbilicus (Fig. 642 A).

Step 3. Separate the superficial fascia from the inner halves of the rectus sheaths on each side, in the lower part of the incision, to a point in the same lateral plane as the upper limbs of the incision.

Step 4. Make a longitudinal incision in each rectus sheath so that one-third of the muscle lies medial and two-thirds lateral to each incision.

Step 5. Incise the rectus muscle in the same plane, carrying the exposure to the posterior sheath of the rectus in the upper three-fourths and to the peritoneum in the lower one-fourth of the incision (Fig. 642 B).

Step 6. Separate the posterior sheath from the peritoneum by inserting a finger between these structures lateral to the outer border of the rectus muscle. The separation is carried inward toward the midline by digital dissection. (This approach is necessary for the development of this plane) (Fig. 643 A).

Step 7. Incise the posterior sheath, not the peritoneum, lateral to the deep epigastric artery leaving the artery on the medial side of the incision (Fig. 643 B).

Step 8. Place the patient in the low Trendelenburg position.

Step 9. Separate the peritoneum laterally from the abdominal fascia and retract the abdominal contents toward the opposite side exposing the aorta and iliac vessels on the left and the vena cava and iliac vessels on the right (Figs. 643 C and D).

Step 10. Close in layers with single continuous chromic catgut sutures the posterior sheath and muscle and single interrupted chromic catgut sutures with simple square knots the anterior sheath, the latter is reinforced with figure-of-eight silkworm-gut sutures.

Step 11. Insert figure-of-eight sutures in the branching limbs of the incision; the lower loops of these sutures alternate on opposite sides of the fascial incisions, one suture passing through skin and fat and looping through the right rectus sheath to exit through the fat and skin on the opposite side, the next suture passing through the skin and fat and looping the left rectus sheath to emerge through to the fat and skin. One end of each superficial loop of the figure-of-eight sutures, after emerging from the skin, is passed

[1] Am. Jour. of Surgery, May, 1936.

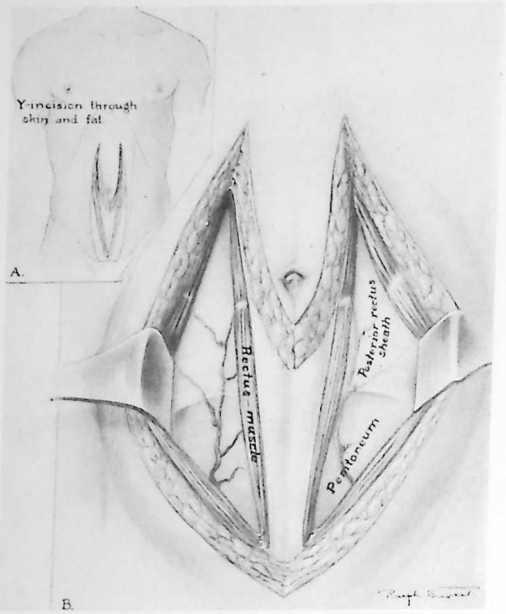


FIG. 642. Extraperitoneal approach to the lumbar ganglia. A. Y-incision through skin and fat. Dotted lines indicate areas of separation of deep fascia from rectus sheaths. If operation is to be unilateral, the incision swings only to the side of the umbilicus on which the operation is to be performed. B. Incision of rectus sheath and rectus muscle on each side exposing the peritoneum in the lower part and the posterior sheath in the upper part of the incision. If the operation is unilateral, the rectus sheath on that side only is opened. (Courtesy, Dr. C. E. Rees.)

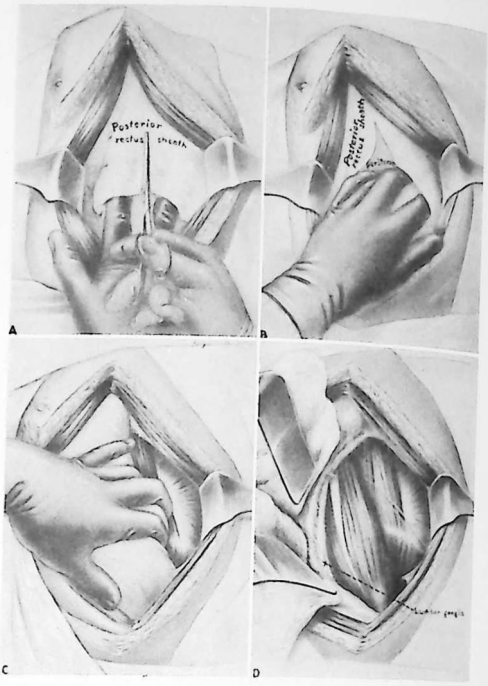


FIG. 643. Extraperitoneal approach to the lumbar ganglia. A. Incision of posterior rectus sheath. This incision does not extend through the peritoneum. B. Separation of posterior rectus sheath from peritoneum. C. Retraction of the peritoneum with its contents, left side. D. Peritoneum retracted and the lower lumbar ganglia exposed, left side. (Courtesy, Dr. C. E. Rees.)

again through the margins of the skin incision and tied to one side of the skin incision.

Step 12. Pass rubber tubing under the silkworm loops above the skin and tie the sutures over the rubber tubes thus obliterating dead spaces within the incision.

Step 13. Close the skin with clips.

Royle Technic

N. D. Royle[1] (1924) described an extraperitoneal approach to the lumbar sympathetic ganglia. This has gradually gained favor over the trans-abdominal route. The advantages claimed for the operation are a lower mortality and smoother postoperative course. Its disadvantage lies in the fact that only one side is treated at a time. It was also pointed out that in the transabdominal approach it is difficult sometimes to remove the second right lumbar ganglia; also that the complications innate to intra-abdominal surgery are eliminated through this approach. In the Royle operation, the external and internal oblique muscles are separated from their attachments to the iliac crest by dividing directly across their fibers close to their insertions. The drawbacks to such division are augmented tissue reaction, accumulation of serum, difficulty to approximate retracted ends without strangulation, additional trauma, delayed healing, possibility of infection and incisional hernia.

Pearl Technic

Felix R. Pearl[2] described an improved extraperitoneal approach for lumbar ganglionectomy which he has developed since 1934, and the excellent features of which are that the entire procedure is accomplished by muscle splitting which eliminates transecting of muscles and the undercutting of skin and subcutaneous tissues. This technic affords prompt and easy access with excellent exposure of the lumbar sympathetic chain over its entire extent. The opposite side may also be operated on without much disturbance. If the postoperative course is smooth, the patient may be allowed up on the third day.

Subarachnoid block is preferable because it gives complete muscle relaxation.

Step 1. Place the patient supine with the side to be operated upon slightly elevated by a small pillow placed under the homolateral hip. Make a straight incision about 18 cm. long through the skin and subcutaneous tissues in the direction of the fibers of the external oblique muscle 4 cm. mesad to the anterior superior iliac spine, and extending from the lower costal margin to midway between the anterior superior iliac spine and the pubic spine. Expose the fascia of the external oblique muscle (Fig. 644).

Step 2. Split the external oblique muscle and fascia over the full extent of the incision in the direction of their fibers. Dissect the muscle carefully from the underlying internal oblique muscle, being careful to undercut only as much as necessary to expose the line of split in the internal oblique. Use retractors to expose the internal oblique where desired.

Step 3. Split the internal oblique muscle in the direction of its fibers so that the line of split points to the body of the second lumbar vertebra. Free the flaps from the underlying transversalis muscle and fascia; place retractors so as

[1] Med. Jour. Australia, 1924, p. 77.
[2] Surg., Gyn. and Obst., Vol. 65, July, 1937.

to expose about 15 cm. of the fascia at the level of the body of the third lumbar vertebra and in the direction of the muscular fibers (Fig. 645).

Step 4. Divide the transversalis muscle and its fascial continuation in the direction of their fibers for about 15 cm., the mesial limit being at the lateral border of the rectus sheath. The retroperitoneal fat is thus exposed. In splitting this layer, be careful not to injure the peritoneum. (Fig. 646.)

Step 5. Free with the hand the retroperitoneal fat containing the ureter from the underlying tissues. Carry the dissection to the fascia covering the quadratus lumborum and the psoas muscles. Dissect the retroperitoneal fat mesad

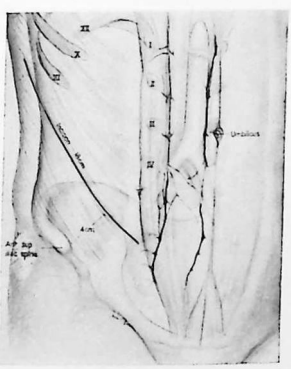


FIG. 644

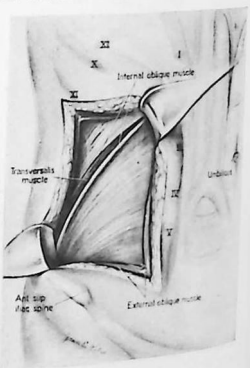


FIG. 645

FIG. 644. Skin incision and anatomic relations.

FIG. 645. The external oblique muscle and aponeurosis have been split for the full length of the skin incision without undercutting the subcutaneous tissue. The internal oblique muscle has been exposed and split in the direction of its fibers in a line pointing to the top of the second lumbar vertebra and from the iliac crest to the rectus sheath. The underlying transversalis muscle is thus exposed. (Courtesy of Dr. Felix L. Pearl and Surg., Gynec. and Obst.)

to the bodies of the vertebrae, cephalad to the crura of the diaphragm, and caudad to the brim of the pelvis. Retract the parietal peritoneum with the abdominal contents. Free the thin fascia covering the psoas muscle, great vessels and sympathetic chain (Fig. 607).

On the left side, the sympathetic chain is found on the bodies of the vertebrae in the sulcus between the psoas muscle and the aorta. (Fig. 647.) On the right side the vena cava usually lies directly over the sympathetic chain. (Fig. 648.)

Be careful to distinguish the sympathetic trunk from the lumbar lymphatic vessels.

Step 6. After the ganglionectomy and trunk resection, the retractors are held in place while the entire field is washed with warm saline solution. A large

number of fat particles will float in the solution and should be removed. Any bleeding points are ligated carefully. Remove the retractors and permit the tissues to come together.

Comment: The operation eliminates the transsecting of muscles, the undercutting of skin and subcutaneous tissues and gives quick, easy and excellent exposure of the lumbar sympathetic chain over its entire extent without harsh retraction; and allows closure without tension. There is no shock,

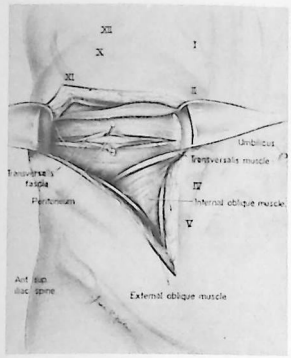


Fig. 646. The external oblique and internal oblique muscles have been retracted so as to expose the transversalis muscle. The latter has been split along its fibers for a distance of about 15 centimeters, the separation extending anteriorly to the lateral margin of the rectus sheath. The retroperitoneal fat is thus exposed. (Courtesy of Dr. Felix L. Pearl and Surg., Gynec. and Obst.)

and the wounds heal per primam. The patient may be discharged from the hospital after four or five days.

CHORDOTOMY

According to Dr. Eric Oldberg, this operation is primarily for the relief of pain which cannot be assuaged by a less radical method.

Historic Notes. Dorsal root-section was first suggested by Dana in 1886. Bennett first performed this operation in 1888. Mingazzini first proposed it for gastric crisis in 1900, and Küttner performed it in 1908. Because of the mortality and incomplete relief, posterior root section fell in esteem. Schüller in 1910 suggested the cutting of the anterolateral tract carrying pain and temperature impulses which Martin first performed in 1912. Beer repeated this the following year and Souttar in 1915. Since then Frazier, Leighton, Peet and Horrax reported a large series of cases.

The operation consists in the removal of the laminae of two or three vertebrae with exposure of the cord and section of the anterolateral tract. In order to expose

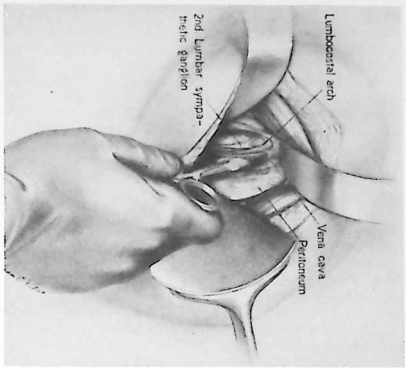


Fig. 647. The retractors have been moved cephalad. Another retractor, Deaver type, has been placed so as to expose the upper limit of the ureter. The ureter, together with the mesenteric fold, is retracted mesad. The vena cava has been further mobilized and held mesad. The highest ganglion seen is the second. The first ganglion lies under the insertion of the crura. Note that the rami connected to the second ganglion are directed sharply cephalad, a fact which allows of its easy identification. (Courtesy of Dr. Felix L. Pearl and Surg., Gynec. and Obst.)

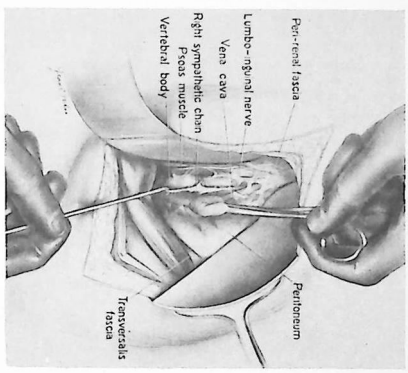


Fig. 648. The retroperitoneal tissues have been separated from the underlying muscles with the hand. The Royle retractor is in place. The ureter, together with the mesenteric fold of peritoneum mesad, has been freed of its surrounding tissues and retracted mesad. The vena cava has been with the help of a mounted gauze sponge. The sympathetic chain has been thus exposed and is shown drawn taut by a blunt hook. At this level one sees the third ganglion with the rami directed transversely or caudad.

the anterolateral tract it is usually easiest to grasp the dentate ligament and rotate the side of the cord upward so as to better expose the tract one expects to cut. The actual section may be done by means of a small sharp knife or by hooking out the fibers with a small specially measured hook which has been devised for the purpose, and then cutting them. The important precautions to remember are, never to injure any of the tissue lying posterior to the plane joining the two opposite dentate ligaments, and never to incise more deeply than 3 mm.

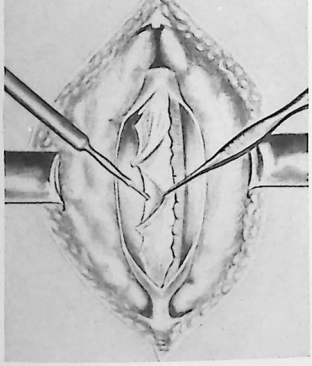


Fig. 648A. Chordotomy. (After Victor Schmieden.)

For lower abdominal and leg pain the site of choice is usually about the fourth dorsal vertebra, this being the easiest place of approach because of the normal convexity of the spine. Chordotomy can be done, theoretically, at any level except in the portion of the cervical cord in which the phrenic nuclei are located. If the pain arises from bilateral sources, bilateral chordotomy is performed. If it arises from one side only, section is made on the side opposite to which the painful area is situated. (Fig. 648A.)

SURGERY FOR VEGETATIVE PAIN (ANGINA PECTORIS, ENDARTERITIS, ETC.)

Felix Mandl points out the following pertinent observations:[1]

The surgery of pain consists in the interruption—elimination or destruction—of the conduction paths of pain in some accessible place. This can be done in two

[1] Wiener klinische Wochenschrift, April 24, 1936.

ways, viz., by the so-called paravertebral injections of alcohol, novocaine or a similar anesthetic, or by the surgical division or exeresis of rami, ganglia, sympathetic-fibers, etc.

Pains in Thoracic Organs (Angina Pectoris). By the paravertebral injection of alcohol at the level of the cervical segments (7th to 3rd or 4th), pains in the thoracic organs, especially angina pectoris, may be relieved. In severe cases, the treatment must be bilateral. As a rule unilateral treatment suffices. The technic is easy to learn. Relief results in angina pectoris in about 50 per cent of cases. The high percentage of failures may be explained by the many and diverse anatomic causes of angina pectoris. The injection, if successful, is also an indicator of an eventual operation on the rami communicantes.

As to the surgical intervention in angina pectoris, this consists in the extirpation of the two cervical ganglia, with or without the first dorsal (stellate) ganglion. Many, in accordance with Leriche, think the extirpation of the stellate ganglion is even more important than the exeresis of the two cervical ganglia (see cervicothoracic sympathectomy p. 553). Relief of pain is here more frequently obtained than with paravertebral injections. No matter whether the operation is successful or unsuccessful, the heart muscle is neither favorably nor unfavorably influenced. The high percentage of failures can be explained by the many and diverse basic anatomic and functional conditions of the symptom "angina pectoris" (coronary thrombosis or stenosis, cardiac defects, anemia, blood pressure crises, hyperthyreoses, spasms, etc.). This goes to show that we are not yet able to determine the path of pain in an individual case, so as to decide upon a definite causal indication, but that there are future possibilities.

The greatest chance of a causal treatment exists in the cases in which angina pectoris is due to spastic conditions or to a pathologic vascular tonus. In these cases, ganglionectomy, as stated, is, at present, the method of choice. The practical value of total extirpation of the thyroid glands in selected cases remains to be seen. If the angina pectoris is due to a blood pressure crisis in the presence of a suprarenal tumor, suprarenalectomy is, of course, the best therapy.

Of the other thoracic pains amenable to surgical treatment, cardiac and bronchial asthma are the most important.

Abdominal Pains. The relief of abdominal pain, on the other hand, is not only difficult but is also dangerous. The paths of pains are better known, it is true, and practically any pain in the region of the biliary and urogenital system can be relieved by a paravertebral injection. But these pains are important clinical symptoms, which it is dangerous to forego. In acute cases, the injection may, therefore, be used as a means of differential diagnosis, but not as a therapeutic measure. In chronic and clinically diagnosed cases, perhaps, it is also permissible as a therapeutic measure, if a surgical operation is contra-indicated.

Further indications for paravertebral injection and, in further consequence, of the division or exeresis of sympathetic elements are: chronic-adhesive conditions in the region of the gallbladder or the kidney, tabetic crises, inoperable carcinoma and the like. In these cases, not only is the pain relieved, but the function of the eliminated organ is fundamentally and intrinsically changed. Over and over again it has been possible to relieve puzzling painful conditions (pathologic peristalsis, chronic inflammatory changes of all kinds, nerve pains, etc.) by the means suggested.

Pains in the Extremities (Endarteritis Obliterans). As to pains in the

extremities, it may be said that the most urgent indication for their relief is endarteritis obliterans. It should be stressed that endarteritis obliterans, also called thrombo-angiitis obliterans, juvenile or spontaneous gangrene, etc., is an autonomous disease, to be distinguished especially from arteriosclerotic and diabetic gangrene, which should never be designated loosely by any of the above names. Pathogenetically, this disease, which occurs with preference in young adults, is due to chronic noxae such as nicotine, lead, etc., toxic diseases, such as typhoid fever and pneumonia, and thermic injury, such as cold and freezing. Constitutional factors, for instance, narrowness of the vessels, play an important rôle, of course, but are seldom recognized before an operation reveals them. Contrary to syphilitic changes, which are located in the media, the endarteritic changes, as their name indicates, are located in the intima.

The first symptom of endarteritis obliterans manifests a lesion of the big toe. This lesion is often reported to have appeared after an injury from cutting a nail. The gangrenous, as well as the pregangrenous stage, is associated with the most excruciating pains. Absence of the podalic pulse is not pathognomonic, since many healthy people are found without this pulse. The fact, however, that the pulse reappears during general anesthesia speaks for a spastic component. This might be used as a test for the selection of the therapy or operative indication. The same is true of lumbar anesthesia, but especially of capillary microscopy.

It is a matter of fact that every endarteritis obliterans is at first treated conservatively, but one may rightfully wonder why the most central operation—ramisection and removal of the lumbar ganglia—is not performed immediately after the diagnosis is made, or very soon, at least before the onset of gangrene, since gangrene is always irreparable. Internists should not demand of the surgeon a therapeutic miracle.

Medical therapy of endarteritis obliterans—mentioned for the sake of completeness—includes glyceryl trinitrate, sodium nitrate, kallikrein, mænformon, papaverine intravenously, strychnine, diuretin, 5 per cent, common salt solution intravenously, etc.; physical measures are diathermy, alternating hot and cold baths, dry heat, oil baths, short wave, roentgen and radium.

SURGICAL TREATMENT

1. Epidural anesthesia of the roots of the sciatic nerve with novocaine or alcohol.
2. Arteriography—Mandl had no results in three cases, but Sgalitzer and Demel among others recommend the method for diagnosis as well as for therapy.
3. Periarterial sympathectomy (Leriche) performed on the femoral artery above the bifurcation, should be used more frequently, in early cases, Mandl adds sympathico-diaphtheresis, that is, destruction by a chemical agent, to the mechanical detachment of the arterial sheath. Incidentally, Leriche's operation is also indicated in traumatic edema, trophic disturbances, severe dermatitides, eczemas, ulcer of the lower leg, Roentgen-ulcer and poorly healing fractures. Jenchel has performed it with advantage on the carotid artery in hemicrania.
4. Freezing of the exposed and exteriorized sciatic nerve according to Laewen and Wiedhopf by means of carbonic acid or ethyl chloride. Mandl has treated three cases, with success in one.

5. Arteriectomy (Leriche).
6. Lumbar ramisection (Leriche, Fontaine, Royle and Hunter) (vide supra).
7. Chordotomy. Atherosclerosis is an absolute contraindication.

DENERVATION OF THE ADRENAL GLANDS FOR NEUROCIRCULATORY ASTHENIA

Based on favorable results of experimental investigations of the adrenal-sympathetic system and on conclusions drawn from operations on the thyroid-sympathetic system in cases of hyperthyroidism, Crile sought to control certain analogous energy-transforming diseases, particularly those due to pathologic activity of the adrenal-sympathetic system. To this end, he has performed operations on the adrenal-sympathetic system in 126 cases.[1]

Anatomic Considerations. The technic of adrenal denervation requires a precise knowledge of the anatomy of the adrenal glands especially in relation to their nerve and blood supply, and to their position with relation to other organs.

The adrenal gland is a diminutive yellow pancake, golden in color, soft, friable and vascular. As indicated by its name, it is situated adjacent to the upper posterolateral aspect of the kidney and always close to the vertebral column. An arrow piercing both adrenal glands would pass approximately through the center of gravity of the body. The gland is held in place by strands of the sympathetic web, by the slender fibers from the neighboring fascial planes, and by its blood vessels. It is completely embedded in fat and, on palpation, the adrenal border gives an impression unlike that of any other organ except the external ear to which it is similar in contour and motility.

Precautions. The artery may vary in direction.

The right adrenal gland lies in proximity to the diaphragm, the vena cava, the liver, the head of the pancreas, the duodenum, the kidney and the vertebral column. The left adrenal gland lies in proximity to the tail of the pancreas, the spleen, the aorta, the diaphragm and the spinal column.

When the fascial sheet which binds the kidney to its halo of fat is opened, long blood vessels may be seen passing downward at the side of the kidney toward the vertebral column. These vessels are arrows which mark the trail to the adrenal gland. Generally there is an artery at the outer border of the adrenal and one also at the inner border, the largest artery being underneath, like the stem of a toadstool. From the adrenal glands thirty or more nerves emerge, and these are found on all aspects of the gland except the anterior surface where they appear at the borders.

In hyperthyroidism, the adrenal gland is greatly changed as to its vascularity, its adhesion to neighboring tissue, its appearance and its texture, just as in hyperthyroidism the hyperplastic thyroid gland differs from the normal gland in respect to vascularity, adhesion, texture and appearance.

In the course of manipulation incident to the exposure of all aspects of the adrenal gland and to the division of the nerves, oozing and sometimes smart bleeding are encountered. In no case, however has Crile found it necessary to tie a vessel because, happily, in this deep operative field clotting is spontaneous. This may well be accounted for by the fact that adrenalin facilitates the clotting of the blood, as demonstrated by Cannon.

Many years ago in researches on blood pressure, Crile found that, during manipulation of the adrenal gland, an immediate rise in the arterial blood pressure occurred and that immediately after manipulation the arterial blood pressure fell.*

[1] Surg., Gynec., and Obst., February, 1932.

* This was graciously demonstrated to the author by Dr. Crile in four consecutive cases.

Crile found from these researches that the only gland or tissue in the splanchnic area, the manipulation of which caused a rise in blood pressure, was the adrenal. The manipulation of every other gland in the splanchnic area caused either a fall in blood pressure or produced no effect.

Crile's Technic

Except in cases of high blood pressure, spinal anesthesia is the method of choice for denervation of the adrenal glands, since it produces complete relaxation and lessens bleeding. The alternative to spinal anesthesia is local and regional block anesthesia combined with analgesia or with nitrous oxide or ethylene. If the operation is being performed under local and regional anesthesia, then the adrenal glands, themselves, are blocked with novocaine, since, although they lie among tissues which are only slightly sensitive to pain, they themselves are sensitive.

In several cases with the patient in the prone position on the table, Crile has made the approach along the lumbar muscles through a vertical incision, believing that in this way he would approach the gland on its posterior aspect and by a shorter route. The special advantage of this method was that the nerves and blood vessels could be seen more directly, but the procedure had limitations due to the position of the patient on the table.

Crile has also made a vertical incision toward the anterior aspect of the adrenal along the tip of the twelfth rib but this method entailed too much contact with the peritoneum.

Recently, Crile's method has been to make a modified kidney incision. This incision, running from behind forward, terminating at about the middle of the twelfth rib, and is then carried downward vertically (Fig. 649a). The incision must be large enough to admit the hand into the renal space. Every bleeding point must be securely tied before the deeper dissection is begun. Since good exposure is essential, by means of a right-angled retractor, the twelfth rib is raised and the bloodless field is disclosed. After the renal fascia has been adequately incised, a long vessel may be seen in the renal fat, the vessel which, as stated above, marks the trail to the adrenal gland. The first step is to mobilize the upper pole of the kidney and to depress the entire kidney when usually the yellow curved edge of the adrenal pancake may be seen. If the adrenal is not seen, the hand is introduced, and by palpation toward the vertebral column and the great abdominal vessels, the external earlike border of the adrenal will be felt (Fig. 649b). At this point special instruments are introduced—namely, long slender dissectors at one end of which is a dull dissecting blade and at the other end a blunt hook. In addition, Crile uses a pair of blunt nerve hooks on a long shaft, a pair of French intestinal forceps, a tonsil dissecting knife, a fork retractor, and a pair of curved tonsil scissors (Fig. 650). These special instruments were constructed by Mr. V. B. Seitz of the Cleveland Clinic.

The softness and brittleness of the gland precludes grasping it in an instrument in order to hold it and orientate its position and also, owing to the nerve and blood vessel attachments, the gland can be moved only within a very short radius. For these reasons the operation must be carried out essentially *in situ*.

After the gland has been exposed by separating the fat, the blood vessels are identified, and then, by means of the blunt nerve hooks, tonsil scissors and

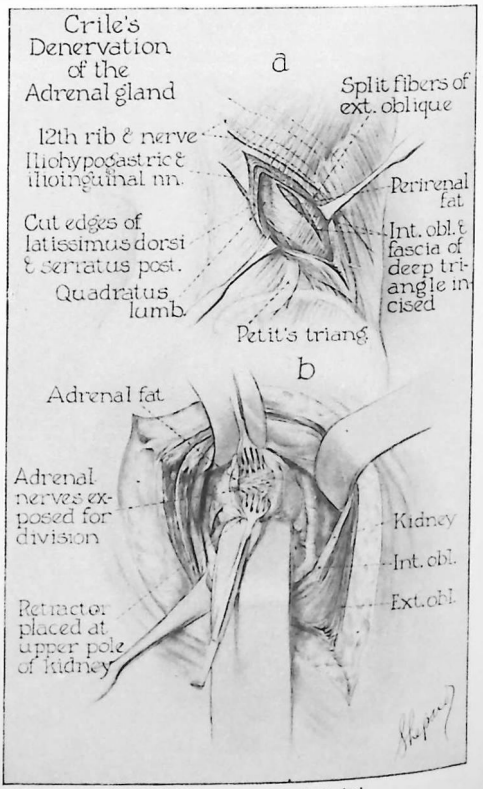


FIG. 649. Crile's denervation of the adrenal gland.

a long-handled tonsil knife, the nerves are divided. When this procedure has been completed, the adrenal gland will be quite mobile. It can then be raised up vertically from the vertebral column for a considerable distance.

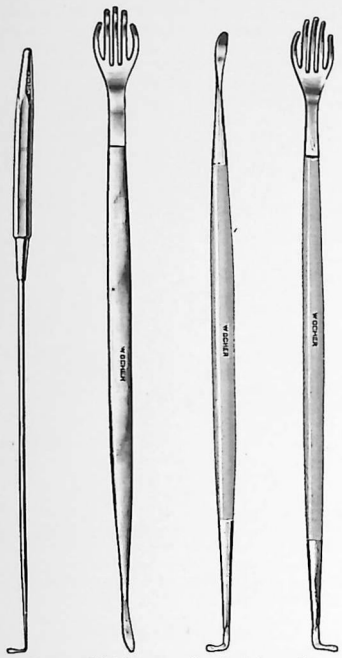


FIG. 650. Crile's instruments for adrenal denervation.

Owing to the loose retroperitoneal tissue and the danger of oozing, Crile has usually inserted two cigarette drains, in the lumen of which iodoform gauze has been placed. The iodoform is used to prevent the contamination of the blood serum along the drains from a staphylococcus infection from the skin. The important point to remember is that, in approaching the glands, rigid attention should be paid to landmarks and the operating field should be bloodless.

Immediate Operative Results

Crile comments:

"Since the operation is performed in a territory of meager sensory innervation, and the blood loss is slight, there is but little shock. In 126 cases, there have been no deaths from anesthesia, pneumonia, shock or hemorrhage. There have been two physiologic deaths, but such deaths are now easily avoidable.

"It is most important to state again that the clinical results in cases of diseases of mental or psychic origin, which may be confused with neurocirculatory asthenia, are negative. The differential diagnosis can be made with reasonable certainty by a careful history and physical examination.

"The first point in the diagnosis is to make certain that the mental and psychic mechanism is normal. Then if an unstable heart is found, as manifested by tachycardia induced by trivial causes, or by no apparent cause such as by changing posture, by turning over in bed, by standing up, by slowing of the heart rate when the patient bends over, by any alterations in the heart beat up to and including paroxysmal tachycardia; if the pupils dilate as the result of pressure on the region of the epigastrium; if hippus, tremors, sweating and cold hands and feet are present, if there are unaccountable nervousness and tremors; if there are intermittent nervous excitation and fatigue; if infections and heart lesions are excluded, then the diagnosis of neurocirculatory asthenia may safely be made.

"The heart cannot initiate tachycardia, but tachycardia is imposed upon it so the sympathetic system cannot initiate stimulation; stimulation is imposed upon it. Our purpose in these cases, therefore, is to interfere surgically with this pathologic stimulation by denervating the adrenal glands, and we are finding the clinical results comparable to the results of thyroidectomy in cases of hyperthyroidism. So also "soldier's heart" could have been relieved by adrenal denervation.

"The day following the first denervation the patient will notice a lessening of consciousness of his heart; he will experience a diminution of the feeling of nervous tension; he will observe a lessening of the cold sweat; a warming of the skin; and the nurse will notice that the patient is less restless—a sequence similar to that which is observed after thyroidectomy for hyperthyroidism. If the first denervation produces none of these beneficial results, it will be because the diagnosis is incorrect; if correct the second denervation will be followed by further improvement along the same lines, and the general improvement in cases continues steadily, just as in the cases of hyperthyroidism.

"Among the inconstant but frequent results is the disappearance of constipation and indigestion.

"As to the end-results in our cases, 1 patient has remained well for 14 years after unilateral adrenal sympathectomy; 1 to 4½ years after unilateral denervation; and of the 21 cases of bilateral denervation performed within the past 18 months, 18 patients have remained well to date, in 2 cases the results are negative, and 1 patient we have been unable to trace. The final decision as to the potency of adrenal denervation must await the test of time."

CHAPTER 21

SURGERY OF THE VASCULAR SYSTEM

OPERATIONS ON THE ARTERIES

ARTERIORRHAPY

Historical Notes. Hallowel and Lambert, in 1750, closed a small wound in the brachial artery by passing a pin through the edges of the wound and winding a thread around it—akin to the old method of treating harelip. Nicholas Senn drew attention to the fact that it is possible to suture a wound in the wall of an artery with the possibility of maintaining the circulation through the sutured vessel unimpaired and without causing subsequent aneurysmal dilatation. The old belief that a cicatrix in the wall of an artery gives rise, sooner or later, to an aneurysm is, in view of Senn's studies, a fallacious conception.

Indications for Arteriorrhaphy

1. Wounds of large arterial trunks.
2. The removal of an embolus.

Essentials for Successful Arteriorrhaphy

1. Perfect asepsis.
2. Clean cut wound.
3. Freedom from tension on the sutures.
4. Careful handling of the tissues sutured.
5. An efficient non-injurious method of obtaining temporary hemostasis.
6. Proper suture material.

Operation

Step 1. The vessel is exposed for an inch or more on each side of the wound in it. Clamp the vessel above and below the area to be repaired with a suitable clamp such as Crile's or Spivack's clamp (Fig. 651). If these clamps are not available, fine linen strips thrown around the vessel and fastened with an artery forceps (not with a knot) will form an efficient substitute. (Carrel and Guthrie.) A tourniquet should be used whenever possible. (Figs. 652-653).

Step 2. Gently remove all blood clots; flush with normal saline solution or citrate solution.

Step 3. If the edges of the wound are lacerated, trim them with a fine scissors. Coat the vessel inside and out with sterile vaseline (Carrel).

Step 4. Resect the external sheath of the vessel cautiously because if fibers of this sheath find their way between the edges of the wound a thrombus will promptly follow. Figures 651 and 654 illustrate various methods used in applying provisional hemostasis.

Comment. A clamp tourniquet made of steel, strong, yet light, firm, reliable and practical has been devised by H. Cohen (Fig. 653). It may be sterilized where necessary, as in blood transfusions. Application is made very quickly and release is instantaneous. A fine adjustment screw regu-

lates pressure after the clamp is applied; the pulse may be made to disappear or to be felt by a few manipulations of this screw. Where no assistants are

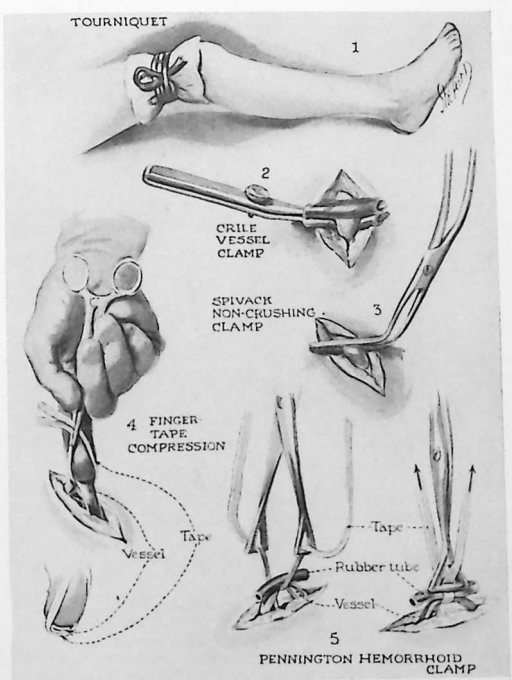


FIG. 651. Methods of temporary hemostasis. (Courtesy of Dr. R. W. McNealy.)

available it is very helpful when injecting solutions intravenously. The vein is made prominent by applying the clamp; the needle is then introduced into the vein and by means of a fine adjustment screw obstruction to the vein may be released without disturbing the needle. The solution is then

injected without any further assistance. It is useful in taking blood for blood-chemistry and in controlling hemorrhage in lacerations of the radial artery. Instruments for blood vessel surgery should be of the finest type (Fig. 654).



Fig. 652. Esmarch's tourniquet.

Robert L. Payne has devised an improved hemostatic forceps.[1] He points out that hemostats as now found on the market are manufactured with a single ratchet catch situated only on one shank of the instrument. No matter how sturdy the clamp may be made, its life depends upon the life of the ratchet. When this is worn down, the artery forceps becomes useless. Payne has designed an artery forceps with three ratchet catches on each shank of the instrument (Fig. 654). This feature offers two factors not found in any of the forceps now on the market. First, the Payne forceps offers 3 times the holding strength when applied to pedicles for short or long time because of its 3 catches on either shank. It obviates the necessity for tying the handles when clamps are to be left in situ for any length of time. An important feature is also the economy effected, because the clamps of the Payne instrument will last three times as long as the ordinary one.



Fig. 653. Harry Cohen's clamp tourniquet.

Sutures may be interrupted or continuous; the latter is preferred.

The needles must be very fine, round, straight or curved (Cambric type). Suture-material consists of very fine silk or linen run through sterile vaseline before use; ooo silk or linen swedged on a proper sized needle is excellent for the purpose. Irregular wounds should be trimmed. Mattress-sutures may be used with the edges of the wound everted.

Eversion Method—Bricau, Jaboulay-Dorrance—Dorrance's Arteriorrhaphy Suturing Longitudinal Incisions

Step 1. The tourniquet or clamps are applied as before. The needle enters close to one end of the incision; it penetrates, if possible, the adventitia and media

[1] Amer. Jour. Surg., May, 1932.

it is desired to cut off the nutrition and reduce the rate of growth of certain types of tumors.

It goes without saying that every surgeon should be intimately acquainted with the position, magnitude, course, connections, branches, and functions of every important artery in the human body. The method of approach to an artery and the structures immediately associated with it at every point of its course should be matters of intimate familiarity to the surgeon. Not only that, but the possibility of anomalies, either in the artery itself or in the structures associated

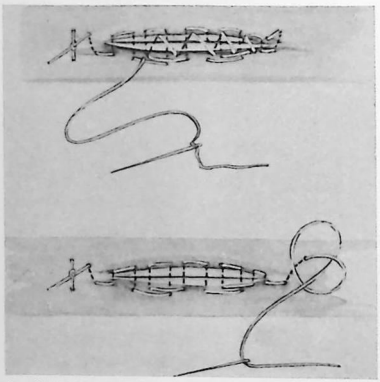


Fig. 655. Dorrance's method of suturing an artery. The suture is used for closing a longitudinal wound in an artery. The lower illustration depicts a continuous mattress suture with the throwback in every third loop. Note how the sutures are begun and finished. The upper illustration shows the suture continued from right to left joining the superficial edges of the wound; when completed, its free end is fastened to the free end of the knot on the left-hand end.

with it are matters to be reckoned with. Much of this knowledge will be assimilated in the dissecting room but the more important details and questions of technic will properly be attained in surgical, clinical, or postgraduate courses.

Before proceeding with the surgical steps necessary for the ligation of a main artery, it is often advantageous to secure temporary hemostasis by a tourniquet applied over a towel well above the line of amputation (Figs. 659-660). When operating in areas where such a step is impossible, secure the main vessels by dissection before dividing them. The larger vessels are secured by ligature; small vessels may be picked up with forceps, and bleeding may often be arrested by forcipressure, torsion and electrocoagulation.

only; it is brought out and tied; the free end is left long. The needle now penetrates the wall of the vessel, from without inward on one side of the cut in the artery, as near the edge as possible; it is then made to penetrate the walls of the vessel on the opposite side of the opening from within outward. The illustration depicts the progress of the suture-line in mattress fashion throughout the length of the wound (Fig. 655). At every third loop carry the stitch back to add stability. At the other end, the suture is passed through the two outer coats of the vessel near the end of the incision and tied.

Step 2. Reinforce by a second continuous running suture, picking up the edges of the incision between the loops of the mattress suture. When this suture reaches the end of the suture line the two ends are knotted together. The vessel thus sutured results in an approximation of the intima on both sides; the suture is buried and out of the current line.

Step 3. Remove the clamps, first from the distal then from the proximal end of the repaired vessel. Make sure that there is no escape of blood along the suture line. Suture the fascia loosely over the sutured artery; close the skin.

End-to-End Sutures

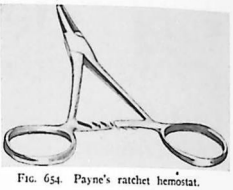


Fig. 654. Payne's ratchet hemostat.

Step 1. Apply the clamps as in the previous procedure.

Step 2. Grasp the edges of the artery with two forceps. Introduce a mattress suture first; pass the needle through all the coats of the artery from without inward. Continue the suture as a continuous mattress suture—dropping back half a stitch every third suture until the starting point is reached (Fig. 656); then a half stitch is made and the suture is continued back as a whip-stitch until it reaches the starting point. The two ends are then tied. The suture is started on the anterior surface near the handle of the clamp.

Step 3. When the suture reaches the farther side of the artery the handle of the clamps are removed from the lower portion of the wound and placed at the upper portion. Thus, the surface of the artery which was anterior is now posterior; in this manner the suture line is constantly under surveillance. (The illustrations (Figs. 657-658) depict continuous suturing instead of the mattress suture as described).

LIGATION OF ARTERIES

Ligation or tying of a blood vessel (artery) means the shutting off of the arterial blood flow in the artery itself and its branches below the place where the vessel is tied. This surgical step may be necessary on account of hemorrhage from the vessel, which if not prevented may lead to the loss of the patient's life; or during an amputation of the whole or part of an extremity, or the removal of a diseased organ; also in cases of pulsating tumors, such as aneurysms or where

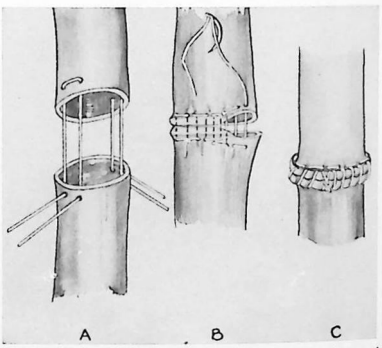


Fig. 656. Dorrance's method of vessel suture: A. end-to-end suture of a vessel. Placement of two mattress retention sutures. B. Mattress sutures continued. C. Anastomosis completed.

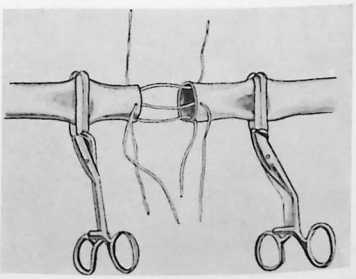


Fig. 657. Carrel's method of suture of the blood vessels. Note placement of compression forceps at a distance from the ends to be united. No tension should pertain. Note placement of sutures.

Ligation of Arteries in the Head and Neck Region

Ligatures of the arteries in the head and neck region are mainly indicated for hemorrhages and for spreading infections. The principal arteries involved

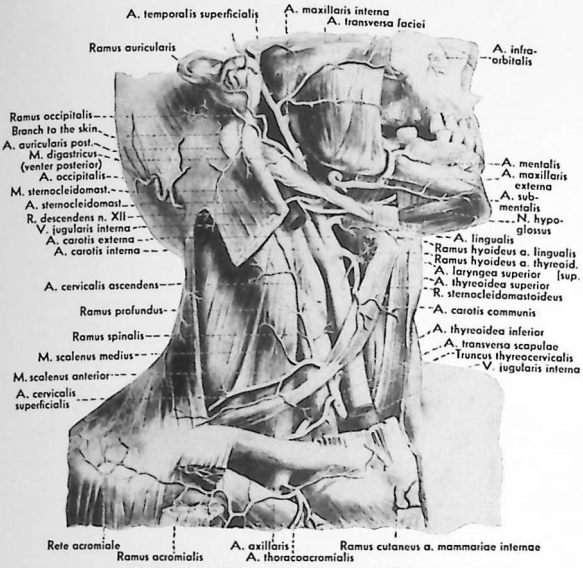


FIG. 668. Superficial arteries of the neck. (Spalteholz.)

in the head and neck region are: the vertebral, the common, the external and internal carotids and their branches, the superficial temporal artery, the occipital artery, the middle meningeal, the lingual and facial arteries.

Ligation of the Vertebral Artery

Anatomic Considerations. (Fig. 667.) Ligation of the vertebral artery may be required for stab wounds or traumatic aneurysm. It is very difficult to perform on account of its deep position and the important structures that surround it.

This vessel arises from the upper and posterior portion of the first division of the subclavian artery close to the inner border of the anterior scalenus muscle; it then passes directly upward along the anterior surface of the vertebral column, entering the foramen in the transverse process of the sixth cervical vertebra. It then ascends through the foramina in the transverse process of all the vertebrae above this, coursing then between the transverse processes of the atlas and axis, finally piercing the occipito-atlantoid ligament.

There are two methods of ligating this vessel:

1. **By an incision made below the omohyoid muscle,** which is divided together with the fascia; locate the inferior thyroid artery first. When this latter artery is found it is drawn downwards and the vertebral artery is then exposed by blunt dissection just below and behind the tubercle of the sixth transverse



FIG. 669. Digital compression of the common carotid artery.

process and just before it enters the bone; great care must be taken not to injure the cervical plexus, the branches of which are in close proximity.

2. **By an incision made along the lower half of the posterior border of the sternomastoid muscle.** The anterior scalenus muscle and the phrenic nerve are exposed and the transverse process of the sixth cervical vertebra is defined in the gap between this muscle and the longus coli. Just below this, the vertebral artery will be found entering its bony canal. Avoid injury to the cervical sympathetic and phrenic nerve.

Ligation of the Common Carotid Artery*

Indications.

1. Wounds of the vessel.
2. Aneurysm of the innominate artery or the aorta.
3. Aneurysm of the carotid trunk or its main branches.
4. Aneurysm in the orbit.
5. Temporary ligation to control bleeding during removal of tumors of the head and face.
6. Hemorrhage (carcinoma of the face and tongue; hemorrhage after tonsillectomy, etc.).

* In emergencies the common carotid artery may be compressed dizitally as shown in Fig. 669.

The common carotid artery (Figs. 668-669) enters the neck deep and projects to the sternoclavicular joint. Between the upper border of the thyroid cartilage and the great cornu of the hyoid bone the main vessel bifurcates into the external and internal carotid arteries. The internal carotid may be considered as the continuation of the common carotid artery and the external as a branch of the

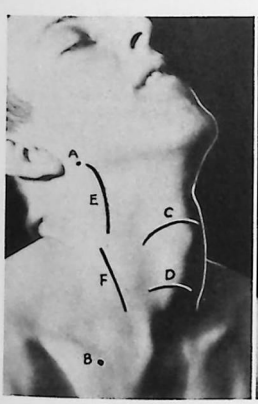


FIG. 670

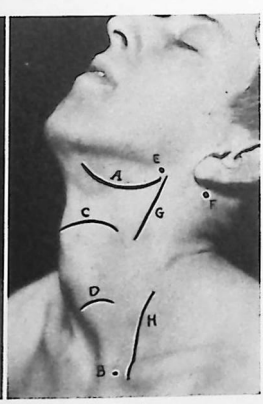


FIG. 671

FIG. 670. Lines of incision for the exposure of the common and external carotid arteries: A. angle of the lower jaw, B. sternoclavicular articulation, C. level of the upper border of the thyroid cartilage, D. level of upper border of the cricoid cartilage, E. incision for ligating the external carotid artery, F. incision for ligating the common carotid above the omohyoid muscle.

FIG. 671. Incisions for ligature of the common and internal carotid and the lingual arteries: A. incision for ligating the lingual artery, B. sternoclavicular junction, C. upper limit of the thyroid cartilage, D. upper limit of the cricoid cartilage, E. angle of the mandible, F. lower border of the mastoid process, G. line of incision to expose the external carotid artery, H. incision for exposure of the common carotid artery below the omohyoid muscle.

common. The common carotid is usually ligated above or below the anterior belly of the omohyoid (Figs. 670-671). It may be ligated at any part of its course. The place of election, however, is at the level of the cricoid cartilage above the upper border of the omohyoid muscle.

Ligation of the Common Carotid Artery Above the Omohyoid

The artery is more superficial here, hence this point is spoken of as the "point of election." The patient is placed on his back with the shoulders slightly elevated and the head turned to the opposite side (Fig. 672).

An incision about three inches long is made in the line of the artery with its

center opposite the cricoid cartilage. The skin, fascia and muscles are retracted downward and the sheath of the artery is seen then with the descendens hypoglossi nerve lying upon it.

The sheath is opened; the artery is exposed and tied.

Ligation of the Common Carotid Artery Below the Omohyoid

An incision 3 inches long is made over the line of the artery and extending up from the sternoclavicular joint. The muscles are separated and the omohyoid identified. It may be necessary to tie and cut a portion of the inferior thyroid venous plexus. The sheath of the artery should be opened on the inner side.

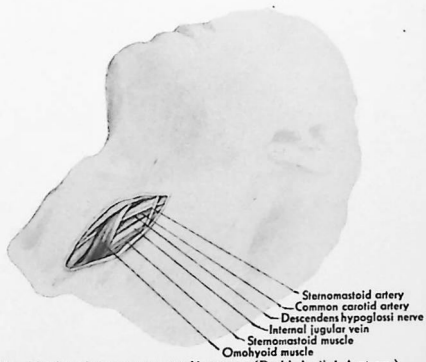


FIG. 672. Ligation of the common carotid artery. (Davis' Applied Anatomy.)

Precautions. The artery may bifurcate at the cricoid cartilage or even lower; if so, both branches should be ligated. The jugular vein may be much dilated, be superimposed over the artery, transmitting its pulsations and thus be mistaken for it. This mistake can be avoided by compressing the vessel and observing the direction of the column of blood. The thyroid gland may cover the artery. If so, displace it laterally; if the face of the patient be turned too far aside, the incision may be made over the sternomastoid muscle instead of along its anterior border. It is wise to ligate smaller vessels as encountered. Below the omohyoid there is risk of injuring the internal jugular vein. Push it forcibly out of the field of operation. If the vein be accidentally injured there is danger of air embolism. If this happens flood the wound with sterile salt solution. Apply pressure on either side of the puncture. Repair the opening with a lateral suture. Avoid injury to the vagus and sympathetic nerves. In the other complications (cerebral softening, coma, death 20 per cent) which

may follow ligation of the common carotid artery; instead the external carotid artery should be ligated.

Collateral Circulation. (Fig. 673.) The superior with the inferior thyroid; the profunda cervicis with the princeps cervicis, branches of the external carotid and the circle of Willis.

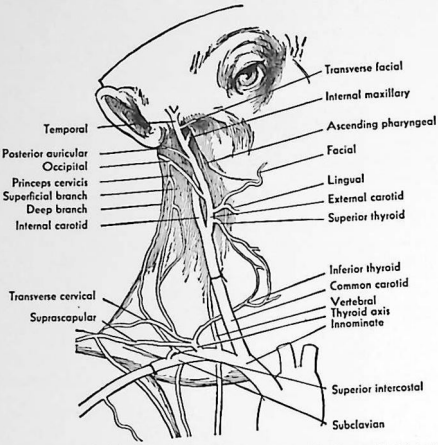


Fig. 673. Collateral circulation after ligation of the common carotid artery. (Davis' Applied Anatomy.)

Ligation of Both Common Carotid Arteries

The surgeon may be called upon to resort to this drastic procedure. It has been accomplished.

Temporary Ligation of the Common Carotid Artery

This procedure has been resorted to in order to arrest hemorrhage from branches of the common carotid. Expose the vessel, pass a ligature around it and lift the vessel sufficiently to close the lumen. The ligature may remain in place for two or three days and then be removed.

Ligation of the External Carotid Artery

Indications.

1. Wounds.

2. Uncontrollable hemorrhage from the tonsils.
3. Aneurysm of the external carotid artery.
4. Temporary ligation during operations.
5. To "starve" malignant tumors.
6. Persistent middle meningeal hemorrhage.

Neither the common nor internal carotid arteries have any branches (Fig. 673). The external carotid, however, has several branch-arteries, the facial, the superficial temporal, the occipital and the lingual being the principal ones. These will be dealt with below.

The external carotid artery itself commences at the upper border of the thyroid cartilage. The "site of election" for its ligation is situated below the digastric muscle and between the lingual and superficial temporal branches of the artery. An incision 3 inches long is made in the line of the artery along the anterior border of the sternomastoid muscle, the center of the incision being at the level of the hyoid bone. The posterior belly of the digastric muscle and the hypoglossal nerve are identified and the apex of the great cornu of the hyoid bone exposed. The sheath of the artery is opened just below this spot taking care to avoid the superior laryngeal nerve which lies just below the artery. Care must be exercised to avoid the external jugular vein and its anastomosis with the facial. The border of the sternomastoid must always be kept in view. The external carotid artery itself lies at the level of the great cornu and between it and the vein. (Figs. 674-675.)

Precautions. Both external carotids may be ligated. Make sure before you throw the ligature around the vessel, that it is the external carotid artery. Enlarged superimposed lymph nodes may be mistaken for the vessel. The superior thyroid artery may be mistaken for the lingual; the latter passes upward, the former downward.

Ligation of the Facial Artery

Anatomic Considerations. The facial artery is one of the important branches of the external carotid; it arises just below the tip of the great cornu, about an inch from the bifurcation of the common carotid artery. It passes through the substance of the submaxillary gland and enters the face at the anterior inferior angle of the masseter muscle. It is usually ligated where it crosses the lower jaw in front of the border of the masseter muscle.

The facial artery may be ligated at either of two points:

(a) Just above its origin. The vessel is the fourth branch of the external carotid artery which it leaves a short distance above the great cornu of the hyoid bone; it is ligatured by an operation similar to that for tying the external carotid.

(b) Where it crosses the mandible. The incision is horizontal and 1 inch long parallel to and just below the lower jaw. The skin and muscles are then drawn up over the bone and the artery will be found lying upon the bone just in front of the masseter muscle.

Caution.—When ligating the facial artery at its origin do not mistake it for the lingual artery.

Ligation of the Occipital Artery

Anatomic Considerations. The occipital artery arises from the external carotid a little above the facial artery. It courses upward and outward to the space between the transverse process of the atlas and the mastoid process. (Fig. 668.)

The occipital artery is ligated best under the mastoid process. It is located by a transverse incision 2 inches long ending in front of the tip of the mastoid process. However, the vessel may be ligatured in either of two places:

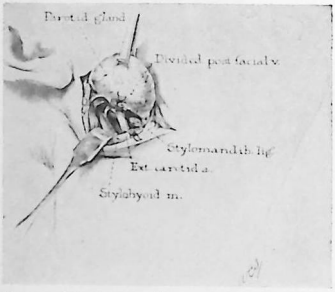


Fig. 674. Exposure of the external carotid artery on the stylo-mandibular ligament.

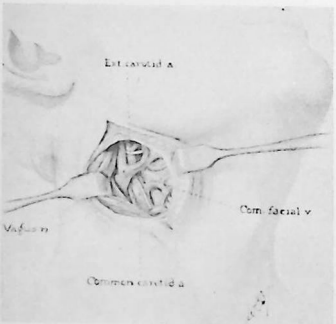


Fig. 675. Exposure of the external carotid artery in the carotid triangle.

(a) In the anterior triangle at its origin. Here the operation is similar to ligation of the external carotid from which it originates;

(b) In the mastoid region. An incision 2 inches long is made from the

back of the apex of the mastoid process in the direction of the external occipital protuberance. The posterior part of the sternomastoid and other neighboring muscles are split and the artery is then seen emerging from the groove of the mastoid process in which it lies.

Ligation of the Superficial Temporal Artery (Fig. 667.)

Anatomic Considerations. The superficial temporal artery is one of the terminal branches of the external carotid. It begins in the substance of the parotid gland between the neck of the mandible and the external auditory meatus. It passes upward across the root of the zygoma. About two inches above the zygomatic process it splits up into its terminal branches.

The artery is reached by a vertical incision 1 inch long between the tragus and the condyle of the lower jaw, and is best ligated where it lies upon the zygoma just in front of the ear. The vessel is easily exposed but care should be taken not to injure the auriculotemporal nerve.

Collateral Circulation. From the facial vessels and other arteries supplying the scalp.

Ligation of the Lingual Artery

The lingual artery passes between the deep surface of the hyoglossus muscle and the middle constrictor of the pharynx about one-third of an inch above the great cornu of the hyoid bone. The artery is deep to the hyoglossus and at a slightly lower level than the nerve. The lingual artery may be ligated at either of two places: (1) at its origin from the external carotid or (2) beneath the hyoglossus in the submaxillary triangle (Fig. 676). The whole region is covered with the submaxillary gland and the border of this gland must be exposed as it is an indispensable landmark.

The incision for ligation at the origin is the same as that for tying the external carotid, the lingual being the second branch given off by that vessel. The external carotid is followed down until the lingual is seen leaving it and lying upon the middle constrictor. In practical surgery the artery is ligated most frequently proximally to the origin the dorsalis linguae and is searched for behind the posterior belly of the digastric muscle.

The incision for ligation of the lingual artery beneath the hypoglossus is made with the patient lying on his back, with the neck extended and the head turned to the opposite side. The incision in this case is not made over the line of the artery but is curved lying under the lower jaw, with its concavity upward, it begins one-half inch below and outside the symphysis mentae passing down to the hyoid bone and curving up again to the angle of the jaw. This flap is turned up and the muscle and fasciae separated. The submaxillary gland and the two bellies of the digastric muscle are then exposed. The tendon of the digastric muscle is drawn downward while the hyoglossus muscle is seen in its angle and the hypoglossal nerve passing across it to disappear under the mylohyoid muscle. The nerve is drawn up and the fibers of the hyoglossus muscle divided transversely about one-quarter of an inch above the hyoid bone. The lingual artery will be seen lying beneath the hyoglossus upon the middle constrictor muscle.

Precautions. The hypoglossal nerve may be mistaken for the artery.

Remember that the nerve rests on the hyoglossus, the artery runs beneath it. Make sure that the structure in question pulsates. Do not mistake the lingual vein for the artery, particularly in individuals with chronic heart disease and persons advanced in years (atheromatous thickening of the vein wall; transmission of pulsations). The artery may be absent; it may take a higher course or it may run in the substance of the hyoglossus muscle. Search for the vessel, after division of the fibers of the hyoglossus muscle, must be conducted with great care lest the pharynx be opened. The operation for exposure and ligation of this vessel is not an easy one. Avoid too short an incision. The submaxillary

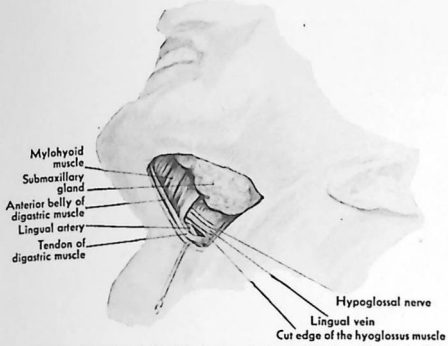


Fig. 676. Ligation of the lingual artery in lesser triangle. (Davis' Applied Anatomy.)

gland should not be incised but the exposure should be rather below those structures which the surgeon should lift out from the field of operation. There is no collateral circulation formed after ligation of the lingual artery.

Ligation of the Internal Carotid Artery

The vessel calls for ligation in

1. hemorrhage from the tongue
2. excision of the tongue
3. wounds of the vessel

The internal carotid artery lies on a deeper plane than the external carotid. It can only be ligated at its commencement. The incision is the same as that for ligation of the external carotid. On separating the muscles the external carotid artery will be found lying deeply in the neck (Figs. 674-675). Care must be taken not to injure the jugular vein, the vagus and sympathetic nerve trunks.

Precautions. The internal carotid artery may arise from the arch of the aorta, be absent or tortuous.

Collateral Circulation. Through the circle of Willis.

Ligation of the Middle Meningeal Artery

(See Operations on the Skull, P. 120)

After entering the skull the middle meningeal artery divides into two branches, an anterior and posterior. The anterior branch runs in a canal or groove on the inner surface of the antero-inferior angle of the parietal bone, upwards and somewhat backward to the sagittal suture lying about three-quarters of an inch behind the coronal suture. At this point the vessel is about one and a half to one and three-quarters inches above the zygoma. The posterior branch courses upward and backward along the inner surface of the squamous portion of the temporal bone.

Step 1. Anterior Branch. A semicircular flap of about one and one-half inches radius is reflected downward in the temporal region so as to permit the skull being trephined at a point one and one-half inches behind the external angular process of the frontal bone and one and one-half inches above the zygoma, the intervening muscles being split vertically.

Step 2. An opening of about one and one-half inches diameter is made in the skull and the artery will be found either running in a groove or channel in the bone or else lying upon the dura. In the former case the vessel should be occluded by crushing the bone in upon it or by forcing wax (Horsley's) or a small wooden peg into the bony canal; in the latter case, the artery is occluded by undermining it with a stitch.

Posterior Branch. This may be exposed by trephining the skull in a situation similar to the above only about one-half an inch lower. Farther back this branch can be exposed by trephining one and one-half inches above the center of the base of the mastoid process.

The Main Trunk. This can be ligated by trephining the skull at the same point as for the anterior branch and cutting away the bone for a short distance. It will be easier to secure the vessel if the dura mater is pushed away from the bone for a short distance.

Ligation of Miscellaneous Arteries

Intercostal Arteries. As each of these vessels lies in a groove under cover of a rib, except at the posterior part of an intercostal space, an incision two inches long is made over the rib and about one and one-half inches of the rib are resected subperiosteally. The periosteum beneath the rib is then divided and the artery exposed and ligated.

Internal Mammary Artery

Ligation of this vessel may be called for in amputation of the breast. The artery runs parallel to and about one and one-half inches outside the border of the sternum. A transverse incision one and one-half inches long is made in the second or third intercostal space and running out from the border of the sternum. The muscles are divided including a few fibers of the pectoralis major. The artery lies upon the pleura; care must, therefore, be exercised not to injure the pleura nor the lung beneath. If preferred, a small portion of the inner end of the second or third costal cartilage may be resected subperiosteally and the artery exposed in this way.

Ligation of the Superior Thyroid Artery

(See Chapter on Thyroidectomy, P. 462)

The superior thyroid artery is the first branch of the external carotid artery and its ligation is sometimes called for in cases of exophthalmic goiter. The incision is the same as that for ligation of the external carotid which must be identified and followed down until the branch artery appears.

Ligation of the Inferior Thyroid Artery

(See Chapter on Thyroidectomy, P. 463)

As in the case of the superior thyroid artery this vessel is sometimes ligated in cases of exophthalmic and other goiters. The incision is the same as that for ligation of the common carotid artery below the omohyoid. The sternomastoid and the whole of the carotid sheath are retracted outward while it may be necessary to divide the sternomastoid and sternohyoid muscles. The tubercle of the sixth cervical vertebra should be found to the inner side of the sheath and immediately below this the artery will be seen running directly inward. Great care should be taken not to injure the recurrent laryngeal nerve which splits into several branches before entering the larynx.

Ligation of the Innominate Artery

This important artery has been tied with success on several occasions (Rose and Carless). An angular incision about 3 inches long is made running down the lower third of the anterior border of the inner third of the clavicle. The muscles are divided, the carotid sheath identified and opened and the carotid artery exposed and followed down to the innominate. It is not usually necessary to remove any part of the sternum or clavicle. The important structures to look for and care for are the internal jugular vein, the two innominate veins, the inferior thyroid plexus, the vagus nerve and the pleura.

Collateral Circulation. 1. Intercostal branches of the aorta with the superior intercostal branches of the subclavian and with the thoracic branch of the axillary and internal mammary arteries; also with the musculophrenic branch of the internal mammary artery;

2. The deep epigastric artery with the termination of the external mammary;

3. Between the branches of the two external carotids and also through the circle of Willis.

Ligation of the Subclavian Artery

Historical Notes. The subclavian artery was first successfully ligated in its third portion by Post of New York (1817). In 1809 Sir Astley Cooper attempted to ligate the first part of the vessel but abandoned the operation, fearing he had wounded the thoracic duct. The first successful ligation of the first part of the vessel was done, according to Treves, by Colles in 1818. The patient died. Halsted successfully ligated the first part of the artery (1802), for aneurysm on the left side.

Anatomic Considerations. On the right side, the subclavian artery arises from the innominate opposite the junction of the right clavicle with the sternum. On the left side it arises from the arch of the aorta. The right subclavian artery is about three, the left about four inches in length. Each courses upward into the neck to the level of the sixth cervical vertebra. Each vessel is divided into three parts. The first portion is situated between the origin and the inner border of the scalenus anticus muscle; the second portion lies immediately behind the muscle, while the third part is

limited by the outer border of the scalenus anticus muscle and the lower border of the first rib.

This artery may be ligated in any of its three parts. Ligation of the first part is practically the same operation as ligation of the innominate artery above the clavicle. The artery is practically never ligated in its second part as it lies under the scalenus anticus muscle (Fig. 677).

Step 1. Place the patient on his back, raise the shoulders, extend and turn the head to the opposite side, pulling the arm down and holding it by pushing the forearm under the patient's back (Treves). This pulls down the clavicle and affords better exposure.

Step 2. Make an incision 3 inches long over the middle third of the clavicle and within half an inch of it. Preserve the external jugular vein if possible; otherwise, ligate and divide it.

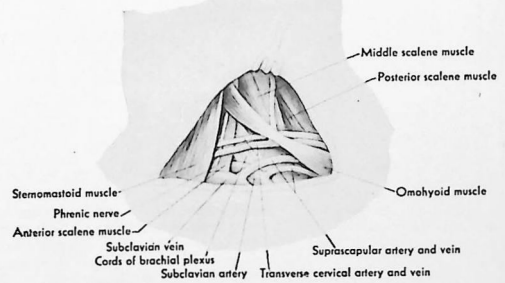


Fig. 677. Ligation of the subclavian artery. (Davis' Applied Anatomy.)

Step 3. Divide the muscles, incise the deep fascia and the posterior belly of the omohyoid muscle is drawn up. Avoid the transverse cervical and suprascapular arteries.

Step 4. Identify the external border of the scalenus anticus muscle and follow it down with the finger to the scalene tubercle on the first rib. When the finger rests on the tubercle the subclavian vein will be in front of the finger and farther down into the chest while the subclavian artery will be felt beneath the finger lying in a groove in the rib and thus can be exposed. In ligating be careful not to include the cords of the brachial plexus which pass all around it or injure the subclavian vein. The artery lies internal to the brachial plexus.

If the field of operation is too small, the trapezius or sternocleidomastoid muscles, or both, should be partly divided, transversely.

Collateral Circulation. The intercostals and branches of the internal mammary with the thoracic branches of the axillary; other branches of the axillary with the suprascapular and posterior scapular arteries.

Ligation of the Axillary Artery

Anatomic Considerations. The axillary artery begins at the lower border of the first rib and extends to the lower border of the tendon of the teres major muscle. It gives off numerous branches. It is intimately connected with the brachial plexus. It may be ligated in three situations: (a) above the pectoralis minor; (b) behind the same; (c) below that muscle. Only the first or lower and third parts of this artery can be ligated.

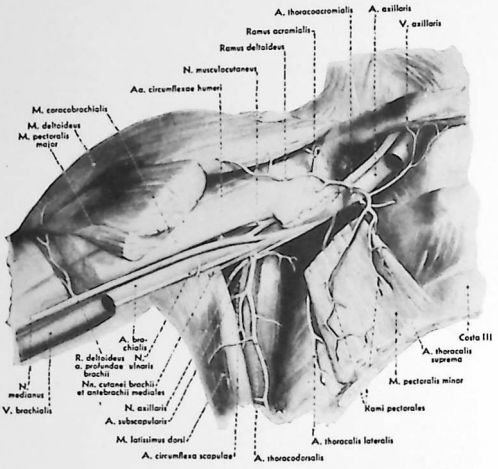


FIG. 678. Arteries of the right axilla, viewed from in front. (Spalteholz.)

Ligation of the first part of the axillary artery was first performed by Chamberlaine of Jamasen in 1815. The operation is difficult and dangerous. The axillary vein (Figs. 678-679), closely attached to the costocoracoid membrane may be torn.

Step 1. The arm should be abducted; the point of the shoulder should not be depressed. An incision 4 inches long should be made immediately below the outer two-thirds of the clavicle, although some surgeons advise that this incision should form a curved flap with its convexity downward, which may be reflected up.

Step 2. The clavicular and sternal portions of the pectoralis major are separated from each other and the adjoining tissues are exposed. The costocoracoid-membrane is divided, the pectoralis minor muscle is drawn downward and the subclavius muscle is drawn up, the branches of the thoracic-axis drawn aside and the axillary vein drawn inward; the axillary artery is then exposed. Care must be taken not to include the veins or any of the cords of the brachial plexus in the ligature.

Ligation of the third part. In ligating the artery in this situation, the arm must be abducted to a right angle. An incision 3 inches long is made in the

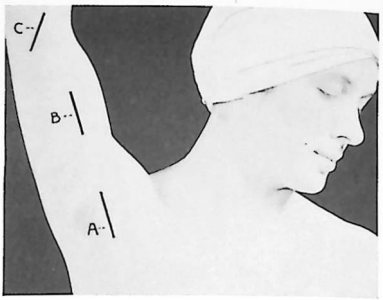


FIG. 679. Incision for ligating the arteries of the arm: A. incision for ligating the third part of the axillary artery, B. brachial, C. the same at the bend of the elbow.

line of the artery (Figs. 679A-680). The neurovascular bundle is exposed in the axilla; it is covered with the median and musculocutaneous nerves which are drawn aside leaving the artery overlapped by the vein. Do not include the ulnar or internal cutaneous nerves in the ligature.

Collateral Circulation. If the ligation is done above the thoracic axis branch, collateral circulation takes place in the same manner as in ligation of the third part of the subclavian artery. If ligated below, collateral circulation takes place by the humeral branch of the thoracic axis with the anterior circumflex vessels and the perforating intercostal arteries; also via the suprascapular and posterior scapular vessels anastomosing with the subscapular and posterior circumflex arteries.

Precautions. The identity of the main vessel may confuse the surgeon because of large branches that are given off from the axillary in its third portion.

Ligation of the Brachial Artery

Anatomic Considerations. (Fig. 681.) The brachial artery extends from the lower border of the tendon of the teres major muscle to about an inch below the bend of the elbow joint. It is closely associated with the veins and nerves of the arm. The

brachial artery is situated on the inner side of the arm; it may be ligated in either of two places.

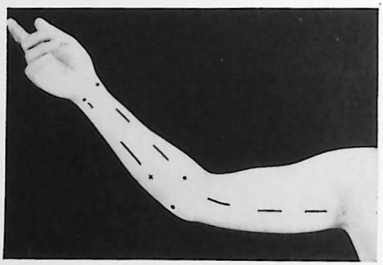


FIG. 680. Lines of incision for the ligation of the third portion of the axillary, brachial, radial and ulnar arteries. The incision for ligature of the brachial artery is in the middle of the arm, the incision for the radial and ulnar arteries is outlined on the front of the forearm, the two incisions below are for ligature of the ulnar artery—one of the lower dots is placed at the tip of the internal condyle and the other on the pisiform bone. The cross at the junction of the upper with the middle third of the forearm corresponds to the position of the ulnar artery, the upper third of which is outlined by a line extending between the upper right-hand dot and the cross.

Ligation at the Middle of the Upper Arm. The arm is abducted from the side at a right angle (Fig. 682). The incision should be about 2½ inches long made in the line of the vessel (Figs. 679 B-680). The basilic vein and biceps

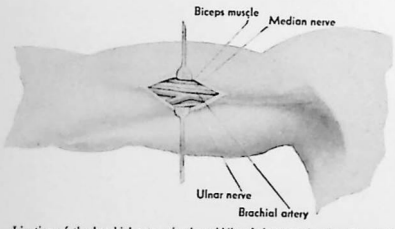


FIG. 681. Ligation of the brachial artery in the middle of the arm showing the median nerve lying on the artery and the ulnar nerve to its inner side. (Davis' Applied Anatomy.)

muscle are moved out of the way. The artery will be found lying upon the triceps muscle with the median nerve in front of it. There is no excuse for

mistaking the basilic vein for the artery as the former is above and the latter is below the deep fascia (Figs. 683-684).

An alternate method of ligature consists in deliberately opening the sheath of the biceps muscle and passing through it so as to approach the artery from the front.



FIG. 682. Esmarch compression of the brachial artery. Note bandage tied over knot in Esmarch bandage and fastened to the opposite shoulder.

Ligation at the Bend of the Elbow. As before, the arm is abducted from the side to a right angle. An incision, 2 inches long, is made starting at the middle of the antecubital fossa and running upward and inward parallel to the inner border of the biceps muscle (Fig. 679 C). The median basilic vein is drawn



FIG. 683. Arresting hemorrhage by compressing the brachial artery.

aside, the fascia is divided and the artery is found lying in the fat with the median nerve on its inner side and the biceps tendon on the outside. It will be found immediately under the aponeurotic expansion of the biceps muscle on the same level as the main biceps-tendon and is accompanied by two veins; the structures lying behind the median nerve should never be displaced.

Precautions. The arteries of the forearm may spring from the axillary;

Ligation of the Posterior Tibial Artery Between the Os Calcis and the Internal Malleolus

Step 1. Flex the knee. The surgeon stands on the opposite side of the table facing the inner aspect of the limb.

Step 2. Make a curved incision, about three inches in length, with the concavity uppermost and the center at a point midway between the inner malleolus and the tuberosity of the os calcis. Divide the fascia and internal annular (lancinate) ligament over a grooved director. This precaution should not be neglected since the artery lies immediately beneath that ligament.

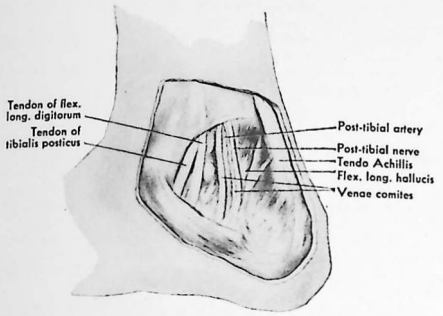


Fig. 702. Dissection of inner side of right ankle, showing relation of tendons, vessels and nerves as they pass between calcaneum and internal malleolus. (Piersol's Human Anatomy.)

Ligate the vessel after having separated it from the veins, from without inward (Fig. 702).

Collateral Circulation. Muscular and other branches of the peroneal and anterior tibial vessels.

Ligation of the Anterior Tibial Artery

The anterior tibial artery may be ligated in three places.

1. In its upper third.
2. In its middle third.
3. In its lower third.

Anatomic Considerations. (Fig. 703.) The anterior tibial artery arises from the popliteal just below the lower border of the popliteus muscle; it passes forward between the bones of the leg above the interosseus membrane, then downward on the anterior surface of that membrane to the ankle-joint where it becomes the dorsalis pedis artery.

Surface Marking. (Fig. 704.) A line drawn from a point midway between

the head of the fibula and the outer tuberosity of the tibia to a point midway between the two malleoli.

In its upper third. In this situation the operation is tedious and difficult. The artery is situated here very deeply between the tibialis anterior and the extensor longus digitorum muscles. An incision four inches long is made in the line of the artery. The intermuscular space between the tibialis anticus and the extensor communis digitorum muscles is identified and the muscles are separated. The anterior tibial artery will be found lying deeply upon the interosseous membrane with the nerve on its outer side and with a vein on both sides. To the outer side of the vessel lies the extensor longus digitorum, above and lower down the extensor longus hallucis. (Fig. 704 D.)

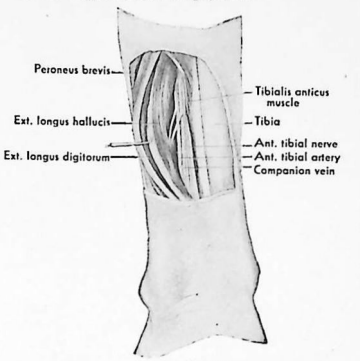


Fig. 703 Fig. 704

Fig. 703. Dissection of middle third of right leg, showing relations of anterior tibial vessels and nerves; extensor muscles have been drawn aside. (Piersol's Human Anatomy.)
Fig. 704. Outline of incisions for ligating the anterior tibial and peroneal arteries.

In its middle third. (Fig. 704 F.) An incision three inches long is made along the line of the artery. The intermuscular space as above mentioned is again found. Upon separating the muscles the extensor longus hallucis is found and pushed aside. The artery will be found lying upon this with the nerve lying in front of it.

In its lower third. (Fig. 704 E.) An incision three inches long is made in the line of the artery ending just about two finger breadths above the line of the ankle joint. The artery will be found lying between the tendons of the tibialis anticus and extensor hallucis muscles and rather under cover of the latter, with the nerve on the outer side.

In ligating the anterior tibial artery it may be necessary to widen the intermuscular space which has been referred to. To do this it is best to introduce the large ends of two retractors transversely and back to back at the midline of the

opening, then turn them at right angles and pull one upward and the other downward; a rectangular space is thus formed and in this space the nerve is first noticed, then the artery and its accompanying vein.

Collateral Circulation. This is formed by the muscular and other branches of the posterior tibial and peroneal arteries.

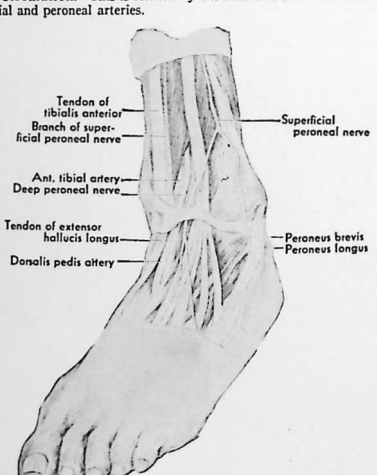


Fig. 705. Dissection showing relations of vessels and nerves in vicinity of left ankle; portion of anterior annular ligament still in place. (Piersol's Human Anatomy.)

Precautions. Do not mistake the head of the tibia for that of the fibula, the latter is situated more posteriorly and constitutes the most external bony prominence in this situation. The anterior tibial artery may be rudimentary or absent. It may be situated more superficially than usual. Do not persist in separating its venae comites, they usually will tear; ligate them together with the artery. The chief difficulty in the upper third is the identification of the proper septum. In the middle third the chief source of error is missing the septum between the tibialis anticus (anterior) and the extensor hallucis longus.

Ligation of the Peroneal Artery

This ligation is performed in exactly the same way as that of the posterior tibial artery.

Ligation of the Dorsalis Pedis Artery

Anatomic Considerations. (Fig. 705.) The dorsalis pedis artery is a continuation of the anterior tibial artery. It begins at the ankle and continues downward

between the metatarsal bones of the big and second toes passing through the interosseous space into the sole of the foot. It lies between the tendon of the extensor hallucis longus internally and the innermost tendon of the extensor digitorum longus externally, between which and the artery the anterior tibial (deep peroneal) nerve is situated.

For ligating the dorsalis pedis artery the foot is flexed plantarwise. An incision is made one and one-half inches long ending at the posterior extremity of the first interosseous space an inch below the ankle (Fig. 706). The artery will be lying between the tendons of the extensor longus hallucis on the inner side and the innermost tendon of the extensor longus digitorum on the outer side. The innermost tendon of the extensor brevis digitorum may have to be pulled aside.

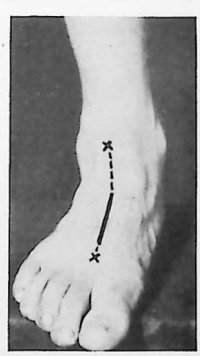


Fig. 706. Incision for exposing the dorsalis pedis artery. The x above is situated between the two malleoli; below, it corresponds to the upper end of the first interosseous space. The dotted line indicates the anatomical course of the artery. The black and white line the site where the incision for the exposure of the artery is to be made.

Detmold's Method of Dealing with Uncontrollable Hemorrhage

During the Civil War, when the usual method of controlling profuse hemorrhage was to bleed extensively, Detmold developed a method of withdrawing blood from the general circulation (sequestering) without loss to the body; it could then be returned gradually when the hemorrhage was controlled. It is still of great value in profuse bleeding when it is impossible to reach the bleeding points, i.e., large hemorrhages from the lungs, stomach and bowels, and possibly, uterine hemorrhages.

Detmold applied bandages to the limbs with circular pressure to the upper parts of the arms and thighs, tight enough to check superficial venous circulation without affecting the deeper arterial influx of blood. When hemorrhage has ceased the bandages are removed. If they must be left in place for a long time, it is wise to release them one at a time temporarily at fifteen to thirty minute intervals.

In a personal communication, Dr. J. F. Baldwin of Columbus, Ohio, recommends the method and states that "so far as I can recall I have never had any unfortunate results but have quite uniformly accomplished the desired end."

OPERATIONS FOR PULSATING TUMORS (ANEURYSM)

CIRSOID ANEURYSM

This is a condition in which a number of dilated arteries, held together by connective tissue, form a tumor which is the equivalent of a venous varicocele. It is most common on the scalp.

According to Raymond W. McNealy "a standard procedure for managing a moderately well-advanced cirsoid aneurysm of the scalp might include (Fig. 707):

"1. Preliminary ligation of the external carotid. If the frontal branch were involved and the patient below fifty years of age, partial or complete occlusion of the common carotid would become necessary.

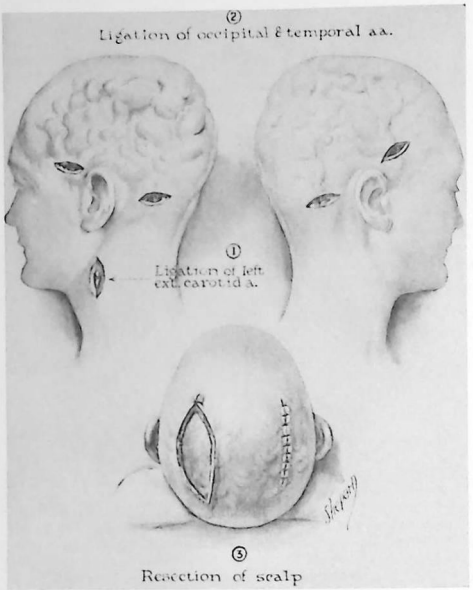


FIG. 707. Cirsoid aneurysm (courtesy of Dr. R. W. McNealy).

"2. This might be followed, within a few days to a week, by independent ligature of the secondary trunks involved, such as the temporal, occipital and auricular arteries.

"3. A short time later the main vessels may be ligated at the edge of the mass.

"4. These procedures will usually have reduced the tumor-mass to such an extent that it then becomes feasible to extirpate completely that portion containing the abnormal arteriovenous communications. In the extremities the same plan of treatment is followed."

TRUE ANEURYSM

Palliative Measures (General, Medical, Dietetic)

Valsalva counseled rest in bed, bleeding, diet to a point above starvation.

Tuffnell advised lowering of blood pressure by diet and rest.

Lancereaux practiced injection of gelatin at some indifferent point.

Dastres and Floresco showed (1896) that intravenous injection of gelatin increases the coagulability of the blood.

Lancereaux and Paulesco at a later date verified the same observations with gelatin injected at some indifferent point.

Carnot showed that the application of gelatin to a wound arrests bleeding.

Pressure by tourniquet: Signorini, Lister, Tuffnell.

Tests Prior to Operative Treatment

This has to be resorted to in the majority of cases. When an aneurysm threatens to rupture, operation of one sort or another is immediately indicated—an emergency operation has to be performed. The condition of the collaterals in case of aneurysm of an extremity should be determined; if these are competent, operate without delay. If incompetent develop them. Matas lauds the following plan to test the efficiency of collateral circulation.[1]

1. **The Sign of Quenu and Muret.** To obtain this, the main artery of the affected limb is compressed and, while compression is maintained, a puncture is made at the periphery. If no bleeding follows the collaterals are regarded as inefficient. This test Matas rejects.

2. **The Sign of Delbet.** When an aneurysm forms on a main artery it is often found that the pulse below it disappears abruptly or gradually. When, in spite of absent pulse below the aneurysm, the nutrition of the part is well preserved, the collaterals are competent. Matas regards this sign as most valuable.

3. **The Sign of Henle and Coenen.** This sign becomes manifest only during an operation. If the blood is seen to egress from the peripheral lumen of the aneurysm when the proximal end is compressed the collaterals are competent.

4. **The Signs of Von Frisch.** These signs can only be made manifest during operation.

(a) When pressure is applied to the proximal side of an aneurysm the peripheral part of the limb retains life.

(b) The sign of Henle and Coenen.

(c) When the main vein is compressed venous stasis arises below.

5. **Korotkow's Test.** This is made by estimating blood pressure in the periphery while the main arterial trunk above the aneurysm is compressed. If the blood-pressure is fairly high the collaterals are competent.

6. **Pachon's Test.** This is also a blood pressure test made by means of an oscillometer.

[1] Jour. Am. Med. Assoc., lxiii.

7. **The Test of Tuffier and Hallion.** If the main artery and vein are compressed in the lower extremity for example, the veins of the foot will swell only if a considerable amount of blood is taken to the periphery by the collaterals.

8. **Stewart's Test.** In this test the amount of blood passing through a part in a definite time is estimated by a calorimeter.

9. **The hyperemic reaction of Moschcowitz.** This test is applied to an extremity if the main artery can be compressed. The limb is elevated. An Esmarch bandage is applied from the periphery to the lower border of the aneurysm. An elastic compressor is applied to the main artery above the aneurysm to cut off all pulse below. After compression has been acting from 6 to 10 minutes the elastic bandage is removed while the compressor is still in place. At once a flush of hyperemia appears below the compressor and descends the limb quickly. Even when the collaterals are competent the digits remain of a waxy hue for some seconds. The longer the time required for the digits to become hyperemic the poorer is the collateral circulation. When the collaterals are impaired 10 minutes or more are required. In cases of great impairment 30 to 40 minutes may be necessary.

If the collaterals are found inefficient they may be reactivated by pressure excited upon the artery above the aneurysm. The pressure should not entirely cut off the circulation; several such séances a day should be held until collateral circulation is improved; or it becomes evident that it is not going to do so.

Operation by Ligature and Suture

Antyllus, a Roman successor to Galen practiced ligature in the third century A.D. Matas named Antyllus' procedure Aneurysmotomy (Fig. 708 A).

Step 1. Apply an Esmarch constrictor.

Step 2. Make a linear incision over the aneurysmal sac along the course of the affected artery. The incision is carried far enough to expose the artery at its entrance and exit from the sac. Retract the veins. Ligate the artery close to its entrance and exit to the aneurysm. Make a small incision into the aneurysmal sac and evacuate its contents.

Philagrius (1680) performed aneurysmectomy (extirpation of the aneurysmal sac) after ligation of the vessels.

Preliminary hemostasis is essential in these operations.

Proximal Ligation (Anel's Method)

In 1710, Anel of Toulouse, suggested that the artery be ligated above the sac, so close to the sac that there are no anastomotic branches between it and the ligature. Anel's operation shuts off the circulation at once thus decreasing the size of the aneurysmal sac (Fig. 708 B).

Desault-Hunter Operation

This operation was described by John Hunter and performed by him in January, 1786, although Desault ligated the artery proximally in June, 1785. Hunter's thought was to place the ligature at some distance from the sac, in a normal segment of the artery (Fig. 708 C). In such instances, the circulation is not cut off permanently, but its force and frequency are diminished sufficiently to favor the formation of a clot within the aneurysmal sac.

Distal Ligation (Brasdor-Deschamps Operation)

In cases where proximal ligation was too dangerous or impossible, distal ligation was resorted to. Brasdor in 1790 suggested this procedure, but this was first carried out by Deschamps in 1798 and by Sir Astley Cooper about the same time. Distal ligation obstructs the outflow of blood, the collateral branches above the aneurysm enlarge, the current of blood is gradually diverted and a clot may

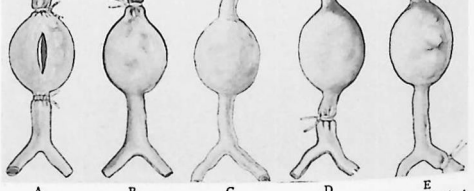


FIG. 708. Ligation of aneurysm: A. Abtyllus' method of treating an aneurysm. Proximal and distal ligation of the artery close to the aneurysmal sac. The sac is incised and its contents evacuated. B. Anel's method of treating aneurysm. The artery is ligated proximal to the aneurysm, close to its sac. C. Desault and Hunter's method of proximal ligation of artery at some distance from the aneurysmal sac. D. Brasdor's operation of distal ligation of the artery close to the aneurysmal sac. E. Wardrop's operation. The artery is ligated distally at some distance from the sac. Wardrop applied the ligature on a main branch after it had been given off from the parent trunk.

form within the aneurysm (Fig. 708 D). Distal ligation is resorted to in some aneurysms of the aorta, the iliac, innominate, carotid and subclavian arteries. John Chalmers DaCosta recorded two notable results by ligating the common carotid and subclavian artery on the right side in aneurysm of the innominate artery, with one patient living and well over five years after the operation.[1]

Wardrop's Operation

James Wardrop of London in 1825 ligated the main branch of the parent vessel at some distance from the sac. In 1809 Wardrop successfully ligated the carotid distally for carotid aneurysm and in 1827 for subclavian aneurysm (Fig. 708 E). The circulation in Wardrop's procedure is but partially arrested.

Halsted in 1906 suggested a method of treating aneurysm by proximal or distal application of an aluminum band to reduce the caliber of the artery. The bands are of 32 to 36 sheet-metal-gauge thickness. Halsted devised a set of instruments for the application of the bands to the vessel. "Experience has shown the method to be ineffective" (Wayne Babcock).

[1] Surg. Gyn. & Obst., June, 1910.