Objections to Ligation Procedures. Matas said, "Gangrene remains a serious objection to all methods of ligation." The aneurysm may recur after a number of years (Delbet, Matas). The presence of the sac and its sclerosis may cause pressure resulting in peripheral motor-paralysis, peripheral sensory-nerve changes, neuralgias, paraesthesias, trophic ulcers, etc.

Aneurysmorrhaphy—Matas's Operation

Matas's operations are performed from within the aneurysmal sac. Various types of operation are used to suit the indications presenting themselves.

Obliterative Endo-Aneurysmorraphy Without Venarterioplasty

This procedure is suited for fusiform aneurysms. In the words of Matas, "No attempt is made to reconstruct the parent artery (arterioplasty), and the arterial orifices are snugly obliterated by suture."

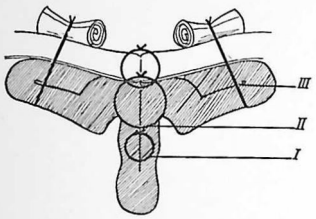


FIG. 709. Diagram of method of obliterating the sac in obliterative endo-aneurysmorrhaphy: I, suture obliterating the opening into the sac and the parent vessel, II, superimposed layer of sutures which reinforce the first tier and reduce the size of the cavity, III, row of stitches which approximate the skin to the enfolded layers which have been previously placed (I and II), uppermost stitches passed through the sac from without inward to approximate the portion of the sac not obliterated by the previous sutures and at the same time to approximate the skin to the sac (after Matas).

Step 1. Apply a tourniquet or elastic constrictor. Make a free incision parallel to the long axis of the aneurysm down to the sac. Avoid injury to important adjacent structures.

Step 2. Incise the sac freely making all its parts accessible to sight and touch: clear out the contents of the sac (Figs. 709-710). Retract its walls so that all orifices opening into it are rendered visible. If there are two main orifices unconnected by a groove of more or less normal arterial wall the aneurysm is of the fusiform variety—and therefore, suitable for the obliterative operation. If the two openings are connected by a groove of more or less healthy arterial wall, see that the groove is sufficiently wide and composed of sufficiently good tissue to permit reconstruction of the artery (restoration endo-aneurysmorrhaphy). If the groove is narrow and its tissue looks suspicious, the obliteration operation is imperative. If only one opening is present in the sac-wall and the aneurysm is sacculated, reconstruction may be done.

Step 3. Select a curved needle without a cutting edge, thread it with catgut; close all the orifices entering the sac. Another similar suture obliterates the deeper portions of the sac, covering all the closed orifices beneath a Lembert infolding suture. Remove the constrictor. If bleeding is observed at some point, additional sutures are inserted. If not, the wall of the sac plus skin are turned inward and fixed with sutures. It is of utmost importance not to separate the sac from its surroundings, because its walls are usually poorly

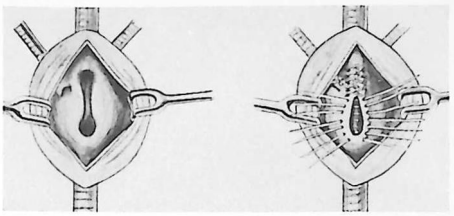


FIG. 710. Matas' endo-aneurysmorrhaphy obliterative suture. The illustration depicts the method of passing the sutures, which are interrupted ones in this instance. A branch coming off from the aneurysmal sac is shown secured in a similar manner.

nourished and sloughing might result from disregarding this point. Apply dressings.

Restorative Endo-Aneurysmorrhaphy (Matas)

This operation is only applicable to saccular aneurysms with a single opening when the parent artery already exists as a formed vessel, and in which the closure of the fistulous opening can be accomplished "with the greatest facility and simplicity."

Operation

Steps 1 and 2 are the same as in the preceding operation. The single opening is closed by a line of Lembert catgut sutures or of vaselined silk sutures carried in a very fine curved needle (Figs. 711-712).

Reconstructive Endo-Aneurysmorrhaphy (Matas)

This procedure is useful in fusiform aneurysms when the openings of the parent vessel into the sac are not too widely separated and there exists sufficient normal arterial wall for the reconstruction of a channel for the flow of blood. A catheter is used as a scaffolding over which the arterial wall is reconstructed. The ends of a piece of soft-rubber catheter are introduced into the two arterial openings. The catheter is removed after the sutures have been introduced. The remainder of the sac is utilized to reinforce the suture line. Figure 713 illustrates the steps in the management of a popliteal aneurysm by obliterative aneurysmorrhaphy method of Matas.

ANEURYSMECTOMY-ARTERIORRAPHY

When the aneurysm can be excised and the size of the vessel permits of end-to-end suture this should, when indicated, be practiced.

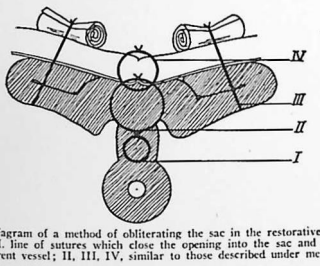


FIG. 711. Diagram of a method of obliterating the sac in the restorative and reconstructive operations: I, line of sutures which close the opening into the sac and restore the continuity of the parent vessel; II, III, IV, similar to those described under method in Fig. 709 (after Matas).

DIFFUSE TRAUMATIC ANEURYSM (PULSATING HEMATOMA)

In this condition there is no true or complete aneurysmal sac. It is caused by an escape of blood from an injured vessel into the surrounding tissues (stabs or

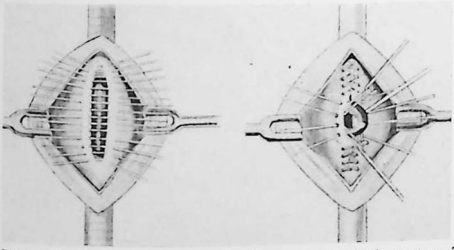


FIG. 712. Matas' reconstructive method of treating an aneurysm of a large artery. The figure shows a piece of rubber tubing laid into the lumen of the parent artery and the walls of the aneurysmal sac brought together by interrupted sutures over it so as to reconstruct the lumen of the artery. The right-hand figure shows the tube hooked out after the majority of the sutures have been tied over it but before the last four are fastened.

bullet wounds). The spurious sac here is composed of clotted blood, compressed muscle, fascia and inflammatory exudate. Secondary hemorrhage is frequent.

If bleeding is continuous the treatment may become one of the emergency

operations, otherwise delay is permissible. Apply tests for collateral efficiency. If operation is decided upon, apply an Esmarch constrictor above the aneurysm. Incise the aneurysmal sac and turn out the blood clots. If the wound in the artery is small, suture it. If suturing the artery threatens to result in excessive narrowing, abandon this procedure and resort to

1. resection of a portion of the damaged artery and perform an end-to-end union; or
2. interpose a piece of resected vein if the gap is too large although this is not often successful. (Circular Angiorrhaphy—Goyanes, Lexer). Matas and Delorme condemn this procedure. Jeger, Bior and von Eiselsberg use it. Or do
3. a Matas Operation or
4. an Antyllus Operation.
5. In grave cases resort to amputation.

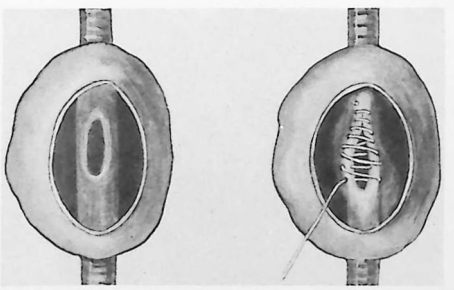


FIG. 713. Matas' endo-aneurysmorrhaphy restorative suture. In the illustration at the left, the orifice of connection between the artery and the aneurysmal sac is shown. In the one to the right, this orifice is closed by a continuous suture, according to Matas' method.

ARTERIOVENOUS ANEURYSM

This condition was first described by John Hunter in 1757. It consists of a communication between an artery and a vein. There are two forms:

Aneurysmal varix; Pott's aneurysm (artery and vein directly communicating).

Varicose aneurysm (artery and vein communicating through an intervening sac).

It is perhaps wisest to refrain from operating on aneurysmal varix as long as the condition appears stationary, causes no inconvenience to the patient and is free from complications.

Varicose aneurysm should be operated upon in most instances. Raymond W. McNealy states that operation becomes mandatory at any time, particularly however when there are signs of:

1. progressive enlargement of the sac or hematoma,
2. venous stasis which gives rise to increasing varicosities; these are usually of greatest significance in the lower extremities,
3. trophic disturbances which impair or imperil the vitality of the part,
4. intractable pain or paralysis arising from nerve involvement,

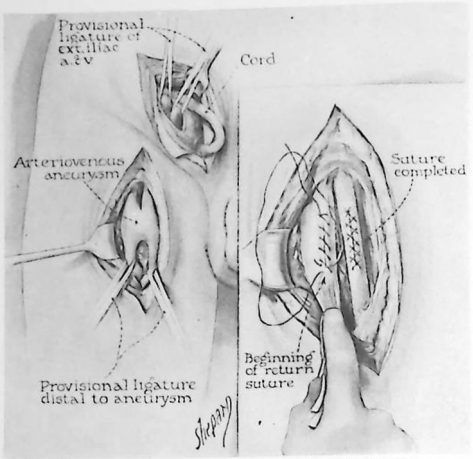


Fig. 714. Arteriovenous aneurysm. (Courtesy of Dr. R. W. McNealy.)

5. cardiac manifestations which signal impending or actual myocardial damage or
6. special complications such as exophthalmos, hemiparesis or convulsions."

Operative Measures

Immediate repair in the absence of infection.

Treatment consists of ligation of the afferent and efferent vessels with or without excision of the sac. This, of course, applies to vessels of lesser magnitude. In important vessels, ligation of the vein carries with it the danger of gangrene. Therefore, preservation of the vein in arteriovenous aneurysm plays a signal rôle. Careful selection of operation to suit special instances is of utmost importance.

LIGATION

Anel-Hunter's method is, on the whole, unsatisfactory.

Preliminary ligation of the main trunk has been practiced with success by McNealy. In 1928 McNealy and Lichtenstein used a special method for applying autogenous fascial bands thus obviating the danger of the suture cutting through.

Mayo reported success from ligation of the fistulous tract. It is hazardous when the tract is large. Direct division of the fistula and lateral suture of the resultant openings in the artery and vein are commended by McNealy (Fig. 714).

DIVERS METHODS OF TREATMENT OF ANEURYSM

1. Ligation of the principal vascular trunks.
2. Compression.

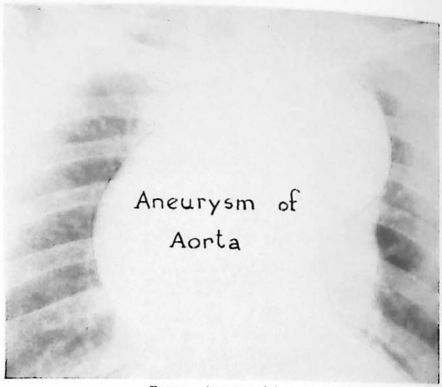


Fig. 715. Aneurysm of the aorta.

3. Introduction of foreign bodies into the aneurysmal sac (Moore-Colt).
4. Electrolysis (Corradi).
5. Acupuncture (Sir William Macewen).
6. Perianeurysmal sympathectomy (Giordano).
7. Amputation is indicated in
   (a) Gangrene.
   (b) Suppuration of aneurysm or its diffusion.
   (c) Uncontrollable secondary hemorrhage.

ANEURYSM OF SPECIAL ARTERIES

Aneurysm of the Thoracic Aorta

This condition is treated mainly by medical measures. When the aneurysm projects in front, the introduction of iron wire or Colt's apparatus is attended with some success (Figs. 715, 716, 717).

In aneurysm of the ascending arch of the aorta, ligature of the right carotid and right subclavian or of the left carotid artery alone should be done.



Fig. 716 Fig. 717

Fig. 716. Saccular aneurysm of arch of aorta. See next Fig. 717.
Fig. 717. Same as preceding. Operation by wiring. Recovery. (Courtesy of Dr. R. W. McNealy.)

Aneurysm of the Innominate Artery

Rest and at times potassium iodide in large doses are of value. Distal ligature may be used. Innominate aneurysm is very frequently associated with aneurysm of the arch of the aorta.

Aneurysm of the Common Carotid Artery

Ligation of the common carotid above or below the omohyoid muscle may be tried. If the aneurysm is near the root of the neck, Brasdor's operation is the procedure of choice (Fig. 718).

Aneurysm of the External Carotid Artery

In suitable cases dissect the sac after ligating the branches that spring from it; if this fails ligation of the trunk of the common carotid is indicated. In older patients hemiplegia is likely to follow ligation of the common carotid (Fig. 719).

Aneurysm of the Right Temporal Artery

Figure 720 depicts aneurysm of the right temporal artery.

Aneurysm of the Internal Carotid Artery (Extra-Cranial Portion)

Ligation of the Common Carotid.

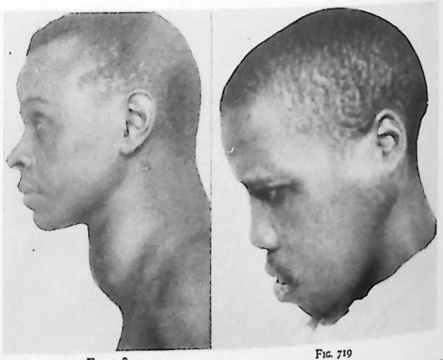


Fig. 718 Fig. 719

Fig. 718. Aneurysm of the common carotid.
Fig. 719. Arteriovenous aneurysm of the external carotid with facial paralysis. (Courtesy of Dr. R. W. McNealy.)

Aneurysm in the Orbit

Ligation of the Internal Carotid.

Aneurysm of the Subclavian Artery

This form of aneurysm is difficult to treat. Extirpation; Matas' Operation; Ligation of the Innominate Trunk (Hunter's method).

Aneurysm of the Axillary Artery

Compression (digital); ligation of the subclavian (third portion) (Fig. 721).

Aneurysm of the Brachial Artery

Extirpation (Fig. 722).

Aneurysm of the Abdominal Aorta

Medical; compression.

Iliac and Inguinal Aneurysm

Extirpation; proximal ligation.

Popliteal Aneurysm

Extirpation; Aneurysmorrhaphy of either type (Figs. 723-724).

Femoral Aneurysm

Compression. In diffuse aneurysm here, extirpation of the sac is indicated or if conditions are propitious Matas' aneurysmorrhaphy may be used (Fig. 725).

Comment. The analytical student will find some food for thought when analyzing what has been said about the various operations for



Fig. 720. Right temporal aneurysm. (Courtesy of Dr. R. W. McNealy.)

aneurysm with a discussion on the subject by G. Menegaux,[1] who has the following to say:

In 1889, Delbet began his work on arterial and arteriovenous aneurysms. In fact, this period marks the beginning of modern surgery. Antisepsis and asepsis and rational technics had difficulty in gaining adherents. Delbet has the merit of having proposed systematically the direct treatment of arterial and arteriovenous aneurysms. Having carefully analysed 695 cases, he was led to recommend extirpation of aneurysms and to discard the employment of all indirect methods that at that time enjoyed great popularity. Three methods were then practiced: flexion, compression and ligature.

Flexion consisted in compressing the artery and the aneurysmal sac by resorting

[1] L'oeuvre Scientifique du Professor Pierre Delbet Livre Jubilare Offert.

to an acute flexion of the leg on the thigh. This uncomfortable and painful position was maintained for several days, 14 or 15 days on the average. It resulted in 42 cures in Barwell's 91 cases. Its greatest danger was rupture of the sac. Gangrene and suppuration were not infrequent. Though this method had disadvantages, Delbet in 1888 did not advise its complete abandonment. He advised its use in aneurysm

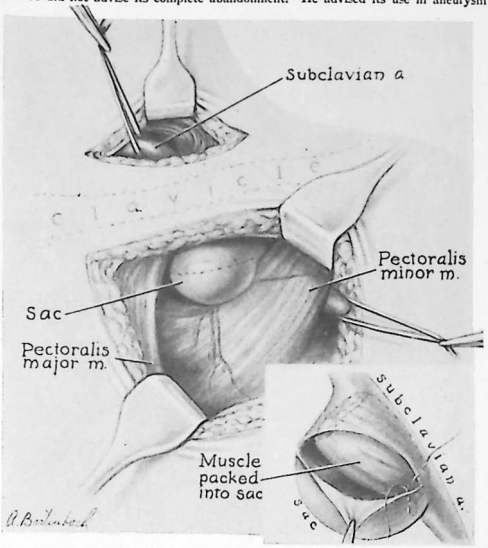


Fig. 721. Aneurysm left axillary artery. Operative procedure. Recovery. (Courtesy Dr. R. W. McNealy.)

located beneath the articulation, in aneurysms of small volume with thick and hard walls. He said, "It is a simple method and should be tried."

In those days, indirect compression was the method most frequently employed. In about 50% of the cases, it was successful. Different methods were employed. One was total elastic compression (Reid's method). The root of the extremity was encircled by an elastic constrictor after placing an elastic bandage around the whole limb without compressing the aneurysm directly. Indirect compression was generally digital. It could be total, continuous or intermittent. In popliteal aneurysms, the femoral artery was compressed at different points. Indirect compression was often followed by inflammation and suppuration of the sac. Frequently gangrene of

the extremity resulted. At times, another aneurysm was produced at the point of application of the pressure. It is a method of limited use. It should be employed only with great gentleness so as to avoid disastrous consequences. (Delbet 1889.) In 1900, he is more positive and states that compression should be abandoned because it is less effective and more dangerous than extirpation. Ligature was also employed in those days. Delbet condemns it because it exposes the patient to secondary hemorrhage. He favors extirpation. Perfect hemostasis can always be secured if the operative field be kept aseptic and dry. In extirpation, the sac is eliminated and the danger of gangrene is thus markedly lessened. In ligature there is coagulation of most of the saccular contents; this is a fruitful source of emboli.

Delbet bases his theoretical considerations and his conclusions upon a series of axillary, inguinal, femoral and popliteal aneurysms. In 68 cases of extirpation, he had 2.94% gangrene. In 224 cases of ligature proximal to the sac gangrene resulted in

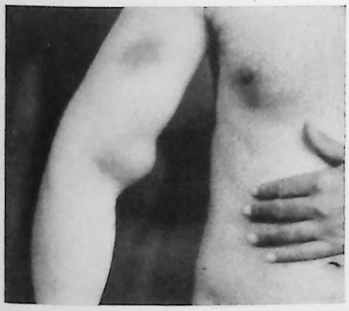


Fig. 722. Aneurysm of right brachial artery. (Courtesy of Dr. R. W. McNealy.)

7.58% of the cases. The mortality is higher after ligature than after extirpation; 20% after ligation, 10% after extirpation. Delbet favors extirpation of the sac for the following reasons:

1. Inflammation of the sac may follow ligation. This inflammation may occur early or late (1 year to 15 months). Neither asepsis nor antisepsis offer an obsolute protection against this complication. It has even followed simple compression.

2. Recurrence of the aneurysm may occur after ligation. Such occurrence may be early or late (7 years in the case of Hawkins; 15 years in the case of Cooper).

3. The aneurysm may persist, being but negligibly influenced by the ligation.

4. A second aneurysm may appear at the seat of ligature. After ligation, the sac persists without marked diminution in volume and the tumor continues to compress neighboring organs, especially the nerves. The latter may be enmeshed in the inflammatory tissue surrounding the aneurysm. Compression of the nerves may determine the appearance and aggravation of symptoms necessitating amputation of the limb.

To summarize: Cures obtained by ligature are incomplete. Recurrences occur. Gangrene due to thrombosis or embolism is frequent. Even in favorable cases there may persist nervous complications causing paralyses, neuralgias, trophic disturbances. Extirpation gives, on the whole, a better result. Recurrences are impossible;

nervous disturbances are suppressed; the treatment is radical. Extirpation is also indicated in ruptured aneurysms, of course. If the aneurysm has ruptured into a neighboring articulation, extirpation is the only operative procedure to be employed before amputation is resorted to. Extirpation has the double advantage of having a lower mortality and of being productive of better results.

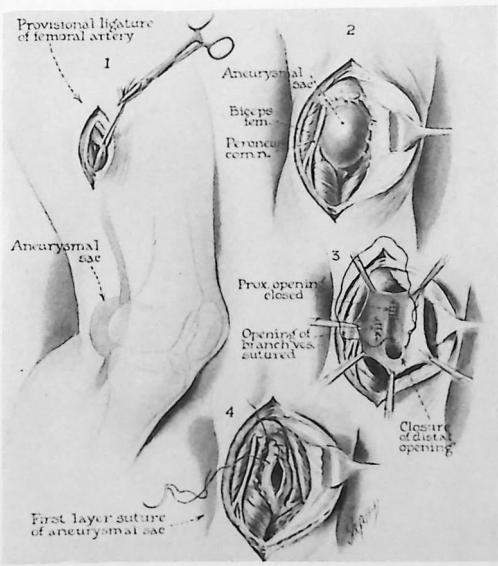


Fig. 723. Aneurysm of the popliteal artery. (Courtesy of Dr. R. W. McNealy.)

When Delbet first recommended extirpation in 1888, his ideas were too revolutionary for the epoch and they were very severely criticized. There was only one surgeon of note to defend Delbet, Trélat. He said that Delbet should be complimented for his investigations and interesting conclusions concerning the rôle of collateral arteries, and for his careful studies of the pathological anatomy of aneurysms. In 1895, Delbet presented before the Société de Chirurgie a case of popliteal aneurysm that he had treated and cured by extirpation. In 1895, he completed his conclusions of 1888 which in substance are: first, ligature is a more serious operation than

extirpation; second, it is more frequently followed by gangrene; third, it is less efficacious; fourth, its recoveries are less complete than those attending extirpation.

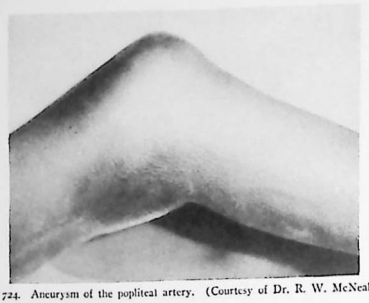


Fig. 724. Aneurysm of the popliteal artery. (Courtesy of Dr. R. W. McNealy.)

In 1905, Delbet stated that his arguments are not contested and that extirpation has become the method of choice. In 1900, discussing a case of Monod he agreed



Fig. 725. Aneurysm of the femoral artery. (Courtesy of Dr. R. W. McNealy.)

with the latter that in the course of the operation, the aneurysm should be opened so as to resect as little as possible of the artery. In 1903, he reports an aneurysm of the

superficial femoral extirpated by him. In 1904, he again discussed gangrene following ligature and its mode of production. (It is usually embolic.) He says that arterial aneurysms are often of syphilitic origin; therefore, syphilitic subjects should be subjected to antisyphilitic treatment, before deciding to operate. In 1906, he stated that a good deal of work had been done on vascular surgery. Extirpation he admits has the disadvantage of suppressing the arterial trunk. Reconstitution of a vessel would be the restitutio ad integrum. To remake a permeable arterial canal, various artifices have been utilized. Delbet discusses them as follows:

1. The closure of the orifice of communication between the sac and the artery, as practiced by Matas. This is only feasible if the aperture be small. Of what value is suture placed upon diseased tissues? It is to be feared that the sutures will not hold.

2. The rebuilding of the arterial wall with saccular tissue. This also is a method proposed by Matas, when the arterial orifice is large. Delbet does not believe that it is possible to obtain a sufficiently resisting arterial wall when the sutures have to be placed upon profoundly modified or pathologically altered anatomical elements.

3. End-to-end sutures of the artery after resection of the aneurysm. This procedure is only possible if the segment of artery to be sacrificed is minimal and if it has been possible to divide the vessel wall in healthy areas.

4. Arterial grafts, auto or homoplastic, or autoplastic venous grafts. These are exceptional methods, often disappointing. In his hands, arterial grafts have been unsuccessful.

Nowadays, the conclusions of Delbet are accepted. Very few surgeons treat arterial aneurysms by ligature except in certain sites where direct access to the sac is impossible and dangerous. Extirpation remains the method of choice.

Arterio-venous aneurysms. Delbet has given this pathological entity considerable study. William Hunter, brother of John Hunter, made a splendid analysis of the symptoms and of the particular anatomy of the first arterio-venous aneurysm diagnosed. He said that arterio-venous aneurysm is a benign lesion. Such is not the belief of Delbet. He shows that aneurysmal varices or varicose aneurysms never heal spontaneously. Many increase rapidly in size and then either end by rupture or by causing gangrene of the limb.

Rarely are they compatible with full functional integrity. They often cause functional or trophic disturbances in the lower extremity (ulcers, muscular atrophy, elephantiasis, etc.). They cause disability. They expose the patient to serious early or late accidents. Though arterio-venous aneurysm may be of long standing, they can at any time cause disastrous complications. Active treatment of arterio-venous aneurysm is indicated. Coagulating injections are to be abandoned. Delbet had 4 cases (2 cures, 1 death, 1 amputation). Galvanopunctures also are to be condemned (8 cases, 8 failures). Compression is less valuable than in arterial aneurysms. (Be the compression total or be it by flexion of the limb, it gives cures in 38% of the cases.) Direct compression has given a few cures. It, however, tends to inflammation of the sac and furthermore, it is painful to endure. Anel's method of ligation in 44 cases, gave 10 cures, 20 failures or recurrences, 9 cases of gangrene, 5 cases secondary hemorrhages. With operations upon the sac or upon neighboring vessels of the sac, gangrene is usually less frequent. Operations upon the vein alone are not curative and should be abandoned. Double ligation of the artery is often followed by recurrence. Quadruple ligature suffices if there be no sac or if the sac be small. Delbet recommends extirpation of the sac. This sac after it attains a moderate size may compress the surrounding nerves and cause functional disturbances. Extirpation properly performed permits accurate hemostasis; it is not followed by recurrence nor gangrene of the extremity. Successful cases are reported. He says that voluminous arterio-venous aneurysm may have a harmful influence upon the circulatory system that it may even lead to cardiac dilatation with asystole.

Comment. According to Delbet, the time-honored, difficult Matas operations seem to yield to the simpler method of extirpation in many cases.

OPERATIONS ON THE VEINS

VENESECTION

(PHLEBOTOMY; BLOODLETTING)

The veins usually selected are: the median basilic vein or median cephalic (Fig. 726) overlying the brachial artery at the bend of the elbow; at times the internal saphenous vein at the ankle is sectioned. The median cephalic vein is usually chosen because of its greater distance from the brachial artery and the posterior relation to cutaneous nerves. One method is to constrict the arm with a

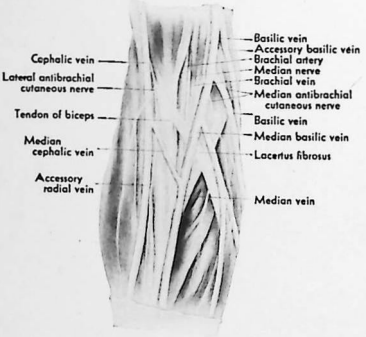


Fig. 726. Superficial dissection of region of elbow, showing relation of veins and nerves (Piersol's Human Anatomy.)

tourniquet of some sort to obstruct venous circulation without interfering with the arterial bloodflow. The veins will become distended, except in obese persons when the position of the vein must be ascertained by the sense of touch. Define the vein to be incised by the finger and hold it in position by the thumb placed just below the point of incision (Fig. 727). Cleanse the area; incise obliquely to the transverse diameter of the vein. The flow of blood may be augmented by having the patient clench his fist forcefully. The required quantity having been taken (½ to 1 pint), arrest the flow of blood by removing the bandage above. Compress the opening with a sterile sponge and reinforce with bandage.

A second method utilizes a hollow needle of large bore introduced into the vein and permitting the blood to flow out or to be aspirated by a suction arrangement. (Fig. 753 as under Transfusion.) This method tends to preserve the vein

from thrombosis, prevents soft tissues from being opened, allows the blood to be more easily measured—even utilized for transfusion purposes—and it is technically cleaner.

EMBOLISM

Embolism may affect any vessel, in the limbs particularly. Emboli are usually lodged at the bifurcation of the main vessels. Emboli are not uncommon in the



Fig. 727. Venesection.

popliteal artery in cases of valvular disease of the heart. In such instances both branches of the vessel are blocked. In case such embolism takes place the patient usually complains of sudden violent pain in the area affected. This is followed by numbness and coldness of the limb below the embolus. Palpation of the area affected elicits exquisite tenderness. Recovery may take place, while gangrene and formation of an aneurysm are not uncommon events. In instances where the diagnosis is made early, embolectomy may be resorted to. This consists of opening the affected vessel, removing the clot and suturing the vessel wall. (Fig. 728.)

VARICOSE VEINS (VARIX-PHLEBECTASIA)

Varicose veins are usually encountered in the lower extremities. Defective heart valves, pressure occasioned by pregnancy, tumors, tight corsets or garters as well as occupations demanding constant standing in an erect position over a considerable length of time and the "age of stasis" so aptly depicted by Frederick Dyas, all contribute to the formation of varicose veins. Nevertheless the definite factors responsible for the enlargement and atrophy of the vein wall are not definitely understood.

Retarded circulation in affected veins is likely to result in phleboliths which are palpable under the skin. If the saphenous or femoral veins are involved,

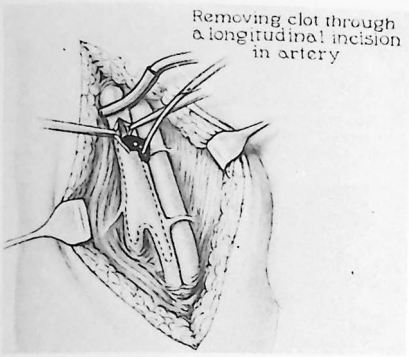


FIG. 728. Embolectomy.

there is danger of embolism from a detached thrombus. The dilatations may be of a fusiform or sacculated character; in the latter variety the vessel wall is likely to break followed by considerable hemorrhage.

The skin of the leg and foot tends to become infiltrated and inflamed. This is likely to cause any minor injury to become infected resulting in a so-called "varicose ulcer." Varicosities affecting large areas of fine veins are much more annoying than those affecting large venous trunks. When large, deep-seated veins rupture, there is a considerable swelling accompanied by ecchymoses; if they become inflamed but do not rupture, the surface area may become red, but with no ecchymoses, a thrombosis of the veins is indicated which may result in periphlebitis and abscess formation if infection supervenes.

All factors which tend to aggravate the condition should be removed before instituting local treatment for varicose veins. Temporary relief may be obtained

by elevating the affected limb. Elastic and flannel bandages are also useful. An elastic stocking which fits snugly gives more lasting effects.

Injection Treatment

Injection treatment of the blood vessels is not recent. Pravaz, in 1851, invented a syringe for injection of ferric-chloride into aneurysms. The obliterating action of mercuric-chloride, salvarsan, and glucose when repeatedly injected into a vein is well known. Sicard, observing this action during the war following injections of luargol, applied the method to varicose veins, first using sodium carbonate. Since then various solutions have been recommended.

The method, if it does not later prove disappointing, has many advantages over surgical work, particularly in that the patient is not incapacitated and can carry on his daily work unhindered. No scars result and many small veins are treated which would not receive attention in surgical work. McPheeters, of Minneapolis, has reported 53,000 cases injected, with seven deaths (0.00654 per cent). From the standpoint of recurrences, the injection method is 5 to 6 times as successful as the surgical; in either case the main saphenous vein must be obliterated.

To prevent pathology following injection, Regard advises that substances chosen for injection be sclerosing and not thrombus-forming chemicals.

Regard describes three distinct phases which take place following injection: first, cloudy swelling of the endothelium extending to the outer coat of the vein; this results in the lumen being punched off and the blood being forced out as the vein becomes narrower. This causes the flow of blood to slow up, thrombosis takes place and the second stage appears. The clot is firmly fastened to the vein wall so there is little danger from embolism. The vein with the clot becomes organized. Sicard calls this process "venitis" as opposed to a phlebitis. This takes place in the vein and varies in accordance with the amount and type of solution used. In the smaller veins Melkson believes the blood is forced out of the vein and no clot forms.

It has been shown in different instances that the bloodflow in large varicosities is slowly in the direction of the heart or stationary when the patient is lying down; when standing, it is toward the periphery. This might be why embolism does not often occur after injection and why the patient should be ambulatory following the treatment. McPheeters' figures show a mortality of only 0.00654 per cent from pulmonary emboli.

The Trendelenburg test (which see) enables the surgeon to learn the direction of the blood flow in varicose veins. If the leg is raised, the veins permitted to empty and the patient stands quickly, the veins will be noticed to fill from above. The constriction tests show that the leg fills slowly from below. When the veins are emptied, a tourniquet is placed around the thigh and the patient permitted to stand. The veins are noted to fill very slowly from below or hardly at all. Immediate filling takes place as soon as the constriction is removed. If the vein happens to fill rapidly before the constrictor is removed, it denotes regurgitation from deep to superficial veins resulting from a dearth of competent valves in the perforating veins.

The treatment is easily given and causes the patient little discomfort; it should not be given to patients who have suffered a recent phlebitis or those who

suffer from cardiorenal disease or any long-standing illness which has left the patient in a run-down condition. Pregnancy is a contraindication for quinine solutions.

The needles used should be very fine and sharp and should be inserted directly into the vein (Fig. 729). A tourniquet may be applied before the vein is entered and after it is emptied of blood the injection should be made and the point of insertion protected by a coating of collodion and a sterile gauze dressing lightly applied. The patient is not incapacitated by the procedure.



FIG. 729. Technic of injection of varicose veins (after Kirschner).

A favorite solution used by many is salicylate of soda in 20 to 40 per cent solution using 3 to 10 cc. at each sitting; this is followed by a stinging pain of short duration and sometimes by muscular cramps which last a few minutes. The injection of Genevrier's solution which consists of quinine hydrochloride, urethane and distilled water is painless although the veins involved may be tender for 24 hours. It is, however, considered superior to the salicylate of soda solution. Sodium morrhuate is preferred by many.

The puncture sites for the injection treatment should be rendered sterile by the application of ether and iodine. Insert the needle at the lowest point of the vein, withdraw it a little so that a drop of blood flows backward through the needle; hold the needle in position for half a minute. Cover the point of puncture with gauze or cotton and insert the needle about two inches higher. When the injections have been completed, sponge the skin again with ether and protect the needle wounds with collodion. The treatments should be given about once a week.

The size and position of the involved veins govern the reaction of the injections. A swelling takes place on each side of the puncture which lasts a few days and the area injected may be slightly painful. Swelling of the foot and ankle may follow the injection of the large veins of the calf. Itching and discoloration may also follow for a short time.

The natural tendency of the patient toward developing varicose veins may result in the invasion of new regions; however, they very rarely recur in the region which has been injected.

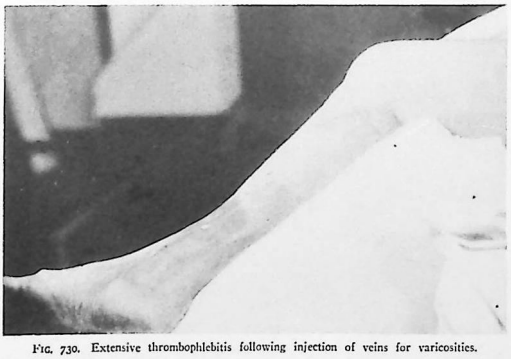


FIG. 730. Extensive thrombophlebitis following injection of veins for varicosities.

The injection treatment also offers the advantage of permitting the patient to go about his work as usual.

Great care should be taken that the point of the needle does not slip out of the vein, thus directing the solution into the surrounding tissues. Such a slip may result in the sloughing of the tissues injected (Fig. 730). In cases where the varicose veins are concealed by venous congestion and edema, steps should be taken to reduce the blood content. The application of proper bandages which have been treated generously with Unna's paste is often effective. The limb should be maintained in an elevated position. When local improvement has been obtained, the injection treatment outlined above is undertaken.

Precautions. The following rules were formulated by Ronald Thornhill:

Don't forget the possibility of quinine idiosyncrasy.

Don't fail to inquire for a history of white swelling or phlebitis.

Don't inject a drop of solution unless sure that the point of the needle is in the lumen of the vein.

Don't inject with the patient in a standing or sitting position.
Don't be tempted to inject compensatory varices.
Don't try to hurry the treatment by increasing the dose too rapidly.
Don't inject solutions of quinine during pregnancy or menstruation.
Don't proceed with the injection of quinine and urethane if the patient complains of pain.
Don't inject the floor of an ulcer.





Fig. 731 Fig. 732
Fig. 731. Trendelenburg test. Marked varicose veins.
Fig. 732. Trendelenburg test. First phase.

Don't, because an ampule has been opened, inject the whole of its contents.
Don't forget in the matter of dosage each vein is a law unto itself and therefore incline to under-dosage if in doubt.
Don't use a blunt needle.
Don't inject air bubbles into a vein.

II. Operative Treatment

The object of operative treatment of varicose veins is to transfer the circulation from the superficial veins to the deep ones. It therefore stands to reason that before such operation is undertaken the circulation in the deep veins must be unimpeded. It must also not be forgotten that superficial varicosities may be Nature's method of "detour" from an obstructed area. The Trendelenburg test depicted in Figs. 731, 732, 733, 734 permits the competence of the deep veins to be tested.

In cases of doubt, Mayo applies an elastic support to the affected limb for a week. If the patient feels relieved, it speaks for competency of the deeper veins.

Trendelenburg conceived the idea that regurgitations of venous blood from the deep femoral vein into the long saphenous vein take place resulting in varicose veins. On this basis the Trendelenburg operation was evolved which consists of

doubly ligating and dividing the long saphenous vein close to the saphenous opening.

TRENDELENBURG OPERATION

Step 1. Local anesthesia (Fig. 735).

Step 2. Surround the upper part of the thigh with a constrictor sufficiently tight to cause superficial dilatation of the veins.

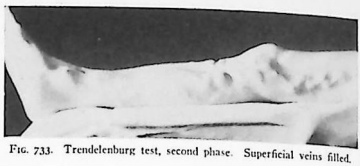


Fig. 733. Trendelenburg test, second phase. Superficial veins filled.

Step 3. Make a longitudinal incision about two inches long along the course of the vein at the junction of the middle and upper thirds of the thigh (Fig. 736).

Step 4. Expose, isolate and ligate the long saphenous vein at the upper and lower angle of the wound. The portion of the vein situated between the two ligatures is excised. Suture the wound. Dress. Keep the limb at rest in an elevated position for a fortnight.



Fig. 734. Trendelenburg test, third phase. Deep veins competent.

EXCISION (MADELUNG'S OPERATION)

Step 1. Apply a tourniquet after emptying the veins as illustrated above. After outlining the veins to be excised, a longitudinal incision is made along the vessel. Avoid cutting into the varicose vein. The excision is carried out as shown in the illustration (Fig. 737).

Step 2. Retract the skin, expose the main trunk of the vein; ligate it. Grasp the distal end with an artery forceps and divide it between two ligatures. While traction is made on the artery forceps, the varicose bundle is excised with scalpel or scissors. Collateral veins are doubly ligated and divided. Close the skin after hemostasis has been secured. Dress.

Note. The removal of varicose veins may be aided by using a Mayo vein dissector. (Fig. 738.) Babcock's acorn stylet, vein-strippers, ring-enucleators are not suitable in cases when the veins are adherent to the skin, brittle or cirsoid in nature.

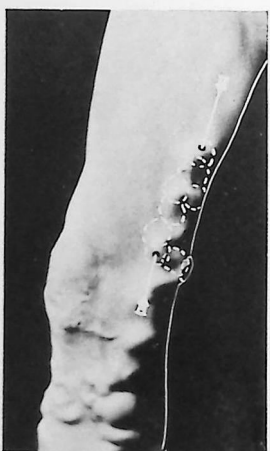


Fig. 735. Local anesthesia for operation on varicose veins.

FRIEDEL'S OPERATION

In cases where there is a marked enlargement of the veins, where inflammation has supervened rendering excision of the veins difficult and hazardous, Friedel's procedure may prove of value. It is certainly worth considering in cases complicated by ulcus cruris and marked inflammatory reactions.

Step 1. Ligate doubly, and divide the long saphenous vein.

Step 2. Mark a spiral line with a scalpel encircling the affected limb above and below the involved region. The rings of the spiral should be rather close, for the more the veins are divided the greater the chances are for cure (Fig. 739).

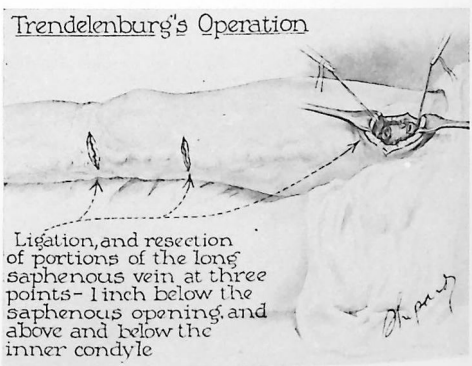


Fig. 736. Trendelenburg's operation for ligation of the saphenous vein.

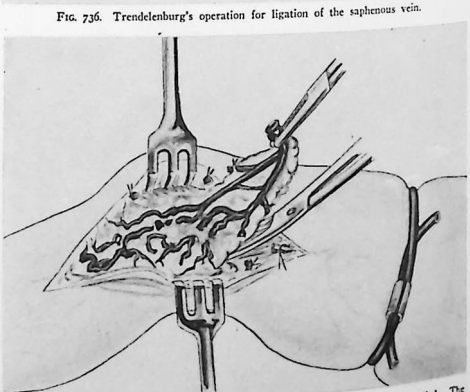


Fig. 737. Madelung's operation for varicose veins. Tourniquet has been applied. The principal group of varicosities have been dissected en masse together with the surrounding adipose tissue. As shown in the illustration dissection is begun above and proceeds downward.

Step 3. Incise the structures along the outlined spiral to the deep fascia. Ligate the vessels as encountered, guided by proper retraction. In ulcerations, join the spirals above and below the ulcer by two vertical incisions. This will divide the veins coming from the ulcers.



FIG. 738. Mayo's vein dissecting forceps.

Step 4. Pack the whole length of the wound. Let it heal by granulation.

Moreschi's incisions are circular dividing the muscular fasciae.

Rindfleisch's incisions are similar but spiral.

DELBET'S OPERATION

The rationale of this operation is based upon Trendelenburg's observation that varicosity of the long saphenous vein is due to incompetent valve action at its junction with the femoral—the weight of the blood column in the inferior cava bearing on the saphenous vein. In the femoral vein there exist valves below the junction of the two veins. The operation is performed as follows:

Step 1. Make an incision about 20 cm. long from Poupart's ligament along the femoral vein.

Step 2. Expose the spot where the long saphenous vein empties into the femoral vein.

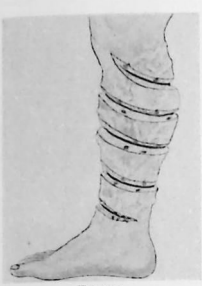


FIG. 739

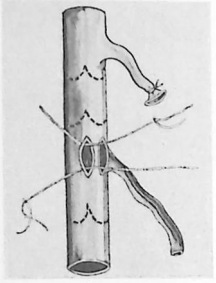


FIG. 740

FIG. 739. Friedel's operation. Spiral incision of skin, subcutaneous tissue and superficial fascia in the treatment of varicose veins. The divided vessels are ligated and the wound is left open to heal either by granulation or primary suture. The latter method is usually adopted; on occasion, the former may be resorted to. (After Kirschner.)

FIG. 740. Delbet's operation of reimplantation of the saphenous vein into the femoral vein (after Hesse and Schaack).

Step 3. Doubly ligate the saphenous as in the Trendelenburg operation and divide it. Ligate collaterals as encountered.

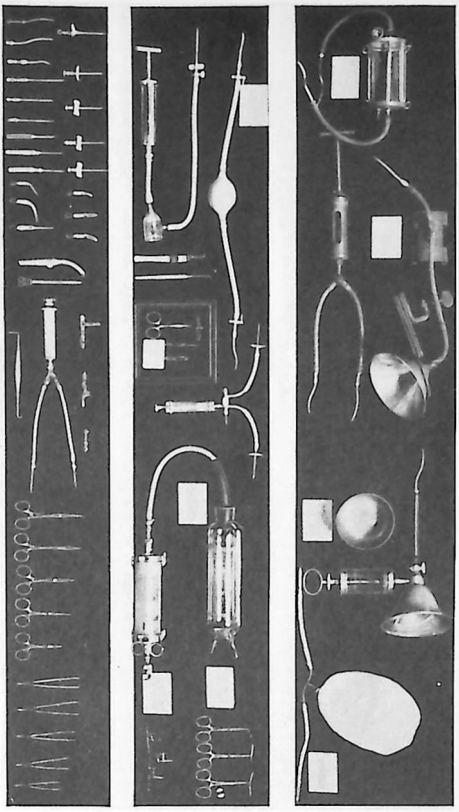


FIG. 741 (Courtesy of V. Mueller, Chicago)

DEVELOPMENT OF INSTRUMENTARIUM USED IN BLOOD TRANSFUSION

FIGS. 741-743.

1656 A. D. The first attempt at transfusion of blood was made by Wren, an English astronomer. A bladder was used as a receptacle and quills as cannulae or tubes.

1819 A. D. James Blundell, an English surgeon, was the first to realize that success in the transfusion of blood depended upon human blood being used. Many types of instruments were tried and the one shown (replica) was the most successful. Modifications of this method are used today. Another of Blundell's instruments consisting of a funnel with tubes attached is shown.

1874 A. D. Collin used what might be considered a combination of Blundell's two methods, using a funnel shaped container to which was attached a syringe for injecting collected blood.

1819 A. D. Graefe, German surgeon, devised an apparatus for direct transfusion of blood where the tube carrying the blood from the donor to the recipient was brought through a glass chamber containing hot water to prevent coagulation.

1863 A. D. Aveling, an English surgeon, devised a method which made use of a "one way" rubber bulb syringe. This led to the development of other methods, some of which are in use at the present time.

1911 A. D. Curtis and Davis, American surgeons, designed a tube, paraffin-coated, into which the blood was collected and then injected under slight pressure from a syringe which was attached to the top of the tube.

1907 A. D. Crile, anastomosis method of blood transfusion. Silver tubes or cannulae with small handles are used. The tubes are held by forceps and the vein is drawn through the tube and cuffed backward over the cannula and tied. The artery is then slipped over the cannula and tied as indicated. After completion of the transfusion, the ends are brought together and sutured with fine silk thread.

1911 A. D. Soresi, American surgeon, devised a method using small tubes, mounted on an adjustable holder. The artery and vein were drawn through the tubes or cannulae then brought into apposition and the ends sutured after which the tubes and carrier were removed.

1913 A. D. Lindemann, American surgeon, devised an instrument for blood transfusion which consisted of three parts: fine trocar needle; inner cannula; outer cannula. Trocar and inner cannula are withdrawn after proper placement is indicated by the flow of blood from the vein. Two 50 cc. all-glass syringes are used for injections.

1920 A. D. De Lee, American surgeon, used a syringe and rubber "T" tube with needles of his own design. This greatly simplified the transfusion operation and had the advantage of doing away with valves, springs, etc.

1915 A. D. Percy,[1] American surgeon, modified the Kimpton and Brown apparatus, using a large container and a new design of tip, was able to transfuse larger quantities in less time than consumed in other methods.

1925 A. D. Soresi blood transfusion apparatus No. 2. This is a hand operated pump known as the "Little Factotum"; and a number of modifications of this apparatus are now in use.

1925 A. D. A. A. Strauss, American surgeon, used syringes and specially designed needles of various shapes and sizes. By using two syringes, one is being filled while the second is used for injecting.

1926 A. D. Scannell, American surgeon, used a three-way valve and syringe in combination, permitting the injection of saline solution when required.

1912 A. D. Bernheim, American surgeon, used two metal cannulae, one of which was attached to the artery, the other to the vein. The two tubes were then connected.

1908 A. D. Lespinasse, an American surgeon, devised platinum tubes of various sizes and lengths. Transfusion is often an emergency operation, and as platinum may be sterilized by flame, the Lespinasse tubes may be quickly sterilized.

1906 A. D. Carrel used his gold tube cannula at this time, thus somewhat simplifying the anastomosis method; an artery and blood vessel were attached to the tube.

1909 A. D. Brewer, an American surgeon, used a series of glass tubes or cannulae which were paraffin-coated to prevent coagulation.

1913 A. D. Kimpton and Brown, American surgeons, designed a glass tube with cannula end, used after coating with paraffin. This method introduced a new era in the transfusion operation and though modifications followed, the original is still extensively used.

1909 A. D. Elsberg, American surgeon, devised a cannula and means of applying it which resulted in shortening the time required for the operation.

1928 A. D. As used at the Mayo Clinic for indirect transfusion with the citrate method, this represents an assembly of few parts. Gravity replaces syringes or pumps used in most modern methods.

1932 A. D. Duflow—a double cylinder in combination with pump is used. While one cylinder fills up the other injects.

1915 A. D. Unger, American surgeon, was one of the first to successfully employ continuous transfusion through mechanical means.

1933 A. D. The De Bakey-Gillentine direct transfusion method.

1910 A. D. Owens, American surgeon, used a pump consisting of a series of rollers mounted in circular form, which pass over rubber tubing. The blood is sent from donor to recipient without coming into contact with valves or other metal parts except the cannula.

[1] Doeliottl designed a much simplified and excellent transfusion apparatus, based, as is Percy's on the Kimpton-Brown principle.

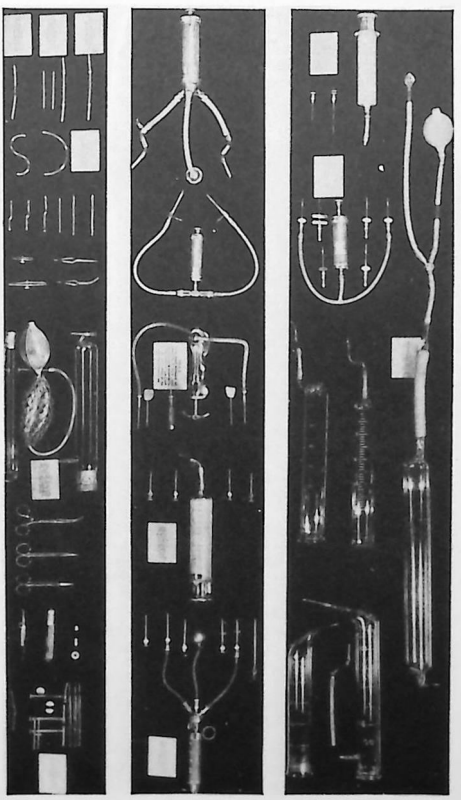


FIG. 742

Step 4. Do an end-to-end anastomosis between the lower end of the saphenous vein and the femoral vein by uniting the open end of the saphenous into an appropriate opening made into the side of the femoral. (Fig. 740.)

Comment. Only those who are expert in vascular surgery should attempt this operation.

BLOOD TRANSFUSION

Historical Notes. (Figs. 741-742-743.) The "Book of the Wisdom of Solomon" refers to blood transfusion. It is also referred to in the anatomy of Herophilus. In Ovid the following line: "Ut replearn vacuas juvenili sanguini venas" is of definite significance in this connection. Villaris "Life of Savonarola" speaks of the transfusion practiced by a Jewish physician on Pope Innocent the Eighth in 1492. Lohr or Lower about 1660, at Oxford University, transfused blood from one dog to another through the medium of a goosequill. Sir Christopher Wren and Archibald about two years later, transfused a drunkard with sheep's blood. No fatal issue followed. In 1666, Dr. Croone told Peppy of an experiment in animal (dog) blood transfusion. The Parliament of Paris issued an edict that no transfusion of blood can be done without the permission of the "Faculty of Medicine" of Paris. The method was ridiculed and attacked by its detractors and soon was suppressed. In 1835 Bishop introduced the use of defibrinated blood; the method proved dangerous. Transfusion was not recognized as a legitimate method until Blundell in 1824 proved its merit. In 1875 Landois showed that animal serum was hemolytic to human blood. In 1892 Maragliano showed that the serum of a healthy man will prove hemolytic to a serum alien to it. This contribution was of great value in emphasizing that human serum alien to another serum is dangerous and may cause death. Von Bergmann pointed out that salt-solution is just as efficacious as blood, the important point being to sustain intracardiac and intravascular pressure and not the nutritive value of the blood. Nicholas Senn condemned transfusion as useless, in fact, blood transfusion was in abject disrepute until Crile in 1898 revived this great aid in medicine by the direct method of transfusion. Crile and Carrel showed that blood is superior to salt-solution. D'Agote of Montpellier devised the citrate method. Frequent reactions were the result. Modern practice consists of transfusing whole, typed blood.

At present many cases deemed inoperable may be brought to operability by means of blood transfusion.

Crile in 1906 has shown that when a patient is nearly dead or apparently so, the introduction of salt solution by a vein may overwhelm the heart and cause death. Crile in such cases, counsels the introduction of salt solution and adrenalin through the carotid artery. The needle is promptly introduced into the artery toward the heart. If the heart begins to act, blood will appear in the tube and the administration of the fluid is discontinued. Blood-pressure in the coronary arteries may thus be reestablished.

DISEASES TRANSMITTED BY BLOOD TRANSFUSION

A survey of the literature, prepared by Harriet Hendrick under the auspices of the Committee on Blood Transfusion in the Hospitals of Chicago,[1] to determine

[1] Proceedings of the Institute of Medicine of Chicago, Vol. 10, No. 10, January 15, 1935.

1932 A. D. Medical-center transfusion apparatus—a syringe made entirely of glass is provided with a grooved plunger and three part connections, one for donor, one for citrate and one for recipient. Valve action is produced by rotating the plunger. A safety device prevents error through reversing the syringe.

1927 A. D. Head, American surgeon, presented a new principle in blood transfusion equipment in a pump of such construction that no springs or check valves are used. Injection is continuous and may be measured.

1915 A. D. Lewisohn, American surgeon, in this year reported the use of sodium citrate mixed with blood to prevent coagulation. This marked a new epoch in the operation and is still extensively used. The utensils shown are all that are needed.

Finally, instruments used by Dr. Alexis Carrel. Temporary anastomosis of blood vessels (artery and vein). Direct blood transfusion (1906).

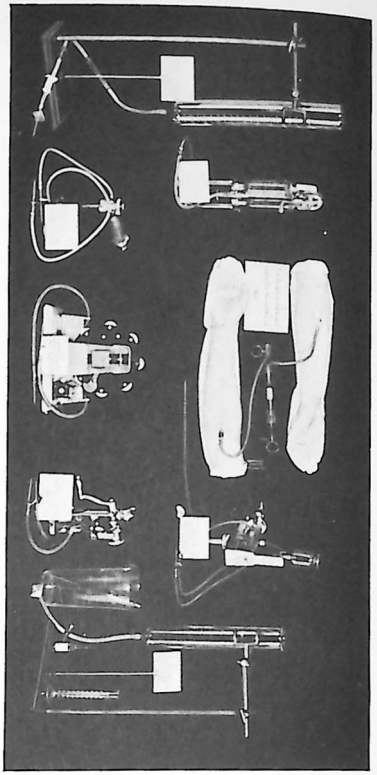


FIG. 743

the incidence of accidental transmission of disease by blood transfusion revealed thirty-five reports of syphilis, thirty of malaria, three of measles, two of smallpox, one of influenza, one of typhus fever, three of allergy, and three of tuberculosis. Undoubtedly these reported accidents represent only a fraction of similar transmissions that have actually occurred, recognized or not, in the course of thousands of blood transfusions. This forcefully implies that properly tested donors must be on call and that any donor must be tested for blood-communicable disease before being used.

SOURCES OF BLOOD

Ordinarily blood is received from living persons, either professional donors or friends, relatives, or volunteers. Occasionally it is possible to use the blood of the recipient himself, for instance in cases of copious internal hemorrhage. Recently a method has been developed for preserving blood from persons who have just undergone violent death, thus permitting a supply to be kept on hand for emergency work.

Preserved Blood

Professor Judine[1] states that the clinical effect of transfusions with blood from persons recently dead does not differ from that with blood from living donors. This conclusion is based on a series of 924 cases. The cadaver-blood also presented advantages in that mild reactions were less frequent than with the blood of living donors.

This method was first studied experimentally on dogs and then was repeated in humans. The blood of the cadaver not only immediately increased the amount of hemoglobin in the recipient but also appreciably raised the volume of oxygen present in the blood.

Persons dying of acute heart attacks or as a result of electrocution were most suitable donors. These individuals yielded easily 2-3½ liters of blood assuring transfusions to 5 or 6 recipients. The technic of collecting the blood is comparatively simple. A glass cannula is introduced into the exposed jugular vein, and the cadaver is placed in the Trendelenburg position. The blood flows out rapidly through rubber tubing leading from the cannula into a series of 500 cc. glass-flasks. The whole procedure takes five to ten minutes. The glass flasks are then capped with cotton and kept on ice for three weeks.

The cadavers are bled within six hours after death in summer and eight hours in winter. The blood is typed and the flasks labeled according to group. Serologic reactions, bacteriologic tests and autopsy findings give an excellent guarantee of safety to the recipient.

Due to fibrinolysin, the blood of victims of sudden death remains liquid during a prolonged time and thus can be preserved for more than three weeks without the addition of an anticoagulant.

PRESERVED BLOOD FROM LIVING SUBJECTS

Because preserved blood is so satisfactory for blood transfusions and because cadaver blood (aside from the repulsion which the idea of its use gives to some

[1] Prof. S. S. Judine, "La transfusion du sang de cadavre aux êtres humains." Presse med. 44:68 71 (Jan. 11), 1936.

persons) is not available in sufficient quantities for needs of a large hospital, Cook County Hospital has devised the ingenious blood-bank. To the bank is sent for deposit the amount of blood needed for transfusion and obtained from a donor, a relative, etc., without regard to the type needed. From the bank is withdrawn an equal quantity of blood of the type needed which is then used for transfusion.

In addition to these usual sources of blood there are many others if the hospital resources be properly used. A mother giving some blood for her child for intragluteal injection may give more against her child's need of further injection, the remainder being used for general hospital needs. A pregnant mother or a patient scheduled soon to undergo an elective operation may have some blood preserved against the day of confinement or operation when she may need it; and some of this blood of pregnancy may be used for premature infants since these seem especially benefited by small injections of blood from pregnant mothers. Patients who need venesection (provided not suffering from blood-borne disease) are another source of supply. Likewise those who have recovered from certain diseases, as hemolytic streptococcus infections, or have been the recipients of blood from the bank should feel an obligation to leave some blood for the specific needs of others.

The limit of blood preservation is reached when lysis begins—at the present time about three weeks. The blood should then be separated and the serum preserved.

The actual procedure[1] is:

"**Depositing blood:** Staff physicians will obtain from the Solutions Laboratory the chilled 500 cc. flasks which will contain 70 cc. of 2.5 per cent sodium citrate solution. These flasks carry two test tubes for the collection of 5 cc. of whole blood in each for the purpose of typing and for the Wassermann test. The blood will be drawn into the flask in the usual manner and taken immediately to the Solutions Laboratory. The date, the name of the donor, his address, his color, the name of the interne, and his service should accompany the flask. By means of this system one donor only needs to be bled and he need not be typed, which greatly lessens the trouble occasioned by transfusion.

"**Keeping of the blood:** In the laboratory the technician at once files it away in the refrigerator, which must maintain a constant temperature between 4 and 6 degrees C., types it, tests it for sterility and the absence of syphilis, and credits it to the service that furnished the blood.

"When a transfusion is required the patient's blood is typed and the amount of blood needed is requisitioned."

From the point of view of immediate availability and reliability, this method seems to have a definite place in large hospitals where many emergency cases are treated.

COMPLICATIONS

The dangers of blood transfusions may be largely prevented by avoiding the following:

1. Use of incompatible bloods.
2. Transmission of blood-borne diseases.

[1] Therapy of the Cook Hospital, Bull. B, April 30, 1937.

3. Excessively large transfusions.
4. Contamination.
5. Deteriorated or altered blood.
6. Introduction of air-emboli or blood-clots.
7. Too rapid introduction of blood.

Agglutination and hemolysis provide the major complications and arise from errors in typing and cross matching. These reactions tend to occur especially in the blood of persons repeatedly transfused and of those people in Group O (Moss type IV).* Indications of incompatibility usually occur after the introduction of 50 to 100 cc. of blood and include tingling pains shooting over the body, fulness of the head, pericardial pain, lumbar pain, slow pulse, cyanosis and, sometimes loss of consciousness. The pulse eventually becomes rapid and thready, the skin cold and the patient may have a chill followed by a high fever. Jaundice and hemoglobinuria may follow. Treatment consists of adrenalin (1:1000) in frequent 1 cc. injections.

Authentic reports of syphilis, malaria, measles, smallpox, influenza, typhus fever, tuberculosis and allergic manifestations having been transmitted by blood transfusion speaks for the imperative great care in the selection of donors.

Large transfusions tend to produce circulatory embarrassment, cardiac dilatation and pulmonary edema as indicated by tightness of the chest, epigastric discomfort and faintness. If these symptoms persist, immediate venesection is indicated. Likewise, too rapid an introduction may produce venous distension, cardiac dilatation and symptoms similar to the above.

The prevention of contamination and air emboli is largely a matter of personal technic and nicety. Blood which has the slightest suggestion of being "granular" or clotted should be discarded or carefully strained. For safety's sake citrated blood should probably not be kept more than 48 hours even though well iced.

BLOOD MATCHING

A transfusion should be regarded as the transfer of living tissue from one person to another. To be successful, the blood of the donor must be compatible with that of the recipient. A simple and rapid method which utilizes a "direct, cross matching" procedure will determine this. The equipment consists of two clean test tubes for each person being tested (one for blood serum, the other for red blood cells suspended in physiological saline solution), a transfer loop, glass slides and cover slips and vaseline to form "rings." The technic is as follows: From the recipient and each prospective donor the following material is secured in 15 cc. test tubes:

Tube 1—5 cc. of whole blood.

Tube 2—1 drop of whole blood (added to 5 cc. of physiological saline solution).

* Corresponding Blood Groups in the Three Standard Nomenclatures

Jansky	Moss	National Research Council
I	IV	O
II	II	A
III	III	B
IV	I	AB

Permit both to stand until the serum separates in Tube 1 (this may be facilitated by centrifuging). In the meantime construct two vaseline rings as illustrated in Fig. 744. Using a transfer loop mix in the center of a cover glass one drop of a recipient's serum and one drop of well mixed donor's cells; the opposite combination being created on another cover glass. Invert and seal each drop downward in the hanging drop chamber formed by the vaseline rings. Agitate occasionally to insure thorough mixing. This preparation keeps for hours and may be observed at leisure. Agglutination and thus incompatibility is manifested by the clumping of the red blood cells producing a "brick dust" appearance, while the lack of agglutination is evidenced by continued homogenicity in the drop. The so-called "strong side" and the portion which must be most carefully checked is that mixture containing recipient's serum and donor's cells. The serum not used in the test is sent to the laboratory for the Wassermann test and other procedures.

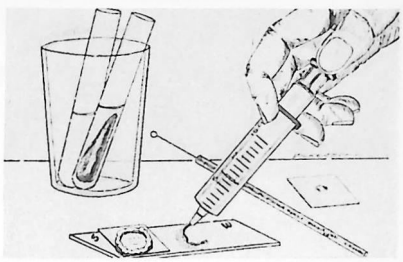


Fig. 744. Direct matching of blood for compatibility. A vaseline ring is being constructed with the syringe while a completed ring is shown with a cover-slip inverted and a hanging drop created.

INDICATIONS

The effects of supplying healthy, whole blood to impoverished circulatory systems are such that the indications for blood transfusion are steadily becoming more numerous. Transfusion is of value (1) in acute anemia following internal hemorrhage, as that of a ruptured tubal pregnancy; or in external hemorrhage as from a crushing injury, surgical procedures or shock resulting from blood loss; (2) in chronic anemia due to repeated small hemorrhages as from hemorrhoids or in debility which might result from malignancies or intestinal diseases; (3) in replacing blood elements to shorten clotting time, to supply functional hemoglobin, antibodies, leukocytes, volume and to increase the blood's bacteriophagic powers; (4) in infections of chronic nature, transfusions are especially indicated but their value decreases in acute conditions; (5) in blood-dyscrasias such as leukemia, purpura, hemophilia, pernicious anemia and jaundice repeated small transfusions are of value; (6) in poisoning as might result from snake-venom

or carbon monoxide. In such cases massive transfusions preceded by copious phlebotomy are indicated.

The transfer of 500 cc. of whole blood may be expected to increase the number of red blood cells by one-half million and the hemoglobin by ten per cent. Esdale believes such a procedure is not contra-indicated preoperatively in cases made moribund by internal hemorrhage and Stegemann asserts it is one of the surest and most rapid ways of arresting small vessel hemorrhage if given in repeated small (200 cc.) transfusions.

METHODS OF BLOOD TRANSFUSION

The choice of a transfusion method is one of individual preference and expediency, selection being between the choice of citrated or whole blood. The former lends itself to a technic simple in equipment and procedure and to circumstances in which the blood is to be transported or given at intervals or over a period of time. The administration of whole-blood undoubtedly preserves certain properties altered by the presence of an anticoagulant and it also produces fewer reactions, but it does require more elaborate equipment. Beck's summary of the statistics regarding reactions resulting from the two methods is as follows:

Method	No. of Transfusions	Range of Reaction	Average Reaction for Entire Group
Citrate Transfusions	5,908	1.2 to 64.8%	29.20%
Unmodified Blood Transfusions	11,094	0 to 64.4%	11.14%

The ratio of citrated blood transfusions to unmodified blood transfusion reactions for the entire series is 2.62 to 1, but nevertheless the citrate method is being most frequently employed.

Scannell Method

The direct transfusion of whole blood is carried out very satisfactorily using the Scannell apparatus or a modification of it. The method utilizes a 20 cc. syringe fitted with a three-way valve to each opening of which is attached a rubber tube communicating with the donor, recipient and a container of citrate solution. The relationship is such that blood can be withdrawn and injected as desired. Likewise the citrate solution can be drawn into the syringe as a rinse and injected into the apparatus to prevent clotting (Fig. 745).

Preparations for the application of this method are made by placing the patients on parallel tables and then fixing in close proximity the extremities whose veins are to be utilized. When the arms have been chosen, a blood pressure cuff is fitted about the upper portion of each extremity to act as a venous tourniquet. The skin areas in and about the cubital fossae which have been carefully scrubbed are now prepared with alcohol and iodine. The apparatus is assembled, the needles checked for smoothness and sharpness, the syringe for perfectness of plunger action and ease with which it can be disengaged from its valve; following this the entire outfit is flushed and finally filled with a 2 per cent citrate solution. The veins readily accessible for transfusion are depicted in Fig. 746.

Now is the time to enter the vein of the recipient and donor. Either one of two methods are used namely, direct insertion or by "cutting down" and exposing the vein. Let it be assumed the later method is to be used; the technic is as follows:

Step 1. The blood pressure cuff which is already in place is inflated about the recipient's arm (of the donor and recipient the latter receives the needle first) until a reading of 100 mm. of Hg. is reached. A small amount of infiltration anesthesia is injected at the selected site (Fig. 747) where a one-inch incision is made over and along the vein which is then completely exposed by blunt dissection (Fig. 748).

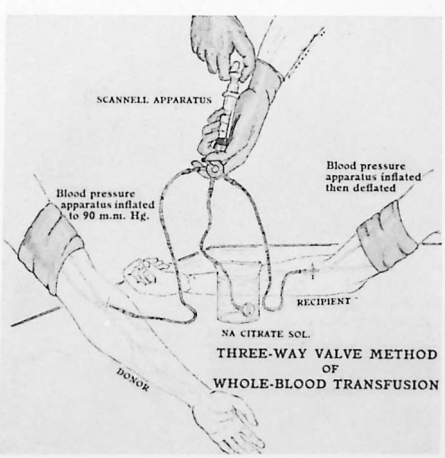


Fig. 745. Three-way valve method of whole blood transfusions.

Step 2. Two catgut sutures are passed beneath the vein and, inasmuch as the recipient is being operated upon, the distal ligature is firmly tied thus obliterating the venous return. The other ligature is moved proximalward for one-half inch and the first loop of a square-knot is loosely tied. The wall of the intervening vein is then carefully picked up with a mosquito-hemostat and incised with a pair of delicate scissors until a flow of blood indicates the lumen has been entered.

Step 3. The needle or cannula is slipped into this opening in a position pointing toward the shoulder in the case of the recipient and the second and securing loop of the remaining ligature tightened about the vein and cannula (Fig. 749). The blood pressure cuff is deflated and the needle is now ready for use;

in case of delay it is kept open by slowly injecting citrate solution through it (Fig. 750).

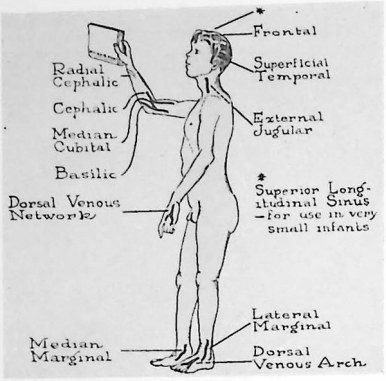


Fig. 746. Veins readily accessible for intravenous procedures.

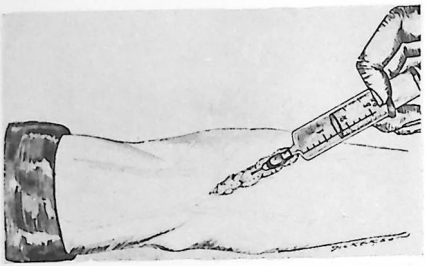


Fig. 747. Infiltration anesthesia preparatory to cutting down and exposing a vein.

Another method of entering a vein with a transfusion needle is the direct insertion method performed with or without anesthesia.

Step 1. The vein is distended as described above, the needle (pointed toward the hand in the case of the donor) pierces the skin and penetrates beneath

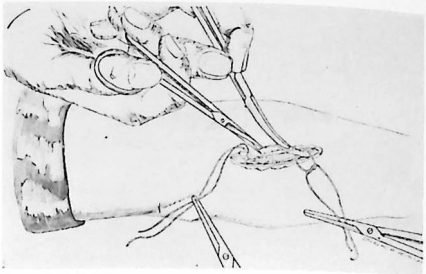


Fig. 748. Vein exposed, caught, tied and held preparatory to incising.

it for about one-half inch thus fixing it firmly. The point is then depressed and the vein entered.

Step 2. The blood pressure cuff is reduced to 60 mm. of Hg and the donor's blood is then available. "Rolling" of the vein may be prevented by distending the vessel then boldly passing a cambric needle through the skin into the vein of the lumen thence out of the vein and externally through the skin (Fig. 751).

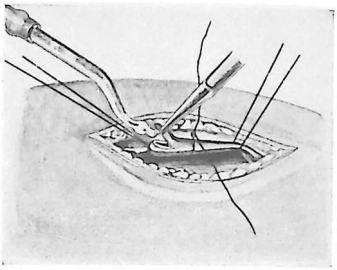


Fig. 749. Technic of tying a glass cannula into an exposed vein for purposes of introducing fluids directly into circulation.

The apparatus is now ready for use. The valve indicator is pointed toward the donor as blood is withdrawn and shifted toward the recipient as it is injected.

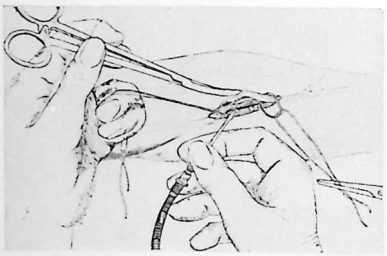


Fig. 750. Vein incised and held open by gentle traction into a position to be tied.

At any time the outfit may be flushed with citrate solution. After using the syringe several time or upon noting the slightest "sticking," substitute another

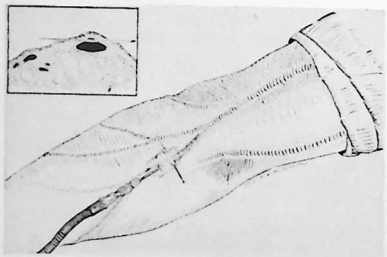


Fig. 751. Fixation of a vein for the insertion of needles of large bore. Note area of infiltration anesthesia, cambric needle "fixing" vein, small scalpel "nick" for the entrance of the transfusion needle which is passed superficially then depressed at the cambric needle thus easily entering the vein.

syringe while the original is being rinsed in citrate solution by an assistant. In this manner blood may be given rapidly, each syringeful being noted by the assistant who also observes the recipient for signs of reactions.

Lindemann Method

This is a desirable method especially when easily accessible veins are present. A 50 cc. Luer syringe is attached to a needle inserted in the donor's vein and filled with blood. It is then disconnected from the needle which is left in situ and connected to a needle which has been placed in the vein of the recipient. While the patient is receiving the blood, connect a second syringe to the donor's needle and repeat the process. Each time a syringe is used it is cleansed in citrate solution. It is well to have several syringes available.

Sisskind Method

Samuel George Sisskind devised an apparatus which approximates continuous flow transfusion (the thought being to keep the blood of both donor and recipient in constant motion, thus avoiding clotting with its possible danger of thrombosis or an embolus).

The time-saving element so essential in an emergency case, is an important feature in connection with the use of this apparatus. Two syringes are used at the same time, operating simultaneously, one drawing blood from the donor at the same time that the other is delivering blood to the recipient.

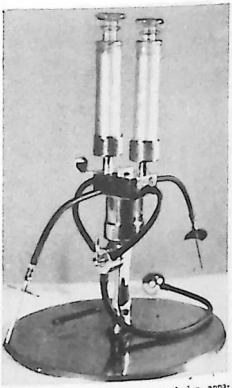


Fig. 752. Sisskind's blood transfusion apparatus.

The device consists of two syringes (Fig. 752), a housing block and a weighted valve which are supported on a base which may be clamped to a table. Rubber-tubing is connected to the distal ends of the donor and recipient tunnels which are bored in the housing block; the free ends of the tubing are attached to the proper style needles for insertion into the donor's and recipient's veins. All tunnels of the apparatus, rubber tubing, needles and syringes are filled with saline solution (to expel all air) by means of a syringe, the three-way stop cock is closed, the needles inserted into their respective veins, and the apparatus is ready to function. The valve-arm is turned to a stop on one side of the housing block. The plunger of the syringe, whose tunnel is connected with that of the donor tunnel, is slowly raised until the syringe barrel is filled with the donor's blood. The weighted valve is now turned through an arc of ninety degrees to the opposite stop. This action shifts the stream of blood in the syringe just filled from the donor-tunnel to that of the recipient-tunnel, and at the same time connects the donor-tunnel with that of the syringe still empty. The plunger of the filled syringe is now depressed, forcing the donor's blood through the re-

cipient-tunnel. At the same time the plunger of the still empty syringe is raised, filling the barrel of that syringe with the donor's blood. The valve arm is then turned back ninety degrees to the first position. This again reverses the direction of the two streams of blood, bringing the syringe-tunnels into communication with the donor- and recipient-tunnels as they were before. The filled syringe is emptied into the recipient-tunnel and the emptied syringe barrel is again filled with blood from the donor-tunnel at the same time. The valve is again turned through an arc of ninety degrees to the opposite side. The procedure is thus continued until

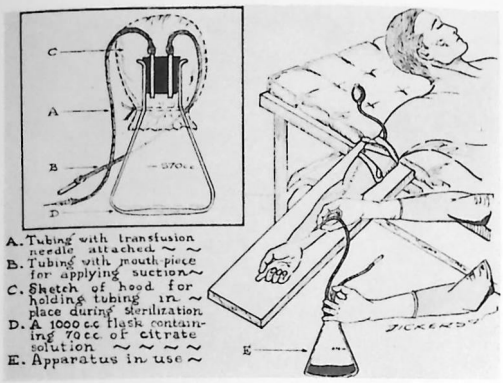


Fig. 753. Transfusion with citrated blood.

the desired amount of blood is transfused. The plungers of both syringes are always moving in opposite directions simultaneously—while one is filling the other is emptying.

Citrate Method

The equipment for this method consists of a 1,000 cc. Erlenmeyer flask containing 75 cc. of a 3 per cent citrate solution. The neck is fitted with a two-hole stopper; one hole permits the entrance of a rubber tube with a needle of large bore attached. The other hole allows the exit of a suction tube. Such a unit is easily handled and autoclaved. Its use is simple: the needle is inserted and the blood allowed to flow into the flask until the 575 cc. mark is reached (700 cc. may be safely withdrawn). (Fig. 753.) If the flow becomes slowed the donor opens and closes his hand while the gentle negative oral pressure is exerted upon the mouthpiece of the suction tube. The blood is ready for immediate

use or it may be preserved for several days when well iced. Administration is by means of an intravenous continuous drip apparatus using a needle of large bore. The recipient's vein is entered and the apparatus checked for function using a flask of physiological saline solution. When it is seen that the vein is receiving the solution well the flask of blood is substituted for the saline infusion.

Auto-Transfusion

Not infrequently during operative procedures to produce hemostasis a very large quantity of blood is found free in the body cavities. This is especially true in ruptured ectopic pregnancy, torn liver, spleen or kidney and in wounds of the heart producing a hemopericardium. Theis as early as 1914, reintroduced this blood into the patient's circulatory system with marked improvement.

A technic that has been gradually evolved is sponging out the cavity with "lap pads" which have been thoroughly wrung out in 2 per cent citrate solution and which are in turn wrung out into a sterile container. For each 100 cc. of blood recovered 10 cc. of 2 per cent citrate solution is added. When all available blood and clots have been collected the mixture is repeatedly filtered through layers of gauze previously wrung out in citrate solution. The blood is then ready for immediate administration as described in the citrate method for blood transfusion.

Tzanck's Blood-Transfusion Aphorisms*

1. It is less important to discover daily, new indications for blood transfusion than to use adequately those that already exist.

2. The fixity of blood-groups is as immutable as that of the species. Faulty (inaccurate) examinations are the basis of the so-called change of blood-groups.

3. The blood-group engraved on the "identity-plate" of an individual avoids hasty blood-determinations and serious accidents.

4. Painstaking control of blood-compatibility among individuals will be the determining factor in eliminating serious accidents of blood transfusion. In fact, by means of a thorough study of the compatibility of blood of the donor and of the recipient, one can predict the probabilities and frustrate the occurrence of serious accidents.

5. Direct tests of blood-compatibility are unreliable.

6. All transfusion apparatus are good, provided they are well constructed, are easily handled and securely arranged.

7. The operation of blood transfusion should never be performed on an automatic basis, such as substituting automatic apparatus which at best is a blind procedure; every movement of the operation should be constantly under the control of the operator.

8. A slow deliberate beginning in a blood-transfusion is a good investment on the point of security.

9. Since the untoward reactions observed in blood-transfusions are not due to "bad blood" it is folly to offer the customary explanations that such is the case or, because of "changing of blood group" (such do not exist) or because of the deleterious actions of hemolysis, which thus far has not been proven, or because

* Arnault Tzanck—Problèmes Théoriques et Pratiques de la Transfusion Sanguine, Masson et. Co., Paris, 1933.

of the toxicity of the anticoagulants which is minimal or because of the use of such and such apparatus. Such reactions are due to the intolerance of the individual.

10. Most of individual-intolerances are not uncovered by tests; occasionally they are suspected after a scrutinizing clinical inquiry; they are usually benign.

11. A chill during transfusion depends less on the blood injected than upon the condition of the patient. It occurs most frequently in subjects suffering from febrile affections.

12. From a practical point of view, syphilis, as a rule, is not transmitted from a donor whose Wassermann test is negative and who suffers from no initial lesion.

13. Henri's reaction is not always positive in individuals afflicted with chronic palludism. However, if it is negative, palludism is not transmitted.

14. Transfusions should reduce the mortality in hemorrhages as asepsis reduced the mortality in infections.

15. In massive hemorrhage resort to massive transfusion; in repeated hemorrhages do repeated transfusions.

16. The pulse of a patient is no index as to the quantity of an existing hemorrhage; symptoms of collapse are more important, the latter, however, may be due to other causes.

17. In cases of collapse from hemorrhage the quantity of fluid injected plays a more important rôle than its quality.

18. If a transfusion or injection of serum is without effect in states of collapse, the latter is not due to hemorrhage.

19. To inject serum before securing hemostasis is unwise as it hinders the natural defenses of the organism.

20. In the presence of a serious visceral hemorrhage everything possible should be resorted to before attempting surgical intervention. One should aim at "spontaneous hemostasis," then fight death from hemorrhage by replacing the blood lost, finally if death seems inevitable consider operation supplemented by sufficient blood transfusion.

21. If one is assured of an ample blood transfusion, anaemia is not a contra-indication to operative intervention.

22. In "big shock" small transfusion.

23. Intracardiac transfusion is only permissible in desperate cases and only after failure to enter a vein, particularly failing to transfuse through the femoral vein.

24. Where a patient has lost a great quantity (many liters) of blood, danger lies not in abundant transfusion but in too little transfusion.

25. In pernicious anaemia, Whipples' method is the basic treatment. Blood transfusion may be useful; in the initial period, to allow hepatotherapy time to act in the course of treatment and to improve a stationary blood-count. Immuno-transfusion is of value only in the treatment of "immunizable infections."

26. Independently of specific immunity, transfused blood may furnish non-specific elements to hasten recovery (*phylacta-transfusion*).

27. True cases of "blood transfusion deaths" are those where blood transfusion was not practiced.

OPERATIONS ON THE LYMPHATICS

HANDLEY'S OPERATION ON THE LYMPHATICS

This procedure establishes artificial passageways in vessels which are obstructed.

A number of long-eyed probes and several lengths of No. 12 tubular woven silk are required in addition to the other instruments for operation.

Operation—Upper Extremity

Step 1. Make an incision in the skin just above the wrist in the midline of the forearm about 1 inch in length.

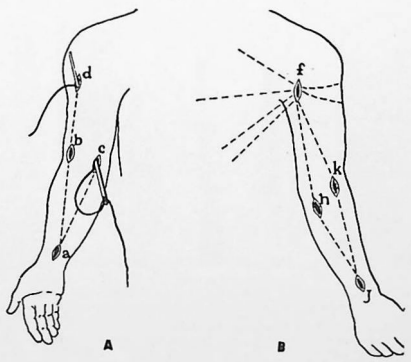


Fig. 754. Handley's operation—lymphangioplasty of the upper extremity: A. anterior view, B. posterior view.

Step 2. Insert a probe in the subcutaneous areolar tissue near the elbow directing it upward and outward.

Step 3. Grasp with a hemostat a double line of No. 12 silk, twice the length of the arm. Wrap half of it in a sterile towel and thread a probe with the other half. The probe and silk are now pulled out of the incision leaving a double line of silk in the subcutaneous channel (Fig. 754 A).

Step 4. Insert the probe again and bring the silk out through the incision made near the insertion of the deltoid muscle.

Step 5. Introduce another probe into the wound directing it upward and inward, bringing it out through another incision as shown in the illustration. Next

thread a probe with the silk which was wrapped in the sterile towel. Retract the probe and silk through the incision mentioned above. Remove the hemostat so that the silk remains imbedded.

Step 6. Introduce the silk under the skin from c to d. Insert probes through d directing them subcutaneously over the shoulder and bringing them out through an incision at the posterior margin of the deltoid (Fig. 754 B). Insert a double line of silk under the skin of the arm posteriorly as shown

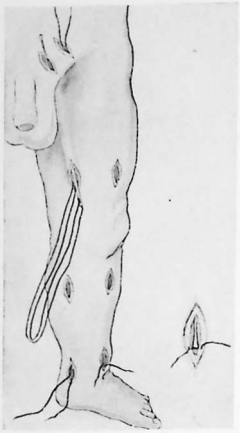


Fig. 755. Handley's operation for lymph stasis of the lower extremity. (After Kirschner.)

in the illustration making a total of 8 threads which are brought out through the incision at the posterior border of the deltoid.

Step 7. Arm the probe with two of these threads cut off so that they are about 4 inches shorter than the probe. Introduce the probe, eye first, through the incision in the back of the shoulder piercing the skin of the back. Since the silk is shorter, the probe unthreads itself. Pull out the probe cautiously leaving the silk in its path. This is done until all of the threads emerging from the shoulder incision are imbedded in different directions into the subcutaneous tissues of the back.

Step 8. All incisions are united with sutures.

Comment. According to Handley, this operation is contra-indicated:

1. After removal of the breast for carcinoma.
2. Where a general anesthetic is prohibited.
3. When it is necessary to insert threads through carcinomatous tissue.
4. When there is a growth in the shoulder or axilla or any nerve-plexus pain.
5. In case of secondary growth or pleural effusion where benefits are only temporary.

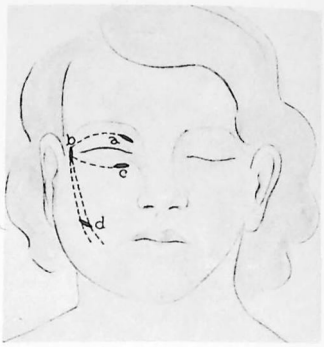


Fig. 756. Lymphangioplasty, Handley's technic. (Used successfully by A. B. Mitchell, British Medical Journal, XX, 1909, in a case of solid edema of the eyelids on both sides following a severe attack of erysipelas.) a. Small curved incision of upper eyelid through which a probe was passed under the skin to point b at the outer margin of the orbit. Incise skin at b. A probe threaded with a coarse strand of silk was pulled through the subcutaneous tunnel created between a and b. Make another similar incision of the lower eyelid at c. Pass a strand of silk under the skin to emerge at b. Pass a probe through b, tunneling its way to a point, d, through which the probe is permitted to emerge through a small incision. Thread two strands of silk emerging at b through the eye of probe and pull them through the subcutaneous tunnel at b and d. Introduce probe or director through incision d. Make a small pouch under the skin below d, into this pouch tuck the ends of the thread. Close the skin.

Handley believes this operation should be reserved for severe cases of lymphostasis.

Operation on Lower Extremity

This procedure is very much the same as that followed in the upper extremity except that it is more difficult to perform on account of the skin being

more thickened and irregular causing infection to be more likely to occur (Fig. 755).

Operation on the Face

This operation was performed for the relief of solid edema of an eyelid which had failed to respond to other treatment.

Step 1. Make a small curved incision near the central part of both the upper and lower eyelids. Make another incision lateral to the outer canthus. (Fig. 756.)

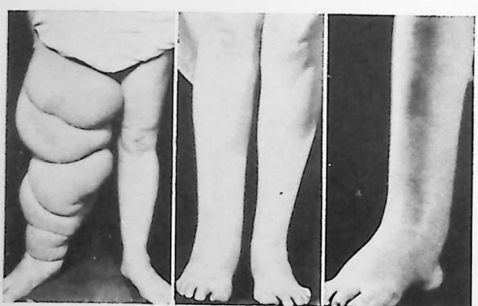


Fig. 757 Fig. 758 Fig. 759

Fig. 757. Elephantiasis of the right lower extremity. Patient had twelve operations with constant recurrences, was returned to Cook County Hospital to have disarticulation of the hip. A number of additional operations were performed by the author in order to save the extremity. Patient is still under observation much improved.

Fig. 758. Elephantiasis involving the right foot and leg, unilateral. Patient case history of similar affliction in mother and aunt. No filaria in repeated examinations. Kondoleon operation. Front view of both limbs.

Fig. 759. Elephantiasis. Same as preceding, lateral view of affected limb.

Step 2. Introduce coarse strands of silk under the skin of both lids and carry them beyond the outer canthus. They are then directed downward through an incision lateral to the angle of the mouth and the ends imbedded under the skin of the cheek near the ramus of the lower jaw. Satisfactory recovery followed.

KONDOLEON'S OPERATION FOR ELEPHANTIASIS OF THE LOWER EXTREMITY

This operation consists in removing an oval-shaped portion of skin and fascia from the thigh and leg thus changing the course of the lymph from the superficial lymphatics to the deeper parts of the muscles (Figs. 757-758-759).

Operation

Step 1. Make an elliptical incision beginning at the crest of the ilium and extending to the external malleolus. Deepen the incision to include the subcutaneous adipose and areolar tissue and remove the segment outlined.

Step 2. Clamp and ligate all blood vessels as they are encountered; this is important as there is likely to be considerable hemorrhage.

Step 3. Dissect back the skin margins for approximately an inch on each side and remove an oval-shaped segment of fascia corresponding to the portion of skin removed.

Step 4. Close the incision by means of No. 1 running chromic catgut suture. Apply an alcohol dressing.

Step 5. Bandage the leg tightly from the toes to the groin and place it at a 30-degree angle which is maintained for about three months. The patient may be accorded bathroom privileges after the leg is completely healed but aside from that should remain in bed with the leg elevated.

Comment. The above procedure may be modified as follows:

1. The operation may be performed on both sides of the limb at one time or a period of 10 days may be permitted to elapse between the two seances.

2. If for some reason complete removal of the fascia is not deemed advisable, it may be "windowed" in different places.

3. In some instances a linear incision is made in the skin and only the fascia is removed.

4. The shrinking in size which follows this operation is most heartening to both surgeon and patient. To prevent early recurrence the patient should be made to understand that a long period of rest while the limb is maintained in an elevated position is most essential. Although recurrence is almost sure to follow at some time, the operation should not be considered futile since repetition of the operation is comparatively free from danger and the patient is made much more comfortable by the procedure.

CHAPTER 22

ORTHOPEDIC SURGERY

GENERAL OPERATIVE CONSIDERATIONS

OSTEORRHAPHY

(See also open operation for fractures. Figs. 1028-1032 incl., p. 918.)

Suturing of bone is done for solutions of continuity of a given bone and may be done by (a) absorbable suture materials; (b) nonabsorbable sutures.

Absorbable suture materials provide the surgeon with his most nearly physiologic means of direct bone repair. Of these, kangaroo tendon is most frequently used. The former has long been used for repairs in and about joints and

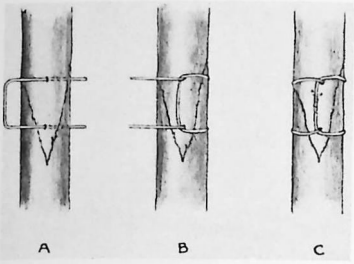


FIG. 760. A, B and C illustrate methods of approximating fractures.

for the fixation of small bone fragments or grafts. The use of live bone either as an intramedullary peg or as a graft is an effective means of reinforcing a bone shaft, preventing bone deformities, and in treating non-unions, but it incurs certain technical difficulties that necessitate instruments and experience to overcome. Clean bone defects may be stimulated and aided to repair by covering them with live periosteum. Payr uses magnesium plates for fixation purposes and although absorbable they provoke undesirable adjacent tissue reactions.

Nonabsorbable sutures are almost legion in number. One of the earliest methods was that of wiring bone fragments (Fig. 760). Wires constructed of silver, annealed steel, bronze and aluminum are wrapped about or passed through drill holes in fractured bones in an effort to provide stability and maintain position (Fig. 761). Nails of bone, ivory, bronze and other metals are also used (Fig. 762). Steel plates (Lane's, Sherman's) have the advantages of being readily available and easily applied although a secondary operation may be necessary to remove them. This is likewise true of Parham's bands. Lane's plates (Fig. 763)

are constructed of vanadium steel and are made in varying lengths so as to accommodate two to eight screw holes.

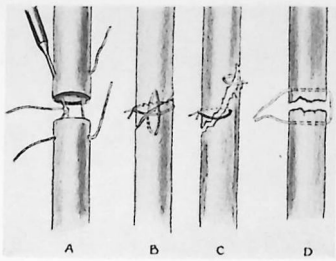


FIG. 761. A, B, C and D depict how transverse or oblique fractures are brought together with stout wire or chromicized catgut.

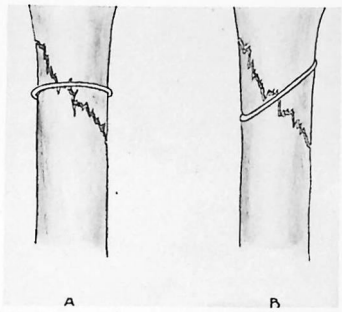


FIG. 762. A, Wire applied incorrectly; B, correct manner of applying wire; observe it is placed at right angles to the line of fracture.

Some of the objections to their use as a routine measure are:

1. Interference with the nutrition of the bone due to the necessity of using long plates.
2. Occasionally delayed or nonunion may occur as a result of the too absolute fixity of the fracture fragments.

3. Local rarefaction of the bone by the screws frequently loosening its hold on the bone.
4. Infection of the wound is usually associated with death of the bone underneath the plate.
5. The plates should never be used in open fractures when the possibility of contamination exists.

Moses Behrend[1] points out that

1. Metal plates, nails or other foreign materials may remain in situ indefinitely under favorable conditions.
2. One should never hesitate to remove these whenever it becomes necessary.

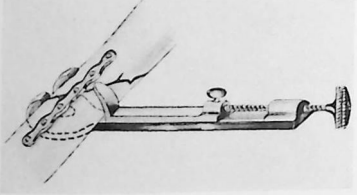


FIG. 763. Lane plating for fracture of long bone. Clamp maintains the fractured fragments in apposition. The Lane plate is kept in place by screws passing through previously drilled holes in the bone.

3. That in the treatment of fractures the closed method is always preferable but one should never hesitate to do an open operation wherever indicated and that
4. In the latter case the "no contact" method must be strictly and conscientiously followed out.

PLASTER OF PARIS TECHNIC

Plaster of Paris offers an ideal working medium for the orthopedic surgeon. When skillfully prepared and handled it can be fitted to any part of the body and provides retention of a superior type. The moderate cost of material, ease of application, stability of the finished bandage and the cosmetic results, give this fixation method unique properties.

Plaster bandages may be purchased or "hospital-made." In the latter case 32 mesh crinoline is torn into three yard strips, three, five and seven inches wide. From the rough edges of each strip three or four threads are pulled. The meshes are then filled with dry plaster, as the crinoline bandage is formed into an even but not tight roll. This is best done by moving a small amount of plaster of paris back and forth over the crinoline with a tongue blade. Each roll is then wrapped and tied in a paper napkin to be placed in a moisture proof container for storage.

Plaster of Paris (calcium sulphate) is crushed gypsum which has been sub-

[1] Atlantic Med. Jour., Oct. 1922.

jected to intense heat so that water of crystallization is driven off. When mixed with water re-crystallization or "setting" occurs. Dental plaster is an excellent grade of material, the setting speed of which may be hastened by the addition of salt or delayed by gelatin or glue. In general, slow setting is desirable. The process may be hastened, however, by the application of a heat cradle or an electric fan, care being taken not to burn or chill the patient.

A limb which is to be encased in plaster should be carefully cleansed and then dusted with talcum. This is followed by bringing the extremity into the desired position and applying a preliminary padding. Such a protective covering, be it sheet wadding or lint, is applied sparingly or only over joints or bony prominences. Later shrinkage with resultant looseness is thus avoided. If the cast is to be bivalved ample padding facilitates the task and protects the patient from being injured during the procedure. There is at present, in selected cases, a decided and justified tendency to apply plaster bandages directly to the skin's surface.

Plaster rolls are made ready for use by immersing them on end in a canvas lined bucket filled with tepid water. Each roll remains submerged until air bub-



FIG. 764. Plaster knife. A piece of sheet steel is sharpened as illustrated and a handle of wet plaster bandage formed and fitted to the operator's hand. One end of the knife is used for cutting and the other for prying.

bles cease to rise, at which time it is grasped at each end and squeezed, toward its center, gently twisting at the same time. The bandage is then applied snugly but not tightly remembering that it neither expands nor contracts in setting. After each turn the plaster is rubbed and molded. The direction of the plaster strip may be changed at will by folding a triangular dart in the bandage. Points of stress call for reinforcement either by extra layers of plaster bandage or by metal or wooden strips. The completed cast should be trimmed and then "polished" by rubbing it with moistened hands. Although plaster hardens in a few minutes it may take hours or several days to dry completely. Until this has taken place, gentle handling is the rule. An anterior and posterior mold may frequently be substituted for a circular cast and very often only a posterior mold is necessary. It is readily prepared, easily applied and of light weight. Compression symptoms are reduced and the fracture site is made easily accessible (Fig. 764).

Once a plaster cast has been applied the operator must then (a) determine bony relationships by x-rays; (b) watch for constrictions caused by too tight an application; (c) detect early evidence of pressure areas; (d) prevent defacement and destruction of the cast; (e) repair immediately plaster breaks or cracks; (f) guard against infestation of the cast. Do not give morphine for pain. Investigate.

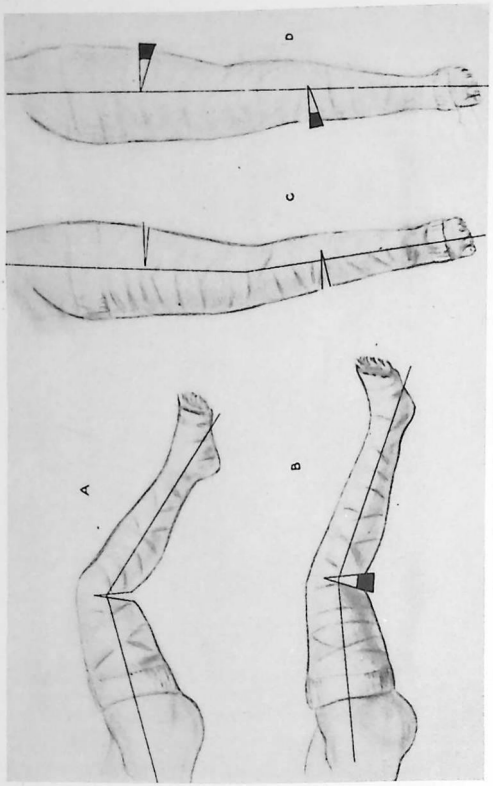


FIG. 765. Method of cutting and blocking a cast to correct muscle deformities.

The purpose of a plaster cast is to maintain proper postural alignment. If radiological evidence shows otherwise, immediately remove the cast and reapply it until perfection is obtained (Fig. 765).

Fingers and toes should be left exposed and frequently observed to see that they are warm, pink, sensitive and capable of voluntary motion. Body casts require a window over the epigastric region to permit abdominal expansion and free respiratory movements.

The edges of a plaster cast may give rise to pressure areas in which event trimming or a postural change is needed. When bony prominences are being traumatized, splitting and spreading of the cast is preferable to cutting a "window."

Moisture from the patient's excretions frequently soils or destroys a cast. This may be largely prevented by proper exposure about the buttocks, careful placement of bed pans and by protecting the cast. The latter may be done by edging the region about the buttocks with rubber sheeting, oiled silk or painting it with several coats of white enamel. The last procedure is useful upon plaster casts applied to children as it permits washing with soap and water. Evidence of purulent drainage from within a cast can be detected if the surgeon will regularly examine the cast or smell it.

Cracks or breaks in plaster casts should be immediately repaired. Clean out and widen the crack, fill with plaster cream and cover with several layers of plaster bandage. An aluminum or wooden strip applied splint-like also provides security.

Crumbs of food carelessly dropped into a cast may attract ants and bedbugs which find body casts to their liking! Once infested, the remedy is the application of a new cast.

The removal of a plaster cast may become a laborious task when not properly performed. If the cast is to be destroyed upon removal place the part in hot water for 20 minutes and the plaster can be easily cut away. When bi-valving is necessary proceed before the cast is entirely set, always favoring the posterior portion. In event the cast has completely hardened a pair of Stille plaster scissors is very useful. More inexpensive is a small cross-cut carpenter's saw. Peroxide placed along the proposed line of cutting readily softens plaster. Vinegar acts equally well.

In fashioning orthopedic appliances a plaster model is necessary. This is made by covering the affected part with stockinet and applying plaster bandage until a firm cast is built up, immediately and carefully bivalving it. When setting has occurred, the cast is removed and accurately approximated; remove the stockinet lining and coat the inside of the cast with soap. Plaster cream is poured into the hollow mold and allowed to set after which it is removed and "fired" for complete drying. The brace maker uses this positive model in the construction of corrective and supportive appliances.

OPERATIONS ON BONES

OSTEOCLASIS

This refers to producing a simple fracture of a bone by external force in an effort to overcome a deformity. The surgeon directs his efforts so as to produce

a complete break at the site of maximum deformity. Following this the position of the fragments is corrected and a plaster of Paris cast is applied. The surgeon may choose to perform the operation manually or with an osteoclast.

Manual Method

Step 1. Place the patient on a low table. Prepare the limb surgically and cover with sterile drapes. Place a wedge under the deformity at right angle to the long axis of the bone.

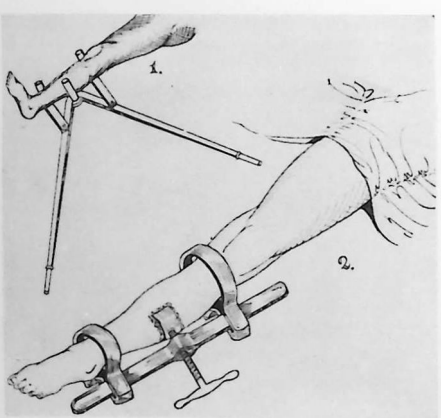


FIG. 766. Osteoclasis: 1. Thomas osteoclast in use, 2. Rizzoli osteoclast applied to limb.

Step 2. Grasp the limb on either side of the fulcrum and press downward until the bone is completely fractured.

Step 3. Correct the deformity and encase the limb in plaster of Paris.

Osteoclast Method

Step 1. Prepare the limb surgically and cover with sterile drapes.

Step 2. Fit the osteoclast to the extremity, seeing that the single and upper fulcrum is at the proposed fracture site. Close the instrument until the bone is fractured, a procedure which should take not more than eight seconds (Fig. 766[1 and 2]), or use the Rizzoli osteoclast.

Step 3. Correct the deformity and encase the limb in plaster of Paris.

OSTEOTOMY

This means a simple, direct division of bone. Its use is confined to the correction of bony deformities occurring near joints in which case splinting, manipulation and osteoclasis are to no avail. It is indicated in deformities due to rickets, ankylosis in faulty position, coxa vara and genu valgum. The procedure may be linear or cuneiform in type; however in either method the bone should be manually fractured after three-quarters of it has been cut through with the osteotome. The postural correction thus effected is maintained with a plaster of Paris cast.

Linear Osteotomy—Subcutaneous Method (Genu Valgum)

Supracondyloid osteotomy for genu valgum (Macewen) will be described as a typical example.

Anesthetize the patient. Apply a tourniquet. Flex the knee to an angle of 135 degrees.

Step 1. An imaginary horizontal line is drawn one finger's breadth above the superior tip of the internal condyle. Another imaginary vertical line is drawn

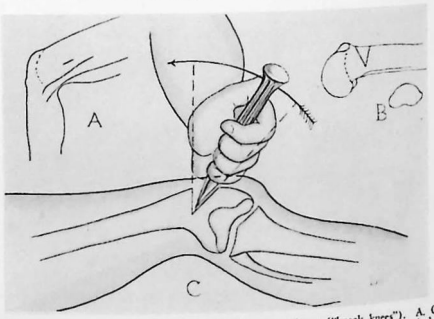


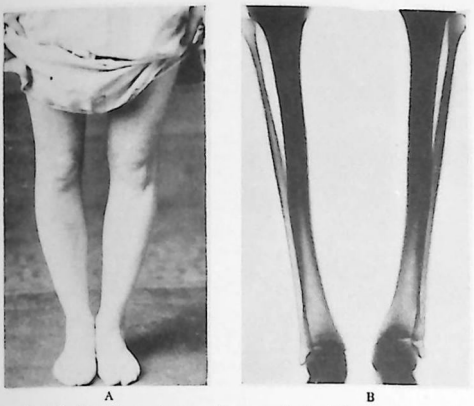
FIG. 767. Macewen's method of osteotomy for genu valgum ("knock knees"). A. Cutaneous incision for supracondyloid osteotomy. B. Lines of incision. C. The chisel is held in line for striking with a mallet. The arrow indicates the direction in which the chisel is levered up and down, thus creating a gap in the femur of the required size.

longitudinally one-half inch in front of the adductor magnus tendon. At the point where these lines cross introduce a long-bladed knife directly to the bone; make an incision upward of sufficient size to admit the largest osteotome (Fig. 767).

Step 2. Leave the knife in situ which acts as a guide to Macewen's largest osteotome down to the bone. The blade of the osteotome is turned transversely to the bone. Guide its edge to the postero-internal border of the

bone; with blows of a mallet it is made to divide the inner and posterior part of the bone first; then the instrument is driven forward and outward until the outer aspect of the triangular surface of the back of the femur is reached. The resistance of the compact part of the bone is recognized.

Step 3. After three-quarters of the bone has been cut through, the remainder of the bone is fractured by grasping the thigh with one hand and the leg with the other and applying adduction force.



A B

FIG. 768. A. Bowlegs. Linear osteotomy. Appearance of patient before operation. B. X-ray of both legs of patient shown in preceding illustration.

Step 4. Remove the osteotome. Rectify the deformity by manual overcorrection.

Step 5. Remove the tourniquet and provide hemostasis. Apply an aseptic pad over the wound. Place the limb in a plaster of Paris encasement.

Linear osteotomy may be done by the open method. An incision exposes the site of the bone to be sectioned. The soft tissues having been divided and thoroughly retracted, an osteotome or saw divides the bone. A Gigli saw is of advantage in this connection. The open operation is safer though the incision is of necessity larger.

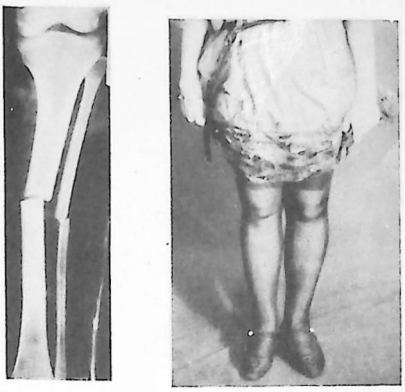
OPERATION FOR BOWLEG (GENU VARUM) AND FOR "KNOCK KNEE" (GENU VALGUM)

The external bowing of the femur and bones of the leg may be corrected either by linear or other osteotomy or by osteoclasis (Fig. 768).

Linear Osteotomy

Step 1. Note which bone and what part of it is most bent; it is there that section must be made. If the middle third of the femur is the part most affected, make a vertical incision through the soft parts down to the bone on the antero-external side and proceed as in supracondylar osteotomy for knock-knee, only in this case cutting the bone from without inward.

If the tibia is most affected, incise the soft parts vertically down to the bone over its inner surface at the point of greatest curvature. Introduce the



C D

FIG. 768. C. X-ray of division of tibia and fibula by linear osteotomy in same patient. D. Same patient two months after operation.

osteotome and turn it transversely to the bone and divide the cortical bone of the inner and outer sides of the tibia especially that of the anterior margin. Fracture the posterior layer of cortical bone by manual force and forcibly fracture or bend the fibula; it may be necessary to introduce a narrow osteotome and divide the latter bone.

If the femur and tibia are both markedly curved operate on both at the same sitting. The operation should be repeated at all points where necessary.

Step 2. Place the limb in good position in a plaster of Paris cast and treat as an ordinary fracture.

Cuneiform Osteotomy

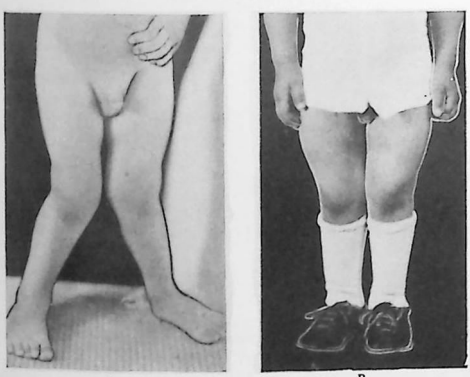
In this operation a wedge-shaped section of bone is removed, the size depending upon the needs of the case. The operation is usually performed for anterior

angular curvature of a long bone, as in the deformities produced by rickets or for the correction of hallux valgus. The surgical correction of genu varum is carried out as follows:

Apply a tourniquet.

Step 1. Incise over the most prominent part of the tibia, down to the bone. Reflect the periosteum. Retract thoroughly.

Step 2. After cleaning the bone subperiosteally, outline the base of a wedge with a chisel, cutting through the cortical bone with a rugine. Hold the chisel



A B

FIG. 769. A. Genu valgum ("Knock Knees") before operation. B. Same patient after operation.

like an osteotome. The base of the wedge should correspond to the apex of the angular deformity and should be smaller than that which is thought will be necessary. It can later be enlarged as required. Chisel off slices of bone until the proper sized wedge has been removed. Do not cut through the entire thickness of the bone. The posterior undivided portion corresponds to the apex of the wedge and can be fractured manually. The limb is now straightened. If the fibula interferes with the straightening of the limb, divide it with a chisel (Fig. 769).

Step 3. Resuture the soft tissues if necessary. Dress. Immobilize in plaster of Paris.

COXA VARA

Normally the neck of the femur forms with its shaft an angle of 130 degrees. When this angle is reduced to 115 degrees or less a condition termed coxa vara is said to exist (Fig. 770). This state arises from certain traumatic or infectious

assaults upon the neck or epiphysis of the femur, deficiency diseases and senility. It is seen most frequently in young males. The condition is recognized by the resulting limp, prominence of the trochanter when the thigh is flexed, tilting of the pelvis and limitation of abduction.

Step 1. Incise along the external thigh over the course of the femur from its greater trochanter downward for 5 inches. Spread and cut the heavy muscles

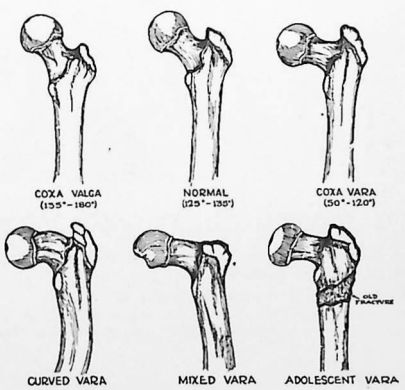


FIG. 770. A curved coxa vara occurs in rickets, ostomalacia and senile osteoporosis. Mixed coxa vara may result from tuberculosis. Perthe's disease, osteomyelitis and arthritis deformans. The adolescent type may be due to separation of the femoral epiphysis or trauma.

down to the bone. Reflect the periosteum and widely expose the subtrochanteric region.

Step 2. Outline and remove a wedge of bone designed to allow the femur to be abducted into its correct position. The shaft is not completely cut through; about one-fourth of its cross area being broken through manually.

Step 3. Close the wound loosely. Dress. Immobilize in extreme abduction.

OPERATION FOR CLUB-FOOT

The condition known as club-foot or talipes may be either congenital or acquired and has a great many varieties. Congenital talipes equinovarus is the most commonly occurring form of club-foot. Correction is either by manipulation or operation. The latter procedure may consist of severing of tendons alone or it may be combined with osteotomy upon the bony structures.

Lorenz recommends the following operations for club-foot:

A. *Osteotomy*
1. Linear division, navicular bone from the sole (Hahn).
2. Linear division, tibia and fibula above the ankle.

B. *Enucleation*
1. Of one bone:
   a. Of the cuboid (Solly).
   b. Of the astragalus (Lund, Mason).
   c. Of the astragalus with resection of the point of the external malleolus (Mason, Reid).
   d. Curettement of the spongy part of the astragalus, leaving the articular surfaces intact (Verebély).
   e. Of the astragalus plus removal of a wedge with base external from the anterior process of the calcaneum (Hahn).
2. Of several bones.
   f. Enucleation of astragalus and cuboid (Hahn, Albert) and of the navicular bone (West).
   g. Enucleation of the navicular and cuboid (Bennett).

C. *Resection*
1. Of the head of the astragalus (Lucke, Albert).
2. Of a portion of bone from the external half of the neck of the astragalus (Hueter).
3. Resection of a wedge from the outer and upper sides of the tarsus (O. Weber, Davis, Colley, R. Davy, Schede, Meussel, König, etc.).
4. Resection of two wedges perpendicular to each other with their bases directed outwards from the astragalo-calcaneal and Chopart's joints (Rydygier).

D. Extirpation of ossifying centres of the astragalus in young children (Meussel's operation).

Tenotomy for Talipes Equinovarus (after Ober)

Step 1. Make a fish-hook incision, with forward bend around the inner malleolus, beginning midway between the posterior border of the tibia and the tendo Achillis, passing under the inner malleolus and forward over the displaced scaphoid. The incision is carried down to the deep fascia and a flap dissected upward exposing the deep fascia, and annular and deltoid ligaments.

Step 2. Through the annular and deltoid ligaments make a semicircular incision down to the bone and surrounding the internal malleolus. Dissect this ligamentous flap from the bone in a downward direction including both layers of the deltoid.

Step 3. Continue the curved incision downward, dividing the superior calcaneoscaphoid ligaments and carrying the incision down to the bone. These ligaments are then separated from the inferior surface of the os calcis with an osteotome or blunt dissector down to the inner surface of the os calcis. The

tendo Achillis may have to be cut and also, perhaps, the plantar fascia according to conditions.

Step 4. The foot is seized by its fore part and heel and brought into an overcorrected position. The overcorrection should be moderate for a few days and then increased. The foot is then put up in a plaster of Paris cast.

Osteotomy for Talipes Equinovarus (after Mercer)

Step 1. Carry an incision forward from below the lateral malleolus along the dorsum of the foot until the area over the calcaneus bone and the mid-tarsal joint is exposed.

Step 2. Locate the mid-tarsal joint. Behind it lies the calcaneus from which a wedge of bone is removed whose base is directed outward; in front is the cuboid upon which a similar osteotomy is performed. From the head and neck of the talus a curved wedge with its base upward and anterior is removed.

Step 3. Make an incision along the medial side of the foot and sever the talonavicular capsule and deltoid ligaments. Following this the foot can be manipulated into its correct position.

Step 4. Encase in plaster for a period of two weeks. Remove the cast and again apply bringing the foot into an overcorrected position where it remains for five weeks.

Forcible Rectification

Hands or a wrench may be used. Tenotomy of the tendo Achillis (which see) usually precedes this as sometimes does tenotomy of the plantar fascia.

MANUAL RECTIFICATION

Step 1. Grasp the heel and ankle in one hand and the distal end of the foot in the other. Leave the calcaneocuboid articulation unsupported by the hand. Lay the convex surface of the calcaneocuboid articulation against the edge of a wedge of wood covered by a towel which acts as a fulcrum (Figs. 771-772).

Step 2. Forcibly straighten or unfold the foot by compressing its convex side against the fulcrum and stretching or tearing the structures on the concave side. Overcorrection may be accomplished in one sitting in young children. Do not tear the skin, if it seems about to tear postpone further manipulation until later. Sometimes as many as four sittings about a week apart are necessary to accomplish the desired results.

Step 3. While the patient is still anesthetized, encase the foot in plaster of Paris. Maintaining the foot in an elevated position for 24 hours will prevent swelling.

Comment: Overcorrection is the aim and should be kept rigidly enforced. Ridlon combines forcible rectification with tenotomies, dividing the fascia and ligaments as necessary. He recommends the application of cotton batting to prevent the formation of ridges on the inside of the plaster which is applied heavily enough so that the patient may walk on it for four or five months. The dressings should not be removed but if they slide off, pad the lid of a cigar box cut to shape of the sole, fix it to the foot with adhesive

straps and apply plaster. Wrap the whole foot and leg in cotton before applying the foot-piece. Plaster must be applied to the knee; when it is

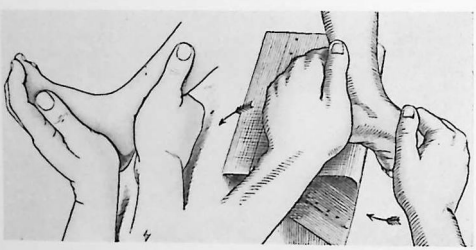


Fig. 771 Fig. 772

Fig. 771. Method of manual correction of club-foot (after Berger and Banzet).
Fig. 772. Manual correction of club-foot over wooden block (Hoffa).

removed the foot should remain in an overcorrected position. The operation may be performed at any age.

INSTRUMENTAL RECTIFICATION

The Thomas wrench is very useful in forcible rectification; the foot may be twisted and bent in any direction with it; speed is a requisite (Fig. 773).

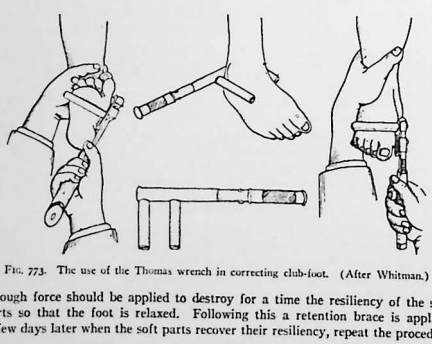


Fig. 773. The use of the Thomas wrench in correcting club-foot. (After Whitman.)

Enough force should be applied to destroy for a time the resiliency of the soft parts so that the foot is relaxed. Following this a retention brace is applied. A few days later when the soft parts recover their resiliency, repeat the procedure

until there is no recurrence. Keep the foot immobilized until the slack is taken up and the parts are oriented. In some instances the tendo Achillis pulls upward on the inner side of the tuberosity of the calcaneus retarding correction of the varus for which R. Jones recommends the following treatment:

Step 1. Make a T-shaped incision exposing the tendo Achillis. Split the tendon longitudinally. Separate the inner half from its insertion.

Step 2. Insert the inner segment of the tendon under the outer segment. Suture its free end to the periosteum of the os calcis outside and in immediate juxtaposition to the attached half. Freshen the opposing surfaces of tendon and suture them.



Fig. 774. Phelps's operation for club-foot.

Phelps's Operation

Soften and cleanse any calluses which may be present by means of soap poultices applied 24 hours before the operation. Twelve hours before the operation the foot should be asepticized.

Step 1. Elevate the limb and apply a tourniquet. Place the foot on a sandbag with its outer side downwards. While an assistant steadies the heel, grasp the distal part of the foot so that the plantar tissues are tense.

Step 2. Make an incision on the inner side of the foot beginning directly in front of the malleolus and extending to one-fourth of the distance across the sole (Fig. 774). Divide all resisting structures to the bone, if necessary.

Step 3. Complete overcorrection of the varus by manipulation.

Step 4. Perform a tenotomy of the tendo Achillis to correct the equinus.

Step 5. Pack the opening with iodoform gauze. Dress. Apply a plaster of Paris bandage extending up the calf immobilizing the limb in a position of overcorrection.

Step 6. Elevate the limb for twenty-four hours after removing the tourniquet. The dressings need not be changed for two or three weeks if they are clean. The incision is usually healed in this length of time.

TARSECTOMY

In some instances the above operation is inadequate for producing overcorrection. After division of the soft parts has been done, incise the neck of the astragalus with a chisel. Do not insert the gauze in the bone cleft when packing.

After treatment. The extremity should be encased in plaster of Paris for

six to eight weeks (renewed when necessary). Massage and exercises are instituted after this and a good, strong shoe horn used. No special club-foot shoe need be worn following this operation.

Jonas' Operation

Step 1. Make an incision beginning below the margin of the plantar fascia on the inner side of the foot, directly below and anterior to the internal malleolus, extending forward and upward to a point on the first metatarsal bone and nearly to the metatarso-phalangeal articulation (Fig. 775).

Step 2. Make a second incision beginning over the astragaloscaphoid articulation, extending forward and downward, connecting the first incision near

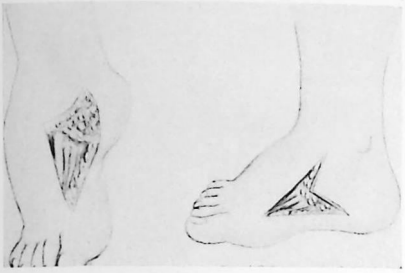


Fig. 775. Jonas' operation for club-foot.

the metatarso-phalangeal joint, forming a V. Make the incisions deep, including subcutaneous tissue and fat.

Step 3. Dissect back the flap thus outlined. Sever diagonally the inner fasciculus of the plantar fascia. Divide the remaining structures in accordance with Phelps's procedure. Avoid injury to the astragaloscaphoid capsule.

Step 4. Make another incision on the outer side of the foot over the head of the astragalus. Divide the neck of the bone with a chisel; if necessary, remove the head. Overcorrection is thus facilitated. Ligate the bleeding points. Replace the triangular flap. Use perforated oiled silk to cover the wound which is not sutured. Dress. Apply a plaster of Paris cast about one third the length of the thigh. Dressings should not be changed for five or six weeks.

Brockman's Open Operation

Step 1. Apply a tourniquet to the limb. Make an incision along the outer side of the foot along the calcaneus. Detach the plantar muscles and fascia from their origins as far backward and inward as possible.

Step 2. Make another incision on the inner side of the foot; detach the muscles

completely. Identify the tendon of the tibialis posterior. Detach it from the tubercle of the navicular.

Step 3. Dissect the soft tissues off the inferior surface of the tarsal bones until all of the inferior and medial surfaces of the navicular and medial surface of the sustentaculum tali are exposed.

Step 4. Mobilize the navicular by dividing the ligaments on its medial surface as well as on its inferior and superior aspects, if necessary. Divide the deltoid ligament of the ankle and the calcaneo-navicular ligament. Manipulate the foot bringing the navicular in front of the head of the talus.

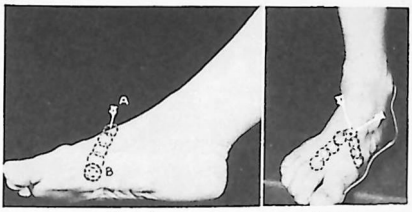


Fig. 776 Fig. 777

Fig. 776. Block anesthesia in operations for hallux valgus: mesial aspect.
Fig. 777. Block anesthesia in operations for hallux valgus: dorsal aspect.

Step 5. Close the incisions and apply plaster with the foot not quite corrected. Two weeks later secure complete correction after removing the plaster and manipulating the foot without removing the sutures. If necessary, tenotomize the tendo calcaneus.

Step 6. Apply a second plaster cast for about eight weeks. After this, fit the patient with an ordinary boot and permit him to walk. Advise him to wear a club-foot splint at night. Attention should be given to exercising and teaching the patient to walk properly.

HALLUX VALGUS (BUNION)

(See also Excision of the head of the metatarsal bone of the great toe p. 743.)

The bony deformity of hallux valgus consists of extreme abduction of the great toe (Fig. 780). Such a condition results in the malposition of the other toes especially the second which may be over or under the laterally directed great toe. The distal and medial portion of the first metatarsal bone is subjected to constant trauma with the resulting formation of callus an adventitious bursa (bunion) and exostosis.

The deformity is provoked by tight, ill-fitting shoes and gives rise to symptoms of pain, swelling and redness which may be complicated by a bursitis, arthritis or neuritis. Curative treatment is surgical and is designed to relieve pain, correct deformity and restore function (Fig. 777).

Operative Treatment of Hallux Valgus

This procedure is especially designed to relieve pain and diminish deformity.

Step 1. Make a dorsal, linear incision extending upward from the base of the proximal phalanx to the midportion of the shaft of the metatarsal bone. Wide retraction makes it possible to dissect out the adventitious bursa and to expose the exostosis present on the metatarsal under local or general anesthesia (Figs. 776-777).

Step 2. Saw or chisel this bony deformity away until the lateral surface of the metatarsal bone is aligned with the foot.

Step 3. If, after this procedure, the deformity cannot be manually corrected perform a tenotomy upon the extensor tendon opposite the tarsophalangeal joint.

Step 4. Carefully close and dress the wound. Place the toe in a slightly overcorrected position.

Step 5. Begin massage and voluntary motion after one week and permit weight bearing in three or four weeks.

Mayo's Operation for Bunion

In order to avoid the stiffness which he considers results from excision of the head of the metatarsus, C. H. Mayo operates as follows:

Step 1. Reflect a flap of skin downward on the inner side of the metatarso-phalangeal articulation avoiding injury to the bursa.

Step 2. Make a flap of the subjacent soft parts with its base at the root of the great toe. Reflect this flap together with the bursa.

Step 3. Correct the valgus by excising the head of the metatarsus; remove any bony excrescences.

Step 4. Turn the flap containing the bursa into the space between the metatarsus and the phalanx and suture it there.

Step 5. Pull the dorsal flexor tendon of the great toe inward so as to lie over the middle of the new joint and suture its sheath in this position.

Step 6. Close the wound and apply alcohol dressings to its surface and between the first and second toes.

The Radical Cure of Hallux Valgus (Soresi's Operation)

SUBARTICULAR RESECTION OF THE HEAD OF THE METATARSAL BONE

The technic to be described, although perhaps slightly more difficult to do than some of the others, has the advantage of preserving the articular surface of the metatarsal bone; at the same time it corrects the deformity. The aim is, therefore, to obtain an anatomically normal articulation and functional efficiency.

Step 1. The head of the metatarsal bone is exposed and the periosteum from the middle of the metatarsal bone to about one-quarter of an inch of the articular surface is incised (Fig. 778[1]).

Step 2. With a sharp thin periosteum elevator the periosteum is separated around the bone (Fig. 778[2]).

Step 3. The articular surface is detached from the bone (Fig. 778[3]). This can be done very easily and without damage if some bone is left attached to the articular surface itself; the spongy bone offers little resistance to a sharp instrument.

Step 4. The head of the metatarsal bone is removed (Fig. 779, A), sufficient bone being cut away to straighten the big toe.

Step 5. The excess of skin is removed with the bursa, and the wound is closed (Fig. 779, B). A splint is applied and the wound dressed with gauze im-

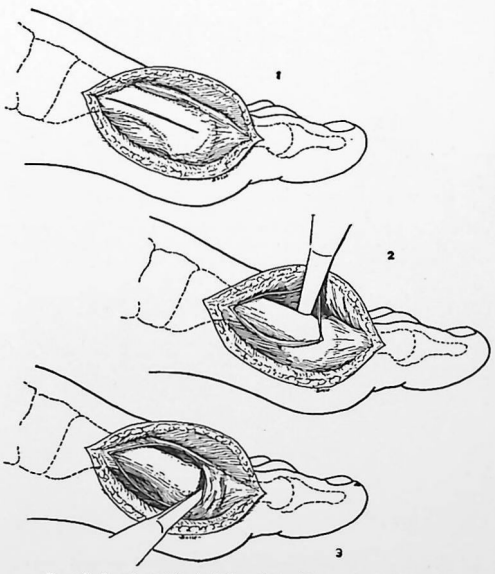


Fig. 778. Soresi's operation for hallux valgus. (Courtesy Dr. A. L. Soresi.)

pregnated with glycerine or alcohol. The toe is kept at rest until all inflammation has subsided. Passive and active movements are then started.

Comment: By this technic, it is seen that, the periosteum and articular surface are separated from about half of the metatarsal bone. When the head of the bone is resected, the articular capsule with its synovia and the periosteum falls back and covers the rough surface of the resected bone, to which it will in a short time adhere. Thus, while the head of the metatarsal

bone has been removed the articular surface has been preserved. As a matter of fact, the relations between the distal phalanx and the metatarsal bone have been reconstructed to conform to normal anatomic standards. The only difference between the unoperated phalangometatarsal bones and its articulation is that in the latter the metatarsal bone is shorter.

HAMMER TOE (DIGITUS MALLEUS)

Hammer toe is characterized by dorsiflexion of the proximal phalanx, plantar flexion of the second, and flexion or extension of the distal. The interphalangeal joint is thus subjected to trauma from the shoe cap which produces an area of keratosis beneath which a bursa usually forms. The tip of the toe is pressed against the sole of the shoe producing callous formation and flattening (Fig. 780).

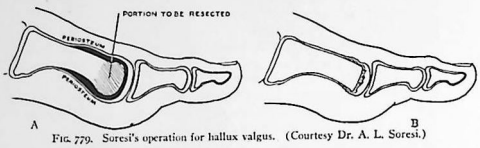


Fig. 779. Soresi's operation for hallux valgus. (Courtesy Dr. A. L. Soresi.)

The condition most frequently involves the second or third toes; it is often bilateral and is usually caused by short shoes which crowd the digits. Congenital cases are seen, however, and any degree of pes cavus or of equinus tends to produce this deformity. Hallux valgus is often associated with the condition.

The patient complains of a deformity, painful corns or bunions and difficulty in walking. Treatment in the young consists of manipulation and postural correction. In adult cases operative procedures are indicated.

Operations

Procedure 1. Tenotomy of the extensor digitorum longus and brevis through a slightly lateral incision just proximal to the interphalangeal articulation.

Procedure 2. Amputation of the toe (in the case of the second and third) through the proximal phalanx distal to the insertion of the interossei muscles with approximation of the extensor and flexor tendons. This procedure is not to be carried out in the presence of a hallux valgus.

Procedure 3. A semilunar incision over the dorsum of the affected joint exposes the underlying bursa which is excised along with the reflected semilunar skin flap. The head and a portion of the shaft of the proximal phalanx are carefully exposed and excised. The skin is closed and the toe fixed on a splint in its proper position (Fig. 781).

INGROWN TOENAILS

There are few cases of ingrown toenail which will not respond to medical measures if much time and perseverance are used. The most popular method consists of inserting a piece of cotton under the edge of the nail once or twice daily and then reducing the thickness of the nail to that of an ordinary piece of paper,



Fig. 780

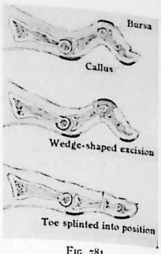


Fig. 781

Fig. 780. Hallux valgus with bunion formation associated with digitus malleus.
Fig. 781. Surgical treatment of digitus malleus.

by rubbing it with pumice stone. Caustic may be applied to the protruding edges; iodoform to the ulcerated area. Caustic soda solution 1 to 40 is used to soften the nail.

If surgery seems advisable, Watson Cheyne's method is recommended Local anesthesia usually suffices (Fig. 782).

Step. 1. Make an incision along the nail-fold down to the matrix, thus forming a flap along the side of the ingrowing nail.

Step 2. Remove a little less than half of the nail and all of the ulcerated tissue, care being exercised to see that the excision has completely destroyed the nail-fold. The operation will be unsuccessful unless this is accomplished.

Step 3. Place the flap on a level below the nail and insert one or two sutures (Fig. 783).

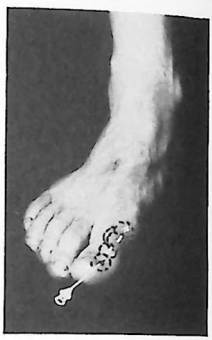


Fig. 782. Deep infiltration for the removal of ingrown toenails.

If it becomes necessary to remove a fingernail, it is better to remove it from its bed entirely than to split it as the latter procedure results in a misshapen nail.

SYNDACTYLISM

Syndactylism is the partial or complete fusion of two or more fingers or toes. It is usually congenital, frequently bilateral and may vary from a thin membranous web to actual osseous union between the affected digits (Figs. 784-785).



Fig. 783. Watson-Cheyne's operation for ingrown toenail. For description see preceding page.

Surgical treatment is resorted to as early as the first year in order to conserve function improve cosmetic aspects and prevent growth distortions (Fig. 786).



Fig. 784



Fig. 785

Fig. 784. Syndactylism of the hand associated with resulting growth deformities. Note the universal webbing.
Fig. 785. Syndactylism of the foot associated with supernumerary digit.

Operations

Procedure 1. When a short web is present or very little soft tissue available, Agnew's procedure is the one resorted to. A generous v-shaped dorsal flap is raised and reflected. The uniting web is divided, hemostasis provided and the flap brought between the fingers and onto the palmar surface of the hand where it is sutured. The denuded area that remains is allowed to granulate in or a skin graft is applied (Fig. 787).

Procedure 2. When sufficient soft tissue is available, Didot's operation is used. One web at a time is corrected. Dorsal and ventral full thickness skin flaps with their bases on opposite fingers are carefully raised. The fused fingers are then separated and the skin flap attached to each is brought around and sutured into place. Gangrene not infrequently follows this operation, thus the vascular supply should be disturbed as little as possible (Fig 788).

When a small amount of soft tissue separates the digits which are extensively fused, the Didot operation may be preceded by the Agnew procedure. Complete separation is then effected six weeks later. Cases with short, soft tissue webs may be treated with a crushing clamp (Woolsey). Under local anesthesia a hemostat is clamped onto the web and there held in place for one or two weeks. Amputation is usually practiced when the toes are painfully involved.



Fig. 786. X-ray of bifid thumb.

OSGOOD-SCHLATTER DISEASE

Osgood and Schlatter in 1903 described a painful condition resulting from the partial separation of the epiphysis of the tuberosity of the diaphysis of the tibia. The disease usually occurs between the ages of 13 to 16 and is probably the result of trauma. Frequently a painful infrapatellar bursitis is present. Radiographically the epiphysis shows anterior separation from the diaphysis, irregularity of contour (osteochondritis) and in some cases, fragmentation.

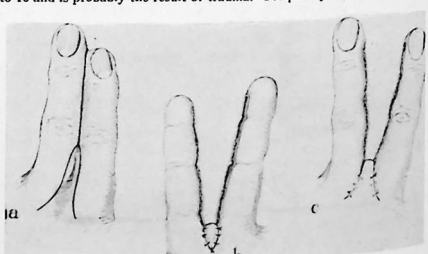


Fig. 787. Agnew's operation for syndactylism: a. line of incision for dividing web, b. V-shaped dorsal flap prevents recurrence, c. denuded area to be filled in by granulation.

The disease has an insidious onset. The patient may first complain of an aching over the epiphyseal region following overexertion or trauma. There is local heat, tenderness, redness, swelling and limitation of movement, especially that of flexion. The condition may be bilateral and in every case both knee regions should be studied. The disease is self-limited and terminates spontaneously although fixation expedites recovery.

Treatment. Treatment consists in fully extending the knee and fixing it in plaster for four weeks. Weight bearing is allowed, immediately. Later the patient wears a stop-joint to prevent undue flexion. Exertion and complete flexion are not permitted until after four months have passed.

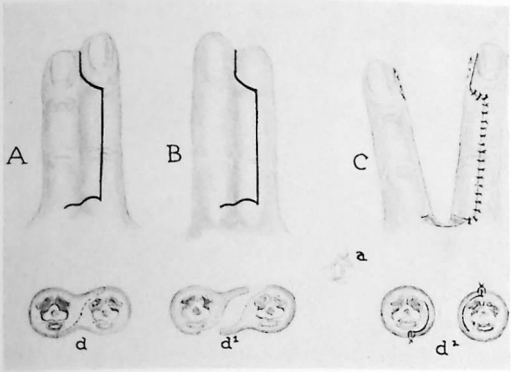


FIG. 788. Didot's operation for syndactylism: A-B. lines of incision for raising the flaps, C. flaps sutured in place, d-d¹-d². thickness of the grafts on the volar and dorsal aspects of the respective digits, a. detail of suture approximating flaps.

OPERATIONS ON THE JOINTS

ARTHRECTOMY

The complete or partial excision of a joint is indicated in a number of conditions, viz.:

1. In tuberculosis or other severe disease involving a joint which is not improving under ordinary palliative treatment.

2. When the joint surfaces have become ankylosed, fixing the joint in an undesirable position or rendering it useless owing to immobility. This indication stands both for fibrous and bony ankylosis especially when a movable joint is imperative for occupational functioning.

3. In certain types of joint traumatisms in which there has been much comminution of the bone forming part of the joint and the fragments cannot be replaced sufficiently to restore good function.

4. In cases of ecchondroses or exostoses of the articular extremities of long bones which extend into the joint cavity and make the articulation practically useless.

5. In some forms where the intra-articular cartilages are so displaced or torn that they cannot be replaced in suitable position and can only be satisfactorily dealt with by removal.

A joint may be excised by different modes. These are known as (a) **the open method**; (b) **the subperiosteal or subcapsular method**; (c) **the osteoplastic method.**

In the first, or **open method**, an incision is made through the soft tissues overlying the joint in order to expose the diseased tissues and facilitate their removal. On reaching the capsular ligament, the soft tissues are turned aside and the ligaments, together with the articular extremities, laid bare. The periosteum is left attached to the bones and the joint is excised either in whole or in part according to the extent and nature of the diseased portion.

In the second or **subperiosteal (subcapsular)** method of excising a joint, the periosteum covering the upper portions of the bones forming the joint, as well as the capsular ligament with its localized thickenings, are turned aside at the same time as the more superficial soft tissues; the diseased synovial membrane and articular surfaces of the bones are removed; and finally, the periosteum and the capsular ligament are replaced in their former positions. To effect this, the first incision is prolonged through the capsular ligament and the periosteum with which it is continuous; and then with a rugine or a periosteal elevator these structures are stripped from their attachments and turned aside exposing the interior of the joint cavity thus enabling all diseased synovial membrane and articular cartilage to be removed. This procedure may rank only as a partial excision of the joint and is applicable to cases of joint disease in which the synovial membrane and the articular cartilages are alone involved, which is usually the case in early joint tuberculosis and certain types of traumatisms and their results. The subperiosteol-subcapsular method is not applicable in extensive joint disease when the periosteum must be removed.

In the third method of joint removal—**the osteoplastic method**—in addition to turning aside the periosteum of the articular extremities of the bones and the ligaments, an attempt is made to detach temporarily all bony prominences with the muscles and ligaments still fixed to them. The joint is exposed, as in the previously described method, and with a chisel and mallet the portions of the bones to which the muscles and ligaments were attached are cut through and turned aside together with their attached soft tissues. The diseased tissues in the interior of the joint are then removed, bony projections are then again fixed in their original positions by means of bone or ivory pegs or by wire sutures. This mode of arthrectomy is best employed in some cases of ankylosis and in severe traumatic affections of the joints.

We will now proceed to consider the technic of excision of some special joints.

Excision of Shoulder Joint

Step 1. The patient is placed in the dorsal position with the affected shoulder somewhat raised from the table and projecting slightly over the edge of the table, the limb being slightly abducted and rotated inward.

Step 2. An incision is made, commencing at the lower margin of the clavicle opposite the lateral border of the coracoid process and extending distally in a direction parallel to the anterior margin of the deltoid muscle for a distance of about 3 or 4 inches (Fig. 789). This incision is made over the medial fibers of the deltoid muscle, thus avoiding injury to the cephalic vein and accompanying artery which lie in the groove between the deltoid and pectoralis major muscles. Do not attempt to retract these two muscles but dissect down through the medial fibers of the deltoid muscle and locate the long head of the biceps muscle.

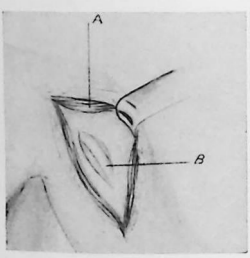


FIG. 789

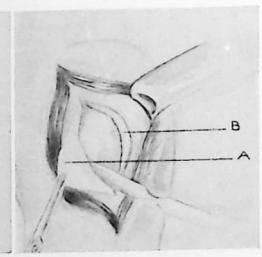


FIG. 790

FIG. 789. Resection of the shoulder joint (von Langenbeck's method): A. deltoid muscle, B. long head of biceps tendon.

FIG. 790. Resection of the shoulder joint (von Langenbeck's method). Detachment of the lesser tuberosity of the humerus: A. periosteum and capsule of shoulder joint, B. tendon of biceps muscle.

Step 3. The pectoralis major muscle is divided transversely at its clavicular attachment, if necessary, in order to obtain a clear and unimpeded view of the shoulder joint. When the muscles are retracted the capsular ligament will be visible in the bottom of the wound (Fig. 790). The humerus is rotated so as to bring its intertubercular groove and the long tendon of the biceps brachii into view.

Step 4. The biceps tendon is separated from its sheath by dividing the capsular ligament along the lateral margin of the tendon together with the transverse humeral ligament; the tendon is retracted medially and the humerus rotated laterally, bringing forward its small tuberosity with the insertion of the subscapularis, the latter being then separated from the bone.

Step 5. The humerus is now rotated medially so as to expose its large tuberosity and attached muscles which, as in the case of the small tuberosity,

are separated from bone connections (Fig. 791). When the head of the humerus together with as much of the shaft as is requisite have been exposed, the proximal extremity of the bone is forced out of the external wound and sawn across distal to the diseased area, the margins of the cut being rounded off so as to make an artificial head to the bone (Fig. 792). If there are any other diseased tissues in the vicinity, they are removed by bone forceps or by a sharp spoon.



FIG. 791

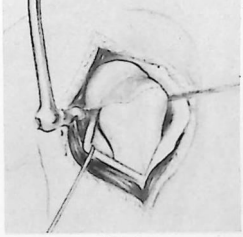


FIG. 792

FIG. 791. Resection of the shoulder joint (von Langenbeck's method): detachment of greater tuberosity of the humerus.

FIG. 792. Resection of shoulder joint (von Langenbeck's method). The head of the humerus has been delivered into the wound. The line of excision of the head of the humerus by means of a Gigli or other appropriate saw is indicated by the dotted line.

Step 6. The external incision is closed following a thorough irrigation of the joint area and the placing of a drainage tube. If all goes well, passive movements of the limb may be begun about 10 days after the operation.

OPERATION FOR PROMINENT SCAPULA (SCAPULA ALATA)

This condition is due to a paralysis of the serratus magnus and the rhomboid muscles.

Pierre Duval's Operation[1]

Step 1. Make an incision along the vertebral border of the scapula beginning at the level of the scapular spine and extending downward to its angle.

Step 2. Divide the trapezius and rhomboideus major muscles to the entire extent of the wound. Retract the latissimus dorsi muscle strongly downward.

Step 3. Incise the periosteum along the exposed border of the scapula. Reflect it from the bone for a distance of about one-half inch together with the infraspinatus muscle.

[1] Revue de Chir., 1905; No. 1.

Step 4. Separate the periosteum together with the serratus magnus muscle from the anterior surface of the scapula.

Step 5. Excise the periosteum and the serratus magnus muscle sufficiently to allow the denuded anterior surface of the scapula to lie freely in contact with the sixth and seventh ribs.

Step 6. Denude the sixth and seventh ribs of their periosteum about two and three-quarters inches from the midline. The seventh rib should be denuded about one-half inch further outward in order to afford the scapula proper obliquity.

Step 7. By means of two wire sutures, the scapula is united to the ribs.

Step 8. Wherever possible the periosteum should be sutured over the wires.

Step 9. By means of strong retraction of the mesial edge of the wound comprising skin, trapezius and rhomboid muscles, expose the long muscles of the back which are situated on the posterior surface of the transverse processes at the upper angle of the wound.

Step 10. Fashion a long, thick flap, with its pedicle below, from the long muscles of the back. This flap should be sutured at the superior angle of the scapula to the periosteum and the supraspinatus muscle.

Step 11. Close the wound without drainage. Dress. Put a plaster of Paris corset on the patient for about 48 hours.

Menciére's Modification of Duval's Operation[1]

Step 1. Separate the periosteum from the fifth, sixth and seventh ribs. This separation is carried out about nine centimeters from the midline of the fifth rib, ten centimeters of the sixth and eleventh centimeters of the seventh. The purpose of this is to create a line of attachment of the scapula which will be oblique, from above downward and outward, the purpose being to raise the acromion process.

Step 2. Separate the periosteum around the ribs.

Step 3. Surround the ribs with appropriate sutures. Proceeding in this manner will prevent compression of the intercostal nerves.

Step 4. Suture the superimposed structures as in Duval's operation.

Step 5. Suture the skin wound.

Step 6. Apply an apparatus (Menciére's) which will fix the arm in an elevated position with the hand resting on top of the patient's head. Continue this immobilization for 65 days, following which passive and actve motions are begun.

SURGICAL TREATMENT OF CONGENITAL ELEVATION OF THE SCAPULA

V. Putti's technic is described by O. Scaglietti (Chir. del org. di Mov. Vol. 21, Nr. 4, 1935) as follows:

Step 1. Make an incision along the vertebral margin of the scapula (Fig. 793[1]).

Step 2. Detach the trapezius muscle and the latissimus dorsi.

Step 3. Free the rhomboids from the vertebral margin of the scapula by subperiosteal dissection (Fig. 793[2]). The scapula now is almost completely freed from its muscular attachments to the torso. In many instances, it is necessary to remove a beak-like protrusion of bone which is frequently

[1] L'Encéphale, March, 1912; Lancet, August 17, 1912.

found growing from the upper inner angle. When present, this must be removed (Fig. 793[3 and 4]), otherwise the scapula cannot be successfully drawn down to its normal level. By the use of retractors, the scapula is drawn as low as can be successfully done without disruption of the shoulder girdle.

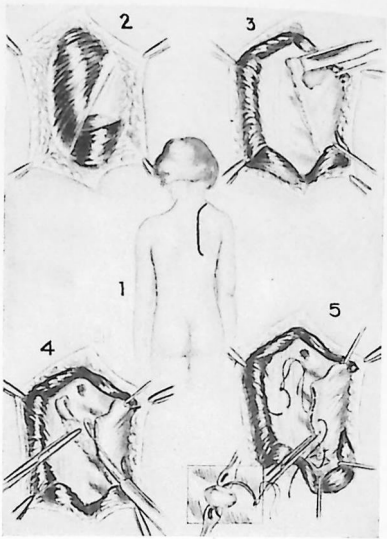


Fig. 793. Putti's operation for congenital elevation of the scapula: 1. Putti's incision, 2. superficial muscular layers of the back, 3. subperiosteal dissection of the vertebral border of the scapula, 4. removal of the upper inner portion of the scapula which is frequently deformed interfering with the successful drawing down of the scapula, 5. fixation of the inferior angle of the scapula by silk suture which penetrates through the scapula and around the rib, usually the sixth or seventh. Insert: detail showing needle passing beneath rib and over guides protecting subjacent tissue.

Step 4. Pass several sutures of braided silk to fix the scapula to the sixth or seventh rib, depending on how low the scapula can be drawn (Fig. 793[5]) An additional number of silk sutures are passed through the vertebral margin of the scapula and are fixed to the periosteum of the nearby ribs as illustrated.

Step 5. After the scapula has been firmly fixed, the cut muscles are reapproximated as closely to their former attachments as possible.

Step 6. A plaster cast is applied, the elbow flexed at right angles, the forearm in mid-pronation. Longitudinal traction must be applied to the arm so as to keep the scapula as low as possible. The sutures are removed at

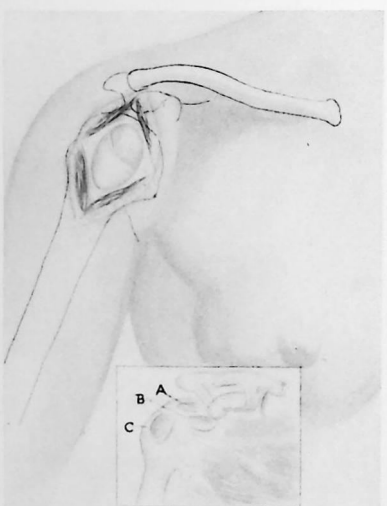


Fig. 794. Operation for subacromial bursitis (Codman). A. subacromial bursa, B. bursa of the coracobrachialis, C. subdeltoid bursa.

the end of 15 days at which time the cast has been opened. A new bivalve cast is applied immobilizing the chest and the arm so that graduated massage and exercises may be given. At the end of five or six weeks, the bivalve cast is discarded.

Comment: Early surgical treatment is most essential. The operative technic is varied, depending upon the anatomic fixation (either by a bony bridge or muscular contraction). Careful radiographic examination is necessary in order to detect whether or not any beak-like formation is present

over the upper inner portion of the scapula. Surgery is recommended immediately after diagnosis and after the correct evaluation of the operative risk to the young patients.

OPERATION FOR SUBACROMIAL BURSITIS (CODMAN)

Step 1. Make an incision about two to two and one-half inches in length beginning at a point midway between the coracoid process and the acromion process running parallel with the fibers of the deltoid muscle (Fig. 794).

Step 2. Split the deltoid muscle and enter the affected bursa.

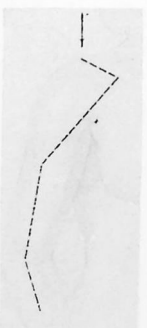


Fig. 795

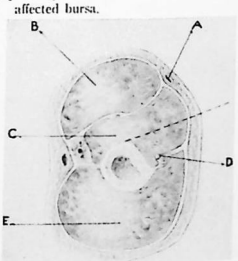


Fig. 796

Fig. 795. Henry's method of exposure of the shaft of the humerus. Make an incision through the skin and deep fascia along the dotted line indicated. The arrow marks the "step down" at the acromioclavicular articulation. Expose the deltoid attachment to the outer third of the clavicle, the inner edge of the deltoid muscle, and the outer edge of the biceps muscle. Continue the division of the deep fascia throughout the upper third of the forearm. Split the brachialis anticus muscle.

Fig. 796. Henry's method of exposure of the shaft of the humerus. The cross section through the middle third of the arm shows the external fourth of the brachialis muscle left uncovered by the belly of the biceps muscle. This part of the brachialis muscle is split in the direction of the broken pointer in order to expose the humerus. The musculospiral nerve is safeguarded. A. Cephalic Vein; B. Biceps; C. Brachialis; D. Musculospiral; E. Triceps. (Redrawn from British Journal of Surgery)

Step 3. Excise the pathologic portion of the bursa.

Step 4. Hemostasis should be perfect. Suture the wound in the deltoid muscle with catgut sutures.

Step 5. Close the wound in the skin.

Comment: Motion is begun after about ten days.

EXPOSURE OF THE SHAFT OF THE HUMERUS

Arnold K. Henry's Technic[1]

Step 1. With the patient's arm resting close to his side, the elbow extended and flexed by an assistant when necessary, an incision is made which commences above, over the coracoid process and extends along the course of the

[1] Brit. Jour. Surg., Vol. XIII, p. 85.



FIG. 801. The internal lip of the skin and fat tissue section is shown displaced internally, leaving the clavicle in view; also Morenheim's triangle and the cephalic vein which passes above the terminal part of the pectoralis major muscle (Gutierrez).

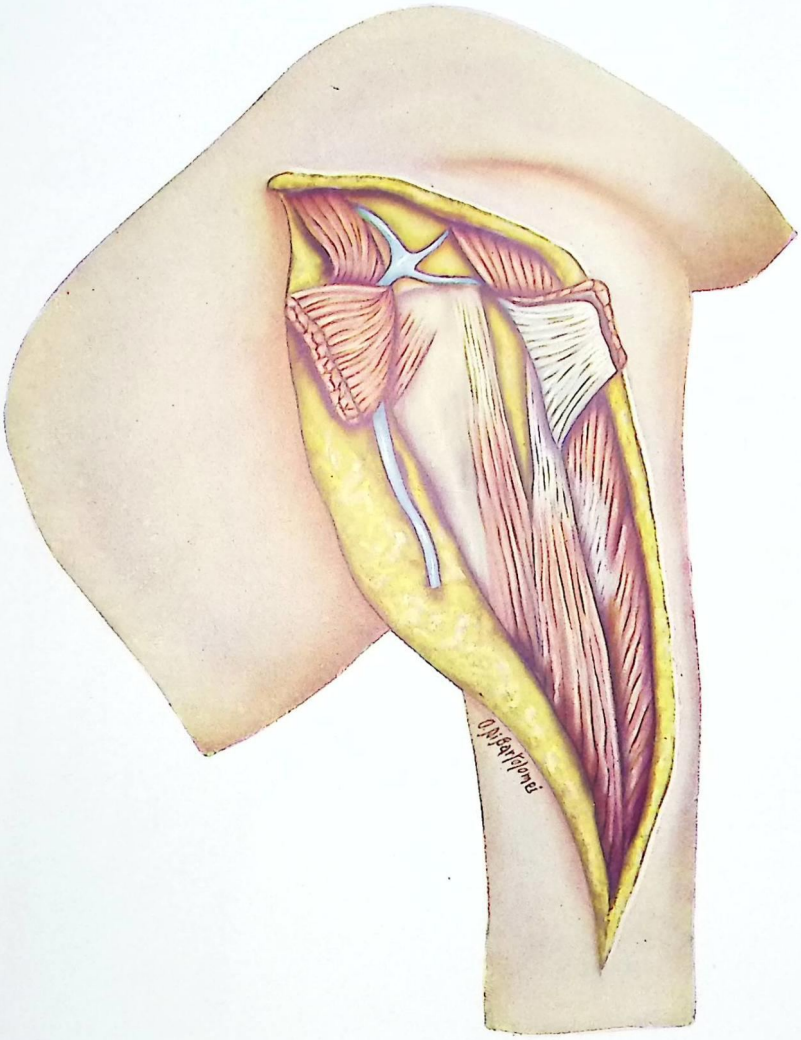


FIG. 802. Pectoralis major muscle is sectioned vertically giving exposure of the biceps muscle (Gutierrez).

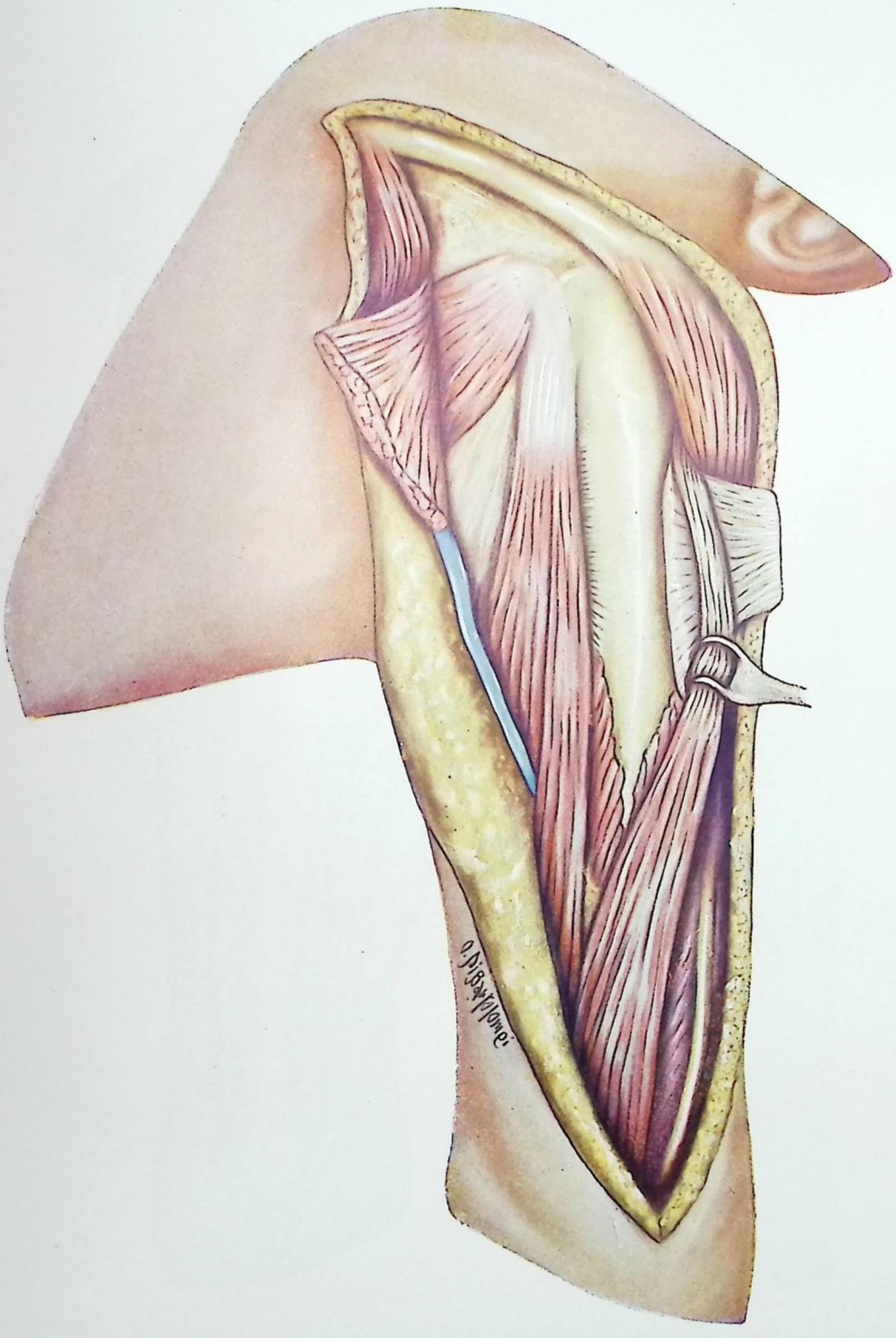


FIG. 803. The two parts of the biceps are separated exposing the upper portion of the humerus; the upper part of the anterior brachial muscle is shown sectioned; the radial nerve is seen (Gutierrez).

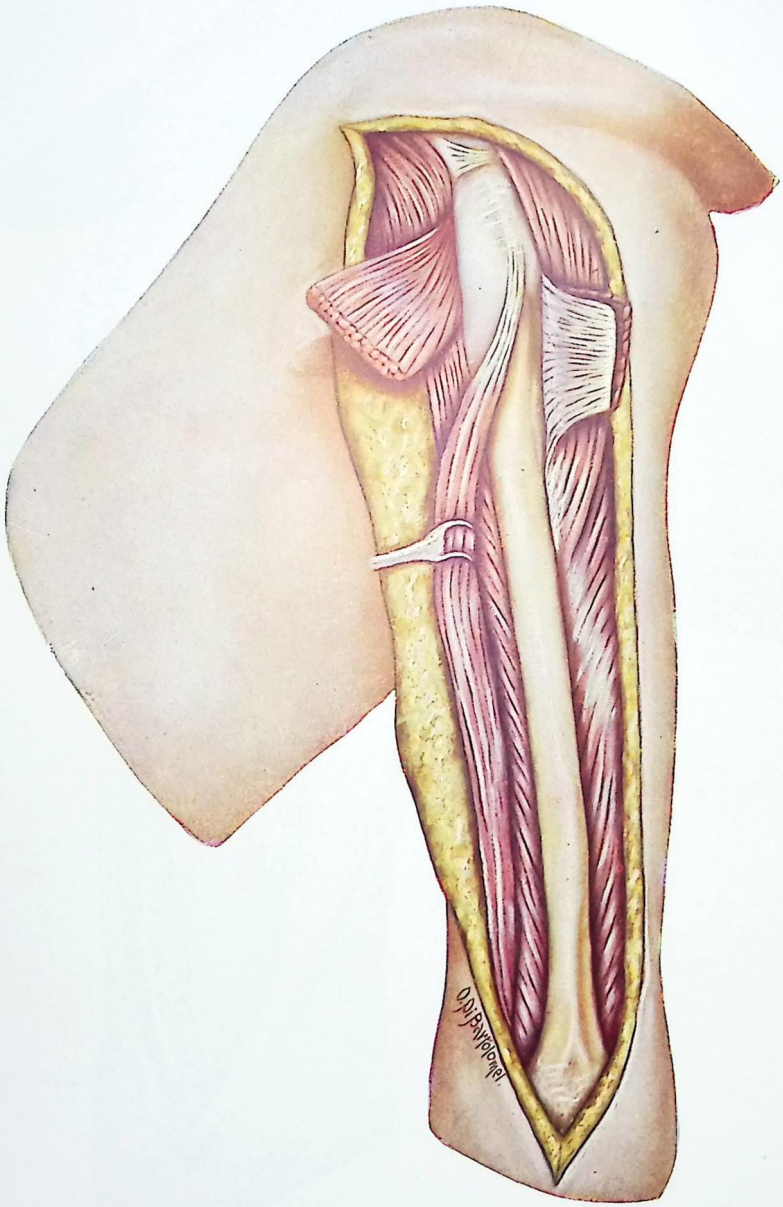


FIG. 804. The biceps muscle is shown drawn back inwardly; the longitudinal section of the anterior brachial muscle is shown completed with the humerus bared. In the lower part of the incision the articulation of the elbow is seen (Gutierrez).

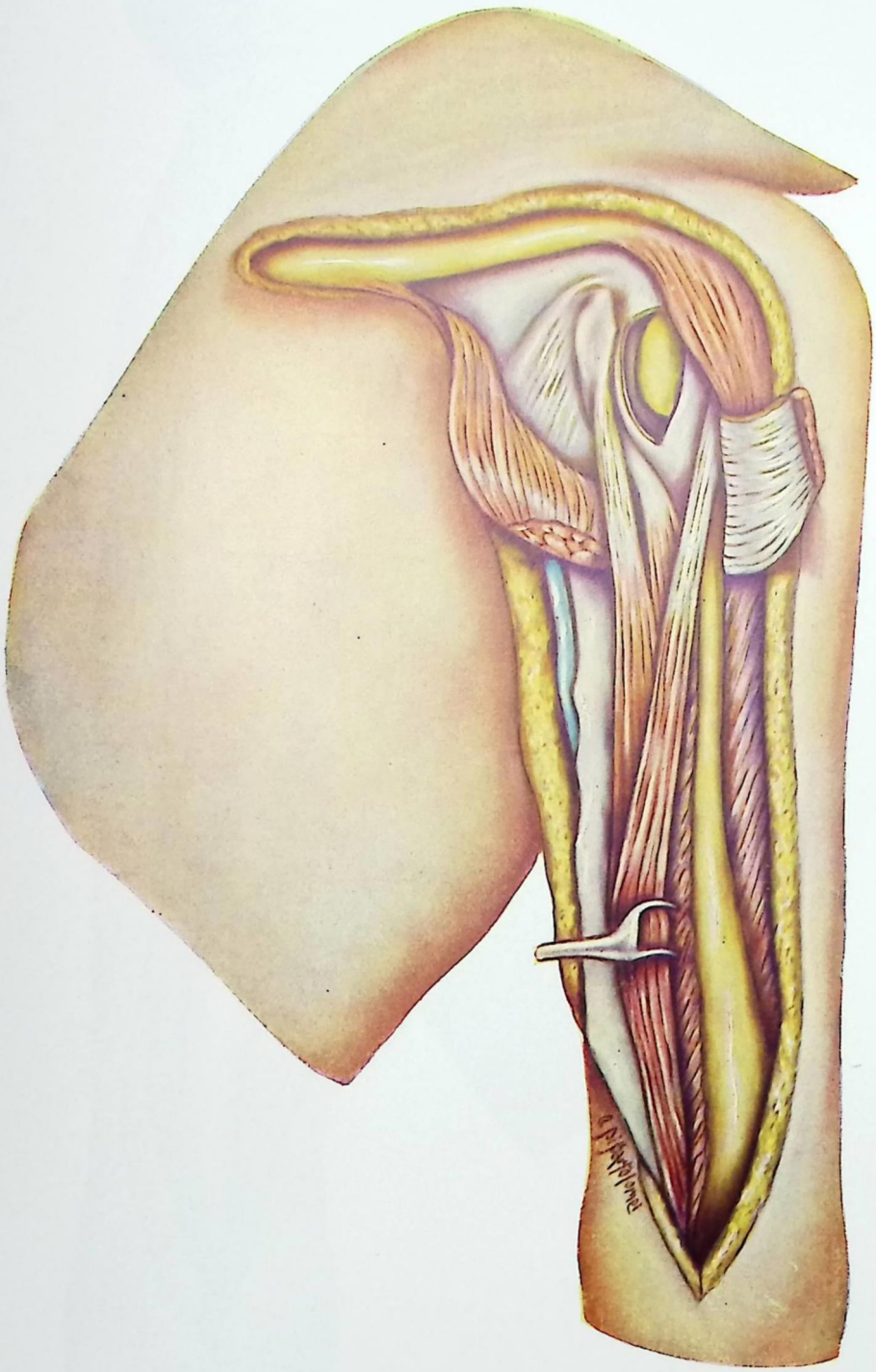


FIG. 805. The capsule of the articulation of the humerus is sectioned and exposes the most antero-internal part of the head of the humerus (Gutierrez).

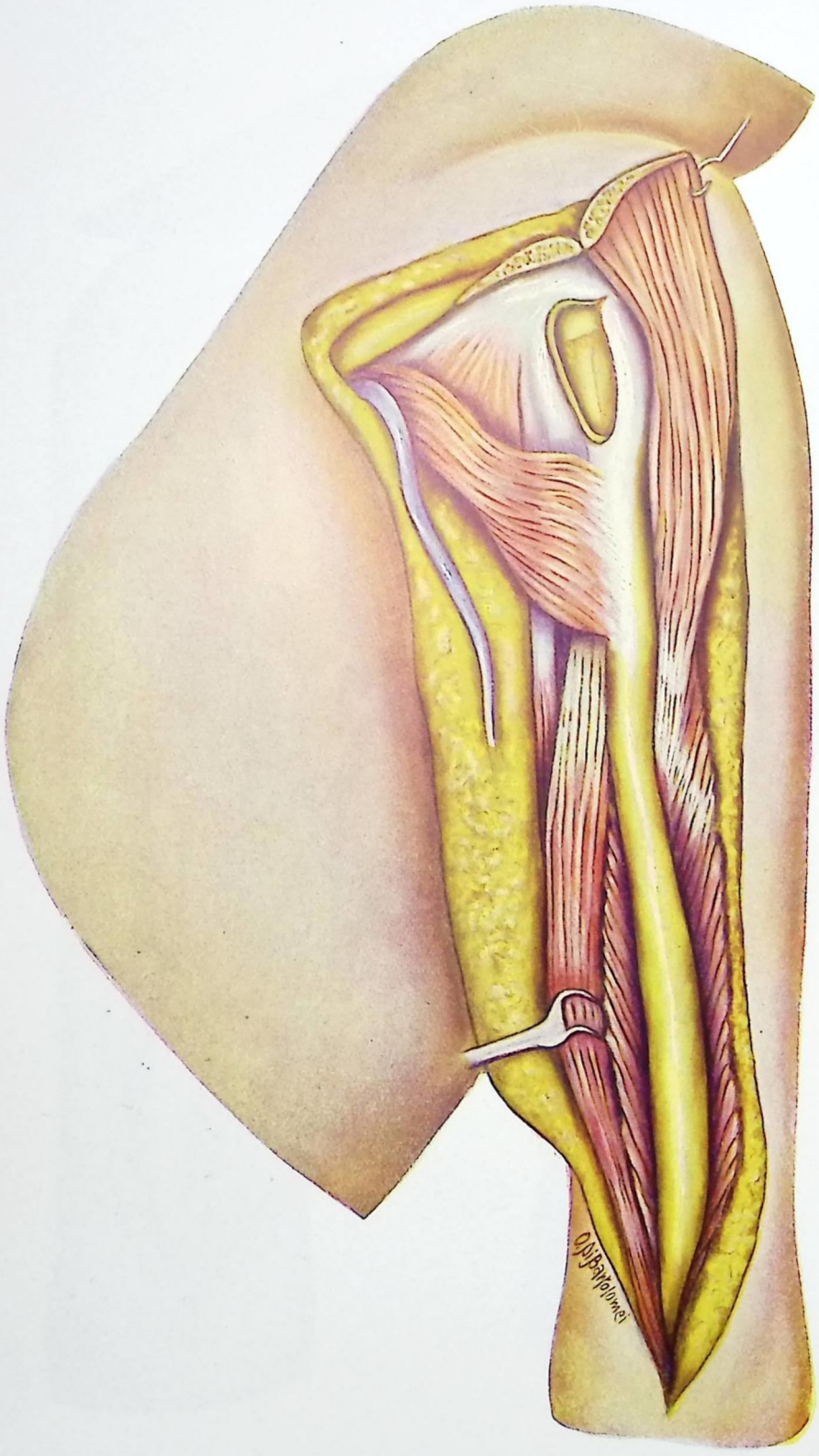


FIG. 806. The scapulohumeral articulation is seen opened inside the external tuberosity.

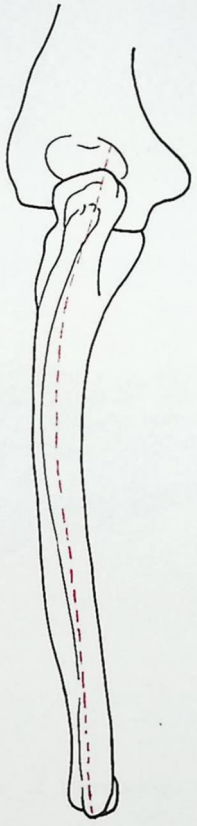


FIG. 807. Cutaneous outline of the incision (Gutierrez).



FIG. 808. Line of cutaneous olecranocubital incision (Gutierrez).



FIG. 809. The antebrachial aponeurosis is shown, divided longitudinally (Gutierrez).

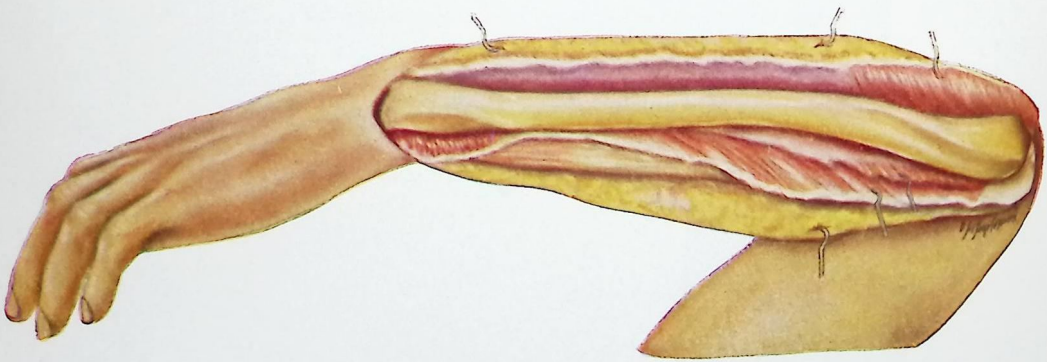


FIG. 810. Periosteum divided, making access to part easy (Gutierrez).

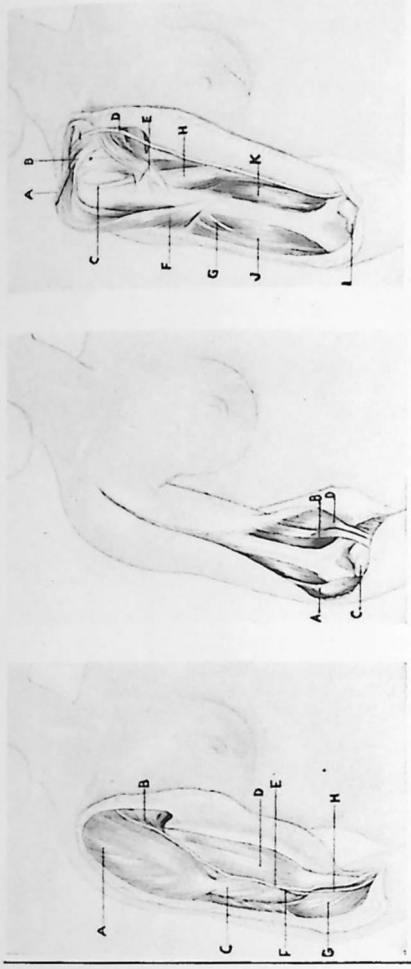


FIG. 799

FIG. 798

FIG. 797

FIG. 797. Henry's method of exposure of the shaft of the humerus. Dissection of the right arm as seen from the outer side. The uncovered outer one-fourth of the brachialis anticus muscle appears between the biceps and supinator longus muscles and extends behind the deltoid insertion. It can be used as a buffer to protect the musculospiral nerve. The occasionally observed small branch of the musculocutaneous nerve running to the brachialis muscle is shown. A, deltoid; B, pectoralis major; C, brachialis; D, biceps; E, cephalic vein; F, occasional branch of the musculocutaneous nerve to the brachialis muscle; G, supinator longus; H, musculocutaneous nerve.

FIG. 798. Henry's method of exposure of the shaft of the humerus. The split brachialis muscle is now separated from the bone. The inner and outer portions of the muscle are retracted. Relaxation is accomplished by flexing the elbow. The lower half of the humerus is now exposed. The elbow joint is now opened and the coronoid process is seen. If exploration of the elbow joint is not required, stop the incision in the brachialis muscle two finger breadths above the epicondyle. A, Brachialis muscle (outer portion); B, brachialis muscle (inner portion); C, coronoid process of the ulna; D, biceps tendon.

FIG. 799. Henry's method of exposure of the shaft of the humerus. The exposure of the humerus is completed by turning the deltoid muscle outwards. A hinged chip is cut from the clavicle (see Fig. 800). If exploration of the musculospiral nerve is required, this can be accomplished by detaching part of brachialis muscle which extends beyond the tip of the deltoid. A, Hinged chip of clavicle with origin of the deltoid muscle; B, cortical surface; C, junction of brachialis and biceps; D, cephalic vein; E, pectoralis major; F, deltoid; G, musculospiral nerve; H, biceps muscle; J, brachialis (outer portion); K, brachialis (inner portion); L, coronoid process.

cephalic vein (Fig. 795). The course of this incision is obliquely outward along the inner margin of the deltoid muscle, as far as its insertion, and then it proceeds vertically downward along the outer border of the biceps muscle, a short distance below the bend of the elbow.

Step 2. Continue the incision down to the bone along the exposed margin of the deltoid muscle.

Step 3. Split the brachialis anticus muscle longitudinally in the direction of its fibers and direct it to reach the humerus at its rounded anterior border so as to avoid Luschka's filament (Fig. 796). Leave a substantial layer of muscle-tissue to protect the musculo-spiral nerve (Fig. 797). Flexing the elbow now renders the lower part of the bone widely accessible. In order freely to expose the upper part of the shaft of the humerus, its tuberosities and shoul-

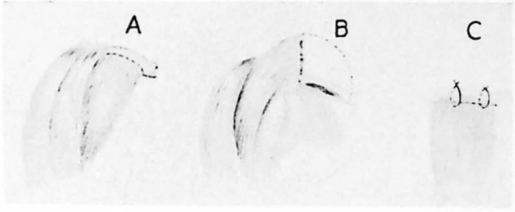


FIG. 800. Henry's method of exposure of the shaft of the humerus. Cut the hinged chip from the clavicle along the outline indicated in A and B. Turn the deltoid muscle out upon the hinged chip. C. Reconstruct the deltoid origin. By means of two sutures, tie the chip back into its original position.

der, Henry advises to continue the upper end of the skin incision outward along the upper surface of the clavicle to the acromioclavicular joint. Reflect the skin and fascia so as to expose the origin of the deltoid muscle (Fig. 797).

Step 4. Detach with a chisel the edge of the bone carrying the insertion of the deltoid muscle continuing the detachment as far as the acromioclavicular joint (Fig. 800). The deltoid muscle can now be turned outward on the hinge of muscle and bone thus produced, affording a clear view to the underlying structures (Fig. 800).

Step 5. When the operation is completed, pass sutures through the muscle and around the clavicle, thus drawing the bone back into position and reconstituting the deltoid origin.

Comment: Mason's incision is a simpler one but Henry's affords better exposure of the head of the humerus and its tuberosities as well as the other parts of the bone.

SURGICAL EXPOSURE OF THE HUMERUS

Gutierrez Technic [1]

Gutierrez is of the opinion that surgical exposure of the humerus is best made by the anterior route. On studying the anterior zones, by which the bone

[1] Revist. de cirug. Buenos Aires, June, 1930.

can be reached without compromising vascular or nerve elements of importance, there are two alternatives: one antero-internal or transpectoral; the other, the pectorodeltoidean.

I. Antero-internal or Transpectoral Method

Step 1. Make a cutaneous incision starting from the middle part of the clavicle, extending first in the direction of the deltoid-pectoral sulcus and, then, the external border of the biceps muscle, until the middle of the elbow region is reached (Fig. 801).

Step 2. Widen the muscle interstice between the major pectoral and deltoid muscles; expose the tendon of the pectoral for some 2 cm. inside the line of its attachment. The external or anterior lip of the biceps is exposed and divided vertically (Fig. 802). This exposes the biceps in two parts; widen the interstice between the two and retract the large part. This exposes the humeral head and surrounding part of the bone. Under this is seen the upper part of the anterior brachial muscle (Fig. 803).

Step 3. Retract the large part of the biceps outward, exposing the most external part of the anterior brachial and divide it longitudinally. The humeral diaphysis and inferior articular portion are also exposed (Fig. 804). Divide this articular portion, thus exposing the anteromedial part of the head of the humerus. Opening the elbow articulation exposes the condylar parts of the humerus (Fig. 805).

II. The Antero-external or Interdeltoid-Pectoral Method

The line of cutaneous incision is similar to that previously described. The soft parts are sectioned and the cephalic vein either ligatured or drawn aside (Fig. 806).

SURGICAL EXPOSURE OF THE ELBOW

Gutierrez Technic

Step 1. Make a straight incision extending from the most prominent point of the olecranon process to the distal extremity of the ulna (Figs. 807-808).

Step 2. Divide the aponeurosis of the forearm longitudinally over the bony surface of the ulna (Fig. 809).

Step 3. Split the muscles of the ulna from its superior to the inferior extremity. Divide the periosteum (Fig. 810).

The exposure of the parts are easily effected owing to the direct relationships of the ulna to the skin.

RESECTION OF THE ELBOW JOINT

This joint may be excised completely or partially according to the circumstances.

Step 1. The patient is in the dorsal position and the affected arm is semiflexed at the elbow and resting upon the trunk.

Step 2. Make an incision, about 4 inches or more in length, commencing on the dorsal aspect of the forearm about 2 inches distal to the elbow-joint and extending proximally to a similar distance above, the prominence of the olecranon being opposite the middle of the incision (Fig. 811). The incision is carried down to the posterior aspect of the bone.

Step 3. A flap is made and turned up, the upper part consisting of the lateral aspect of one-half of the triceps brachii muscle, the corresponding part of the anconeus and the origins of the extensor muscles which are attached to the lateral epicondyle of the humerus; the lower part of the flap includes the rest of the anconeus and the downward continuation of the extensor muscles.

Step 4. Turn up a similar flap on the medial side, care being taken not to injure the ulnar nerve lying in the groove upon the posterior aspect of the medial

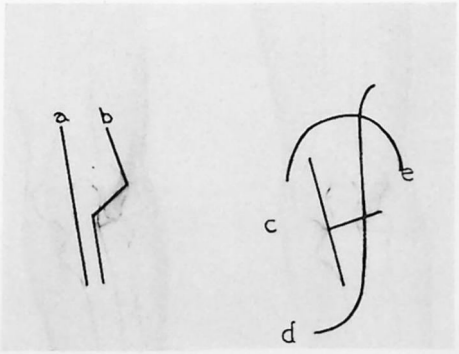


FIG. 811. Excision of the elbow joint (after Bryant): A. Langenbeck's incision, B. Ollier's incision, C. incision of Liston and of von Bruns, D. Kocher's incision, E. Rutherford-Morison's incision.

epicondyle of the humerus. Care must be exercised not to injure nerves. On the lateral side, the lateral epicondyle, if not diseased, may be cut through with a chisel preserving, as far as possible, the attachments of the extensor muscles.

Step 5. Proceed similarly on the medial side, subjecting the medial epicondyle to the same treatment.

Step 6. Flex the joint; cut through the posterior part of the capsular ligament close to the olecranon process and the joint cavity is opened exposing the bone extremities.

Step 7. The distal extremity of the humerus is now protruded, the trochlear portion grasped with forceps and sawed along a plane which is above the articular surface. The base of the olecranon, together with the articular portion of the coronoid, is removed with the saw, as well as the head of the

radius below the articular surface but above the attachment of the biceps tendon.

Step 8. The operative area is thoroughly examined for any other diseased tissues which can be scraped away with a sharp spoon or dissected out with scissors.

Step 9. Hemostasis. Close the wound. Insert a drainage tube. Splint and bandage the arm in a semiflexed, semisupinated position for at least a few days, following which passive movements are cautiously commenced.

Several different incisions have been recommended for excision of the elbow joint. Kocher's curved incision commences at a point opposite the upper part of the lateral supracondylar ridge of the humerus and extends distally along the lateral aspect of the limb as far as the head of the radius; it then crosses the extensor aspect of the forearm in an oblique direction to a point on the posterior border of the ulna about 3 inches distal to the elbow joint terminating by curving medially for a short distance.

SURGICAL EXPOSURE OF THE RADIUS

Gutierrez Technic[1]

Step 1. Make a straight incision extending from a little below the radial styloid process to the lateral epicondyle (Fig. 812). Divide the skin and subcu-

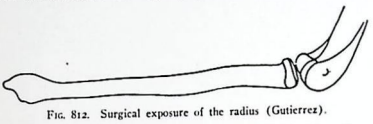


Fig. 812. Surgical exposure of the radius (Gutierrez).

taneous fat (Fig. 813). In the lower part of the incision the cutaneous branch of the radial nerve is seen, passing about the tendons of the large abductor and short extensor of the wrist (Fig. 814). Incise the aponeurosis of the forearm over the muscles mentioned and continue the dissection to the lateral epicondyle.

Step 2. Widen the intermuscular interstices between the common extensor of the fingers and the second external radial thus exposed. A small part of the radial bone is seen in the lower part of the large abductor of the wrist between both muscles (Fig. 815).

Step 3. Separate the second radial from the common extensor reaching the deep muscle plane which is made up of the large abductor below and the short supinator muscle above. In the upper part the separation between the second radial and the common extensor must be made by the knife since at this level the muscles form a single mass.

Step 4. Divide the short supinator longitudinally, exposing the postero-lateral surface of the radius in all directions (Fig. 816). In the upper part, the articulation of the elbow can be opened widely exposing the humero-radial articulation. The posterior branch of the radial nerve should be recognized before the short supinator muscle is sectioned.

[1] Revist. de cirug., Buenos Aires, Nov., 1931.

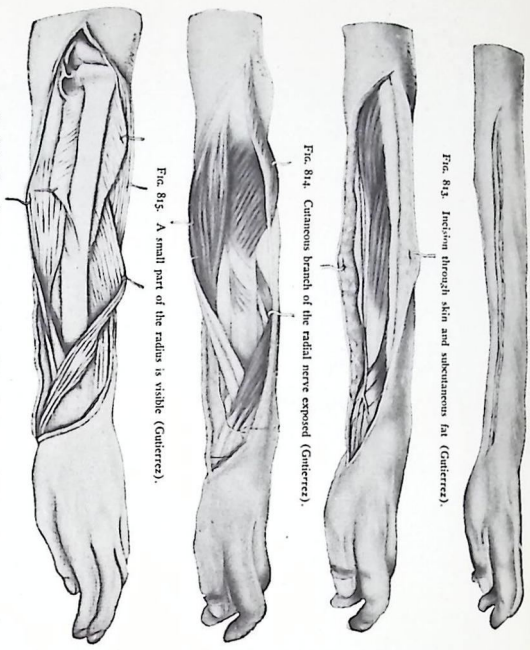


Fig. 816. The entire postero-external surface of the radius is exposed (Gutierrez).

Fig. 815. A small part of the radius is visible (Gutierrez).

Fig. 814. Cutaneous branch of the radial nerve exposed (Gutierrez).

Fig. 813. Incision through skin and subcutaneous fat (Gutierrez).

EXPOSURE OF THE RADIUS OR ULNA[1]

ARNOLD K. HENRY'S TECHNIC

Indications.

a. Tumors (especially myeloma)
b. Tuberculosis
c. Sequestra
d. Exposure for plate grafting, etc.

Step 1. Apply a tourniquet as high as possible.

Step 2. Extend the patient's elbow and fully supinate the forearm.

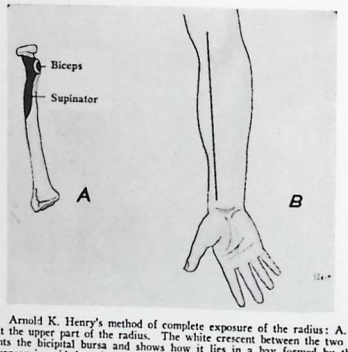


Fig. 817. Arnold K. Henry's method of complete exposure of the radius: A. Anatomical relationship at the upper part of the radius. The white crescent between the two black insertions represents the bicipital bursa and shows how it lies in a bay formed by the supinator edge. The surgeon is guided to the bursa by the outer face of the biceps tendon. B. Henry's incision in complete exposure of the radius. Divide skin and superficial fascia from the lower end of the biceps belly to the radial styloid. Begin dividing the deep fascia over the biceps tendon. (Redrawn from British Journal of Surgery.)

Step 3. Make an incision beginning about two inches proximal to the bend of the elbow, at the outer border of the biceps muscle and ending below at the tip of the styloid process of the radius Fig. 817B).

Step 4. Divide the deep fascia at the outer border of the tendon of the biceps and open the fascia to the entire extent of the wound.

Step 5. Retract outward the brachioradialis, the extensor carpi radialis longus, the extensor carpi radialis brevis muscles and the radial nerve; then retract the radial vessels inward (Fig. 818).

Step 6. Ligate and divide the recurrent radial vessels at the outer side of the biceps tendon.

Step 7. Flex the elbow to about 90° to relax the muscles. Retraction of the

[1] Brit. Jour. Surg., Vol. XIII, p. 506.

muscles will bring into view the supinator brevis muscle as it embraces the upper third of the radius.

Step 8. Cut down on the radial tuberosity, keeping the knife close to the outer border of the biceps tendon and open the bicipital bursa (Fig. 819).

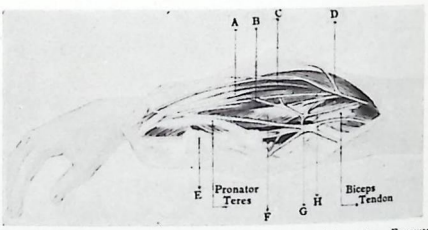


Fig. 818. Arnold K. Henry's method of complete exposure of the radius. Exposure of biceps tendon: slide a finger downwards along its outer side till it meets the resistance of the recurrent vascular-loop. Divide and tie this loop and mobilize the three long muscles which flank the radius; flex the elbow and retract them outwards. (Redrawn from British Jour. Surg.)

The knife, Henry points out, strikes the radial tuberosity where it lies in a bay formed by the supinator edge. From this strategic point the rugine peels the supinator muscle off the bone. The muscle is turned outward, carrying within its substance the posterior interosseous nerve.

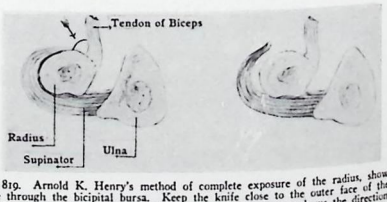


Fig. 819. Arnold K. Henry's method of complete exposure of the radius, showing the cut made through the bicipital bursa. Keep the knife close to the outer face of the biceps tendon. The supinator is then peeled off the radius. The arrow shows the direction of the incision through the bursa. (Redrawn from British Jour. Surg.)

Step 9. Detach the pronator radii teres and the pronator quadratus muscles and displace them inward. Pronation of the forearm at this stage of the operation exposes the radius in its entire length (Fig. 820).

Comment: The important phase of this operation is that the incision is placed between the flexor muscles which are supplied by the median nerve, and the extensor muscles as well as the supinators which are supplied

by the musculo-spiral nerve. Should it become necessary to expose the distal portion of the radius only, the lower half of the incision is sufficient. On the other hand, where the proximal end of the radius is to be exposed, the necessary exposure is obtained by resorting to the upper half of the incision.

Excision of the Radial Portion of the Proximal Radio-Ulnar Joint

When this excision is indicated and the location of the head of the radius is determined, an incision, 2 inches or so in length, is made over the projecting part of the bone, parallel to the long axis of the forearm and carried down to the bone. The orbicular ligament which surrounds the head of the radius is divided

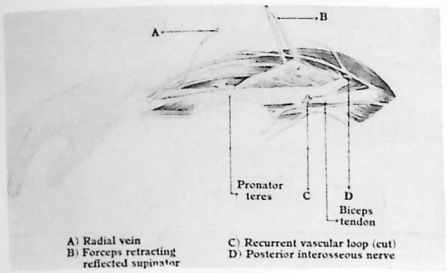


FIG. 820. Arnold K. Henry's method of complete exposure of the radius: completion of the exposure by putting the forearm in full pronation. (Redrawn from British Jour. Surg.)

and the soft tissues pulled aside with retractors. The radius is then cut through either with a bone forceps or saw, the section being made above the tubercle of the radius, and care being taken not to injure the branches of the radial nerve.

EXCISION OF THE WRIST

This excision may be indicated in cases of tuberculous disease involving the wrist, in severe compound fractures and in certain inflammatory conditions. Of the many operative procedures that have been devised, the best appear to be those which are performed through dorsal incisions and of these the most satisfactory appears to be that of Ollier. Excision of the wrist by Ollier's method may be described as follows:

Ollier's Method

Step 1. Skin Incisions and Exposure of Bones. Two incisions are made, one on the radial, the other on the ulnar side of the dorsal aspect of the limb, using an Esmarch tourniquet on the arm to control bleeding.

Radial Incision. This commences on the dorsal surface of the second metacarpal bone at a point opposite the middle of the shaft and extends proximally along the lateral margin of the most lateral tendon of the ex-

tensor digitorum communis to a point situated at the center of a line joining the styloid processes of the radius and ulna (Fig. 821). Beyond this level it is prolonged upward in a vertical direction for about one inch or so. The whole incision measures about 3 or 4 inches, one-third being situated proximal to the line joining the two styloid processes and two-thirds distal to it.

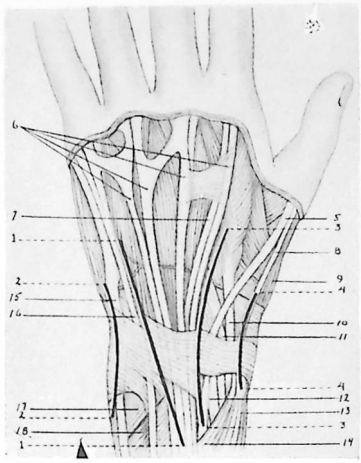


FIG. 821. Ollier's operation of excision of the wrist-joint: 1-1. Kocher's incision; 2-2, 3-3, 4-4. Ollier's incisions; 5. extensor secundi internodii; 6. extensor communis; 7. extensor indicis; 8. extensor primi internodii; 9. extensor ossis metacarpi pollicis; 10-11. radial extensors of the carpus; 12. radius; 13. extensor ossis metacarpi pollicis; 14. extensor primi internodii; 15. extensor carpi ulnaris; 16. extensor minimi digiti; 17. ulna; 18. extensor indicis.

The incision is deepened until the bones are reached, care being taken not to divide the tendon of the extensor carpi radialis brevis which is inserted into the base of the third metacarpal bone. The dorsal aspect of the bones is laid bare by detaching the posterior ligaments and the periosteum.

Ulnar Incision. This is made along the ulnar margin of the tendon of the extensor carpi ulnaris, beginning opposite the middle of the shaft of the fifth metacarpal bone and extending proximally to a point about 1 inch or so above the prominence of the styloid process of the ulna (Fig. 822). The skin and soft parts are divided (avoiding the branch of the ulnar nerve) to the dorsum of the little finger as well as the muscles, which are retracted

exposing the dorsal aspect of the lower portion of the ulna, the cuneiform and unciform bones and the proximal part of the fifth metacarpal; the ligaments and periosteum are separated from their bony attachments.

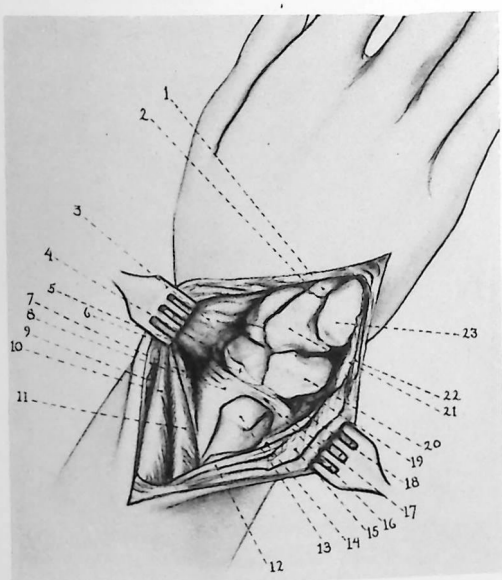


FIG. 822. Excision of the wrist by the dorso-ulnar incision (after Kocher): 1. base of the fourth metacarpal; 2. base of the third metacarpal; 3, 5, 7. periosteal and dorsal ligaments; 4. scaphoid; 6. semilunar; 8. radius; 9, 15. posterior annular ligament; 10. extensor digitorum communis; 11. extensor indicis; 12, 22. extensor minimi digiti; 13. head of ulna; 14. extensor carpi ulnaris; 16. triangular cartilage; 17. styloid process; 18. internal lateral ligament; 19. pisiform; 20. cuneiform; 21. unciform; 23. base of the fifth metacarpal.

Step 2. Excision of the Joint. When the carpal bones have been detached each is seized separately with forceps and removed (Fig. 823). On the radial side the large trapezium bone should be left unless diseased. The articulation between this bone and the base of the first metacarpal has a separate

synovial membrane. The pisiform bone may be disarticulated and the hook of the unciform bone cut through and both left if not diseased. The shafts of the extremities of the radius and ulna are now cleared of their periosteum for about half an inch or so (according to the extent of the disease process) and then made to protrude through the lateral incision. The ends are sawed

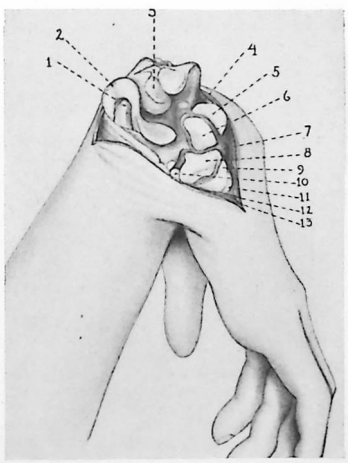


FIG. 823. Excision of the wrist by the dorso-ulnar incision (after Kocher): 1. styloid process of ulna; 2. ulna; 3. radius; 4. tendon of the extensor minimi digiti; 5. scaphoid; 6. semilunar; 7. os magnum; 8. cuneiform; 9. unciform; 10. pisiform; 11. fifth metacarpal; 12. dorsal branch of the ulnar nerve; 13. posterior ulnar vein.

off beyond the limits of the articular surfaces, or it may suffice to scrape them with a sharp spoon. The proximal extremities of the metacarpal bones are protruded through one of the dorsal incisions, usually the medial, and the articular ends sawed off.

Step 3. Closure of the External Wound. The cavity from which the bones have been removed is sponged dry, freed from all débris and the margins of the skin incisions united by interrupted sutures, a drainage tube being left in.

The limb is fixed in a position of slight dorsiflexion with the fingers gently flexed, a splint of suitable shape being used. The fingers should be passively

moved after 36 hours and during the time that a splint is worn which may vary from three to six months. The splint should then be replaced by a leather wristlet.

EXCISION OF THE HIP JOINT

This excision is usually only partial, the femoral elements being the parts which are generally removed. The excision is mostly indicated for tuberculous disease; less frequently for ankylosis in a faulty position, or for inflammatory affections or traumatisms (Fig. 824).

Excision of the hip joint may be carried out either through a postero-lateral incision or through an anterior incision, the first type being employed



Fig. 824. Ankylosis of the hip joint.

for extensive operations. Whatever incision is employed, the important thing is to give access not only to the head and neck of the femur but also the acetabulum and lining of the capsule when the latter are diseased. The anterior route does not give access to the acetabulum, a difficulty which is overcome by the use of a modified Smith-Peterson incision.

Kocher's Method

This method gives good access to both bones and is usually preferable to any other.

Step 1. The incision is a modification of the external vertical incision: the upper half runs obliquely, parallel to the fibers of the gluteus maximus muscle and practically to the axis of the head of the femur: this part of the incision extends from the posterior-superior angle of the great trochanter

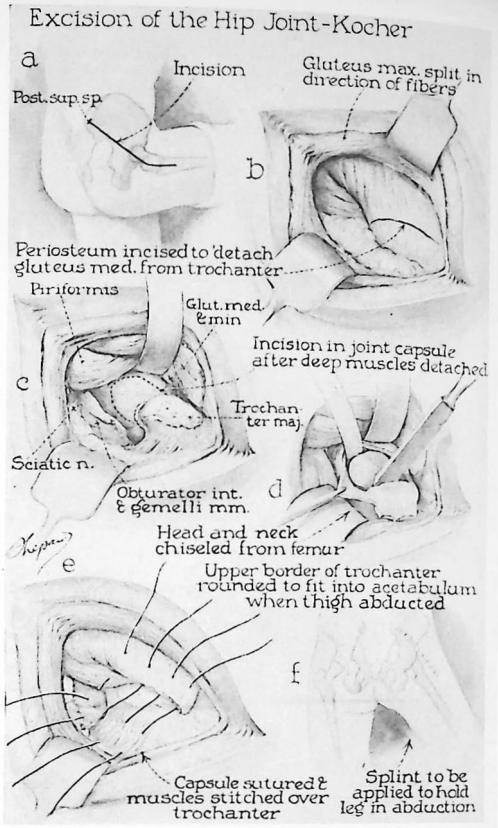


Fig. 825. Excision of the hip joint (Kocher's method): in studying the illustrations compare the legends with the text.

upward and backward toward the posterior-superior spine of the ilium (Fig. 825, a). The lower half runs downward from the great trochanter, in the axis of the femur slightly below the root of the greater trochanter.

Step 2. Divide the soft parts; split the muscles until the insertion of the vastus externus is exposed. Hemostasis must be carefully attended to here, applying ligatures or forceps to any divided vessels.

Step 3. This step in the operation consists in detaching the insertion of the gluteus medius muscle (Fig. 825, b). In a child this is easily done by using a resection knife and including a slice of the subjacent cartilage along with the tendon; in adults the operator must use either a sharp rugine or apply the hammer and chisel and detach a layer of bone with the tendon. When the insertion of the gluteus medius is separated, the insertion of the gluteus minimus is reached and, if necessary, this may also be detached from the anterior border of the trochanter.

Step 4. The insertions of the pyriformis, of the obturator internus and the gemelli are now detached from the trochanter. The posterior part of the capsule is now fully exposed (Fig. 825, c) and, in cases of displacement of the femur, more or less of the head of the bone may project outside the acetabulum, the capsule being stretched over it.

Step 5. The capsule is usually incised in the coronal plane over the projecting head of the femur. The opening is extended right up to the margin of the acetabulum and well down to the trochanter. By rotating the limb, the head of the femur is made to project through the opening. The ligamentum teres, if still present, must be separated from the femur either with a probe-pointed knife or by a curved scissors.

Step 6. The whole region of the joint should now be carefully investigated to ascertain the extent and nature of the disease process present. If necessary, removal of the head and neck of the femur may be called for. In fact, most authorities agree that, whether the head of the femur be much diseased or not, it is wiser to remove it, and the same generally applies to the neck of the femur. The saw or hammer and chisel may be employed (Fig. 825, d). If the disease extends into the trochanter, this latter should be curetted with a sharp spoon or the periosteum separated and the trochanter removed if it is absolutely necessary to do so.

Step 7. The acetabulum must now be investigated. Any diseased soft tissues should be removed. If the acetabulum is affected, the nature and extent of the disease process will determine the amount of the bone to be removed. The synovial membrane lining the capsule and any diseased spots in the exposed region should receive attention, widening the incision in the capsule if necessary.

Step 8. Remove all débris; thoroughly irrigate the joint cavity with antiseptic or sterile salt solution.

Step 9. Round off the upper border of the trochanter so as to make it fit into the base of the acetabulum when the limb is abducted.

Step 10. Unite the deeper structures over the trochanter by catgut sutures, (Fig. 825, e) the capsule first, then the gluteus medius to the pyriformis and superior gemellus, next suture the edges of the split gluteus maximus with

catgut tied over a piece of fine rubber tubing to forestall too early cutting into the skin.

Step 11. The question of drainage is debatable. Unless an antiseptic has been employed in irrigating the joint cavity, drainage is perhaps better omitted.

Step 12. The hip must be kept in abduction (Fig. 825, f) by suitable splints during the whole period of after-treatment and every care should be taken to prevent the trochanter becoming displaced from the acetabulum. When the wound has fully healed, usually after about three weeks, a plaster of Paris cast is substituted for the splint, but no effort should be made to reduce the amount of abduction. The cast or splints may have to be worn for at least six months.

When the hip joint is excised through an anterior incision this is made on the antero-lateral aspect of the thigh, commencing above about 1½ inches below the anterior-superior spine of the ilium and extending distally and medially until a total length of from 3 to 4 inches is reached. The deepened incision opens up the region between the rectus femoris and sartorius on the medial side and the tensor fasciae latae and gluteus medius and gluteus minimus on the lateral side until the surface of the capsule is exposed. The capsule is incised and the interior of the joint opened; this is irrigated and any diseased parts of the femur sawed off; any other diseased spots are dealt with as in the previously described operation, debris removed and after irrigation the wound is closed up and a drain left in. The further treatment is similar to that followed in the case of a postero-lateral incision.

OPERATIONS ON THE PELVIC BONES

Excision of the Ilium

SPRENGEL'S METHOD



Fig. 826. Sprengel's incision for operations on the ilium.

Step 1. Make an incision beginning at the anterior superior spinous process of the ilium. Extend it downward along the anterior border of the tensor vaginae femoris and divide the deep fascia (Fig. 826).

Step 2. Divide the fascia and the origin of the gluteus medius and minimus muscles by cutting backward from the upper end of the incision along the crest of the ilium.

Step 3. Through the incision thus made separate the muscles and periosteum from the pelvis downward and backward. Good exposure of the ilium and part of the acetabulum is thus obtained.

Step 4. Perform the indicated operation.

Step 5. Close the wound.

Comment: Where there is considerable involvement of the pelvic bones Larghi's high curved incision is used.

Removal of Half of the Pelvis

Step 1. Begin the incision at the sacro-iliac synchondrosis and extend it forward along the crest of the ilium to Poupart's ligament.
Step 2. Divide the abdominal muscles attached to the crest of the ilium and to Poupart's ligament.
Step 3. Separate the transversalis fascia and peritoneum from the existing tumor.
Step 4. Expose the iliac vessels. Retract these together with the nerve structures.
Step 5. Isolate and divide the muscles passing under Poupart's ligament external to the great vessels.
Step 6. Divide the rectus femoris, sartorius and tensor vaginae femoris muscles.
Step 7. Separate the gluteus medius and minimus muscles by blunt dissection exposing the sacro-iliac articulation.
Step 8. Divide the ileo-psoas muscle and the capsule of the hip joint in front.
Step 9. Divide, with a Gigli saw, the horizontal ramus of the os pubis as well as the ramus of the ischium.
Step 10. Separate the sacro-iliac articulation and dislocate the bone downward.
Step 11. Separate the rest of the pelvic attachments by means of blunt and sharp dissection. Divide the flexors arising from the tuberosity of the ischium and the sacrosciatic ligaments.
Step 12. Excise the head of the femur.
Step 13. Remove the mobilized portion of the pelvis.
Step 14. Suture the abdominal muscles to the glutei.
Step 15. Close the wound by means of deep and superficial sutures. Provide drainage.

Comment: According to Kocher, bleeding is only moderate. He suggests it might be well to ligate the internal iliac vessels before retracting them.

Excision of the Symphysis Pubis

VON BÜNGER'S OPERATION

Step 1. Make a transverse incision immediately above the os pubis.
Step 2. Separate the soft tissues. Divide the bone subperiosteally beyond the limits of the disease (Fig. 827). Remove the affected bone.
Step 3. Close the wound. Drain.

Excision of the Acetabulum

SCHMIDT'S OPERATION

Step 1. Through a Langenbeck incision open the hip joint.
Step 2. Dislocate the head of the femur and, if necessary, excise it.
Step 3. Adduct and rotate the limb outward.
Step 4. Make an incision beginning at the midline of the wound cutting across at right angles toward the anterior inferior spine of the ilium. Carry this incision downward to the bone.
Step 5. Separate from the ilium, by means of blunt dissection, the periosteum and superimposed soft tissues above the acetabulum extending from the anterior inferior spine to the sciatic notch.

Step 6. Divide the ilium transversely above the acetabulum by means of chisel and mallet (Fig. 828). Exercise care not to injure the pelvic contents. Divide the horizontal ramus of the os pubis with a Gigli saw.
Step 7. Separate the soft parts from the ischium below the acetabulum with a periosteal elevator.
Step 8. By means of a Gigli saw or chisel divide the ischium.
Step 9. Grasp the separated acetabulum with powerful bone forceps and remove it. Any ligamentous, muscular or osseous connections are divided with scissors.



Fig. 827

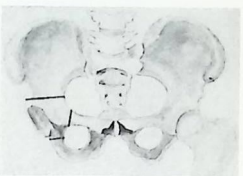


Fig. 828

Fig. 827. Excision of pubis (von Bünger).
Fig. 828. Excision of acetabulum (Schmidt).

Step 10. Close the wound. Drain.
Step 11. Put up the limb in marked abduction.

EXPOSURE OF THE SHAFT OF THE FEMUR[1]

Arnold K. Henry's Technic

Step 1. Make an incision of the skin and deep fascia along a line beginning at the anterior superior spinous process of the ilium and extending to the outer angle of the patella (Fig. 829).
Step 2. Find the line of cleavage with the finger between the rectus femoris and vastus externus muscle, a hand breadth below the great trochanter.
Step 3. Separate the muscles by means of the finger. Some blood vessels may be encountered which are ligated and divided. The finger may be stopped in the lower third of the thigh where the aponeurotic fibers of the rectus tendon are encountered; use the knife to separate these. In keeping the blade of the knife parallel to the face of the quadriceps tendon, a plane of cleavage will be found in this trilaminar structure between the prolongations of the rectus and vastus muscles which will permit the separation of the structures down to the patella. In septic conditions be careful not to separate the laminae of the quadriceps tendon beyond a level one hand breadth proximal to the apex of the patella. This will avoid infection of the synovial cavity of the knee. (Fig. 830.)
Step 4. Draw the mobilized muscles strongly apart exposing the silvery surface of the crureus femoris muscle. The oblique descending branches of the ex-

Brit. Jour. Surg. July, 1924. Vol. 12, No. 45, p. 87.

ternal circumflex vessels and the nerve to the vastus externus muscle are now seen passing across the crureus from beneath the rectus femoris to meet the free edge of the vastus externus muscle with which they cross.
Step 5. Retract the neuro-vascular bundle just described, proximally (Fig. 831).

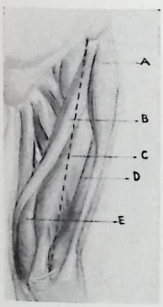


Fig. 829

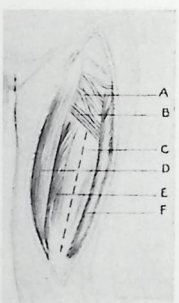


Fig. 830

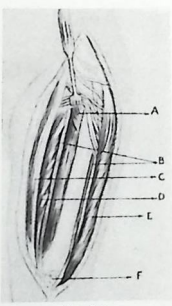


Fig. 831

Fig. 829. Henry's method of exposure of the femur. An incision is made through the skin and fascia, indicated by the dotted line in the illustration. The incision begins at the anterior superior spinous process of the ilium and extends to the outer angle of the patella. A plane of cleavage is found between the rectus femoris and vastus externus muscle one hand's breadth below the great trochanter of the femur where the rectus muscle sinks into the angle between the sartorius and the tensor fasciae. A. Tensor fasciae, B. sartorius, C. rectus femoris, D. vastus externus, E. vastus internus.

Fig. 830. Henry's method of exposure of the femur. The rectus femoris muscle is separated from the vastus externus; the crureus is now exposed and is crossed obliquely by a neuro-vascular bundle consisting of the descending branches of the external circumflex vessels and the nerve to the vastus externus muscle. The artery shown above the nerve is the transverse circumflex branch which lies in front of the neck of the femur. A. Nerve to the vastus externus muscle, B. descending branch of the external circumflex artery with its accompanying veins, C. crureus muscle, D. rectus femoris muscle, E. vastus internus muscle, F. vastus externus muscle.

Fig. 831. Henry's method of exposure of the femur. The neuro-vascular bundle is now mobilized and retracted. The crureus muscle is split along the dotted line shown in Fig. 830. The supra-patellar pouch should be avoided by checking the incision through the crureus muscle one hand's breadth proximal to the pointed end of the patella. A. Incision of the ileopsoas muscle, B. split crureus muscle, C. rectus femoris, D. vastus internus muscle, E. vastus externus muscle, F. supra-patellar pouch.

Step 6. An incision may now be made down to the bone through the upper portion of the crureus muscle. Frequently a large vein is encountered here. Care must be taken not to injure the suprapatellar pouch which extends about a hand's breadth above the apex of the patella. Opening this is easily avoided by not continuing the incision through the crureus muscle above this level. The rugine adheres closely to the bone, working in a layer of fat and separating the pouch from the femur. A retractor may be slipped between the suprapatellar pouch and the bone and when the thigh is flexed, the quad-

riceps is relaxed thus affording access to the lower end of the shaft of the femur.
Step 7. When the two split halves of the crureus muscle are separated from the bone and retracted forcibly, over a foot of the shaft of the femur is exposed from the lower epiphysis to the lesser trochanter. On the inner side of the shaft the attachments of the muscles to the linea aspera are visible. If it becomes necessary to clear the linea aspera, note carefully the direction of the muscle fibers. The edge of the rugine should travel into the acute angle which the fibers make with the bone (Fig. 832). If used in the opposite direction, the instrument will tend to leave the bone and tear into the muscle. It is well to keep in mind that the direction of the muscle fibers varies, i.e., the adductors travel down to the femur while the vastus and the short head of the biceps travel down from the femur. Separation of the fibers should be

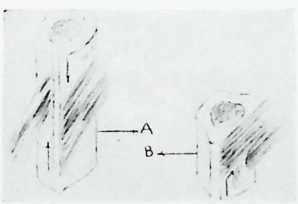


Fig. 832. Henry's method of exposure of the femur. A rugine is worked into the acute angle, A, which the muscular attachments form with the bone. B. How the rugine tears into a muscle when used in the reverse direction against the obtuse angle.

begun on the inner side of the linea aspera on the external surface of the shaft of the femur. The rugine is worked up against the origins of the vastus externus and the short head of the biceps muscle. Deal with the strong external intermuscular septum last. It can be exposed by drawing the vastus externus toward the back of the thigh. The perforating vessels emerge through the arched openings of the septum.

EXCISION OF THE KNEE JOINT

The knee joint may be completely excised and such an operation is usually required in extensive tuberculous disease; but by the term "arthrectomy of the knee" only a partial excision of the joint is usually meant. In the complete excision, the surgical object is to obtain a firm ankylosis of the tibia and femur. In arthrectomy the surgeon aims to produce, if possible, a movable joint.

Step 1. Make a longitudinally curved incision (Fig. 833, a) across the front of the knee.
Step 2. Partial excision.. Cut through the ligamentum patellae at the lower part of the incision; open the joint cavity from below by lifting up the ligament, patella and capsule of the joint (Fig. 833, b).

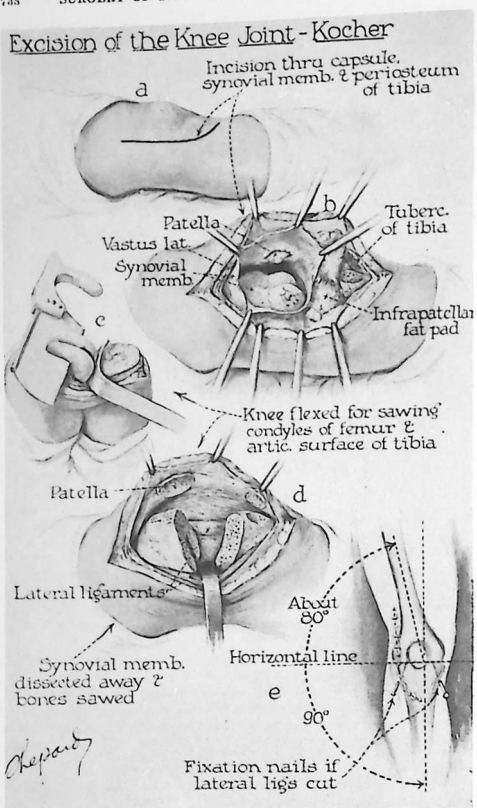


FIG. 833. Excision of the knee joint.

Step 2. Excise the patella subaponeurotically. Leave the divided ends of the quadriceps femoris tendon as well as the tendon of the patella exposed. (Fig. 834[2].)

Step 3. Fashion a flap consisting of portions of the quadriceps femoris tendon and vastus externus muscle.

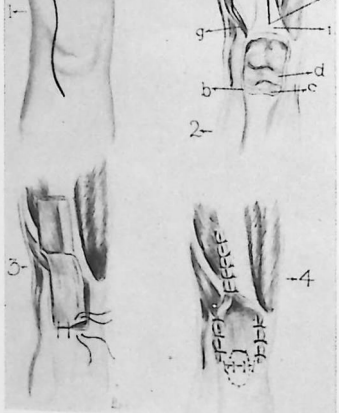


FIG. 834. Excision of the patella (John B. Murphy): 1. cutaneous incision; 2. patella has been excised; a. quadriceps extensor muscle; b. capsule of knee joint; c. severed ligamentum patellae; d. infrapatellar pad; e-f-g-h. flap fashioned from quadriceps extensor muscle; i. tendon of quadriceps muscle; 3. extension flap placed in position; 4. extension flap sutured in position and borders of divided quadriceps muscle united with interrupted catgut sutures. (After J. B. Murphy, Surg., Gynec. and Obst., 6:266-268.)

Step 4. Reflect the flap thus made downward (Fig. 834[3]). The flap must be of sufficient length to reach the divided end of the patellar tendon without tension.

Step 5. Suture the end of the flap (e, f) to the ligamentum patellae (b, c) either by an end-to-end suture or an overlapping one.

Step 6. Close the defect (e, f, g, h) with chromic catgut sutures. (Fig. 834[4].)

Step 3. All thickened, synovial membrane is now scraped or dissected away (Fig. 833, c-d); also the articular ends of the bones, if affected.

Step 4. The joint cavity is next thoroughly irrigated with normal saline or a mild antiseptic solution.

Step 5. The ligamentum patellae and the margins of the incision in the capsule are united by the insertion of a series of silk or chromic catgut sutures.

Step 6. Close the external wound in the usual manner and put up the limb in a suitable splint. When the wound has completely healed, passive movements are begun and an attempt made to obtain a movable joint. (Fig. 833 e.)

Some, such as Kocher, recommend a reversed-U incision, as in the complete joint excision and that, after the skin flap and fasciae have been dissected up, the knee joint should be opened on each side of the patella and all necessary manipulations carried out through this incision.

If there is extensive involvement, a greater amount of removal of the articular surfaces may be necessary. In order to do this, the crucial ligaments are divided which allows the tibia to be separated from the femur and the lower end of the latter bone to be projected from the wound. The lateral ligaments are pushed aside or cut. The bone is now sawed through, the saw being so held that the plane of its blade corresponds with the transverse plane of the long axis of the leg when the joint is at an angle of 135 degrees. The head of the tibia is next cleared. It is usually only necessary to clear the extreme top of the tibia so as to cut a level surface; this will remove most of the cartilage together with the semilunar cartilages and the projecting spine of the tibia. The saw is applied from before backward and its blade is held strictly horizontal. When the bone sectioning has been done accurately, the cut surfaces should fit exactly when applied together. The limb is then carefully splinted and bandaged so as to obviate bone displacement.

When only a portion of the articular surface is to be removed, the chief aim will be to retain the movements of the knee. The sawed surfaces where part of the joints have been removed should be left as smooth as possible and, to prevent union of the opposing raw joint surfaces, some kind of arthroplasty must be employed.

In the case of an excision for arthrodesis the object is to obtain a stiff joint with the least amount of shortening. This can be done by merely removing the cartilage from the articular surfaces with a broad chisel or gouge. The joint is opened by a trans-patellar incision and the patella is sawn across. It is not necessary to disturb the ligaments.

In excision for ankylosis in a faulty position the external transverse incision should be made across the prominent angle of the deformity and the patella divided if adherent to the bone. If, however, the patella is free, the ligamentum patellae should be detached from its insertion into the tibia, the patella being turned upward with the flap.

EXCISION OF THE PATELLA

Murphy's Operation[1]

Step 1. Enter the knee joint on the outer side of the patella through an incision about seven inches in length. (Fig. 834[1].)

[1] S.G.O. 6:262, 1908.

Step 7. Unite the aponeurosis of the patella firmly to the divided edge of the flap (Fig. 834[4]).

Step 8. Close the skin wound. Drain. Dress. Apply a posterior splint.

Comment: Before resorting to this operation the late John B. Murphy produced a chemical arthritis first. Murphy believed that the artificial arthritis creates a local immunity to infection and to trauma incident to the operation. He used a solution of formalin, 2 to 5 per cent in glycerine which is prepared 24 hours before being used. Of this solution two to six drachms are injected into the joint about two weeks before the operation.

EXCISION OF THE ANKLE JOINT

This excision may be indicated in cases of compound dislocation of the joint with comminuted fracture of one or more of the bones forming it; for tuberculous disease or severe suppurative conditions showing no tendency to heal; also in certain cases of talipes, etc.

The best operation for excision of the ankle joint appears to be that recommended by Kocher and Reverdin in which the joint is excised through a single incision situated on the anterior and lateral aspects of the foot.

Step 1. Make an incision across the dorsal and lateral aspects of the foot, commencing at a point one-half an inch below the center of the ankle joint and extending laterally and backward to the distal margin of the lateral malleolus and then proceed proximally and somewhat medially to the fibular margin of the tendo calcaneus. (Fig. 835, a.) This incision, which is usually from 3 to 3½ inches long, is curved in outline, the concavity looking toward the tibial margin of the limb.

Step 2. Following section of the superficial tissues, the lateral portion of the superficial peroneal nerve is sought for in the medial part of the wound and retracted to the medial side.

Step 3. When the deep fasciae and the fibers of the transverse ligament of the leg have been cut through, the tendons of the extensor muscles will be exposed in the anterior part of the wound and those of the peronei in the posterior part.

Step 4. The deep fascial processes of the crucial ligaments and the peronei tendons are separated and peeled backward; it may be necessary in some cases to cut through these tendons (Fig. 835, b).

Step 5. Separate and retract toward the tibial side the extensor tendons at the anterior angle of the incision, the processes of the transverse ligament of the leg and the anterior ligament of the ankle joint.

Step 6. Separate also the other ligaments in the vicinity of the joint from their bony attachments and when this is accomplished the joint will be opened on its posterior, lateral and anterior aspects. The deltoid ligament is not disturbed.

Step 7. Forcibly adduct the foot toward the tibial side and completely dislocate it medially until the plantar surface lies in contact with the skin on the medial side of the leg (Fig. 835, c).

Step 8. Saw off the diseased portions of the exposed bones; scrape away or dissect out all thickened and diseased synovial membrane and other soft

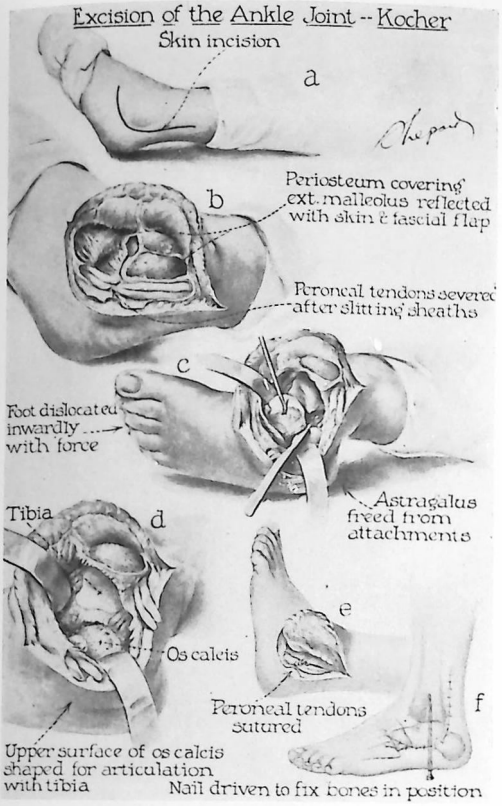


FIG. 835. Excision of the ankle joint (Kocher's method). In studying the illustrations compare the legends with the text.

parts. It may, in some cases, be necessary, to remove the talus entirely together with all infiltrated tissues. (Fig. 835, d.)

Step 9. When all affected tissues are disposed of, bring the foot into its original position. Reunite sectioned tendons with sutures; if possible suture the ligaments on the lateral aspect of the joint (Fig. 835, e).

Step 10. Close the external wound without drainage.

Step 11. Splint the limb until healing is complete and union of the divided tissues has taken place. (Fig. 835, f.)

EXCISION OF HEAD OF METATARSAL BONE OF THE GREAT TOE

This excision is frequently done in cases of hallux valgus. (See Hallux Valgus, p. 703.)

Step 1. Make an incision from 2 to 2½ inches long over the anteromedial aspect of the metatarsophalangeal joint in the direction of the long axis of the toe.

Step 2. Divide the soft tissues; open the joint.

Step 3. Separate the ligaments forming the capsule of the articulation from their attachments to the bone and the head of the bone is made to protrude.

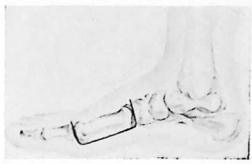


FIG. 836. Excision of the metatarsal bone of the great toe.

Step 4. Remove the head of the bone with either a saw or bone forceps in such a way that the cut and trimmed off surface fits the base of the phalanx when the toe is forcibly straightened.

Step 5. Close the wound in the usual manner.

Excision of the Metatarsal Bone, Metatarso-phalangeal and Interphalangeal Joints

Excision of these joints is made in much the same way as the preceding and are illustrated in Figs. 836-837.

MEDIOTARSOTARSAL RESECTION

De Francesco's Operation

Resection of the foot may be indicated in tuberculosis of the bone when climatic, general and physical therapy prove unsuccessful. Localized bone infections can be evacuated in a typical manner where indicated, completing the procedure with a Mosetig-Moorhof plug. The latter procedure seems logical where the affected area is strictly localized. In a rather large series of cases of this type, bones near the affected area were apparently healthy. Small pieces of bone were obtained after proper preparation and guinea-pigs were inoculated with the material for the purpose of ascertaining the presence of tuberculosis.

Often amputation is performed in cases of tuberculosis involving the mediotarsus and metatarsus. De Francesco considers amputation too mutilating a procedure and, in many cases, tried conservation of the foot by removing only the

affected part. Such a surgical concept is not new—Studsgaard and Obalinski attempted it long ago. It may be noted in Giordano's book on Operative Medicine, that Obalinski incised the foot between the 3rd and 4th toe, passing between the cuboid, the cuneiform and the scaphoid bone to the posterior tarsus, astragalus and calcaneus. The tendons of the toes and peroneus longus are of surgical importance in operating for the equilibrium of the foot. Studsgaard progressed between the 2nd and 3rd toes, then between the 2nd and 3rd cuneiform so as to be nearer to the lesions of the internal side of the foot. Such procedure enables the surgeon to clean out the diseased bones and fungous tissues and while leaving a foot without bone, nevertheless leaves the patient a foot useful for walking with the aid of a proper prosthesis. It must be remembered

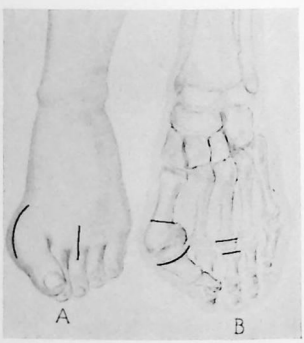


FIG. 837. Excision of the metatarso-phalangeal and interphalangeal joints: A. cutaneous incision, B. areas of excision.

that Ollier noted that such resections may result in deformities of the foot when bony parts are left on one side. Another objection to the Obalinski method is that the plantar cutaneous scar may at times be painful in walking.

Let us consider the methods of anterior incision of the foot as in classical amputation. Delbet, Soulagne, Hallopeau and Revel speak of a temporary disarticulation of the foot in tuberculosis. The anterior approach offers the advantages of great visibility and perfect access to the anatomic structures concerned. Sorrel, in a monograph on tuberculosis of the foot also prefers the anterior approach. His technic consists of a dorsal incision as if a Chopart amputation were contemplated, section of the tendons and of the small branches of the peroneal nerve. The tendons of the tibialis anticus and peroneus tertius are not molested. After opening the posterior articulations (Chopart) and outlining the parts to be removed, the osseous structures are sawed in such a way that reunion

of the bone gave rise to a curved foot instead of leaving a flatfoot. The cut tendons were then reunited. As a rule the results were unsatisfactory.

The lateral approach is obviously preferable to the anterior or Obalinski method. The diseased bones are removed without injuring the tendons, vessels and nerves. For this reason, at the roentgenologic and clinical examination, the zone to be removed is divided accurately into planes (Figs. 838-839). When this zone affects not only the median tarsus but also the heads of the metatarsus, resection seems preferable to amputation.

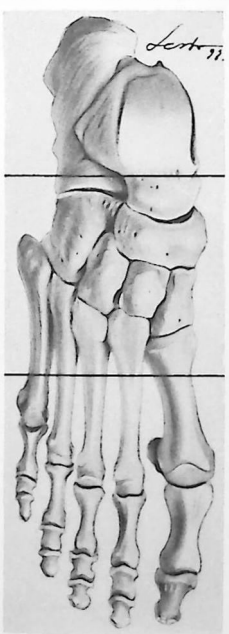


FIG. 838. Mediotarsotarsal resection. (Courtesy Prof. Donato de Francesco.)

Step 1. The internal incision is of utmost importance because often, through this alone, it is possible to complete the operation. De Francesco also used an external incision in his first operations, extending it slightly beyond the limits of resection, starting at the internal malleolus or a little in front of it and extending it to the head of the first metatarsus (Fig. 840).

Step 2. After having incised the teguments the most important part of the procedure consists in the separation of the tendons and vessels near the bone (Fig. 841).

Step 3. Following that, attention is given to the tendons of the tibialis anticus and posticus (internal cuneiform, scaphoid) and to the tendon of the peroneus longus at the inner side of the first metatarsus. The tendons are separated with their insertions (osseous lamellae) by means of mallet and chisel (Fig. 842). All soft parts are separated close to the bone so that only the tarsal area with the ligaments remains. This dissection is extended to the external margin of the foot.

De Francesco used in his first cases an external incision and through this wide lateral opening he found it easy to pass the blade of a saw that was united from the other side sawing the bones in a manner similar to that used in the anterior method. In his succeeding cases he preferred to work with a chisel, using it horizontally to

the axis of the foot and progressing with it until it was felt below the skin of the opposite side, beginning the division of bone distally, then on the

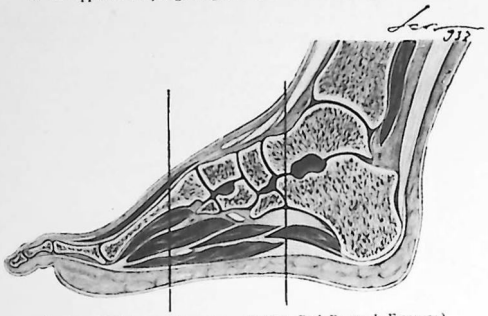


Fig. 839. Mediotarsotarsal resection. (Courtesy Prof. Donato de Francesco.)

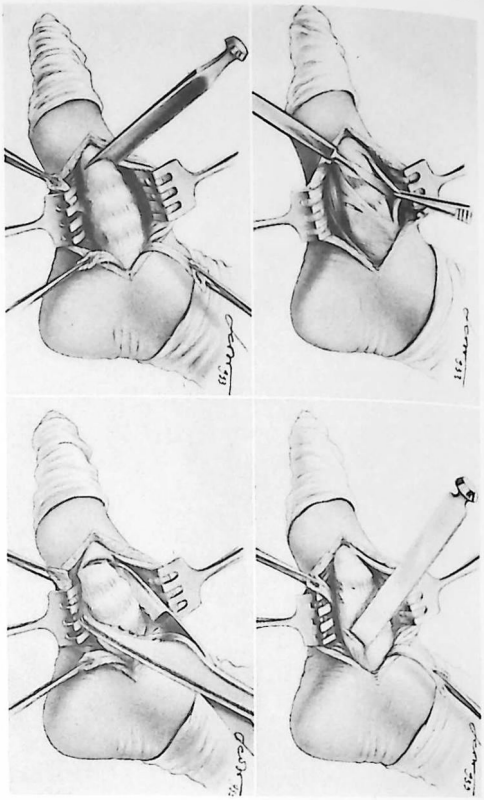
proximal side with the result that the curved surfaces were parallel to one another (Fig. 843).



Fig. 840. Mediotarsotarsal resection. (Courtesy Prof. Donato de Francesco.)

Step 4. The resected segment of bone is grasped with a Farabeuf bone forceps and slowly liberated (Fig. 844).

Step 5. A large cavity results. Ligate bleeding vessels; explore the soft tissues and remove suspicious portions down to healthy bone.



Figs. 841-842-843-844. Mediotarsotarsal resection. (Courtesy Prof. Donato de Francesco.)

Fig. 843

Fig. 841

Fig. 842

Fig. 844

Step 6. The curvilinear parallel sections permit of a perfect union of the bone ends without any amputation. If the bone section is effected with a straight chisel the planes must be parallel to each other and perpendicular to the long axis of the foot.

The bone surfaces are fixed in position by means of a metallic sufure or with temporary spikes and in some instances with lateral bone grafts of healthy bone (Fig. 845).

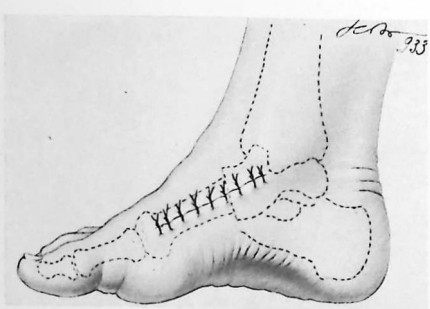


Fig. 845. Mediotarsotarsal resection. (Courtesy Prof. Donato de Francesco.)

Step 7. A well molded plaster of Paris cast supports the arch. Later a metallic arch support is useful to prevent flatfoot.

Patients treated in the manner described were able to walk with a shortened but useful foot.

EXCISION OF THE TEMPOROMANDIBULAR JOINT

(See Surgery of the Head — Chapter 14, page 285)

Excision of this joint must be carried out with particular care owing to the important anatomical structures which are in close association with it. These are, principally, the auriculotemporal nerve and the superficial temporal artery which lie posterior and external to the joint, the internal maxillary artery below and internal, the glenoid lobe of the parotid gland immediately behind the condyle and the facial nerve lying in the parotid gland at a lower level.

An incision about 1½ inches in length, is made along the inferior margin of the posterior part of the zygomatic arch, commencing immediately in front of the anterior margin of the external auditory meatus and extending forward toward the prominence of the zygomatic bone. In dividing the overlying tissues, the nerves and blood vessels are carefully avoided. The fibers of the masseter muscle are retracted forward and the parotid gland backward. The external

portion of the capsule of the joint is divided and the cavity opened. The neck of the lower jaw is next freed and is divided with a fine saw from in front backward. The condyle is then seized with a pair of heavy forceps and forcibly pulled outward. The undivided parts of the capsule are cut through with the scalpel and the external pterygoid muscle is detached from the anterior and internal aspect of the neck of the mandible immediately below the articular surface. The head of

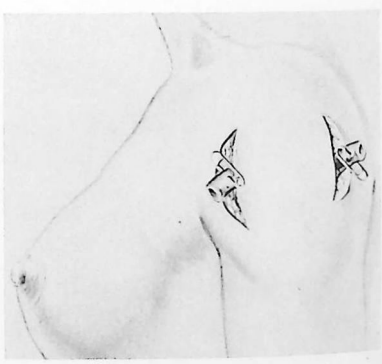


Fig. 846. Open method of arthrotomy of the shoulder joint.

the bone can then be removed, the interior of the joint examined and diseased tissue or tumor removed. The condyle is usually the only portion that is removed.

ARTHROTOMY

This surgical procedure is usually resorted to for evacuating an articular effusion. The surgeon may actually open into the joint cavity by means of a short incision (open arthrotomy) or enter the joint space with a trocar through a puncture wound (closed arthrotomy). The approach selected may be from an anterior or posterior aspect depending upon the joint to be entered.

Arthrotomy of the Shoulder

OPEN METHOD

Step 1. Abduct the arm slightly and identify the coracoid process. One inch lateralward to this point, begin an incision which proceeds downward in the direction of the fibers of the deltoid muscle for a distance of about three inches. Locate the anterior border of the deltoid and divide its fibers avoiding the cephalic vein and a branch of the acromiothoracic artery.

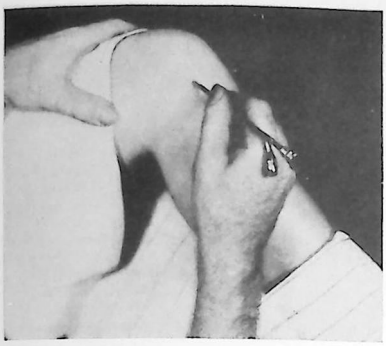


Fig. 861. Aspiration of the knee joint. Use a rather large sized trocar. Steady the patella by embracing the lower part of the thigh. Direct the needle upward and inward.

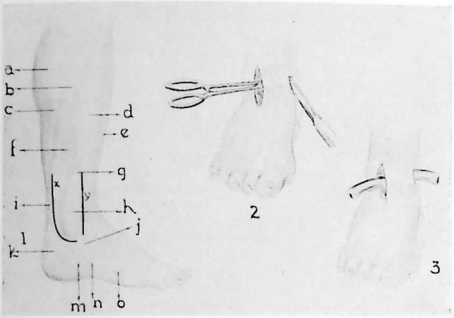


Fig. 862. 1. Arthrotomy of the ankle joint: x. Kocher's incision, y. Labey's method. a. gastrocnemius externus, b. peroneus longus, c. soleus, d. extensor dig. communis, e. tibialis anticus, f. peroneus brevis, g. peroneus tertius, h. malleolus externus, i. tendo Achillis, j. extensor brevis, k. calcaneus, m. peroneus brevis, n. peroneus longus, o. tuberositas metatarsi. 2. The ankle is drained through a Labey incision. A closed forceps crosses the ankle and a scalpel divides the soft tissues on the point of the forceps. 3. A rubber tube drains the affected area.

conditions most frequently associated with this condition are osteo-arthritic changes, displaced epiphyses or detached portions of articular surfaces.

Osteo-arthritic changes give rise to several forms of loose bodies. One is the chondroma which is an oval pellet composed of cartilage cells. They occur singly

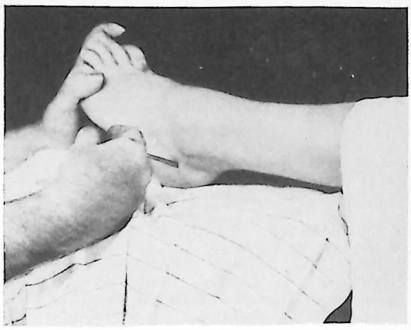


Fig. 863. Aspiration of the ankle joint.

or in great numbers. Another form of joint bodies results from hyperplasia of injured osteophytes.

Epiphyseal displacement occurs most frequently in the elbow joint due to the medial epicondyle being traumatically displaced into the joint cavity. Limitation

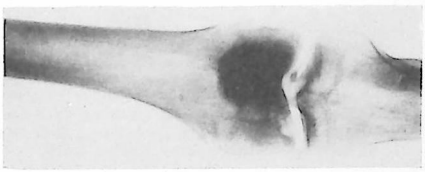


Fig. 864. Floating cartilage.

of motion and not pain is the major symptom although the area over the epicondyle is very tender. (Fig. 864.)

The internal semilunar cartilage of the knee often becomes torn or detached following a sudden twist or forceful extension of the foot and leg. The knee locks in slight flexion and the pain is great.

Treatment consists of opening the joint cavity and removing the offending body. This is not always easy; careful and adequate exposure is necessary.

Inasmuch as the knee joint is most frequently opened, the approach will be given. Thorough exposure may necessitate exposing both the anterior and posterior compartments.

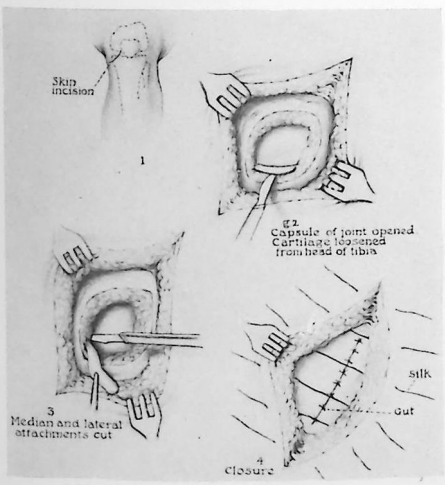


Fig. 865. Operation for removal of semilunar cartilage.

EXPOSURE OF THE ANTERIOR COMPARTMENT

Step 1. A four-inch incision is made between the vastus medius and rectus femoris one-half inch medial to the patella (Fig. 865[1]).

Step 2. Bluntly spread and retract the tissues until the joint capsule is exposed. Incise widely (Fig. 865[2]).

Step 3. Flex the leg, strongly retract the patella lateralward and the anterior compartment is exposed (Fig. 865[3]). Search carefully and remove all loose bodies.

Step 4. Effect complete closure (Fig. 865[4]). Dress the wound.

EXPOSURE OF THE POSTERIOR COMPARTMENT

Step 1. Extend the knee. Make a four-inch incision along the mediolateral border of the biceps cruris muscle and over the joint space.

Step 2. Flex the knee. Forcefully retract the biceps laterally. Identify the iliotibial band and divide it.

Step 3. Bluntly dissect downward to the joint capsule. Incise it widely thus exposing the posterior compartment.

Step 4. Close and dress the wound.

ARTHROPLASTY—THE MOBILIZATION OF ANKYLOSED JOINTS

Until recent years, surgeons have believed that ankylosis in good position constituted the best curative result to be sought in certain traumatic or infectious joint lesions. With the development of surgical technic and particularly with the advancement of the specialties, surgeons, alert to the great disability caused by an ankylosed limb, have endeavored to restore motion to the joint by the use of many different operative procedures. The surgical methods devised and practiced have shown a logical advance in keeping with the broader understanding of the pathology of ankylosed joints, until finally the method termed arthroplasty was evolved.

An arthroplasty is a highly technical operative procedure, which aims not only to restore motion to a joint, but also to preserve stability. With these two objects in view, the component parts of the joint are reconstructed, and material of some kind is interposed between the articular ends to prevent re-ankylosis.

Arthroplasty has become a standardized form of treatment for the mobilization of ankylosed joints.

In general terms, an arthroplasty is the creation of an artificial joint for the purpose of restoring motion to a joint which is either completely ankylosed, or which has such a limited degree of motion that the limb is not serviceable.

Modern Arthroplastic Methods

The development of the fascial flap method in modern arthroplasty methods is due to the late John B. Murphy of Chicago, who was more persevering than any other surgeon in his endeavor to restore motion to ankylosed joints. The method devised by Murphy has formed the basis of the great majority of modern arthroplastic measures.

The essential feature of the Murphy operation is the insertion of a pedicled flap of fascia and fatty tissue taken from the vicinity of the operated joint. Murphy believed that the transplant received its nourishment through the pedicle. He also placed a great deal of emphasis upon the inclusion of a considerable quantity of fatty tissue, for he believed that the fat aided in laying the foundation of the new joint by forming a bursa. The technic of the Murphy operation varied as necessitated by the anatomic structure of each joint. Murphy was most successful in treating ankylosis of the hip-joint.

The fundamental changes that have taken place in the technic of arthroplasty since the Murphy method was perfected are the omission of the pedicle of the flap, and the use of free fascia lata without the inclusion of fatty tissue. Careful study and experimentation have led to this development. In the first place, experimenters proved that the flap did not receive nourishment through its pedicle. Furthermore, it was demonstrated both experimentally and clinically that free flaps of fascia remained viable after transplantation. Kirschner and

Kostenko and Rubaschew used free fascia to replace abdominal fascial defects, to reinforce sutures, and to consolidate reconstruction of walls. Kirschner reported 10 cases in which he used free flaps successfully. They healed without reaction, and several months after intervention, they had retained their structure and were viable. The omission of fatty tissue obviated the dangers of embolus and fat necrosis, which are likely to be encountered in dealing with this substance. Fascial sutures are now used for the repair of hernias (which see).

The use of free fascial flaps has certain advantages over the implantation of pedicled flaps. Free flaps are more easily handled and they require less space for insertion than the pedunculated flaps.

The application of free fascial flaps in the field of arthroplasty has been studied especially by Kirschner, Payr, Putti, Campbell and the MacAuslands. Albee, Groves, Dickson, Monjardino and others have also contributed to the work with free grafts. Kirschner was the first to propose the use of free fascia in joint mobilization. At his inducement Payr, in 1910, performed an arthroplasty of the knee using a free fascial flap. Within the next few years, Payr, Putti, Rehn, Ritter and the MacAuslands also tried the insertion of free fascial flaps in joints.

The MacAuslands used a free transplant in an arthroplasty before the work of the early experimenters in Europe came to their attention.

The methods of arthroplasty in use, although essentially alike in principle, have slight differences in technic. Some surgeons emphasize the removal of a large amount of bone; others recommend a sparing resection. One group of surgeons advocates following the anatomic contours in modeling the new joint surfaces while another group, knowing that it is impossible to duplicate exactly the normal surfaces, advises a technic that aims to restore function and stability by a mechanical remodeling, a principle that ignores entirely the natural outline of the joint ends (Albee). The majority of surgeons prefer to use flaps of fascia alone, but there are a few surgeons who have more success with a flap of fascia and fat (Albee), and in Kukula's Clinic (Jirasek), omentum from the abdominal cavity is used.

Payr advises excision of the vascular connective tissue and any altered cartilage, a step which he believes helps to prevent re-ankylosis. Extirpation of the capsule is almost sure to result in an unstable joint with lateral mobility (MacAusland).

The MacAuslands[1] stress that careful preparation of the patient for arthroplasty is very important. The operative field, including not only the joint involved, but also the joint above and the joint below the affected member, is subjected to a thorough aseptization for two days. The operative field is prepared for securing the fascial flap. If the upper extremity is to be mobilized, the fascia is removed from the leg on the same side of the body as the ankylosed joint, and this leg from the hip to the knee is prepared; if the knee or hip is to be mobilized, the fascia is taken from the opposite leg, which is prepared from the hip to the knee. A tourniquet is applied and iodine applied to the skin. An incision adequate for good exposure is made. The skin-edges are clamped off with towels to avoid handling the skin during operation. (Albee uses no skin

[1] MacAusland, W. Russell, and A. R. MacAusland: Mobilization of Ankylosed Joints by Arthroplasty, Lea and Febiger, 1929.

drapes.) When the joint has been exposed, a careful study of it is made in conjunction with previously prepared x-ray films.

In breaking down the ankylosis, one should try, insofar as possible, to follow the contour of the old articular surfaces. Only a sufficient amount of bone is removed from each surface to allow free motion. If too much bone is removed, a flail joint will result. New articular surfaces are carefully modeled to conform as closely as possible to the natural contours of the bone-ends. The joint surfaces must fit accurately, and there should be no hitch in the motion. Extreme care must be taken to preserve stability. In the preparation of the joint-ends, all periosteum is removed.

There are two important principles in the after-treatment. First, the joint must be protected against strain. Overuse or attempts to put the joint through arcs of motion that will bring tension on the tissues before convalescence is well established must be avoided. The best guide in the regulation of mobilization is pain, in the presence of which motion should never be attempted. The second principle of after-treatment is the prevention of atrophy of the bones and musculature (heat, diathermy, massage, and gentle passive motions).

Traction is an essential of after-treatment, and its purpose is three-fold.

The intrinsic traction apparatus devised by White is most useful, not only because of its accuracy in measuring the amount of traction, but also because of its convenience. A Thomas ring splint forms the basis of this apparatus for knee and hip cases, and the Jones humerus extension splint forms the basis for elbow cases.

Passive motion is started when the traction is applied (a week or ten days after operation). At first the movements are carried out very gently only two or three times a day, and are later gradually increased. Pain and sensitiveness are the best guides in the regulation of the increase of motion. Active exercise is begun as soon as conditions are favorable for further mobilization. No weight-bearing should be allowed until the ligamentous structures have tightened.

There are general precautions and procedures which are applicable to all such operations. The part to be operated upon is most carefully prepared by shaving and cleansing the skin thoroughly the day previous to operation and again immediately before operation; when the patient is already upon the table, the skin must be again cleansed with alcohol and ether; Murphy advised a coating of gutta-percha solution, namely, 1 per cent gutta percha in acetone. Owing to the ease with which synovial fluid becomes infected, the strictest asepsis and no contact with hands must be observed throughout the whole procedure of operating which includes the opening and exposure of joint cavities and surfaces.

The general principles of arthroplasty for any joint include full exposure of the joint and, when there is union between the joint surfaces, the bones are divided by knife, saw or chisel. The articular surfaces must then be shaped in the way the surgeon thinks fit to facilitate movement in the easiest way, the essential thing being that the surfaces in contact should be chiseled or scraped until they are perfectly smooth. When this is accomplished, the limb is carried through the full range of movement so that assurance may be obtained that there are no contracted structures that will obstruct the desired movements of the joints. All cicatricial bands and ligamentous structures that interfere with joint movements must be removed and tendons of muscles may have to be lengthened.

The changes which have finally resulted in ankylosis may have been so great that in the straightening process and forced separation of the joint surfaces blood vessels and nerves may be endangered. After thorough inspection, the surgeon must decide whether the limb should be gradually stretched by extension and the arthroplasty finished at a subsequent date when the limb is straight, or whether sufficient bone should be cut away to enable the limb to be brought into the desired position without endangering these important structures. The question will be to a great extent determined by the particular joint. In the upper limb the sacrifice of much bone is of far less consequence than in the lower limb where it affects locomotion to a large degree.

Before deciding on an arthroplastic operation, it is necessary to remember:

1. To note the character of the ankylosis—whether bony or fibrous and whether the joint cavity is or is not obliterated.
2. To note the condition of the muscles which should move the joint. If they are insufficient or destroyed, operation is evidently useless.
3. To note the conditions of the periarticular structures. If they are fused together into a mass of scar tissue, arthroplasty is impossible.
4. To determine whether or not the disease causing the ankylosis is cured.
5. To note the general condition of the patient.

Murphy Method of Arthroplasty

In this method a thick layer of the neighboring soft structures is detached in the form of a flap, corresponding in its dimensions to the cross-section of the joint being repaired, this flap being inserted between the bone ends and fastened in position by sutures. The flap should contain plenty of fat and areolar tissue, which seems most suitable for promoting movement as under pressure it develops bursae readily and in practice has been found to accomplish the desired purpose better than anything else. When the flap has been sutured in position, the capsule of the joint is closed without drainage. As soon as conditions appear favorable, passive movements are begun. If ligamentous connections have been sectioned, these movements may be started by the third or fourth day; but a week or ten days may be allowed to pass if necessary. The passive movements should be regular and the range of movements progressively increased. At the same time the region should be massaged, the object being to develop a fairly thick layer of connective tissue between the joint surfaces and the formation of a bursa in this to take the place of a synovial cavity: otherwise, the joint surface will not be lubricated and adhesion between them may again occur.

The technic of arthroplasty of the knee joint will now be described as a typical example.

Arthroplasty of the Knee

Indications:

1. Ankylosis following trauma or nontuberculous infection.
2. Joint instability associated with deformity.
3. Painful osteoarthritis.

Step 1. Place an Esmarch constrictor high up around the thigh.

Step 2. Make two incisions, one on the inner, the other on the outer surface of

the knee, parallel to the long axis of the limb. Each of these incisions should be about 5 inches in length and extend 3½ inches above and 1½ inches below the point where the new joint is to be formed. The incisions pass through the skin and fat down to the fascia; the wound margins are retracted and the skin freed sufficiently to expose the field of operation. (Fig. 866.)

Step 3. Prepare the flaps to be interposed between the joint surfaces. The outer flap will include a portion of the vastus externus and such portions of the capsule and ligaments as may be present on the outer side of the knee;

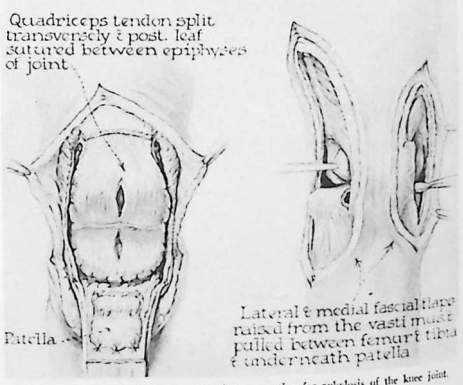


FIG. 866. Putti's and Murphy's arthroplasty operation for ankylosis of the knee joint.

the inner flap includes a portion of the vastus internus and the capsule and ligaments on the inner side of the knee joint. These flaps should be 3½ inches long and 2½ inches wide, the base of the flaps being left attached on the tuberosities of the tibia just below the line of bone division for the new joint. After preparation of the flaps they are placed in towels of sterile gauze and held downward out of the field of operation. If the patella is ankylosed to the femur, it is freed by the use of a flat chisel, preferably a thin-bladed artist's chisel, maintaining the normal groove in the femur.

Step 4. Retract the skin fully. Choose a line in which to make the new joint desired. Keep in mind that the normal joint is just under the tip of the patella when the leg is fully extended. Separate the tibia from the femur on each side with a curved chisel. Maintain the normal anatomic configuration

of the joint surface. Five-eighths of an inch distal to this incision drive the chisels again from either side, this time cutting through the upper end of the tibia and taking out a wedge of bone about five-eighths of an inch in thickness.

Step 5. By dextrous shaping with a chisel and a bone rasp, depressions are made which should resemble the normal articular concavities of the external and internal tuberosities of the tibia. Preserve the intercondyloid ridge. Excavate the intercondyloid groove of the femur; this groove must be deep enough to accommodate itself to the ridge of the tibia. If the ankylosis is in a flexed position, then a sufficient wedge must be removed to permit the leg to be fully extended without putting undue tension on the vessels and nerves in the popliteal space.

Step 6. The interposing flaps which were previously prepared are now drawn over the upper end of the tibia; the deep (glistening) surface must be toward the joint. Suture it firmly in position through drill holes made in the bone; no raw surface should remain exposed. Insert catgut sutures all around the margin of the graft. While it is not absolutely necessary to cover the femur, it can be covered with fascial tissue, if so desired.

Step 7. Close the newly made joint. Usually no drainage is necessary. Place the limb into a molded wire or plaster of Paris trough. A Buck's extension of from 8 to 12 pounds is applied. Passive motion is begun about the twelfth day. If the patella is ankylosed, a small piece of fascia is passed between it and the femur and sutured in position so that it may not again adhere to the femur.

Arthroplasty of the Hip

Indications:

1. Bilateral ankylosis—absolute indication.
2. Unilateral ankylosis in bad position.
3. Ankylosis following gonococcal arthritis or trauma (Baer).

Indications (Hey-Groves):

1. Simple bony ankylosis following old nontuberculous infection.
2. Massive ankylosis following trauma, with superadded infection.
3. Painful osteo-arthritis.

Step 1. Make a U-shaped incision extending from the posterior superior spine downward across the trochanter, and then upward toward the anterior superior spine. If necessary, an incision beginning at the base of the U and extending downward can be made.

Step 2. Reflect the flap and expose the trochanter with its muscle attachments.

Step 3. Divide the trochanter through its neck and reflect it upward with the glutei.

Step 4. Split the joint capsule parallel with the neck of the femur and separate it from the bone underneath it.

Step 5. Separate the head of the femur from the acetabulum with the aid of a broad gouge, the line of separation following the old joint line.

Step 6. Extrude the head of the femur from the joint socket, round it off and make it as smooth as possible with the aid of a file.

Step 7. Hollow out the acetabulum in sufficient amount to fit the new head of the femur. Remove as little bone as possible. Excise any fibrous tissue that may be present in the immediate vicinity.

Step 8. Cover the bone ends with autogenous grafts of fascia lata or any other preferred material. Murphy's pedunculated flap may be used here. Suture the flap to the fibrous periosteum of the femoral neck with chromicized catgut. Some surgeons also cover the floor of the acetabulum with the flap.

Step 9. Place the head of the femur in the acetabulum and nail the trochanter to its point of attachment to the shaft.

Step 10. Close the wound. Do not drain. Immobilize the leg for about three weeks in a plaster spica, and then bivalve the spica. Active movements are then begun. Massage and radiant heat are later instituted. Allow the patient to walk after two months with the aid of a traction splint and crutches; one month later attempts at weight-bearing are gradually undertaken.

CAMPBELL METHOD

Willis C. Campbell[1] recommends the following technic in arthroplasty of the hip:

Step 1. Place the patient on the unaffected side. Make a U-shaped incision (Kocher) beginning below the anterior superior spinous process (Fig. 867) extending downward and backward about one and one half inches below the greater trochanter and then upward for several inches. Incise the deep fascia and gluteal muscles in the same direction, but within and encompassed by the skin incision.

Step 2. Divide the greater trochanter and dissect it upward together with the gluteal muscles. Make a straight incision down to and parallel with the entire neck of the femur, extending about two inches upon the ilium.

Step 3. Separate the capsule and adherent soft structures from the neck borders and roof of the acetabulum with a heavy periosteal elevator. In this way, all scar tissue is separated en masse, thus minimizing hemorrhage (Fig. 869).

Step 4. Select a point about one-fourth inch above the acetabulum; divide the osseous fusion with a large woodcarver's chisel conforming the curve to the head of the femur (Fig. 870). Dislocate the hip by forcible adduction when outward rotation gives excellent exposure to all parts. Remodel the head to three-fifths or four-fifths of the normal size and smooth it with a shoemaker's rasp (Fig. 871). Excise about one-quarter inch of bone from the acetabulum; repolish it with a Murphy reamer. If at all possible, be sure that healthy spongy bone forms the basis of the new articulation. A strong magnifying glass is useful in removing bone particles. Transpose tissue as a substitute for synovial membrane and to prevent bony fusion. Campbell recommends that some material should be interposed between the raw bony surfaces, such as fascia lata from the side of the thigh. A sheet from six to eight inches by three to four inches is sufficient. This is taken from the same side of the patient as the hip to be operated on. One end invests the re-

[1] Surg., Gynec. and Obst., July, 1926.

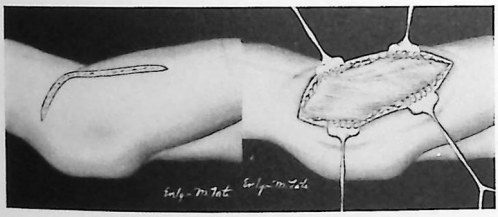


FIG. 867 FIG. 868

FIG. 867. Campbell's arthroplasty of the hip. Kocher's U-shaped incision beginning below the anterior superior spinous process.

FIG. 868. Straight incision down to, and parallel to, the entire neck of the femur. (Courtesy of W. C. Campbell and Surg., Gynec. and Obst.)

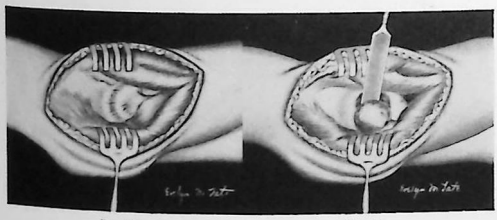


FIG. 869 FIG. 870

FIG. 869. Capsule and adherent soft structures separated from the borders of the neck and the roof of the acetabulum.

FIG. 870. Bony fusion divided with a large wood-carver's chisel. (Courtesy of W. C. Campbell and Surg., Gynec. and Obst.)

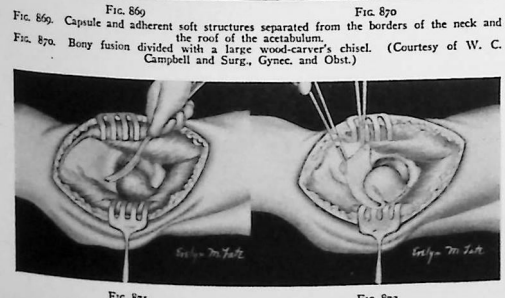


FIG. 871 FIG. 872

FIG. 871. Head of femur remodelled and smoothed with a shoemaker's rasp.

FIG. 872. Flap of fascia lata interposed between the raw bony surfaces and cupped to invest the head of the femur. (Courtesy of W. C. Campbell and Surg., Gynec. and Obst.)

shaped head and is held by a purse string suture (Fig. 872). The other end of the flap should be stitched to the soft tissues around the margins of the acetabulum, and is cupped so as to invest the surface (Fig. 873). It is also stitched to the adjacent soft parts or through drill holes in the neck of the femur to prevent possible derangement on motion. This makes a continuous membrane investing the entire joint and forming a double layer between the raw articular surfaces.

Modify the procedure as follows when malposition and contracture occur:

Omit the posterior end of the U-skin incision; carry the anterior end along the crest of the ilium so that the contracted flexors and abductors may be severed at their origin. Correct adduction by subcutaneous tenotomy of the adductor tendons.

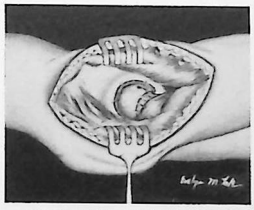


FIG. 873. Other end of fascial flap placed over acetabulum and stitched to adjacent soft parts. (Courtesy of W. C. Campbell and Surg., Gynec. and Obst.)

The operation is rendered more difficult in bilateral or multiple ankylosis. Take care not to contaminate the draping. The method is the same as for single hips with the exception that the acetabulum is enlarged and the head made smaller.

After the operation is completed, place adhesive strips two inches wide on both sides of the limb from the upper third of the thigh to the ankle with the free ends extending about six inches below the foot. Apply thick padding to the affected limb from groin to ankle to permit traction on the hip without impingement of the cast. Apply a plaster cast from the ankle on the affected side to the nipple line and to the knee on the opposite side so as to stabilize the opposite hip. In bilateral ankylosis, the opposite limb is not included at the first arthroplasty, as fixation exists by nature, but if the operation on the hip is successful, immobilize both hips at the second operation.

After the patient has been placed in bed, attach adhesive straps to an ordinary Buck's extension apparatus at the foot of the bed, with from ten to twenty pounds of weight.

On the tenth day, bivalve the cast on the affected side from the ankle to just below the crest of the ilium, so as to permit hip-flexion. At this time the wound is dressed. If drainage is present, the anterior half of the cast is reapplied for one week, but if there is complete healing of the wound or only a drop or two of serum, passive motion is instituted by means of an overhead pulley and rope which may be attached to a bar over the bed. The patient controls this apparatus directly. Movements must be given at regular intervals starting with every two hours during the day and every four hours at night. Later on they are increased to about ten minutes of motion each hour. If in spite of all treatment, fusion takes place, employ brisement forcé, carefully. It is well to resort to physiotherapy continuously for a year.

Remove the cast at the end of four weeks and allow the patient to walk with crutches. At night he is placed in a cast and also twice a day for one hour periods to avoid malposition and contracture of the soft parts. The cast may be used for several months to fix the pelvis and prevent compensatory movement in the hip joint when passive motion is carried out at regular intervals.

Determine the increase in weight-bearing by the density of the head and neck disclosed by the roentgenogram. Osteoporosis or bone atrophy may follow any operative procedure on a joint and so decrease the resistance of the cancellous bone that compression and disintegration may occur from pressure induced by the weight of the body. These complications may be best avoided by the adjustment of weight bearing through apparatus which places the weight of the body on the perineum and tuberosity of the ischium gradually permitting weight to be borne on the foot as the tensile strength of the bone increases.

Arthroplasty of the Elbow

Indications:

1. Ankylosis following trauma.
2. Ankylosis resulting from acute pyogenic infection.
3. Tuberculosis.

Step 1. Make an incision on the posterior surface of the arm and forearm just external to the midline; the incision starts above at the center of the humerus, extending downward to about 3 inches below the elbow joint and divides the skin, superficial and deep fasciae without separation. Dissect the deep fascia laterally about an inch. In cases of ankylosis in extension, cut the broad aponeurosis of the triceps transversely at the upper end of the incision, and divide it at its inner and outer borders.

Step 2. Form a long flap of thick fascia, attached to the tip of the olecranon process.

Step 3. Make a further incision in the midline passing through the triceps muscle and periosteum over the lower half of the humerus. Strip the periosteum from the lower third of the humerus. This exposes the head of the radius and olecranon process (Fig. 874 A).

Step 4. Cut the fusion between the olecranon process, radius and humerus with a curved chisel. Flex the joint and dislocate it to the mesial aspect.

Step 5. Fashion the lower end of the humerus into one condyle convex from before backward. (Fig. 874 B.) Do not attempt to reproduce the anatomic contour of the capitellum and trochlea.

Step 6. Excise the superficial bone from the sigmoid cavity, and denude the head of the radius to the level of the inferior portion of the sigmoid cavity.

Step 7. Smooth all surfaces with a rasp.

Step 8. Transplant and suture a large piece of fascia lata from the lateral surface of the thigh over the lower end of the humerus, and reflect it over the sigmoid cavity. When the ulna and radius are united, remove enough bone to allow free movement of the radius (Fig. 874 C). The two bones are then separated by a fold of the fascia, and the head of the radius is covered with it.

Step 9. Reduce the articulation and close the joint capsule from below upward with the elbow flexed at 90 degrees. The tongue of the triceps aponeurosis, when cut, is sutured at a point below its former position, to allow free play of the joint when it is in flexion.

Step 10. Close the deep fascia and skin.

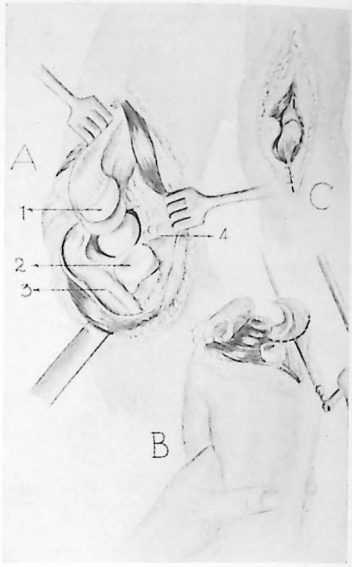


FIG. 874. Arthroplasty of the elbow-joint (Kocher). A. The joint has been opened: 1. external epicondyle has been freed from capsular attachment and periosteum, 2. capitellum radii and 3. upper end of ulna are also dissected free, 4. inner surface of capsule and synovial membrane. B. Shaping of ends of radius, ulna and end of humerus. C. The arm is extended allowing approximation of reshaped ends of bone. Tendon and muscle reunited. Transplanted fascia covering ends of bone not shown in illustration.

In cases of ankylosis with the elbow flexed, the triceps, instead of being cut transversely is severed longitudinally along the outer border and retracted inward.

Immobilize the arm in a splint at a ninety-degree angle or cast for about 2 weeks. After complete healing, remove the cast every 2 hours and begin gradual passive and active motion.

WILLIS C. CAMPBELL'S[1] TECHNIC OF ARTHROPLASTY OF THE ELBOW

Step 1. Make an incision six or eight inches long on the posterior aspect of the arm and forearm, just external to the midline (Fig. 875) beginning above, about the middle of the humerus and extending to about two or three inches below the elbow joint.

Step 2. Expose the broad aponeurosis of the triceps by dividing the skin, superficial and deep fascia without separation. Dissect the deep fascia laterally about one inch. Dissect the broad aponeurosis from above downward making a long tongue attached to the tip of the olecranon process below (Fig. 876 A).



FIG. 875. Campbell's arthroplasty of the elbow: incision along posterior aspect of arm and forearm. (Courtesy of W. C. Campbell and Ann. Surg.)

Step 3. Make a further incision in the midline penetrating the muscular fibers of the triceps and periosteum to the humerus over the lower half. Use a periosteal elevator to strip the periosteum from the lower third of the humerus. Remove all scar tissue, callus and loose bone particles. Reduce any dislocation, if present, with periosteal elevator, scoop or any blunt instrument (Fig. 876 B).

Step 4. Avoid nerve and vessel injury by staying close to the bone. If the ulnar nerve is exposed, isolate and anchor it safely. Remove about one-half to one inch from the lower extremity of the humerus and convert it into a surface convex from before backward; do not try to reproduce the trochlea or capitellum (Fig. 876 C).

Step 5. Remove about a half inch of bone from the olecranon process. Dissect all scar tissue from the sigmoid cavity. Remove the affected surface with a sharp chisel to healthy spongy bone. Do not disturb the radio-ulnar articulation but make the surface of the head of the radius the same level as the coronoid process.

Step 6. Dissect the periosteum and triceps muscle into a double flap; stitch this to the anterior capsule, thus separating the raw bony surfaces by a living mass of tissue with sufficient blood supply and free from pressure necrosis (Fig. 876 D).

In cases where the radiohumeral articulation is normal with bony ankylosis between ulna and humerus, the radiohumeral joint is not destroyed but a hemi-arthroplasty is done between the humerus and ulna. In these cases it is sometimes impossible to obtain sufficient posterior flap in lieu of which the aponeurotic broad tongue from the triceps is placed between the surfaces. Use this structure also when the posterior flap cannot be secured.

Step 7. Suture the capsule of the joint to the posterior aspect of the triceps

[1] Annals of Surgery, November, 1922.

muscle and deep fascia, closing off the new joint. Close the wound in layers with catgut and dermal for the skin.

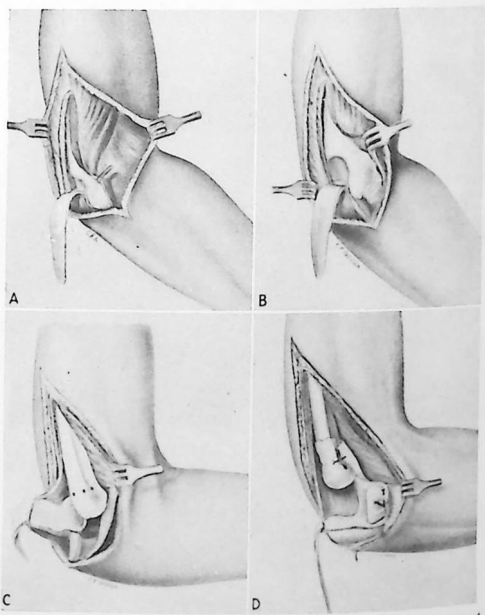


FIG. 876. Campbell's arthroplasty of the elbow: A. tongue of the broad aponeurosis of the triceps dissected out, B. dislocation reduced, C. end of humerus converted into a surface convex from before backward, D. periosteum and triceps muscle dissected into double flap covering raw bony surfaces. (Courtesy of W. C. Campbell and Ann. Surg.)

Arthroplasty of the Wrist

NÉLATON'S OPERATION

Step 1. Make a longitudinal incision along the radial side of the extensor tendons of the index finger, exposing the wrist joint. Continue the incision upward exposing the lower part of the extensor communis digitorum. Re-

tract the extensors of the fingers inward and of the thumb outward. (Fig. 877.)



Fig. 877. Nélaton's arthroplasty operation for ankylosis of the wrist joint.

Step 2. Reduce the ankylosis with a chisel or by means of manipulation. Remove the first row of carpal bones, leaving the pisiform. Shape the second row of bones into a condyle by means of resection.

Step 3. Cut a flap about a half inch wide and two inches long with its pedicle from the outer side of the fatty part of the extensor communis digitorum.

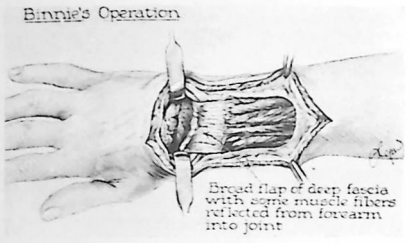


Fig. 878. Binnie's arthroplasty operation for ankylosis of the wrist joint.

Adjust the flap transversely in the furrow remaining after the carpal bones have been removed. Fix the end to the fibrous tissue at the inner side of the joint.

Step 4. Attend to hemostasis. Institute drainage and close the wound. Movements are begun after two weeks.

BINNIE'S METHOD

Step 1. Make a longitudinal incision along the radial side of the extensor of the index finger exposing the wrist joint. Divide the skin, fascia, etc., so as to open the joint but do not divide the fascia any more than is necessary.

Step 2. Continue the incision dividing the skin only and exposing a large area of fascia of the forearm. Dissect a flap from the fascia, fat and muscle fibers having a pedicle below and enough above or to the side of the incision made in the fascia for the arthrectomy to allow satisfactory nutrition. (Fig. 878.)

Step 3. Turn the flap of fascia downward, placing it in the opening so that it completely envelops the articular surface of the radius. Secure the flap in place with catgut sutures.

Step 4. Institute drainage and close the wound. Dress and apply a splint. Leave the drain in place from 24 to 48 hours. As soon as the wound is healed, begin movements.

SURGICAL TREATMENT OF INFECTIONS OF THE BONES

ACUTE OSTEOMYELITIS

(Acute Osteitis)

In order to frustrate the ravages of osteomyelitis, bone drainage should be established as soon as the diagnosis of bone infection seems quite certain. In these cases, the inflammation is very acute and usually affects the spongy portion of bone near the epiphysis. Various sized sections of bone or even all of the bone soon succumb to necrosis and sequestration results. These, when not removed (sequestrectomy) perpetuate the inflammation.

Step 1. Locate the point of greatest tenderness. Apply a tourniquet. Incise freely the cutaneous and subcutaneous tissues.

Step 2. Some incise the periosteum and free it widely from the infected zone. This, however, is not advisable as it leaves denuded bone which tends to die.

Step 3. Exploratory trephining of the underlying bone with a Doyen burr (electric) is done, or, in the absence of such, an opening is drilled with an appropriate sized drill (Fig. 879[1]) to expose the medullary cavity and afford drainage. A gouge and mallet may also be used. Multiple openings may be necessary.

Step 4. If pus is encountered, the bone is chiseled away and free exposure of the involved area secured regardless of the extent of bone that need be sacrificed. Do not curet bone marrow unless convinced that it is hopelessly involved in the inflammatory process; light packing will in many instances suffice (iodoform gauze). Judgment is necessary as to how much bone should be removed; experience teaches that it is a mistake to ruthlessly sacrifice bone thus robbing the limb of valuable reparative tissue. On the other hand, if obviously diseased, the bone should be removed with chisel, rongeur or curet. This is followed by a

Step 5. Thorough gentle cleansing by irrigation.

Step 6. Pack the wound open with sterile vaseline gauze.

Step 7. Immobilize the limb in plaster of Paris.

B.I.P.P. TECHNIC

Two sets of instruments are used in this procedure. The "pus table" holds the instruments necessary for exposing and removing the infected part of bone,

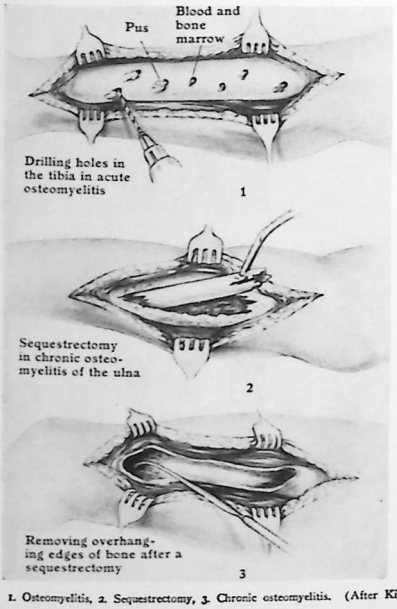


Fig. 879. 1. Osteomyelitis, 2. Sequestrectomy, 3. Chronic osteomyelitis. (After Kirschner.)

sequestra, etc. On the "clean table" are the instruments for removing the free fat transplant.

Step 1. Where possible, apply a tourniquet.

Step 2. Sterilize the field of operation and adjacent parts.

Step 3. Make an incision long enough to thoroughly expose the affected area (Fig. 880 a).

Step 4. All diseased tissue and bone must be removed. Cleanse the field with absolute alcohol (Fig. 880 b, c, d).

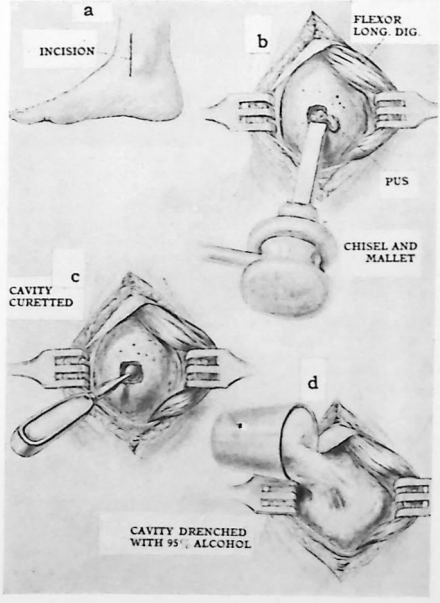


Fig. 880. Osteomyelitis operation devised by Rutherford Morison of Newcastle, England. Technic printed by his permission, showing B.I.P.P. technique. (Courtesy Dr. C. R. G. Forrester.)

Step 5. Apply a film of Bipp paste to all surfaces (Fig. 881 a). Bipp paste (B.I.P.P.) is composed of bismuth subnitrate, one part; iodoform, two parts; paraffin paste, q.s. Some drug houses in America are selling a B.I.P.P. composition with vaseline as a base.

Step 6. Change gown, gloves and use fresh instruments laid on the clean table.

Excise a segment of free fat from either the abdomen or the buttocks, of sufficient size to fill the bone cavity.

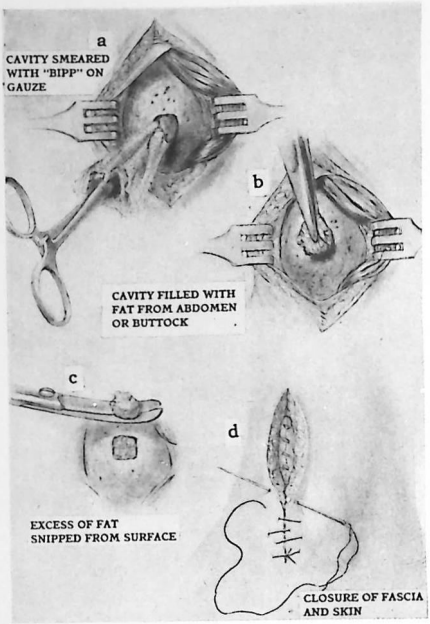


FIG. 881. Continuation of operation shown in Figure 880.

Step 7. Apply Bipp paste to the fat transplant and introduce it into the bone cavity. Any protruding parts of the fat transplant above the bone surface should be trimmed away (Fig. 881 b, c).

Step 8. Close the skin with silk or silkworm-gut sutures (Fig. 881 d).

Step 9. Apply gauze dressings saturated with alcohol protected by voluminous gauze or cotton dressings; avoid pressure over the wound.

Step 10. Immobilize the limb with either splints or cast.

Step 11. Change the dressings the day following the operation. Redress the wound for two or three weeks with B.I.P.P. paste.

The above method may also be used in all cases of chronic osteomyelitis. The presence of suppuration is no contra-indication for the operation. If a sinus exists, the extent of bone involvement may be ascertained by injecting bismuth paste into the sinus. Where no sequestrum is present the bismuth paste may clear up some cases.

CHRONIC OSTEOMYELITIS

In the days gone by surgeons waited for an involucrum to form; modern trends point toward removal of the dying or dead bone (sequestrectomy) after a reasonable delay; this may be done in the subacute stage or when the disease has become chronic.

Sequestrectomy

Step 1. Make a longitudinal incision over the soft tissues down to the bone. Usually fistulae are present. Excise them. Retract the soft tissues thoroughly.

Step 2. Expose the abscess cavity thoroughly and evacuate its contents painstakingly. If the sequestrum is found superficial remove it with sequestrostomy forceps (Fig. 879[2]). If it (the sequestrum) is situated in the involucrum remove with a chisel only enough of the latter to permit the extraction of the former. Do not molest the newly formed bone more than is absolutely necessary.

Step 3. Remove all pathologic tissues (granulation tissue), débris, necrotic bone, etc.) with gentle irrigations; projections with a curet (Fig. 879 [3]). If in doubt that all infected tissue has been removed, pack with vaselined iodoform gauze for a few days. Close later with sutures. If it is believed that no infectious material has been left behind, the wound may be closed. Binnie lauds filling the remaining cavity with a powder consisting of iodoform one part and crystals of boric acid, four parts.

Step 4. Dress. Fix the limb in a splint.

The Winnet-Orr Treatment of Osteomyelitis

The Orr Method of treating osteomyelitis is a "method of management" of acute and chronic pyogenic infections of bone whether primary or secondary to such conditions as compound fractures. The method includes not only the technic of the operation itself, but the postoperative management as well. The entire plan of campaign rests upon several general fundamental principles of treatment.

The underlying principles of the Orr Method are, in essence, that infections of bone call for adequate drainage and prolonged rest. Drainage must not only occur at the time of operation, but must continue throughout the period of healing. The term "adequate drainage" is a sine qua non. Rest must be complete and constant. This applies to the infected part and the healing wound; the latter must remain undisturbed. If the surgeon fulfills these requirements, the natural resources of the patient can be counted upon to overcome the infection and insure healing.

OUTLINE OF THE ORR TREATMENT

Step 1. Immobilize the patient at once on the operating table in the best possible position, anatomically.

Step 2. Do a thorough drainage operation, preceded by débridement if necessary.

Step 3. Pack the entire wound with vaseline gauze so that it is wide open from bottom to surface.

Step 4. Apply an extensive, well-fitting plaster of Paris cast.

Step 5. Do not disturb the cast, the dressings, the wound, or the injured part except in the face of definite complications.

DETAILS OF THE ORR TREATMENT

Step 1. Preliminary. Before any surgical procedure is begun, the patient is immobilized on a traction table with all of the injured or affected parts in as nearly correct anatomic position as possible. This may require manipulation in the case of contractures or the use of skeletal traction in the presence of fractures. The patient is placed in the best possible position in order that the operation may be carried through and plaster-of-Paris applied without further motion of the injured or inflamed parts and so that the position desired, once obtained, will not be disturbed in any way during the postoperative course.

Step 2. Operation. Make an incision that will thoroughly uncover the infected area. Retract the skin, muscles, fasciae and periosteum far enough to expose thoroughly the diseased bone in its entire extent. Remove foreign materials and dead or dying tissues; chisel out necrotic bone; remove sequestra and convert the wound into a saucer-shaped cavity ("saucerization"). Do not remove bony or soft parts that may contribute to repair. The operation is not to be unnecessarily prolonged or traumatizing, but is to provide an open cavity without over-hanging edges from which free drainage will be possible. Wipe out the wound with tincture of iodine followed by alcohol, and dry with sterile gauze.

Step 3. Closure. Fill the cavity with a sterile vaseline gauze pack from the depths to the surface of the wound. Pack gently, firmly, but not tightly. When the packing is flush with the surface, add flat strips of vaseline gauze so that this flat dressing extends somewhat beyond the margins of the wound. Cover with a dry, sterile, absorbent pad to take up drainage at the edges of the vaseline dressing. Use no drainage tubes or other foreign materials in the wound. Do not suture or otherwise cover the infected area with flaps of muscle, fascia, or skin.

Step 4. Splinting. The desired position having been previously established, the affected part is now immobilized so as to preclude muscle spasm and to avoid contractures. A well-fitting and extensive plaster of Paris cast is the most efficient device to use. Into the plaster may be incorporated, in the case of fractures, pins, nails, or moleskin straps used to control the fracture fragments. The splinting device, usually plaster of Paris, is to be extensive enough to control the affected part and the patient.

Step 5. Dressings. Dressings in the usual sense of the word are not done. The plaster of Paris cast is applied so as not to be fenestrated or split, and

so as to prevent tampering with the wound. The postoperative course of the patient is to be taken as an index of the condition of the wound. If immobilizing devices become inefficient or if odor, because of mixed infection, becomes unendurable, dressings may be changed in the operating room and under anesthesia (usually) without disturbing the anatomical relationships of the affected part and with minimal disturbance of the healing surface. In most instances the original dressing and cast may be left undisturbed for from four to eight weeks, or even longer, by which time the wound is protected by healthy tissue. But even these secondary dressings should be as carefully and as infrequently done as possible.

OPERATION FOR OBLITERATION OF BONE CAVITIES

This is often difficult to accomplish. The sequestrum and all diseased tissues must, of course, be completely but gently, removed. Failure is to be expected if free drainage is not obtained. Sinuses must be excised.

Schede's Aseptic Blood Clot

The method finds its greatest application in bone cavities not resulting from septic osteomyelitis. The gauze pack is removed from the cavity in the bone. The soft parts are united with buried catgut sutures. The skin is closed. Provide drainage (Penrose tube; strands of silkworm-gut). Dress. Immobilize the limb. Remove the tourniquet. Enough bleeding will ensue to fill the cavity. The excess is drained off with dressings. After a day or two release the limb from the elevated position. When no infection ensues, the cavity will heal in about a month or two. If infection supervenes evacuate the clot and institute free drainage.

Senn's method consists of using decalcified bone chips to fill the cavity.

Neuber's method substitutes iodoform-starch as filling material.

Mosetig-Moorhof, an iodoform wax-plug.

BONE PLASTICS

Beveling Off the Edges of the Cavity

Here an endeavor is made to cause the soft tissues to project and adhere to the walls of the cavity, producing a depression lined by skin. Figure 882 depicts the method.

COMPOSITE PEDUNCULATED FLAP

Von Eiselsberg's Operation

This operation is particularly adaptable to large defects in the tibia.

Step 1. Apply a tourniquet. Plan a pedicled flap so that it may be easily swung into the asepticized and vivified defect (Fig. 883). Do not detach the skin from over the bone any further than is sufficient to enable a chisel to cut through the cortical plate of the tibia corresponding with the planned flap; in other words a composite skin periosteo-osteal flap should result. This flap is rotated into position into the defect in the tibia, avoiding too much torsion of the pedicle. Suture the flap into position.

Step 2. Undermine the flap in the upper wound and bring the edges together

by interrupted sutures. Avoid pressure when applying the dressings. Secondary skin grafts to fill defects are often needed. Remove the tourniquet. Dress. Immobilize in a splint.

Comment: In treating an established osteomyelitis (Fig. 884) one should not use a sharp spoon or curet to remove the suppurating medulla, as it is likely also to remove osteogenetic portions of the medulla which have escaped suppuration. No bone should be removed except what is actually necessary for the purpose of ample drainage; on the other hand removal of all devitalized tissue must be complete, otherwise sinuses may result.

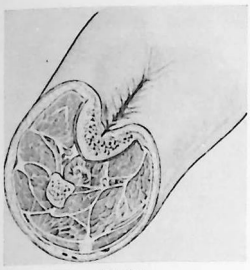


FIG. 882

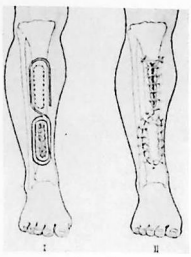


FIG. 883

FIG. 882. Obliteration of a cavity in the shaft of the tibia. The diagram shows how the soft parts are pressed down into the groove into which the cavity has been converted.

FIG. 883. von Eiselsberg's pediculated flap operation for the obliteration of a tibial bone cavity: I. Margins of the bone cavity and the cavity itself have been prepared by freshening and curettement; the adjacent skin is removed in connection with the flap to be applied. The composite flap of bone and soft parts to be raised and twisted downward, the former indicated in a broken line and the latter in a solid line. II. The downwardly displaced, pedunculated flap sutured into position and the margins of the upper wound are brought together by sutures as nearly as possible.

Definitely necrotic bone should be removed before it degenerates into a true sequestrum; that is, before the dead portion has become locked in and buried by newly formed periosteal bone (involucrum). The best time to remove necrotic bone is while the periosteum is still soft and plastic.

Rib Resection in Osteomyelitis of the Rib Ends

CHURCHILL'S TECHNIC

Step 1. Make a longitudinal incision through the periosteum overlying the affected rib. Reflect the affected anterior periosteal layer with a periosteal elevator (Fig. 885).

Step 2. Free the posterior layer by means of a Doyen raspatory and remove a section of the rib with a costotome (Fig. 886). As a result of the single longitudinal incision, V-shaped areas of the ends of the ribs have been left devoid of periosteum, and, if left exposed in an infected chest wound, it is easy

to see that sequestration may take place followed by separation of the devitalized fragments and their retention in the empyema cavity.

Step 3. To avoid the above, Churchill separates the periosteum from the rib in the manner shown in Fig. 887. Make a transverse incision at each end of the longitudinal one, permitting the periosteum to be elevated in the form of two flaps. This affords clean reflection of the periosteum and gives a line for the section of the rib by the costotome leaving the cut ends of the rib squarely covered by periosteum.

To cover the ends of the rib by suturing flaps of periosteum over them is, according to Churchill, "not only time consuming but by the introduction of suture material may actually invite infection." Churchill believes this simple technic is adequate, and that it will facilitate the operation as well as prevent the formation of chronic sinuses after the drainage of empyemas (Fig. 888).



FIG. 884. X-ray of extensive osteomyelitis of the humerus.

SUBPERIOSTEAL EXCISION OF SCAPULA AND CLAVICLE

Scapula—Ollier's Operation

The operation is performed in cases of osteomyelitis and its sequelae.

Step 1. Make an incision penetrating the tissues to the bone along the spine of the scapula from the acromion to the vertebral margin. By means of sharp and blunt dissection, divide the trapezius from the scapular spine (Fig. 889).

Step 2. Incise and expose the entire vertebral border of the scapula. Divide the soft parts from the bone both above and below the scapular spine, subperiosteally, through this incision.

Step 3. Retract the vertebral border of the scapula from the chest and divide the subscapularis and other tissues subperiosteally from the front surface of the scapula to the axillary border and neck of the bone.

Step 4. Separate the acromioclavicular joint from below upward; incise the tendons and articular capsule on the upper end of the humerus; incise the base of the coracoid process. Unless removal of the scapular head is deemed essential, it is better to leave the articulating surface of the bone intact and divide only the neck.

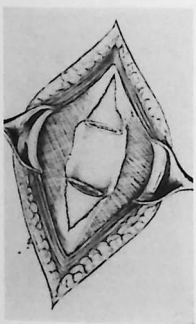


FIG. 886. Churchill's technic of rib resection: ends of the rib left devoid of periosteum by usual operative technic. (Courtesy Dr. Edward D. Churchill.)

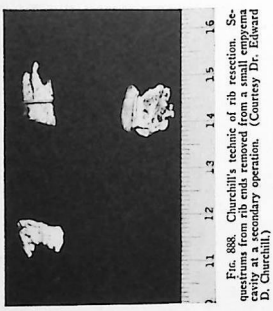


FIG. 888. Churchill's technic of rib resection. Sequestrums from rib ends removed from a small empyema cavity at a secondary operation. (Courtesy Dr. Edward D. Churchill.)



FIG. 885. Churchill's technic of rib resection: elevation of the periosteum after a single longitudinal incision. (Courtesy Dr. Edward D. Churchill.)

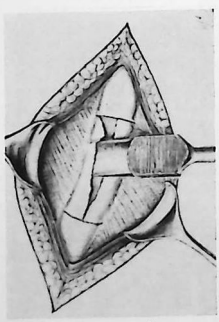


FIG. 887. Churchill's technic of rib resection: addition of transverse incisions leaves the ends of the rib squarely covered by periosteum. (Courtesy Dr. Edward D. Churchill.)

This operation is much more easily performed upon a patient in whom it is indicated than on a cadaver because disease renders the periosteum thicker and causes it to become detached from the bone.

Subperiosteal Resection of the Clavicle

This operation is indicated in cases of necrosis of the clavicle.

Step 1. Make an incision along the clavicle from the acromion process to the sternum including the periosteum (Fig. 890).

Step 2. Divide the periosteum from the anterior surface of the bone with a periosteal elevator.

Step 3. Detach the periosteum from the posterior surface of the bone, near the middle, with a curved elevator.

Step 4. (a) Divide the bone near the center with a Gigli saw or bone forceps. With a strong forceps, grasp the end of the inner fragment, pulling it forward. Removal of the fragment is easily accomplished by blunt dissection and the occasional use of the scissors which should always be made to cut against the bone. It is preferable to leave the articular end of the bone in

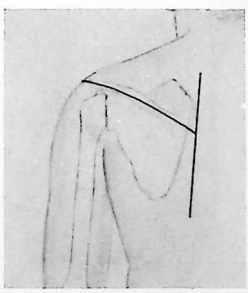


FIG. 889. Resection of scapula (Ollier's method).

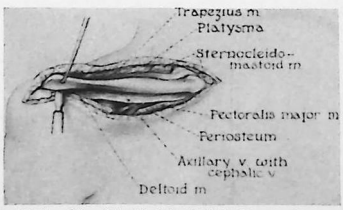


FIG. 890. Subperiosteal excision of clavicle (after Rudolph Nissen). Freeing of the acromioclavicular joint nearly completed. All muscular attachments divided.

place and divide the bone near its sternal circulation. Repeat at the external end of the bone. Sharp dissection is necessary where the subclavius joins the outer and middle thirds of the bone. A knife is used to divide the coraco- and acromioclavicular ligaments if the external end of the bone is to be sacrificed, but the acromioclavicular joint should always be preserved, if possible.

(b) Incise the clavicle close to its external end or open the acromioclavicular joint instead of the middle. Pull the outer end of the bone forward. Detach the soft parts from the clavicle subperiosteally and remove it partially or completely.

Step 5. Clean out the wound and close it. Institute free drainage where it is required.



FIG. 891



FIG. 892

FIG. 891. Cutaneous reaction of application of aluminum-potassium-nitrate over affected area.
FIG. 892. Osteomyelitis of humerus. Observe zone of reaction on forearm.

Adjuvant Nonsurgical Treatment of Osteomyelitis

BAER'S MAGGOT TREATMENT

This form of treatment has been reported upon favorably as a useful adjunct in the surgical treatment of chronic osteomyelitis. In small hospitals, however, the breeding and care of sterile maggots is impractical and their purchase rather expensive. Moreover, the permanency of the results obtained by this method cannot yet be reported upon unequivocally.

ALUMINUM-POTASSIUM-NITRATE TREATMENT[1,2]

In chronic infective suppurative processes, especially of bones, I have obtained excellent results from the application of a special compound of aluminum-potassium-nitrate. These results have been reported in the literature (Fig. 891). The paste is made by combining one part, by molecular weight, of aluminum nitrate with three by molecular weight of potassium nitrate. These are dissolved in hot nitric acid, the double salt crystallizing out upon cooling. This salt is mixed with sterilized rolled oats to make a paste and applied about ⅛-inch thick on the affected area extending well over the healthy skin margins and is covered with a waterproof dressing, since the paste must be kept moist. The dosage depends upon the sensitivity of the patient to skin irritation—and varies between 5 to 40 gr. of the salt to the ounce of sterilized rolled oats. The dressing is changed as often as it is saturated with exudate. There is increased exudate formation and drainage of purulent material as long as infection persists, i.e., the treatment is self-limiting, for it causes no reaction in healthy tissue. In many old cases, where persistent surgical treatment and other methods resorted to yielded repeated failure, the results gained by the application of this compound cannot be regarded as other than excellent. The compound is not an antiseptic, but acts as an accelerator of bacterial growth, which at the same time lowers the virulence and vitality of the organisms and increases the normal resistance of the body. In a series of 116 cases which I have reported, over 75 per cent of the patients became ambulatory and able to pursue their vocations, coming to the clinic only for dressings, in contrast to the results of the radical surgical procedures of the past. This method eliminates long hospitalization and later invalidism, with its attendant expense and discomfort. This aluminum-potassium-nitrate compound method should certainly be given a trial when other methods of treating osteomyelitis and similar chronic suppurations have failed to produce satisfactory results.

In prolonged drainage in an osteomyelitic area there is danger of erosion of the vessels by the drain.

In an extensive removal of necrotic bone in osteomyelitis, the possibility of fracture should be remembered and guarded against.

In extensive osteomyelitic processes involving the femur or humerus, the risks of shortening and deformity are great (Fig. 892).

In obscure fevers, particularly in children, always think of the possibility of acute osteomyelitis. Treat it promptly; surgically.

CARREL-DAKIN METHOD

This method combines the merits of continuous irrigation with those of extensive exposure of the involved area. Following the x-ray visualization of an established osteomyelitic process the affected bone is widely and completely excised and the surrounding soft tissues "saucerized." With the removal of infected bone and sequestrum, granulation proceeds from the depth of the wound. The process is then facilitated by inserting perforated capillary tubes connected with a Carrel-Dakin tube providing continuous wound irrigation. After two or three weeks the cavity may be obliterated by a muscle graft.

[1] Ann. Surg., Jan., 77:38, 1923.
[2] Int. Clin. 1:38, Ser. 38, March, 1925.

TUBERCULOSIS OF THE BONES AND JOINTS

Richard B. Dillehunt reemphasized[1]:

"The treatment of tuberculosis is rest, no matter where the lesion. The hope of cure is in obliteration by cicatrization, no matter where the lesion. But rest involves much more than relative general inactivity or 'just taking it easy.' In addition to the conservation of the forces of general resistance by general physical rest, dietetic regime, heliotherapy, and fresh air, the matter of functional rest of the part affected becomes a complex problem. No organ, whether lung, kidney,

[1] Medical Sentinel, Portland, Oregon, June, 1928.

intestine or joint, can continue its function and at the same time vanquish a tuberculous infection, and that type of rest that eliminates all function of the mechanism is the treatment of tuberculosis. Fortunately, in a joint this can be done more readily than in the lung or other viscus. In spite of the results reported from heliotherapy alone or from other general measures, we are convinced that the desideratum in a tuberculous joint is absolute and complete immobilization for an indefinite period. (Fig. 893.)

"In the early case, prompt removal of superimposed weight and the prevention of deformity are mandatory. This is to be followed by gradual correction of deformity by traction or other device, followed by immobilization in a position which will yield the maximum usefulness to the affected limb. When thus treated, nearly every case will experience marked and immediate benefit, gain in weight, increase in blood-cell count, improved appetite, and disappearance of pain. The plaster of Paris cast must extend far above and far below the lesion. In vertebral tuberculosis the Bradford frame should be used, but only when skilled orthopedic nursing is at hand. Otherwise, and when delegated to the mother, the child gets one or two manipulations of the lesion daily in the bath or at the bed pan, which defeats the object. Immobilization must be complete. The plaster spica including both thighs is best in low lesions; in higher lesions the head should also be immobilized. In the hip and knee a long plaster spica is used. These plasters should be bivalved to permit turning without moving. The hope of cure in every tuberculous joint lies in complete and permanent destruction of the joint and its function. The disease itself usually destroys the joint but does not destroy all joint function, and thus, though quiescent for years, the joint constitutes a constant source of trouble, general and local. Ideal treatment is ankylosis of the joint by surgical means. This is accomplished at the spine by spinal fusion, at the hip by extra-angular arthrodesis, and at the knee by erasure, all followed by immobilization for several months. Pulmonary tuberculosis as a concomitant or complication of bone and joint disease is rare. Complications such as compression of the spinal cord or tuberculosis meningitis are occasionally seen in cases without draining sinus, but they are rare."



FIG. 893. Tuberculous arthritis.

Pott's Disease

Tuberculosis of the Spine, Caries of the Spine, Angular Curvature of the Spine

Tuberculosis of the spine was first studied by Percival Pott and has since borne his name. He described the "stiffness" of the vertebral column and the pain produced by slight movements or jarring; he noted that the disease developed slowly with resulting spinal deformity. His report called attention to the formation of "cold abscesses" and the occasional paralysis that occurred.

The disease is the most common form of bone and joint tuberculosis as illustrated by the 10,850 cases reported by Whitman of which 4,799 involved the spine. The condition affects both children and adults although fifty per cent of all cases are between the ages of three and five years. Children under two years of age are seldom affected but boys are more susceptible than girls.

Early symptoms are frequently attributed to an injury of the spine. Certainly this is a factor as that portion of the vertebral column most subject to stress and strain is most frequently involved. However, in as much as tuberculosis of the spine is a blood-borne infection secondary to a central focus, heredity and surroundings are of paramount importance as etiologic factors. Not infrequently the onset dates from an attack of one of the acute exanthemata which tend to disseminate tuberculosis from its central focus.

The pathology of Pott's disease is best understood when the spine is regarded as a segmented, flexible, bony rod with three physiologic curves, the task of which is weight bearing. A defect in any segment therefore tends to produce a deformity that aggravates the causative condition and renders natural repair difficult. Likewise these bony segments or vertebrae have terminating in their spongy bodies many end-arteries which readily entrap embolic bacteria circulating in the blood stream. Thus in children spinal caries tends to have its origin in the central portion of the vertebral body which eventually breaks down and produces a kyphos or gibbus. In the adult patient the process frequently begins beneath the anterior common ligament of the vertebral body which tends to reduce the occurrence of deformity but to increase the incidence of abscess formation. Originally one vertebra is affected but ultimately the usual number is from three to six.

A vertebral body whose center has become caseous eventually collapses along its anterior aspect as a result of superimposed flexion. The contents of the cavity are forced out and the resulting deformity is that of backward projection (gibbus) (Fig. 894). The dorsal region with its concave curve is especially prone to this deformity, a condition which is frequently prevented by the convex curve of the cervical and lumbar region. As the spinal deformity progresses certain secondary changes of the viscera, skeleton, and muscular tissues take place which are unsightly and incapacitating. In about 20 per cent of all cases the material expressed from the vertebrae upon its collapse contributes to a cold

abscess. In the cervical region pus may collect in the retropharyngeal area or as a deep cervical abscess. The involvement of the upper dorsal region may point in the posterior mediastinum. The most frequent site of abscess formation is in the lower dorsal and lumbar regions where the course is downward along the psoas muscle pointing in the groin, flank or over the buttock. An intraspinal

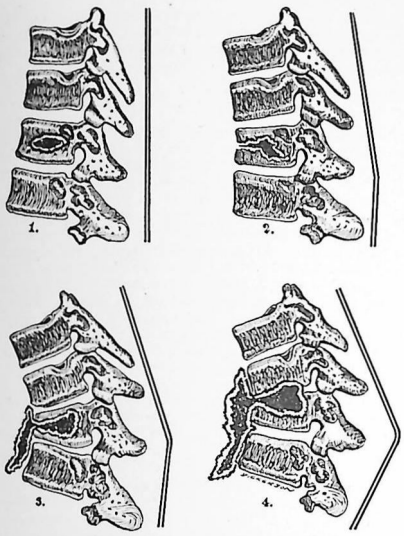


Fig. 894. The progress of a tuberculous focus in the body of a vertebra with resulting collapse, gibbus and abscess formation.

abscess is probably the most frequent cause of the paralysis seen in these cases. Bone compression of the cord is rare. This "abscess paraplegia" (usually bilateral) most frequently manifests itself about two years after the onset of the disease and even though established for a considerable time it is amenable to treatment by prolonged fixation.

Actual symptoms of spinal caries may be preceded by a period of lassitude, malaise, poor appetite or loss of weight. The first indication of spinal disease is often pain. In the infant all movements cause acute distress and pain is frequently worse at night. Older children voluntarily assume a rigid attitude made more acute by involuntary spasm (Figs. 895-896-897). The patient is reticent to stand and muscular weakness may be marked. Deep palpation elicits pain over the affected area or an early deformity can be detected. The adult patient tends to have fewer premonitory symptoms and the onset of pain is often acute. Special attention should be given to the loss of body height, peculiarities in attitude or gait and finally gross deformities as gibbus, abscess formation or paralysis. A primary focus may be determined by a systematic investigation.



Fig. 895. Child with evidence of rigidity and muscular weakness as a result of tuberculous foci in the dorsal region of the spine.

Treatment has for its object the cure of the disease and to correct or prevent further deformity. The first employs the usual antituberculosis measures and the latter employs local treatment. Local treatment of uncomplicated cases which constitute the majority of the cases of Pott's disease is first, complete and fixed recumbency followed by a careful and gradual return to activity. Forms of fixation generally used are the Thomas splint method, plaster shell and Whitman's frame. Wherever an abscess forms aspiration alone may effect a cure. When the material by virtue of its thickness cannot be withdrawn a solution of thymol and camphor (1:2) may be injected to produce liquefaction. Paralysis arising from compression responds surprisingly well to fixation.

Surgical treatment is generally reserved for the adult patient. Albee, however, urges operation at all ages. the main indications being pain, muscle spasm,

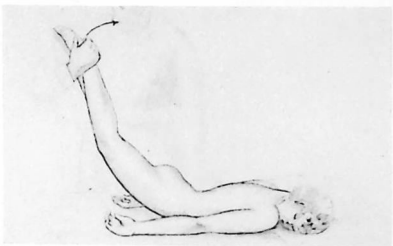


Fig. 896. Demonstrates the normal flexibility of the spine.

increasing deformity, abscess formation and paralysis. Calot is of the opinion that operative procedures in this disease are definitely harmful. American

surgeons in general have favorably accepted spinal osteosynthesis in the treatment of Pott's disease in the adult. The operations of Albee and Hibbs or similar procedures are used (see text).

Albee's Bone Graft Operation for Tuberculosis of the Spine

Fred H. Albee pointed out that in tuberculosis of the spine the only definite curative measure consists of production of ankylosis of the parts affected. In 1909 Albee's first attempts were directed toward fusion of the spinous processes. He was not satisfied with the results obtained and after thorough study concluded that the principles upon which the fusion operation rested were faulty—the spinous processes of the vertebrae offered an insufficient amount of bone to anchor the vertebrae securely and the low osteogenetic power of the vertebrae resulted in bony unions of little strength; this latter suspicion was verified by



Fig. 897. Illustrates the limited motion of the spine as a result of Pott's disease.

Albee's experiments on dogs in 1908 and 1909. Albee solved the difficulty of the problem by applying a strong single graft from a long bone to compensate for the local deficiency, by supplying bone of high osteogenetic power and by providing immediate immobilization of the affected vertebrae. "My hope," says Albee, "was that this graft of living bone would not only provide immediate mechanical support and added osteogenic power to promote ankylosis but also act as a vessel-conducting scaffold from each spine to the next and from the unaffected ones to those whose circulation might be impaired by the effect of the tuberculosis on the blood supply. A diagrammatic representation of the procedure is shown in the accompanying illustrations (Figs. 898-899-900-901). The renewal of the blood supply I have always considered the first step in union, whether in the treatment of pseudarthrosis, the arthrodesis of a joint or the fusion of spines. That the graft lives and increases in size in accordance with Wolff's law has been clearly demonstrated again and again. The physiology of healing bone and of bone grafts has been subjected to rigid investigation in many schools. Some of this work has supported my thesis, some has not. Whether the graft has any other

effect than that brought about by its immobilizing influence cannot be stated. It would seem reasonable to attribute the unusual success of the method, in part at least, to the linking up of the cancellous circulation in each affected vertebra

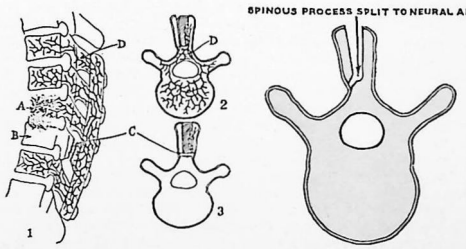


Fig. 898. Albee's bone graft operation for tuberculosis of the spine (for description see text). (Courtesy Dr. Fred H. Albee.)

with that of its neighbor and, through the graft, with that of the healthy vertebrae adjoining the affected area, as shown in the illustration. At least it is difficult to account for the phenomenal results on the basis of immobilization alone, al-

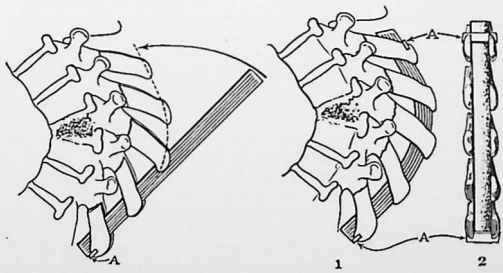


Fig. 899. Albee's bone graft operation for tuberculosis of the spine (for description see text). (Courtesy Dr. Fred H. Albee.)

though it is realized that complete immobilization cannot be effected in any other way."

Indications and Contraindications. Albee operates on any patient at any age provided the surgical risk is good.

1. General condition of the patient and operating facilities must be good.
2. Paraplegia, perivertebral and psoas abscess are additional indications for operation.

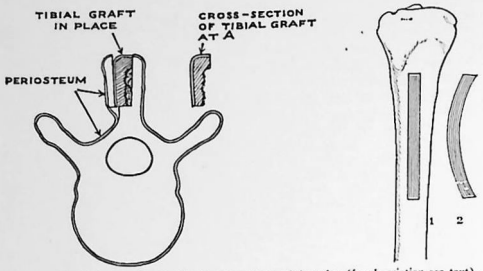


FIG. 900. Albee's bone graft operation for tuberculosis of the spine (for description see text). (Courtesy Dr. Fred H. Albee.)

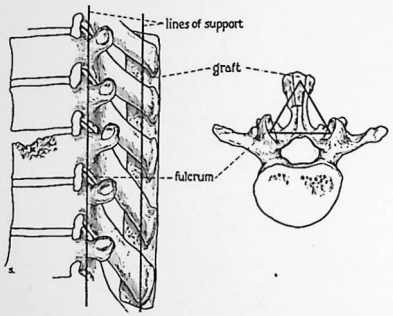


FIG. 901. Albee's bone graft operation for tuberculosis of the spine (for description see text). (Courtesy Dr. Fred H. Albee.)

3. High temperature due to secondary pyogenic infection is a contraindication to operation. These should be combated, by blood transfusion and supportive measures, before operation is undertaken. Pyrexia solely due to tuberculosis is not a contraindication to operation.

4. The presence of a second tuberculous focus forms no contraindication to operation.
5. Abscess or sinus are not contraindicative. On the contrary, they demand surgery. The field of operation must be thoroughly prepared and sinuses closed with collodion before operation is begun.
6. Any age is proper for operative intervention.

Operation. Correct the kyphosis on a Bradford frame for a varying period. The graft should hold the spine either in the position of deformity to which the disease has progressed or in the position of correction attained prior to or at the time of operation. Albee uses two methods:

(a) the single graft inlay and
(b) the bent single method or the "bundle of reeds."

Step 1. Expose the affected area and prepare the spinal gutter by making a median dorsal incision over the tips of the spinous processes from about the last healthy one or two vertebrae above to the first below the affected bone.

Step 2. The spinous processes of the involved vertebrae and of two above and two below in the dorsal region (only one above and one below in the lumbar region) are split, in situ, in halves longitudinally almost down to the neural arches. Albee uses a special broad thin osteotome and cautions that the saw is not satisfactory because it is difficult to guide. The soft structures are separated parallel with the muscle between the processes. A greenstick fracture is produced at the base of each of the processes. Pack temporarily the long, gutter-shaped wound with hot lap packs. After one process has been split, Albee anchors one edge of the osteotome in the cleft so as to guide the other edge while it splits the next process above and below. Albee admonishes that: "Care must be taken to fracture only one of each pair of spinous-process halves; if both halves are fractured, the continuity of blood supply through the graft into the vertebral body is interfered with, immediate immobilization of that particular vertebra is not effected and there is the risk that, because of low osteogenic power, reunion of the fractured spine may not occur and the vertebral body will not receive that mechanical support and vascular rehabilitation which the operation is designed to provide. The gutter for the graft must be founded by a row of fractured half-spines on one side and a row of unfractured half-spines on the other" (Fig. 898).

Step 3. Make an incision over the side of the tibia and reflect the skin so as to expose the crest of the bone. Do not leave the skin incision directly over the segment of bone to be removed. Remove with a bone chisel a prism-shaped piece of tibia with its periosteum intact on two of its surfaces from the antero-internal aspect of the tibia. The section of bone from the tibia must be long enough to reach from the uppermost to the lowest of the split vertebrae and should be about one inch wide, one-fifth the diameter of the tibia, and must be of sufficient stamina to withstand the strain to which it will be subjected (Fig. 900).

Albee describes the shaping of the graft as follows:

"The shaping of the single graft can be accomplished only to a limited degree. By cutting the upper and lower portions of the graft at an angle to the

axis of its middle portion, which crosses the crest, one can secure a graft with a greater or lesser curve; but the tibia is not wide enough to provide a single graft suitable for more than a moderate kyphosis. In more extreme cases the bundle-of-reeds technic is followed. If the operation is undertaken as early as it should be, the kyphosis will not be too great and a straight tibial graft can be used.

"After the exposure of a sufficient area of the central portion of the antero-mesial surface to provide a graft of the requisite length and diameter, longitudinal cuts are made with the twin saws approximately one-half inch apart, down to the marrow. With the single saw, cuts are made between these two, down to the marrow, so as to provide four very thin strips. These intermediate cuts fall somewhat short of the original two, so that, when the latter are jointed by a transverse cut at each end, the entire graft is lifted out in one piece, with a bridge across each end where the intermediate cuts fell short. This flexible graft is then placed edge-wise in the spinal gutter, so that one end of it is in contact with the least favorable end of the graft bed. It is held there with kangaroo sutures through the split supraspinous ligament. A thin strip of bone three-fourths inch long, taken from the side of the gutter in the tibia, is now placed transversely over the tip end of the graft and under the supraspinous or interspinous ligament, in close approximation to the two halves of the spinous process, which are stripped of periosteum and recessed to receive it. Having been firmly fixed at one end, the graft is now grasped in a clamp and bent into the gutter and held with interrupted sutures of kangaroo tendon as the molding progresses. The extreme end is held with a transverse locking graft of bone, such as was used to fix the first end. This cross graft is ideal for use with both the shaped graft and the bundle of reeds, to prevent any possibility of the end of the graft springing posteriorly out of the gutter. It is used whenever, in the early stages of the disease, straightening of the kyphosis has been attempted either by conservative treatment before operation or by manipulation at the operation. This form of anchorage becomes even more secure as convalescence progresses since the cross graft, being of autogenous, living material, unites with the spinous processes and with the main graft (Fig. 901).

"Should the kyphosis be so extensive that the tibia will not supply a long enough graft to fill the gutter, as occasionally happens, the intermediate cuts in the graft may be carried to its entire length, so that the strips are separate. This 'bundle of reeds' is then placed in the gutter and fixed at the midpoint with a kangaroo tendon; the individual grafts are then telescoped out so as to cover the entire graft bed. One need not be deterred by any fear of the fragility of these strips for, even in the adult, if they have been cut accurately with the motor saw, they will bend readily without breaking. Since practically the whole length of the tibia is available as a source of bone graft, this method is resorted to only in extreme cases."

Step 4. Suture the soft tissues over the osseous structures. Close the skin wound. Dress. Immobilize.

Step 5. Close and dress the wound in the leg.

Comment: The originator of the operation warns against technical faults which may jeopardize the results. Meticulous observation to detail

is essential. Modification of the details of the operation as outlined by Albee diminishes its efficiency and may unjustly bring it into disrepute.

Commenting on Hibbs' Operation which consists of removing the spinous processes, Albee states: "it cannot be satisfactorily combined with the Hibbs technic because in that operation the spinous processes are cut off. In spite of the interference with the blood supply, the graft might unite with the processes, but, if these did not all reunite with the neural arches, there would be a break in vascular continuity and immobilization would be defective."

St. Jacques Method of Osteosynthesis[1]

In order to simplify Albee's operation, St. Jacques removes portions of ribs instead of obtaining a graft from the tibia. Two cases thus operated upon yielded excellent results. In one case, the cervicodorsal region was affected with pains along the arms. The thoracic wound heals rapidly. There is no need of changing position of the patient during the operation.

Step 1. Place the patient in the ventral position. Make an incision anywhere between the sixth and eighth ribs. Leave a one-half cm. band of periosteum on the anterior surface of the rib thus operated on.

Step 2. No change of position is required because the patient already is in the proper position. Carefully prepare the respective posterior spinal apophyses in a V-shaped fashion for the reception of the rib graft. Place the graft. If the region operated upon is somewhat curved, it may easily be corrected by forcible redressment.

Step 3. Reunite the divided soft tissues with interrupted chromic catgut sutures.

Step 4. Plaster of Paris dressing.

KÜMMELL'S DISEASE

Kümmell's disease is a posttraumatic spondylitis of the spine which comes on a few weeks to several years after a back injury and results in a crumbling collapse of a vertebral body with resulting kyphosis. Kümmell's original paper described lesions from the third to the eighth thoracic vertebrae although the condition may occur in the lower thoracic and lumbar regions. The disease is usually limited to one vertebra.

The usual history is that of a blow on the back of varying severity followed by soreness; less frequently by definite signs of localized contusion. An interval of symptom-free days, months or years pass and then the patient begins to complain of pain, tenderness and weakness over the old site of injury. As the disease progresses the affected vertebra collapses, a kyphosis appears and occasionally paralysis ensues.

Treatment consists of hyperextension by means of a spinal brace, the management in general being that of Pott's disease. With rest and effective immobilization complete consolidation readily occurs and symptoms soon disappear.

SCOLIOSIS

Scoliosis is a deformity of the trunk resulting from a lateral deviation and a certain degree of rotation of the spine. The condition results in secondary changes

[1] Bruxelles Med. No. 24, April, 1937

of the vertebrae, ribs, pelvis, and extremities, and viscera. The thoracic and abdominal organs may be so embarrassed by this shifting as to give rise to distressing symptoms.

The etiology of this disease gives rise to the following classification by Brooke: (1) Congenital, (2) Rachitic, (3) Postural, (4) Paralytic, (5) Functional, (6) Secondary. From the standpoint of pathology the designation of functional and structural types does very well.

Scoliosis when uncomplicated causes the patient little inconvenience. The physician's advice is generally sought as a result of some gross deformity which means that the disease is well established. Cases of lateral curvature occurring before puberty should suggest the diagnosis of scoliosis, especially when it is associated with little pain. In these cases it is most important to ascertain the etiologic factor as a guide in treating the deformity.

In event the condition arises from a functional cause the treatment consists of adjusting faulty school-room postures, ill-fitting clothes and the like; combined with a series of exercises designed to restore tone and strength to the trunk muscles. Lateral curvatures arising from structural causes constitute a complicated treatment problem. The surgeon is dealing with:

Established bony changes associated with malposition of the vertebrae,

Tissue alterations adapted to and tending to maintain the lateral deformity, and

Associated postural changes of the viscerae and bones making corrective procedures painful and difficult.

Operative treatment of structural scoliosis is to be undertaken with considerable forethought. In general only the adult patient is a candidate. Spinal fusion is the treatment of choice, but even this operation fails to give support to the anterior spine. Before any operative procedure the surgeon must correct the existing deformity as much as possible by other means. Among his adjuncts are the MacCrae-Aitken and the Abbott jackets, Whitman's frame, halter and right angle countertraction. The most desirable preoperative care is absolute bed rest on a Whitman frame with later application of a Sayre head halter and a weighted pelvic girdle. After six to eight weeks, maximum correction can be expected and the patient is eligible for surgery. Before operation a plaster jacket may be applied so that it will take the outline of correction that the above treatment has provoked. This is bivalved and removed before operation, following which it may be reapplied providing stability to the spine and facilitating handling of the patient.

Any operative procedure will be beset with certain difficulties major among which are:

The extent of the operative field is often very large even as to require two sittings for the procedure.

Structural changes obliterate landmarks and distort anatomic structures. This is especially important as regards establishing the midline in order to keep to the subperiosteal plane and thus preserve a dry field.

Extensive bone grafts are necessary and to obtain and insert them one is often hardpressed for osseous material; likewise the patient must be handled to bring him into position for both procedures.

The method of operation is very similar to that for Pott's disease although

more extensive. The technic is a matter of personal choice; those of Hibbs, Albee and Kleinberg are a few of the desirable methods. The first two have been described elsewhere, that of Kleinberg is as follows:

KLEINBERG'S OPERATION

Step 1. Estimate the dimensions of the bone graft that will be needed and cut it from the tibia. At ¼-inch intervals nick the graft with transverse cuts, thus providing flexibility and facilitating later vascularity. Preserve the graft and close the wound.

Step 2. Place the patient in a prone position, carefully mark out the midline and carry a vertical incision along it over the affected area.

Step 3. Dissect deeply along the subperiosteal plane, thus exposing the spines, laminae and finally the entire posterior articulations. These are thoroughly roughened and from the laminae bone flakes are raised and laid as bridges across the interlaminar spaces.

Step 4. Using the technic of Albee split the spines of the two vertebrae above and the two vertebrae below the affected area. Fit the prepared graft into the defects thus produced and form it into contact with the laminae and transverse processes on the concave side of the lateral deviation.

Step 5. Split the spinous processes of the intervening vertebrae and turn them over the graft.

Step 6. Carefully cover all the defects thus produced with periosteum and muscle. Close the fasciae and skin in layers.

Step 7. Place the patient in bed or in a prepared jacket for one week. After this, tractions may be reinstituted for six months. The patient is then allowed to be up with a light plaster jacket for support. After six months this is removed but the patient kept under supervision.

HAND INFECTIONS

Allan B. Kanavel's many illuminating researches have done much to clarify obscure problems pertaining to hand infections. Satisfactory results are dependent to a great extent upon ascertaining the site of the suppurating focus. A sound knowledge of anatomy coupled with clinical experience are essentials in this important field of surgical activity (Figs. 902-903).

Faced with a case of severe infection of the hand, a careful diagnosis, whether one is dealing with a lymphangitis, tenosynovitis or an infection of the fascial spaces, is paramount in determining the course of therapeutic procedure to be followed.

Lymphangitis is occasioned through a breach in the continuity of the skin which acts as a port of entry for the invading micro-organism. Red streaks, the classical sign of infection, supervene along the lymph paths of the forearm and settle the diagnosis of an existing lymphangitis (Fig. 904). Lymphangitis pure and simple should not be operated on, as surgical intervention tends to provoke rapid extension of the process. The patient should be placed in bed and the involved extremity enveloped in a wet dressing. Such a dressing should be sterile, wet to a comfortable warmth and should cover the entire affected area. An abundance of fluids must be insisted upon (Fig. 905).

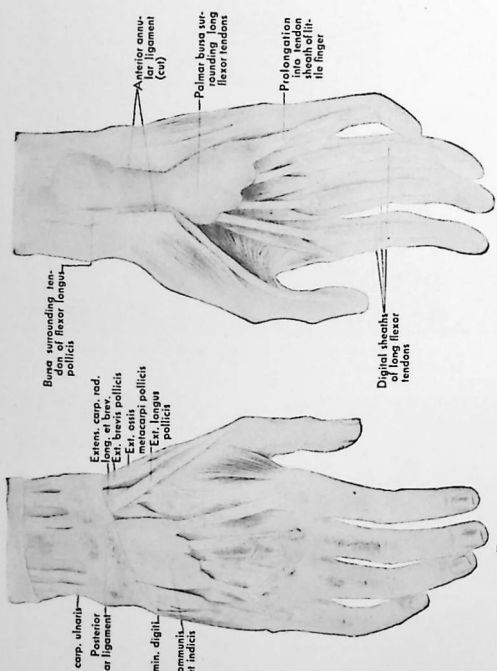


Fig. 903. Dissection of palmar surface of right hand, showing artificially distended sheaths of flexor tendons. (Piersol.)

Fig. 902. Dissection of dorsum of hand, showing artificially distended sheaths of extensor tendons. (Piersol.)

Operation for Suppurative Tenosynovitis

Tenosynovitis arises from an infection of the tendon sheath as a result of direct bacterial inoculation as from a puncture wound or by extension from neighboring tissues. The process tends to spread rapidly and in a destructive manner. Treatment in the form of immediate and adequate drainage should be provided. Procrastination means the sacrificing of limb or life itself.

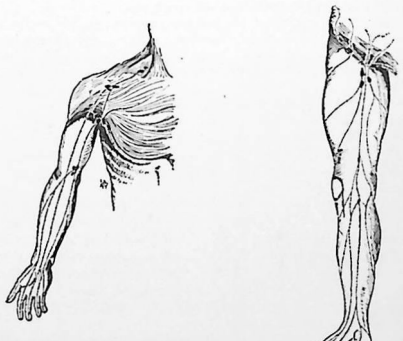


Fig. 904. Course of the main lymphatics most frequently involved in the extension of acute lymphangitis.

Where indicated, administer a general anesthetic, gas or ethylene oxygen being used.

Step 1. Elevate the arm. Apply a tourniquet a little above the elbow.

Step 2. Make an adequate incision, to one side of the midline of the tendon sheath (Figs. 906-907). Pus often distends the tendon sheath; incise it liberally. If frank pus is present and the tendon is visibly affected, extirpate it; however, this should not be practiced routinely.

To prevent infection from being carried into the palm further by the retraction of the cut ends of a tendon, Hamilton Bailey advises[1] suturing these to the periosteum of the proximal phalanx with catgut. Where the tenosynovitis is so intense that gangrene ensues, disarticulate the finger at the metacarpophalangeal articulation. Leave the wound open.

Operation for Tenosynovitis of the Index Finger

Step 1. Make an incision into the sheath of the affected tendon on its radial

[1] Hamilton Bailey. Emergency Surgery. John Wright and Sons, 1936.

side. If the lumbrical canal between the index and middle fingers is involved then the incision is placed on the ulnar side (Figs. 906-908).



Fig. 905. Infected burn followed by lymphangitis four days after burn was sustained. (Surgical Service, Cook County Hospital.)

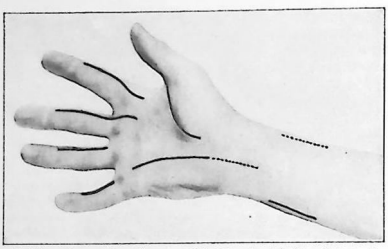


Fig. 906. Lines show regions of suggested incisions for infection of the tendon sheaths. In case of doubt the free incision of the whole sheath is to be advised. (Kanavel, Infections of the Hand, Lea & Febiger.)

Step 2. If pus issues from the lumbrical canal when the ulnar side is opened, institute drainage by dividing the web, up to the crease of the distal palmar

flexion. If the radial side has been incised and pus issues from the thenar space, institute drainage by inserting a hemostat to the radial side of the middle metacarpal. The middle palmar space is only rarely infected from the index flexor tendon sheath.

Operation for Suppurative Tenosynovitis of the Middle Finger

Ascertain which side of the lumbrical canal is the more painful; when in doubt incise the ulnar side. Extend the incision down to the distal palmar flexion

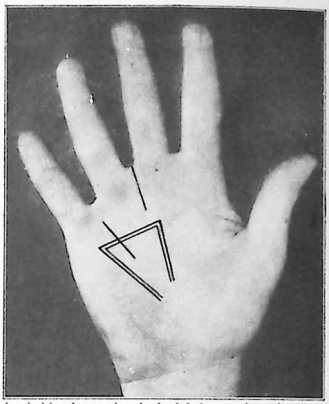


Fig. 907. Showing incision for opening the lumbrical space, in conjunction with the middle palmar space. (Kanavel, Infections of the Hand, Lea & Febiger.)

crease. In cases of recent origin the middle palmar space is not involved; the space between the flexor tendon and the palmar fascia holds the pus and it is sufficient if the original incision is extended into the palm (Fig. 907).

If the middle palmar space is infected, institute drainage by introducing blunt pointed hemostats between the ring and middle metacarpal bones sufficiently deep until they project on the back of the hand; cut the skin over the projecting points. Draw a rubber drain through the thickness of the hand and remove it 24 hours later.

Tenosynovitis of the Ring Finger

This is treated in the same manner as pertains in the case of the middle finger except that when a question arises as to which side of the sheath to open, choose the radial side.

Little Finger and Ulnar Bursa

According to Hamilton Bailey, the flexor tendon sheath is frequently not connected with the ulnar bursa. Practical experience reveals, however, that a communication is more often present than not (Fig. 910).

Characteristic Symptoms of Ulnar Bursitis

In these instances, the palm is much swollen but not enough to completely obliterate the palmar concavity. The portion above the anterior annular ligament is very swollen. Considerable edema is present on the dorsal aspect of the hand. Kanavel's sign (Fig. 911) is observed at the onset, but this disappears in a few days. In the majority of cases, there is a communication between the radial and ulnar bursae. Thus, if adequate drainage is not instituted in the ulnar bursa at first, the radial bursa is very likely to become infected.

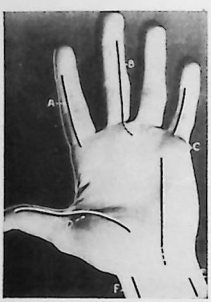


Fig. 908. Incisions for draining infected flexor tendon-sheaths. A. Usual incision for opening an infected tendon-sheath. B. When a lumbrical canal is infected in addition, the incision is prolonged into the appropriate web space. C. Incisions for opening an infected ulnar bursa. D. Incision for opening an infected radial bursa. E. Incision for opening all infections of the forearm from the hand. F. Counter-incision used in the case of infection of the forearm from the radial bursa. (After Hamilton Bailey, "Emergency Surgery," John Wright & Sons, 1936.)

Operation for Suppurative Tenosynovitis of the Little Finger

Incise the ulnar side of the tendon sheath over the two proximal phalanges of the little finger. The incision does not extend beyond the finger where the tendon sheath is not included in the ulnar bursa.

Method of Treating Radial and Ulnar Bursa Infection

Pressure exerted on the palmar part of the bursa, following the incision, will result in pus issuing from the lower end of the incision, confirming the diagnosis. (Bailey.)

As shown in the preceding illustration a second incision is made on the radial side of the middle of the hypothenar eminence beginning at the distal flexion crease. Open the bursa by inserting a director into the sheath from above, incising it close to the ulnar side. Pus is usually searched for over the portion of bursa which continues over the forearm. Divide the anterior annular ligament. Drainage is instituted. If it is deemed advisable, drain the radial bursa also (Fig. 910).

The radial bursa is a continuation of the flexor longus pollicis sheath. Beginning at the base of the distal phalanx of the thumb it courses through the thenar eminence, ending under the anterior annular ligament; its blind termination courses under the flexor profundus digitorum lying on the pronator quadratus.

The symptoms of tenosynovitis of the flexor longus pollicis are characterized

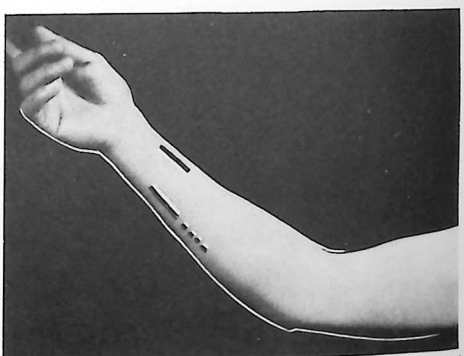


Fig. 909. Infection of the forearm from the palm. Dotted line shows the position of the incision when the pus extends far up in the forearm. (After Hamilton Bailey, "Emergency Surgery," John Wright and Sons, 1936.)



Fig. 910



Fig. 911

Fig. 910. Incisions for draining suppurative tenosynovitis of the fifth digit complicated by ulnar bursitis. (After Hamilton Bailey.)

Fig. 911. Incisions for drainage of suppurative tenosynovitis of the flexor longus pollicis complicated by radial bursitis. The cross indicates the site of maximal tenderness elicited in ulnar bursitis (Kanavel's sign). (After Hamilton Bailey "Emergency Surgery," Wright & Sons, 1936.)

by a bending of the distal phalanx of the thumb accompanied by stiffness and pain over the tendon sheath, the greatest swelling being discerned immediately over the anterior annular ligament. The surgeon should always keep in mind the communication between the radial and ulnar bursae and that there is very little swelling of the palm in a recent secondary involvement. Hamilton Bailey urges that both (the radial and ulnar bursae) should be opened together upon the slightest suspicion (Figs. 908-911).

Technic. Incise the tendon sheath of the flexor longus pollicis on the front of the proximal phalanx; continue the incision through the muscles of the thenar eminence. Continue the incision within a short distance of the anterior annular ligament. Drain.



Fig. 912. Infected frost bite of the hand resulting in osteomyelitis of the index and middle fingers complicated by trophic disturbances. (Surgical Service, Cook County Hospital.)

In cases of long standing or where the infection does not respond readily to treatment, it may occasionally be advisable to completely excise the tendon of the flexor longus pollicis; this is preferable to losing the motor nerve to the thenar eminence (Bailey). In addition to the incision already made, make an incision on the front surface of the wrist a quarter of an inch to the radial side of the midline and on the radial side of the flexor sublimis digitorum. The flexor longus pollicis is identified in the forearm by inserting a probe along the tendon sheath. Separate and retract the tendon until its muscle belly comes into view. Suture the muscle to the wound and excise the tendon.

Make an incision about 2 inches in length an inch and a half above the styloid process of the ulna, thus avoiding the radial artery. A curved, blunt-pointed artery forceps is inserted in the incision. Open the jaws of the artery forceps which are insinuated under the flexor tendons across the flexor surface. Where the radial bursa is affected, a counterincision is made on the radial side of the forearm and the flexor tendon searched for with the surgeon's left index finger. The artery forceps is pushed through the incision until its points are felt by the finger. The distal end of the radial bursa is now punctured; a similar procedure is followed in the case of ulnar bursa infection (Figs. 906-908-909-910-911).

Following the operation, bathe the affected arm in hot salt solution. These immersion baths should be frequent (alternating hours). If, as a result of too much immersion, the hand becomes sodden in appearance, desist from the baths for a while. Paraffin dressings are warmly lauded by Hamilton Bailey. Heliotherapy is a good adjunct. Potassium permanganate irrigations served me well in many of these cases.

Osteomyelitis of an affected finger may be treated by the author's aluminum-

potassium nitrate method (which see) or where urgently indicated, by amputation of the affected digit (Figs. 912-913-914).

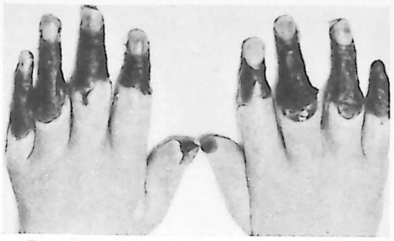


Fig. 913. Frozen fingers. During the acute stage of such a condition linear incisions are sometimes necessary to relieve tension. Avoidance of secondary infection is very important.



Fig. 914



Fig. 915

Fig. 914. Frost bite on hand followed by gangrene (four fingers fell off spontaneously). Observe dry gangrene of the thumb. (Surgical Service, Cook County Hospital.)

Fig. 915. Incision for draining infected terminal pulp compartment. The incision should be well up on the side of the finger avoiding the flexor surface. (After Hamilton Bailey.)

Infections of the Fascial Planes

The pulp, thenar, middle palmar, dorsal subaponeurotic, lumbrical, dorsal subcutaneous and hypothenar spaces may become filled with pus.

When pus accumulates in the dorsal subcutaneous space, it is likely to spread all over the hand. Although the purulent collection is in the palm of the hand in almost all hand infections, the back of the hand is often incised by mistake on account of the swollen appearance it presents.

The hypothenar space is quite independent of any other space or tendon sheath and is unimportant surgically.

Due to pin pricks, etc., the pulps of the fingers and thumbs are more likely to become infected than any other part of the body. The fascial space in this instances reaches from the fingertip to the epiphyseal line of the distal phalanx. It is very important that the surgeon be thoroughly acquainted with this space. Incisions made for pulp infections should extend no further than half an inch from the terminal flexor crease (Fig. 915).

Treatment of Pulp Infections

Hot salt solution baths and fomentations of magnesium sulphate are used until the pulp feels indurated. Place a rubber tourniquet around the affected finger. Make a lateral incision, the distal end of which is curved; after this continue the fomentations. Irrigate with any good nonirritating antiseptic solution. Frequently the diaphysis of the distal phalanx becomes necrotic; remove it. (Fig. 915.)



Fig. 916. Infection in thenar space (dorsal aspect) resulting from stab wound of forty-eight hours' duration. (Surgical Service, Cook County Hospital.)

Thenar Space Infections

The thenar eminence in these cases becomes edematous, while the metacarpal bone of the thumb is forced away from the rest of the hand. The distal phalanx may be flexed.

The thenar space is bounded by the palmar fascia on the palmar side; by the adductor transversus pollicis on the posterior surface and by a fascial septum fastened to the middle metacarpal bone which forms a wall between the thenar and middle palmar spaces (Figs. 916-917).

Drainage should be instituted promptly. Make an incision on the back of the hand as shown in Fig. 918, A; incise on the radial side of the metacarpal bone of the index finger. Insert an artery forceps; pass it across the palmar side of the bone into the thenar space. Do not penetrate beyond the radial aspect of the middle metacarpal. Such drainage is usually sufficient.

The Middle Palmar Space

In this form of infection the hand swells immensely; a slight bulging of the palm is to be noted.

The middle palmar space is bounded posteriorly by tissue fibers which separate it from the interosseous muscles; on the palmar side of the hand a fascial wall separates it from the flexor tendons of the fingers together with their lumbrical muscles. The fascial septum which is fastened to the middle metacarpal bone separates it from the thenar space on the radial side (Fig. 919).

The lumbrical canals of the middle, ring and little fingers lie in the middle

palmar space. The ulnar bursa lies partly over it on the ulnar side; incisions into the palm carry with them the likelihood of infecting the ulnar bursa.

Giving way of the tendon-sheaths of the middle, ring or little fingers may infect the middle palmar space; the latter may also become infected from wounds in the palm of the hand or osteomyelitis of the middle and ring metacarpal bones. Occasionally, the space may become infected, when the fascial septum between the thenar and middle palmar space gives way in case of thenar space infection.

Drainage is the treatment. This is accomplished through an incision of the web between the ring and middle fingers or between the ring and little fingers. Never extend the incision beyond the distal flexion crease. In the presence of



Fig. 917

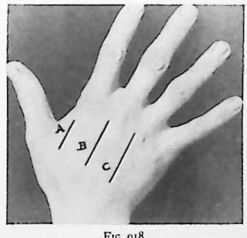


Fig. 918

Fig. 917. Infection in thenar space (volar aspect) resulting from stab wound of forty-eight hours' duration. (Surgical Service, Cook County Hospital.)

Fig. 918. A. Incision for draining the thenar space, B-C, for draining of the dorsal subaponeurotic space. (After Hamilton Bailey.)

free pus, introduce a grooved director along the lumbrical canal. Insert an artery forceps under the flexor tendon and spread it open.

When the middle palmar and thenar spaces become infected simultaneously, drain the middle palmar space. Introduce an artery forceps under the flexor tendons and pierce the septum of fascia which is connected with the middle metacarpal bone. Direct a hemostat superficially to the adductor transversus until it can be seen on the back of the hand between the thumb and index finger. Make an incision here and draw a cigarette drain through the tunnel thus made; a portion of rubber dam thus emerges from each incision; apply hot fomentations.

The Dorsal Subaponeurotic Space

Purulent accumulations rarely occur on the dorsal aspect of the hand. Drainage is the treatment. It is accomplished by two incisions in the inter-metacarpal spaces (Fig. 918, B and C).

Infection of the Middle Palmar and Dorsal Subaponeurotic Space

This type of infection often follows an infected compound fracture of the metacarpal bone or of osteomyelitis. This space is drained by making an incision

extending through the palm to the back of the hand, on the middle palmar flexion crease between the ring and middle fingers. After incising the palmar fascia, plunge a pointed artery forceps through the space between the ring and middle metacarpal bone. Insert rubber drains. Apply fomentations.

The Lumbrical Spaces

The lumbrical canals are the avenues of transmission of pus from the fingers to the palm. They arise from the flexor profundus digitorum tendons; the ex-

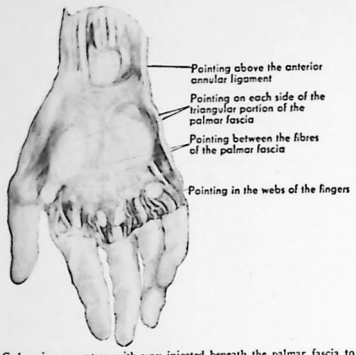


Fig. 919. Cadaveric preparation with wax injected beneath the palmar fascia to illustrate where palmar abscesses tend to find an exit. (From Davis: Applied Anatomy, J. B. Lippincott Company.)

ternal two by one head, and the internal two by two heads. The tendons follow a course around the radial side of the corresponding finger to their insertion in the extensor communis digitorum. Pus often follows in these canals to the dorsum of the web between two fingers.

To drain, expose the lumbrical spaces and divide the web between the fingers.

Paronychia (Onychia, "Runaround")

This is a common, pyogenic infection about the side and root of the finger-nail. Pus accumulates lateral to and along the edge of the nail whence it tends to spread around the nail and beneath it (Fig. 920). The condition tends to be obstinate unless proper surgical care is instituted (Fig. 921).

Abortive Treatment. If seen early the condition may be circumvented by soaking the hand in very hot water to which "green soap" has been added. After ten to fifteen minutes the affected area is gently pushed away from the nail which

is then elevated slightly. This procedure usually discloses a single drop of pus; drainage is then facilitated by cutting away a portion of the overlying nail. Continue hot soaks until pain has virtually disappeared.

Surgical Treatment. When the process has completely encircled the nail lateral incisions are made on each side of the nail bed (Fig. 922); the overlying tissue is reflected back (Fig. 923) exposing the nail root. That portion which has been undermined by pus is cut away, exposing the nail bed (Fig. 924, b). A small gutta-percha wick is laid across the area to keep the wound open. Hot moist fomentations of magnesium sulphate may then be applied to the digit (Figs. 925-926).

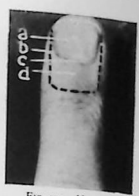


Fig. 920. Normal surface anatomy of the finger: a. body of nail, b. lunula, c. nail root, d. paronychia.

Felon (Whitlow)

This name is given to a variety of acute suppurative inflammations confined to the pulp of the finger tip. The anatomy of the terminal phalanx imparts rather unusual characteristics to the condition. The connective tissue of the distal phalanx forms a closed space encompassing the diaphysis of the terminal

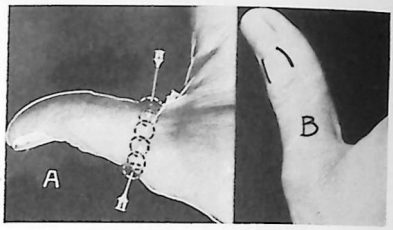


Fig. 921 Fig. 922

Fig. 921. Local anesthesia for operations on the thumb. This may also be used on the fingers in similar fashion. A 1 per cent solution of novocaine is injected subcutaneously around the base of the finger making an intracutaneous wheal at the dorso-lateral aspect. The needle is then passed across the dorsum of the finger in the subcutaneous tissue depositing the solution after the point of the needle advances. Another intracutaneous wheal is made at the dorso-medial site without withdrawing the needle. This is continued until a complete ring of anesthetic blocks the nerves of the respective digit.

Fig. 922. Since both sides of the nail are involved in the average case of paronychia, lateral incisions are made along the lateral margins of the nail.

phalanx; thus suppuration readily produces tension with resulting necrosis of surrounding structures. The epiphysis of the phalanx escapes this process, however, as its blood supply is not affected (Fig. 927, a).

Following a pin prick or minor injury the patient develops sticking pain. As

the distal portion of the finger becomes swollen, tense and red, the pain becomes very severe. The hand is held in a manner to cause the finger to point upward. Because the blood supply to the diaphysis is interrupted very early, necrosis of the

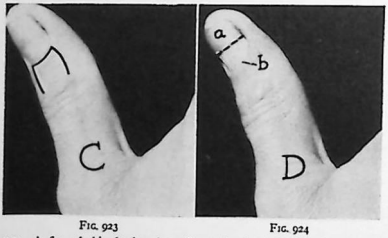


Fig. 923 Fig. 924

Fig. 923. A flap of skin freeing the nail root is dissected and reflected backward. A strip of rubber dam or gauze smeared with petrolatum is laid beneath the flap and left in place for twenty-four hours.

Fig. 924. Where a purulent collection is found under the nail the portion outlined in b is removed leaving the upper segment of the nail.

bone readily occurs. Immediate and complete drainage is the proper treatment.

Operation. Under general anesthesia the tissue space distended by pus is entered from a lateral aspect (Figs. 927, d-e) and opened widely. The condition



Fig. 925



Fig. 926

Fig. 925. Paronychia of little finger resulting from a cut with a wire. Lymphangitis. (Surgical Service, Cook County Hospital.)

Fig. 926. Syphilitic paronychia.

of the diaphysis is investigated and only when the periosteum is completely destroyed is the bone removed (Fig. 927, i). Drainage is instituted by the insertion of a gutta percha or vaseline gauze wick (Fig. 927, g-h). A massive dressing is

placed on the hand and the extremity elevated. Moist heat stimulates healing. The so-called horseshoe incision of the finger is to be avoided.

Volkmann's Contracture

Ischemic Paralysis, Ischemic Myositis, Ischemic Contracture

In 1875 Volkmann described a condition in which the muscles contract following the application of tight bandages in treating fractures. The skin of the

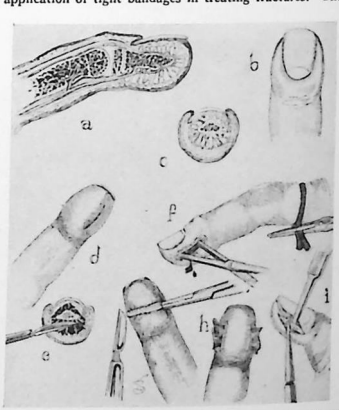


Fig. 927. a. Longitudinal cross section of a normal finger showing the anterior closed space and the blood vessels supplying the epiphysis and diaphysis. b. Normal surface anatomy of the distal portion of the finger. c. Cross section of a finger through the nail region showing the closed space separated into many portions by fibrous septa. d. Lateral incision for treating a felon which avoids the insertion of the deep flexor tendon on the base of the distal phalynx. e. Knife being passed laterally through the pus-filled closed space and severing the fibrous septa. f. Closed space being bluntly opened with resulting drainage. g. Blunt dissection method when bilateral incisions are indicated. h. Vaseline gauze "through and through" to facilitate keeping the wound open. i. Curettement and removal of undetached dead diaphysis.

affected limb turns blue, vesicles appear while the limb itself is very swollen and painful.

Injury near a joint or the application of bandages too tightly result in swelling under the deep fascia thereby obstructing the return flow of blood causing these muscular contractures (Figs. 928-929).

Experiments carried out by Barney Brooks in 1923 proved venous stasis to be the cause of such contracture.

Prevention is the best treatment to prescribe for this condition; however once established physiotherapy and the "banjo-splint" with elastic traction are most

helpful. Surgery, which aims to liberate the muscle fibers and lengthen the contracted tendons, should be employed as a last resort. This is not always successful.

It should be kept in mind that this condition may follow any fracture of the leg or arm and measures should be taken to prevent it, viz., avoid the application of tight bandages or casts.

When the condition is established, the treatment is highly unsatisfactory. If the patient complains of pain, swelling or numbness of the fingers or discoloration following the application of a plaster bandage, it should be promptly released and

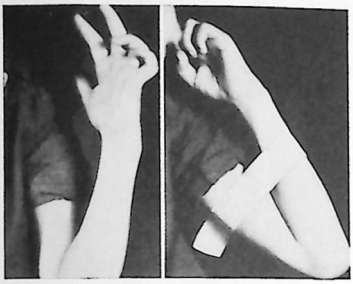


FIG. 928 FIG. 929

FIG. 928. Volkmann's ischemia and paralysis of radial nerve following fracture of the inner condyle of the humerus and forceful immobilization with adhesive straps.
FIG. 929. Same as preceding. Manner in which the arm was immobilized for three weeks by adhesive straps.

reapplied. A dressing which causes pain is not properly applied. Concerning the pathology of the condition little is known. Many theories and deductions have been made but all are more or less conjectural.

Non-operative Treatment. The etiology of this condition being known, it is therefore, avoidable. The treatment should be prophylactic.

The utmost care should be assumed in the application of bandages, splints and plaster encasements in injuries of the forearm and in the region of the elbow particularly in children. Separation of the lower epiphysis of the humerus, which is usually treated with the elbow in full flexion, calls for special care. Avoid tight bandages or splinting. Allow certain movements where increased swelling exists; adjust splints frequently. Watch the fingers for swelling, paraesthesias, impeded circulation, etc. If the deformity is slight, massage, passive motion and physiotherapy are in place. Forcible movements under an anesthetic are of no use. In the more severe forms of deformity the following methods are indicated:

1. **Tendon-lengthening.**
2. **Bone resection.**
3. **Muscle lengthening by "sliding" (Max Page).**
4. **Freeing of nerves.**

In some cases a combination of two or more of these methods may be used to advantage.

TENDON-LENGTHENING

For these see pp. 847-848. Owing to the large number of tendons affected (all the flexors and pronators) the operation is usually long and tedious. Matting of the tendons with resulting weakness and interference with muscular action are likely to occur.[1]

RESECTION OF BONES

Portions of the radius and ulna are excised, the shortening of the forearm thus obtained allows the wrist and fingers to be straightened without interfering with the tendons.[2]

The advantages of this method are (a) the operation is easier and takes less time to perform than tendon-lengthening does. (b) The radius can be drilled and wired in such a fashion as to correct the crippling limitation of supination. (c) The tendons are not interfered with. The chief disadvantage is possibility of non-union.

MAX PAGE'S OPERATION

This is an excellent and effective method of treatment. No attempt is made to lengthen the shortened muscles. The contraction is overcome by "sliding" the origins of the affected flexors and pronators. Max Page described this operation.[3] He has used a similar method in the treatment of contractions in ulnar nerve paralysis, monoplegia and hemiplegia, as well as in ischemic paralysis.

Step 1. Make an incision in the line of the ulnar nerve extending from three inches above the internal condyle of the humerus, passing down the back of the forearm just to the inner side of the subcutaneous border of the ulna, as far as the junction of its middle and lower thirds.

Step 2. Isolate and transpose the ulnar nerve out of harm's way to the front of the joint.

Step 3. Detach systematically the attachments of the whole group of flexors from their origin. Clear the supra-condylar ridge.

Step 4. Separate the common tendon of the flexors from the internal condyle and the internal lateral ligament.

Step 5. At this stage, open the elbow joint.

Step 6. Divide the aponeurosis on the inner aspect of the posterior border of the ulna close to the bone.

Step 7. Raise the separated muscle mass from the surface of the bone with a raspatory. Divide any tendinous origins from the coronoid process of the ulna. Expose fully the insertion of the brachialis anticus muscle. If the flexor longus pollicis is contracted, the process of muscle stripping is carried across the interosseous membrane so that the attachment of this or of the flexor sublimis digitorum can be raised.

Step 8. Divide the bicipital fascia where it offers any resistance to the descent of the muscle group. The separation of muscles and of any tight fascia must be so thoroughly carried out that nearly full correction of the contraction, apart from phalangeal joint deformities, is possible at once. The whole muscle

[1] See Barnard, Lancet, vol. i, 1901, p. 1138.
[2] See R. P. Rowlands, Lancet, vol. ii, 1905, p. 1168.
[3] Jour. of Bone and Joint Surgery, Vol. xxi, 1923, p. 233.

group will be made to descend an inch or more from its origin. Correction usually appears to be more complete a week or two after the operation (Fig. 930).

Step 9. Suture the common tendon to the periosteum of the ulna. Close the wound. Put up the hand in the corrected position on a metal splint. Replace this by a plaster mold after a few days. Following the operation voluntary control of the muscles is at first weak, but is gradually recovered. The postoperative care consists of careful splinting, massage and graduated move-



FIG. 930. Surgical treatment of Volkmann's contracture: Left. The attachment of the flexor communis digitorum to the internal epicondyle of the humerus; Middle. Max Page's operation. Note the tendon of the flexor communis has been separated from the epicondyle of the humerus and is sutured to the periosteum of the ulna; Right. Hamilton Bailey's modification. The epicondyle is sawed through and sutured to the periosteum of the ulna.

ments. The plaster mold is worn for most of the day during the period of muscle re-education so as to enable the extensors to recover their tone.

FREEING THE NERVES

While nerve lesions are not the cause of the deformity, yet secondary affection of the nerve trunks from involvement in connective-tissue proliferation is frequent.

Comment: Jenks Thomas says: "Disturbance of sensation in the hand can only be produced in this way, especially when it is limited to the area of skin corresponding to the distribution of one of the nerves of the arm. The same thing is true of atrophy of the small muscles of the hand, and the presence of the reaction of degeneration in these muscles is positive evidence of involvement of the nerve-trunks. Paralysis of these hand muscles can only be due to nerve involvement, and this point is one frequently overlooked." In such cases considerable benefit may be obtained by freeing the affected nerve or nerves, but it must be understood that in true ischemic paralysis this treatment alone will not suffice.

DUPUYTREN'S CONTRACTURE

Anatomic Considerations (Fig. 931). The Deep Fascia of the palm, known as the palmar fascia consists of three parts, a central and two lateral. The lateral parts, which are thin and weak, cover the muscles of the thenar and hypothenar eminences respectively, while the central part, which is dense and fibrous and triangular in shape, covers the flexor tendons. The apex of the central part is attached to the anterior annular (transverse carpal) ligament, and is there blended with the insertion of the palmaris longus. The base, which lies immediately above the webs of the fingers, divides into four slips, which are inserted partly into the integument and partly into the fibrous sheaths of the index, middle, ring and little fingers

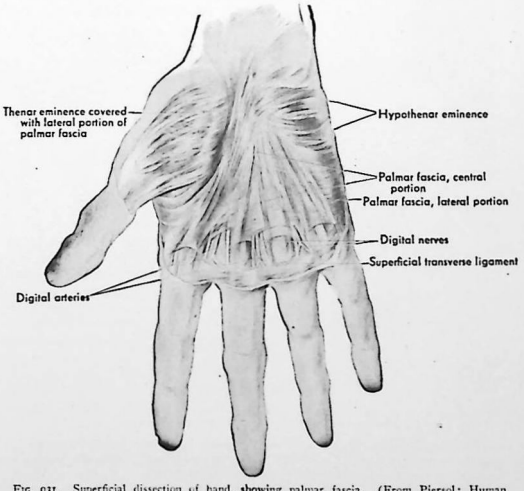


FIG. 931. Superficial dissection of hand, showing palmar fascia. (From Piersol: Human Anatomy, J. B. Lippincott Company.)

respectively. The base of the palmar aponeurosis is strengthened by a number of transverse fibers termed the superficial transverse metacarpal ligament. The deep fascia of the fingers is attached to the sides of the phalanges and interphalangeal joints, and forms the fibrous digital sheaths, which bind the flexor tendons to the

palmar surface of the phalanges. Each sheath terminates just beyond the insertion of the flexor profundus digitorum and there blends with the periosteum of the terminal phalanx.

Dupuytren's contracture (Fig. 932) is the gradual shortening of the palmar fascia causing one or two fingers to become bent (usually the ring and little fingers) though at times it affects all of the fingers. It may involve one or both hands and while its cause is not fully understood the occupation of the individual seems to be about the only place to put the blame. Heredity plays a role.

The characteristic symptoms of this condition are that the fingers are all in flexion; generally it is gradual, however, it may be sudden. The hand is quite painful.

Many different operations have been suggested to relieve this affliction. Keen's operation consists in freely dissecting the fascia and its prolongations. Gill complements this procedure by the use of a flap of fascia lata between the



Fig. 932. Dupuytren's contracture affecting both hands. The patient is a musician 50 years of age.

skin and tendons. The whole surface of the palm may be covered by a full-thickness skin graft after the Italian pedicle method. Complete relief is hardly ever permanent following any treatment, though a great deal of improvement may be attained by interposing, persistent and well directed surgical efforts.

In operating for Dupuytren's contracture the following essentials must be observed (Fig. 933):

1. The skin must be carefully dissected away from the underlying fascia in the area affected. During such dissection, if care is not exercised, the skin will be buttonholed. Liberal undercutting of the remaining skin will usually afford sufficient flaps to cover the denuded area even when the fingers are extended.
2. Thick bands of contracted fibrous fascia must be dissected out.
3. The vinculi (prolongations of the fascia running to the sides of the phalanges) should be divided.
4. Correct the deformity.

5. The patient should wear a splint during the healing process. The fingers during this period must remain in hyperextension.
6. Resort to physical therapy early.

Ely points out that when the band of fascia has been exsected, an attempt should be made to extend the fingers. In advanced cases this will usually be

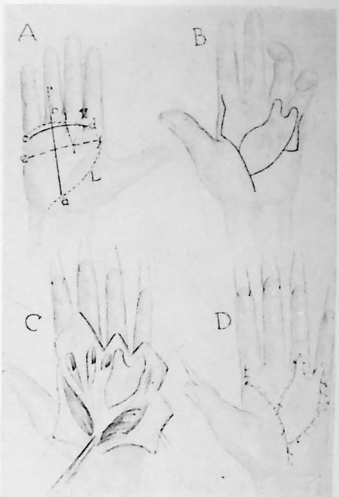


Fig. 933. Operation for Dupuytren's contracture. A. Incisions to expose the palm of the hand, particularly for Dupuytren's contracture; a-b. Hardie's longitudinal incision, dotted line extending to the middle of the second joint of the finger represents Lexer's modification of Hardie's incision; i-i-k V incision of Busch where only one finger is involved; L. Flap with ulnar base; a-b-d-c and a-b-e-f. Lexer's additional transverse incisions for additional flap formation (after Rudolf Nissen). B. Incision circumscribing affected area in Dupuytren's contracture (Lexer). C. Freeing of the exposed aponeurosis together with the involved segment of skin (Lexer). D. Suture of the margins of the wound augmented by a free transplanted skin flap to cover remaining defect (Lexer).

found impossible until a small knife has been slid down alongside the first phalanx and the tense vinculi divided. Care must be exercised not to divide the blood vessels which run alongside the fingers.

ANOMALIES OF DEVELOPMENT AND TUMORS OF THE SPINE

GENERAL OPERATIVE PROCEDURES

Laminectomy

Terminology. Earlier surgeons employed the term trephining the spine. Some refer to the operation as laminectomy, rachiotomy, resection of the vertebral arches and resection of the spine. However, laminectomy is the term used by most surgeons.

Historical Notes. Laminectomy is of rather recent development. Nevertheless, suggestions for the procedure may be found in the writings of Paulus-Aeginetus

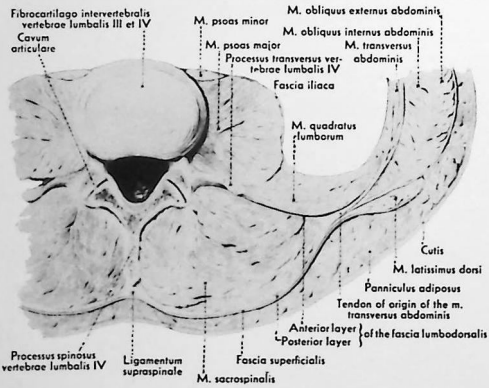


Fig. 934. Transverse section through the muscles of the lumbar region. (From Spalteholz: Atlas of Human Anatomy, J. B. Lippincott Company.)

and Fabricius Hildanus; Louis (1762) was apparently the first to remove fragments of a shattered vertebral arch, the result of a gunshot wound. Sir Astley Cooper suggested it first as a deliberate procedure which was carried out by Cline (1814) in a case of fracture-dislocation of the eleventh dorsal vertebra. Cline removed two spinous processes and one arch. In this case the spinal cord was almost severed completely and the patient died on the nineteenth day after the operation. About 75 similar operations were undertaken up until 1889 in England and America with rather unsatisfactory results.

Jackson of Sheffield (1882) was first to do a spinal decompression operation with satisfactory results on a case of paraplegia occasioned by spinal caries. Macewen (Glasgow) followed suit and advocated laminectomy for paraplegia, thus giving im-

petus to the development of the operation. Gowers and Horsley (1887) removed an intrameningeal tumor. Further study of localization of function of various spinal segments and a thorough appreciation of the effects of trauma and disease caused rapid strides in the development of this procedure.

Anatomic Considerations. Thorough understanding of the anatomy of the spinal column, the spinal canal and its contents is a sine qua non to successful operations in this region.

The spinous processes are fairly thin and well separated from one another. Each spinous process can be removed with comparative ease. In the dorsal region the spines point backward and downward and gradually increase in thickness; they overlap each other to a considerable extent in the upper ten vertebrae. The lower two dorsal and lumbar spines are very short and thick; they are deeply situated between the voluminous paravertebral muscles, and point directly backward. The muscles are thickest in the lower dorsal and lumbar regions (Fig. 934). The blood vessels are not very numerous. Those of the largest size run in the intermuscular septa. The ligamenta flava are very thick particularly in the lower dorsal and lumbar regions. The dura mater enclosing the spinal cord does not contain blood vessels of any considerable size to afford the operator difficulties on that score. However, there is a plexus of veins between the anterior surface of the dural sac and the posterior surface of the bodies of the vertebrae. Here troublesome bleeding may ensue in attempting to separate the dural sac from the posterior surface of the bodies of the vertebrae.

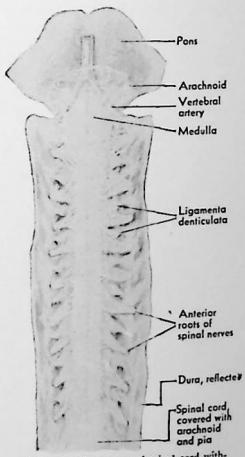


Fig. 935. Upper part of spinal cord within dural sheath, which has been opened and turned aside; ligamenta denticulata and nerve-roots are shown as they pass outward to dura. (From Piersol: Human Anatomy, J. B. Lippincott Company.)

The pia mater closely invests the cord. The arachnoid is separated from the pia by the cerebrospinal fluid. The arachnoid is contiguous but normally not adherent to the inner surface of the dura mater. It is, therefore, usually possible to incise the dura mater without injuring the arachnoid sac.

The nerve-roots and the ligamenta denticulata hold the cord in place in the spinal canal (Fig. 935). The dentate ligament may be used to rotate the spinal cord in order to expose its anterior surface.

The spinal cord terminates at the level of the lower border of the first lumbar vertebra. It must be remembered that in the cervical as well as in the lumbar regions the cord enlarges (cervical and lumbar enlargements). This is important to remember in operating in these areas lest injury to the parts be inflicted.

The principal dangers of the operation are hemorrhage, shock, sepsis and impairment of respiratory function.

PREPARATIONS FOR OPERATION

Preparation of the patient. Bed-sores should be healed, if at all possible, before undertaking operations about the spine. Prepare the field of operation

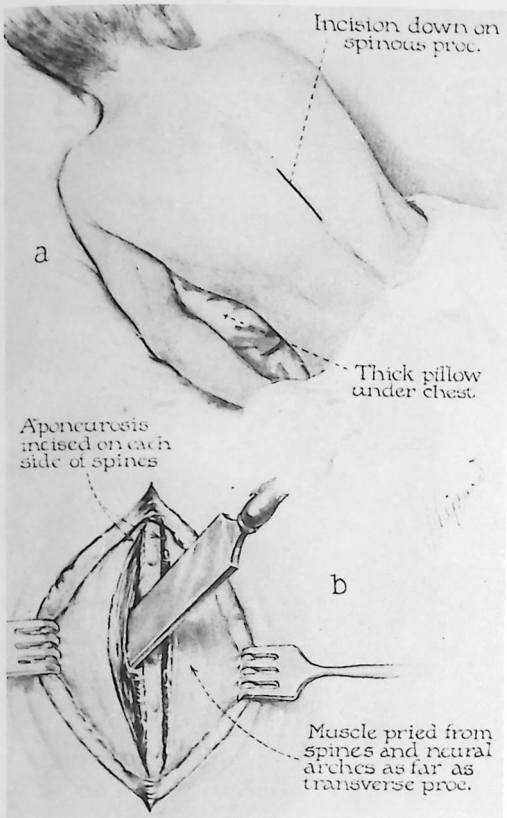


FIG. 936. Laminectomy. a. the patient is placed in a prone position with a thick pillow under the chest to induce kyphosis; b. the erector spinae muscle is raised from its bony attachments with a broad, flat chisel, using the spines of the vertebrae as a fulcrum.

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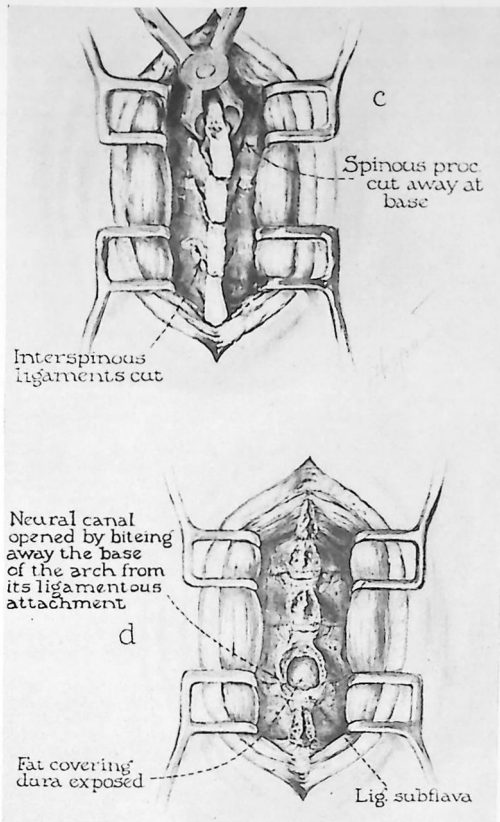


FIG. 936. Laminectomy. c. the spinous processes are seized one by one with bone-cutting forceps and cut away as close to the neural arches as possible; d. showing the first neural arch partly cut away.

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thoroughly. The position of the patient must be prone. The part of the vertebral column to be operated upon must be flexed ventrally as much as possible. This will tend to separate the spinous processes and bring them near the surfaces of the skin—in other words, an artificial kyphosis of the spine should be sought (Fig. 936 a).

Impeded respirations should be avoided. A large firm sandbag or pillow placed at the level of the pubes and iliac spines is essential. Another pillow is

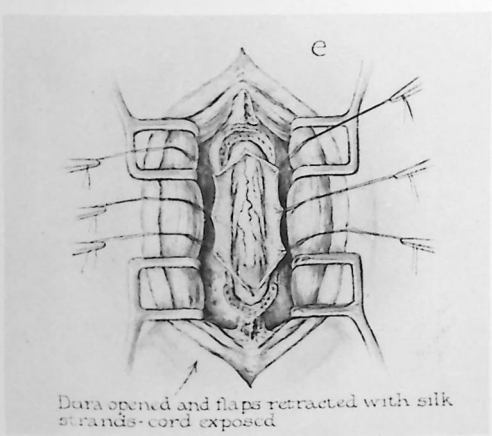


FIG. 936. Laminectomy. e. the cord is exposed showing the posterior root branches of the spinal nerves.

placed under the upper part of the chest and a third (smaller) one supports the patient's forehead (if the cervical spine is to be operated upon).

A good steady operating table is essential. It should be equipped with a reliable cerebellar headrest.

Anesthesia. No matter what form of anesthesia is used, respiration must never be permitted to become impeded. Tracheal insufflation is of great aid, particularly in operations on the cervical spine. Paravertebral, general or rectal anesthesia may be chosen depending upon the indications in a given case. Some counsel infiltration anesthesia (Fig. 937).

OPERATION

Step 1. Make a vertical incision over the spinous processes (Fig. 936 a) this should be at least four inches in length and reach down to the spinous processes proper.

Step 2. Incise the aponeurosis on each side of the spine (Fig. 936 b).

Step 3. Separate with chisel or periosteal elevator the erector spinae muscles from the sides of the spinous processes and from the back of the laminae (neural arches) as far as the transverse processes (Fig. 936 c). Bleeding is usually brisk. Forcipressure and packs usually suffice to control it. Both sides are treated similarly.

Step 4. Choose a point at which to enter the spinal canal. Divide the interspinous ligaments, care being taken, while so doing, not to injure the cord.

Step 5. Cut away the spinous processes at their bases with bone-cutting forceps (Fig. 936 d). The laminae are now completely exposed. Hemostasis (ligation of larger vessels). Place a self-retaining retractor (Frazier) and spread it strongly.

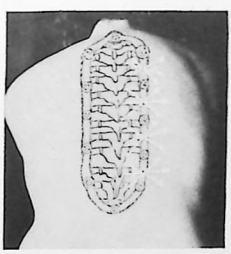


FIG. 937. Laminectomy under infiltration anesthesia (Farr). The wheals show the subdermal infiltration on either side of the spine which are made about five cm. from the midline. The dark points indicate the site for the introduction of the needles and the direction for depositing the anesthetic solution to effect deep anesthesia. After exposure of the structures has been effected, the anesthetic may be augmented by injecting more novocain solution between the transverse processes of the vertebrae. It must be remembered that the cord membranes are very sensitive. Infiltration anesthesia such as described with the blocking of respective nerves often calls for supplementary analgesia by inhalation methods (nitrous-oxide oxygen). For explorations, fractures and dislocations, infiltration anesthesia is excellent.

Step 6. Division of laminae may be accomplished by the following methods:

Method 1. Apply an osteotome to the lower edge of the laminae and with strokes from a mallet drive it through the bone. The long axis of the osteotome is to be kept parallel to the plane of the bone to be divided. If this precaution is not observed the chisel may penetrate and injure the contents of the spinal canal. The incision of the bone should be at right angles to the laminae, otherwise, the chisel may cut its way into the pedicle of the vertebra and much time will be lost. The laminae having been divided, their opposite fellows are treated similarly and the bone removed. As many laminae as are deemed necessary are removed next.

Method 2. Perforate the lamina with a Doyen's burr and complete the division of the bone with bone-cutting forceps.

Method 3. The laminae may be divided with a Doyen's burr.

Method 4. Removal of the laminae by rongeurs (Fig. 936 d). This is accomplished in the midline. The spinal canal is opened by biting away the base of the arch from its ligamentous attachments with proper rongeur forceps. The removal is begun at the lower border of the lowest arch chosen for removal. An

opening (about 1 cm.) is created in the lamina and is made to extend upward to the top of the uppermost lamina to be removed. The fat covering the dura now comes into view. Absence of epidural fat is often the first indication of intradural pathology. Expose the dura. Remove as much of the bone as is necessary in the particular case (fracture, tuberculosis, tumor). Adequate exposure is essential. Remove the laminae close to their attachment. Particular caution is necessary on this point in operations in the cervical region. Hemilaminectomy is often good practice here. Laminectomy is often a bloody operation. The closer one sticks to the bone and the more thorough the stripping of the muscle, the less bleeding. Horsley's wax is used to control bleeding from the cut bone ends. Packs wrung out of hot saline solution will arrest venous oozing. Never open the dura before adequate exposure is obtained through the removal of neural arches. A bluish cord indicates the presence of blood; if yellowish in color the presence of pus is indicated. Increased tension denotes the presence of a tumor: absence of pulsations indicates interference with the subdural space by adhesions, etc.

Step 7. Opening the Dura (Fig. 936 e). The dura is opened in the midline with a delicate bladed scalpel over a grooved director insinuated into the subdural space. Only fine instruments should be used in this procedure. The dura is opened along the entire length of the defect created by the removal of the vertebral arches. The cut edges of the dura are held by silk stay sutures (see illustration) and retracted laterally. Explore. Pathologic conditions are dealt with according to indications.

Step 8. Closure of the Dura. Meticulous hemostasis is essential. The dura is closed tightly with a running suture of fine silk, the stitches being placed about 3 or 4 mm. apart. Dural defects may be patched with fascial grafts. Avoid leakage of cerebrospinal fluid. Painstaking closure of the dura will accomplish this. The dural sac is drained only in the presence of suppuration. Unite the overlying erector spinae muscle with interrupted tanned or chromic catgut sutures. The skin and subcutaneous tissues are closed with interrupted silkworm-gut sutures. Avoid dead spaces. Apply voluminous dressings.

Osteoplastic Laminectomy

Donati admonishes that, "if no tumor is found a careful survey is to be instituted," for arachnoiditis, large varices of the pial vessels, parasitic infections, etc. These may mimic the existence of syringomyelia or sclerosis of the vessels of the spinal cord, etc.

Donati objects to classical laminectomy on the ground that it often entails excessive bone destruction and that it is frequently followed by marked loss of blood and untoward manifestations that persist for considerable periods. He prefers osteoplastic laminectomy which he modified and improved.

DONATI TECHNIC

Step 1. Make a curved incision (Fig. 938 a) beginning in the midline, digressing to the right and returning after its curved excursion to the midline again. Between its two points a sufficient area is embraced for the performance of the laminectomy.

Step 2. Dissect down to the aponeurosis (Fig. 938 b). Incise the musculo-

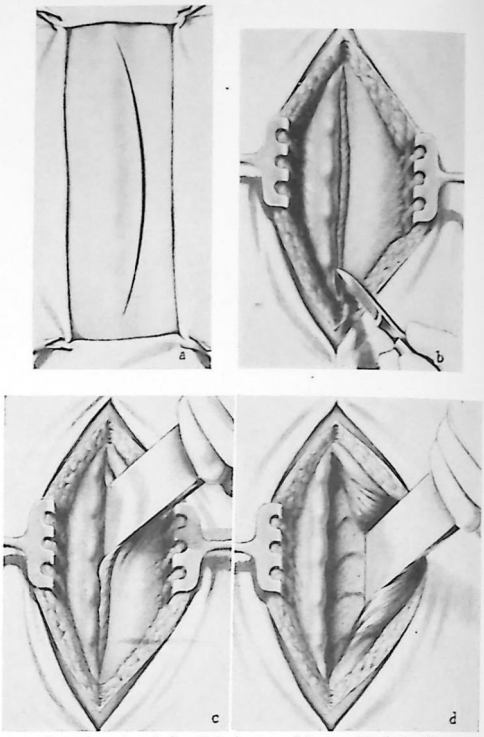


FIG. 938. a, b, c, d. Donati's laminectomy. (Courtesy of Prof. Donati.)

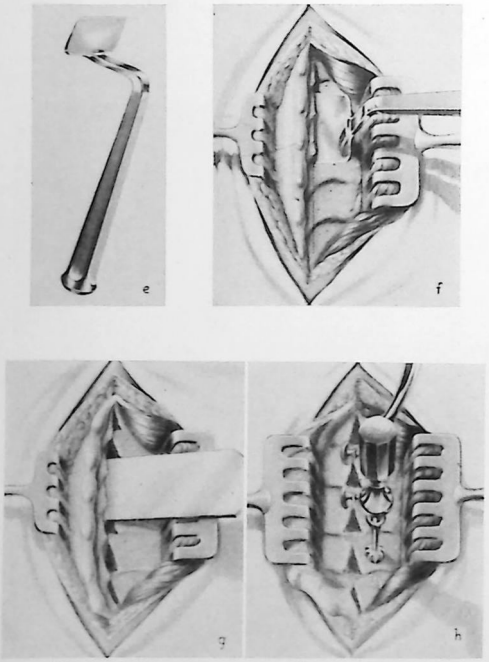


FIG. 938. e, f, g, h. Donati's laminectomy. (Courtesy of Prof. Donati.)

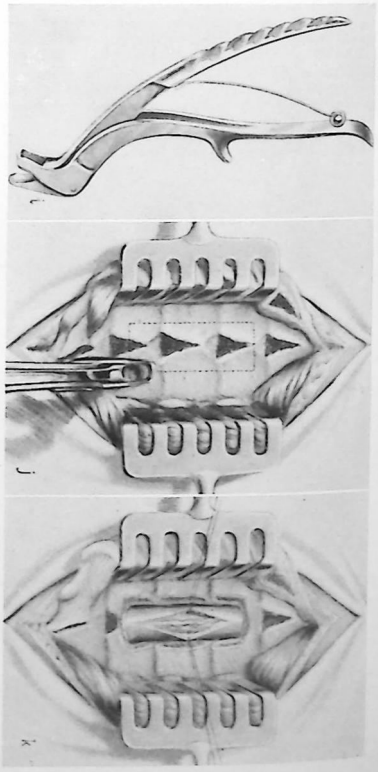


FIG. 938. i, j, k. Donati's laminectomy. (Courtesy of Prof. Donati.)

periosteal structures on the right side with a periosteal knife and separate these from their bony attachments (laminae) to the desired length (Fig. 938 c and d).

Step 3. The spinous processes are divided by a special instrument designed by Donati (Fig. 938 e) which permits perfect sectioning of the spinous processes by reason of the construction of its blade and the angle at which the latter faces the bone to be divided (Fig. 939). The blades of the instrument are of various sizes to suit a given case (Fig. 938 f and g). After the desired number of spinous processes have been removed the procedure of separating the musculo-aponeurotic structures is repeated on the left side of the spine.

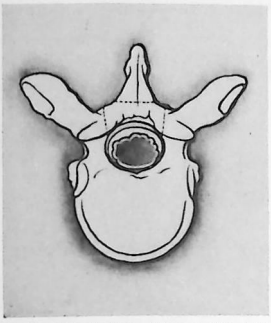


Fig. 939. Donati's laminectomy. (Courtesy of Prof. Donati.)

Step 4. The laminae are next undercut with a Doyen or de Martel drill (Fig. 938 h) creating a large enough opening to permit the introduction of the lower jaw of the Donati laminotome by which the section of the desired osteoplastic flap is accomplished (Fig. 938 i). The laminae are readily sectioned. The flap thus produced permits its displacement in one piece (Fig. 938 j and k).

Step 5. The spinal operation is completed and the dura closed, the osteoplastic flap is replaced and kept in position by interrupted or continuous sutures.

Restitution of the spinal column without weakening it is effectually accomplished by this procedure.

Gaenslen's Simplified Technic in Laminectomy

The important feature of this procedure is that instead of stripping the soft parts and the periosteum from the posterior vertebral spines on either side and then cutting off the spines at their bases, the spines are split longitudinally into right and left halves similar to the Albee operation for insertion of a bone transplant in Pott's disease, except that the halves are deflected on both sides instead of one. This facilitates the separation of the periosteum with attached soft parts from the laminae laterally as far as the articular processes. The posterior spines are split down to their bases, leaving only a small remnant which is cut away with bone-cutting forceps.

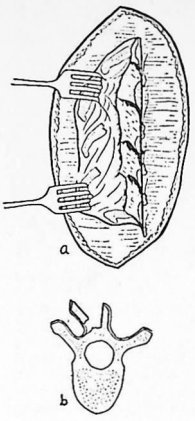


Fig. 940

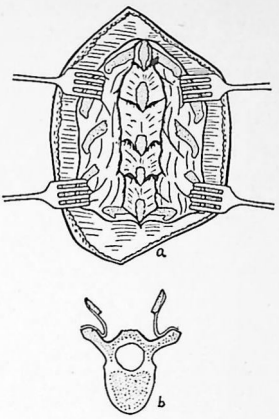


Fig. 941

Fig. 940. Posterior spinous processes: a. split in the middle; the left halves are deflected with the periosteum, leaving the denuded laminae on that side exposed; the right halves remain standing; b. cross section, showing splitting of posterior spinous process and denudation of lamina on left. (Courtesy, Jour. Amer. Med. Asso.)

Fig. 941. Broken spinous processes: a. deflected on both sides, exposing denuded laminae on both right and left; b. cross section. (Couresty, Jour. Amer. Med. Asso.)

Step 1. Make a curved incision to one side of the row of posterior spinous processes through the skin and subcutaneous tissue. Reflect the flap rapidly, exposing the deep fascia on either side of the midline.

Step 2. Make a straight incision with a stout knife down the midline, splitting the supraspinous ligament and incising or at least marking the tips of the spinous processes themselves (Fig. 940).

Step 3. Insert a tenotomy knife between the individual spinous ligaments. Split the spines with a very fine chisel through the line indicated, keeping as close to the midline as possible. Drive the chisel slightly to one side at the base of the spinous process; break the corresponding halves and deflect to one side.

Step 4. Strip the periosteum from the corresponding laminae to the articular processes with a gauze sponge over a periosteal elevator. Break off the standing halves of the posterior spines close to their bases with a chisel, deflect them to the side and strip back the periosteum (Fig. 941).

Step 5. Bite off with suitable forceps the remnant of the bases of the spinous processes and cut through the laminae. Remove the laminae and deal with the spinal contents as conditions warrant (Figs. 942 a, and b).

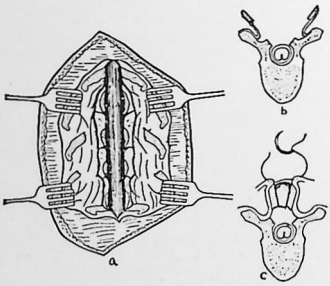


Fig. 942. Laminae removed: a. cord exposed; b. cross section; c. cross section of vertebrae in laminectomized area, showing bone graft in place and suture introduced. (Courtesy, Jour. Amer. Med. Asso.)

Step 6. Closure of the wound is simple. If the split spines are not too thick insert a stout, full-curved cutting needle through the corresponding halves, securing them in apposition. This is not absolutely essential as they will be held by the sutures of the periosteum and dense tissue above and below (Fig. 942 c).

Comment: The chief advantages of this method are the speed, diminished trauma, lessened hemorrhage and better closure.

In some instances it may be necessary to fix the spine with a tibial transplant after decompressing the cord, which is accomplished very satisfactorily following this method of treatment.

SPINA BIFIDA

This condition is due to an abnormal congenital opening in the posterior part or laminae of one or more vertebrae and comprises a number of varieties, the best known being spina bifida occulta and the meningocele (Fig. 943). In spina bifida occulta there is a cleft in one or more of the spinal vertebrae but no protrusion of the spinal cord or membranes. In the various meningocele forms



Fig. 943. Spina bifida (meningocele). Baby, two days old.

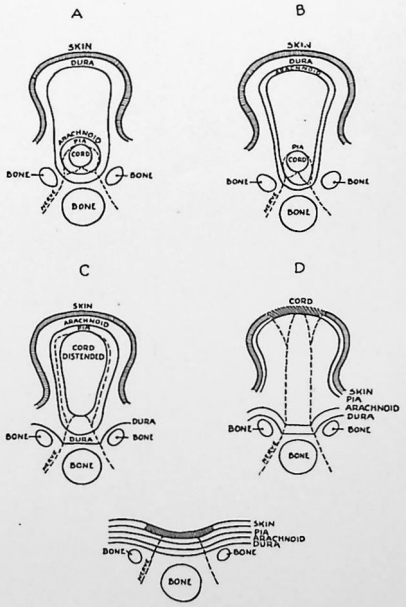


Fig. 944. Types of spina bifida (after Binnie). For details see text.
A. Pachy-meningocele. B. Lepto-meningocele. C. Meningo-myelocele.
D. Complete herniation of cord and meninges (myelo-cystocele).

either membranes or cord or both protrude through the vertebral cleft and form a protruding sac. Here there are defects in both the posterior osseous wall of the spinal canal and in the dura (Fig. 944).

The most generally adopted method of dealing surgically with spina bifida with a sac is by excision of the excisable portions of the sac, the returnable medullary parts being returned to the spinal canal, and the protection of the gap by means of superimposed flaps of muscle, fascia and skin. Many myeloceles are inoperable.

Of the many technics devised by various authors, the methods of Frazier are given here. In the first method, personally devised by Frazier, the sac is exposed by a U-shaped flap, incised, and its contents examined and, if returnable, the medullary portions are returned into the spinal canal. The hernial sac is then excised at its neck. In this procedure, after excising the sac and closing its mouth an incision is made in the erector spinae muscle around the margins of the hernial opening, extending 2 cm. or more above and below the orifice. If the sheath of the muscle and the muscle itself cannot be approximated without undue tension, vertical incisions are made in the aponeurosis of the muscle near its outer origin thus sufficiently relieving tension to make approximation in the median line possible.

A second method in which the names of Frazier and Bayer are associated is characterized by reflected flaps of the aponeuroses. In this procedure curvilinear incisions are made on either lateral aspect of the hernial opening, over the erector spinae muscle, forming an ellipses which enable the surgeon to form flaps having their bases toward the spinal opening. If possible, without endangering the nutrition of the aponeurotic flaps, incisions are made along the margins of the hernial orifice as in Frazier's first method, so that the muscular structures can be mobilized in order that they may be used to reinforce the aponeuroses. This method may be modified so that instead of forming the lateral flaps, a U-shaped flap is formed, the upper aspect raised from the wound with the base downward after mobilization of the muscles. This modification is reserved for cases in which material for lateral flaps is inadequate or is not available, so that great tension would be necessitated.

Spina Bifida Occulta

As there is no protruding herniated mass in this condition, operation may very frequently be dispensed with. However, if symptoms occur from mechanical pressure or any other cause, some attempt should be made to close the bony cleft by a myoplastic or osteoplastic operation. Large bony defects have been effectively closed by muscle flaps alone.

Meningocele

One variety of meningocele appears as an anomaly of the posterior bony structure of the spinal canal. The spinal membranes, skin and cord are affected. Hernia of the dura takes place through the aperture and the subdural space contains a quantity of fluid (Figs. 943-944 A and B).

Another variety has the same characteristics as the one described above except that the fluid is found in the subarachnoid space and the arachnoid is involved in the hernia.

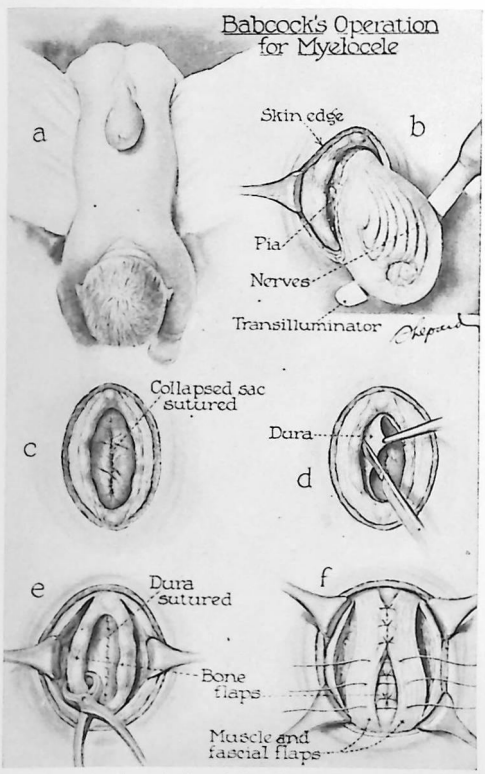


Fig. 946. Babcock's operation for myelocele: a. Child suspended head downward; b. Sac separated from skin edge and position of spinal nerves noted by transillumination. The amount of redunant sac dissected away is determined by the position of the adherent nerve elements; c. Sac or remnant of sac allowed to collapse in the spinal cavity and stitched so it cannot unfold; d. Dura freed from inner surface of the laminae; e. Dura sutured over sac and cord. Laminae divided at base with bone forceps providing flaps for restoration of canal; f. Muscle and fascial flaps brought over sutured laminae. The skin is closed in most feasible manner to prevent leakage.

A third variation affects the dura as well as the bone and the hernia protrudes through these defects, the hernia being made up of the arachnoid and fluid.

Myelo-cystocele

This appears as an abnormality in the posterior bony structure of the spinal canal and part of the dura. The pia and arachnoid are unaffected. Fluid distends the central canal of the spinal cord so that a hernia appears, the sac of which is formed by the arachnoid and pia. Due to distention, the cord is spread in a thin layer over the interior of the sac (Fig. 944 D).

Myelocele

This abnormality involves the skin, posterior bony wall of the spinal canal and corresponding parts of the dura, arachnoid and pia. The back surface of the cord is either split or obliterated. The middle canal of the cord is exposed to the air. The collection of fluid is between the pia and arachnoid anterior to the cord material. If fluid collects in the arachnoid it will form part of the sac and the nerve roots will project forward in the wall of the sac (Fig. 944 C).



Fig. 945. Spina bifida. Position of patient for operation. Same patient shown in Fig. 943 after operation.

Another variety of myelocele has the same characteristics as those described above except that there is no fluid formation. The remaining cord substance is continuous with the skin and lies in a furrow in the back. The meninges are a continuation of the subcutaneous tissues.

Surgical intervention is contraindicated in cases of myelocele or in cases of spina bifida complicated by paralyses or serious abnormalities of the cord substance; also in cases of severe hydrocephalus or abdominal or vesical fistulae.

Step 1. Place the patient in position shown in Fig. 945. Make two skin flaps from the base of the growth large enough to cover the opening which remains after the sac is removed.

Step 2. Make a transverse incision in the sac but do not extend it over the apex of the tumor.

Step 3. Explore. Ascertain whether or not the nerves are enveloped in the walls of the sac. If they are not, trace them to their source in the medullary substance forming part of the sac. The latter is separated from the rest of

the sac and reduced into the spinal canal. Excise the redundant portion of the sac. If meningocele is present, suture the base of the sac and remove it.

Step 4. Unite the edges of the wound with deep and superficial sutures.

BABCOCK'S OPERATION

Place a blanket on the legholders of an operating table and fasten it tightly. Hang the child over this by its groins (Fig. 946 a). Place a hot water bottle opposite the child's abdomen to prevent chilling. Have the assistance of a trained anesthetist. Pure carbolic acid followed by alcohol is used to sterilize the affected regions. The entire region is painted with tincture of iodine.

Step 1. Inject 30 mg. of novocaine or 20 mg. of stovaine, dissolved in ½ cc. of sterile 10 per cent alcohol, into the cephalic portion of the sac. Inject slowly so as to insure thorough mixing of the analgesic with the cerebrospinal fluid.

Step 2. Dissect all abraded or ulcerated parts and sterilize again. Ascertain the location of the nerve filaments and spinal cord so as to avoid them. Liberate and retract the skin from the sac (Fig. 946 b).

Step 3. Pierce the sac. Resect the sac or if conditions permit, let it collapse into the spinal cavity. Fix the sac with a continuous fine chromicized catgut suture so that it cannot unfold (Fig. 946 c).

Step 4. Divide the dural border where it merges with the inner surface of the laminae and separate it from the osseous canal (Fig. 946 d). Restore the dural canal by suturing the mobilized dura over the cord.

Step 5. Expose the borders of the osseous canal and incise the laminae with bone forceps. This forms a strip of bone and fiber on either side of the abnormality. These strips are sutured together (Fig. 946 e).

Step 6. Two flaps of muscle and overlying aponeurosis, fastened above and below are formed from the erector spinae muscles. The two flaps are sutured in the midline. Unite the edges of the wound with mattress sutures so that there is eversion and the skin is brought together so that leakage and necrosis is unlikely (Fig. 948 f).

INTRASPINAL TUMORS

Based upon his own experiences together with a thorough study of the work of other authors, Arnold Jirasek has arrived at the following deductions and conclusions.

With spinal tumors as with brain tumors, a special technic is necessary to meet the particular case. The general principles upon which Jirasek bases his operative technic in intraspinal tumors is as follows:

The patient should be prepared properly. It is of utmost importance to be thoroughly informed as to the function of the urinary apparatus, particularly with reference to the existence of possible infection and kidney function (cystoscopy, ureteral catheterization, x-ray studies of the kidneys, etc.); proper preparation of the skin of the back is of signal importance; particularly is this the case where the patient is afflicted with paraplegia. In severe infections of the bladder as well as of the upper urinary tract, epicystostomy is recommended.

The general condition of the skin can be improved by having the patient lie prone for a few days and proper preparation made of the operative field. The vertebrae to be operated upon must be identified by means of x-rays and their

position marked on the skin surface. The surgeon must be thoroughly informed not only about the urological condition of the patient but of his general physical condition as well.

The patient is placed for operation in a prone position with the head and upper part of the body lower and the side to be operated on higher. This, for the purpose of avoiding excess loss of cerebrospinal fluid. While some do not consider such loss of cerebrospinal fluid of much importance, Jirasek as well as von Eiselsberg, consider it unnecessary and even dangerous. The experimental work of Lamaché-Poulet, Gordon and Saucet (1931) have proved Jirasek's deductions to be correct, and while the latter prefers the position described for operative intervention, Horsley, Bull, von Eiselsberg and Ranzi operate with the patient in the lateral position while de Martel and Leriche perform the operation with the patient in a sitting position. Jirasek prefers local infiltration anesthesia which he states is most satisfactory. He condemns nitrous oxide as an anesthetic for the reason that it causes increased venous bleeding. Heymann used avertin, 0.9 grains to 1 kilogram of the patient's weight, with success, combining this form of anesthesia with local infiltration analgesia and ether inhalation. The incision is made with a scalpel and is longitudinal, overlying the entire area to be operated upon with its convexity toward the surgeon. The muscles are separated from the vertebrae in the midline with an electrosurgical knife. The back portions of the vertebrae are removed completely. Osteoplastic methods are not resorted to except in unusual cases such as where one has to operate in the region of the last cervical and the first two thoracic vertebrae where the spinal cord would not be sufficiently protected after the operation from the replaced soft structures only (Heymann); or in places where the fixed thoracic portion of the spinal column passes into the free lumbar region (von Eiselsberg). Jirasek does not use a chisel or electric fraise. His instrumentarium consists exclusively of Luer forceps.

The bone is removed laterally as far as is necessary for thorough exposure (in the region of the tumor as far as the intervertebral articulations). While formerly, Jirasek was an ardent advocate of hemilaminectomy, he no longer resorts to its use.

Bleeding may become very troublesome during the process of removing the bone, not so much from injury to the vertebral artery when one is operating on the cervical spine (Chipault) but from the veins. Such bleeding is not only hampering to the progress of the operation but may become actually dangerous because of the possibility of air embolism (Fedorov-Višnievsky). Such hemorrhages result from the veins issuing from the inner vertebral venous plexuses and from the circular and longitudinal sinuses from which the blood passes through ventrally stretched veins which are firmly attached to the periosteum surrounding the intervertebral space. By reason of their peculiar anatomic disposition, these veins do not collapse when wounded but remain open. The negative pressure under such circumstances causes aspiration of air which is most marked in the upper part of the azygos veins. According to Fedorov, the area most exposed to air embolism is the region between D III and D V, on the right side especially. Particularly is this true when the operation is performed under general anesthesia. Jirasek stresses the fact that the only way to avoid injuring these veins is to use Luer forceps in such a manner that the inner branch of the instrument is inserted close to the bone and while so doing pushes

the veins aside. When such hemorrhage does take place it should be stopped by compression with a piece of muscle taken from the wound or as suggested by de Martel, with bird muscle. The surgeon should consider the number of vertebrae to be removed, particularly when operating in the cervical or lumbar regions (Frazier). Jirasek removed from the thoracic region as many as nine vertebrae without inconvenience to the patient. Lehmann removed ten vertebrae. Great caution should be exercised in the border-region between the cervical and thoracic and between the thoracic and lumbar areas of the spinal cord.

The surgeon should note with much care the fullness and tension of the dura and its movements as related to respiration and pulse beat. If after thorough inspection and very gentle palpation it does not appear clear whether the tumor is definitely situated in the field of operation, Jirasek's two-needle test is resorted to. In this test two needles of equal size are thrust into the dural sac in the upper and lower portions of the field of operation. The movements of these needles and the out-flow of the cerebrospinal fluid is then carefully noted. One of the advantages of this test is that until proper localization of the tumor has been made the dura remains closed and the loss of cerebrospinal fluid, hampering in the operative maneuvers, is avoided; it also circumvents the danger of sudden loss of cerebrospinal fluid. It is evident that with a closed dural sac there is less danger of injuring the spinal cord inadvertently than when the cord is laid bare. Jirasek described this test first in 1892 before the introduction of Sicard's test. It is based on the observations made by Becher, Ayer, Queckenstedt, Peter, Weigeldt, Stookey and others.

Conclusions to be Drawn from Jirasek's Two-Needle Test. 1. If cerebrospinal fluid issues under the same pressure and at the same rate from both needles and both pulsate, there is either no tumor present or it is so small that it does not encroach much upon the subarachnoid space. Under such conditions, open the dura.

2. If both needles remain quiescent, the cerebrospinal fluid flows from them feebly and under low pressure or, perhaps, no cerebrospinal fluid issues at all, the conclusion to be drawn is that either the needles have entered the tumor itself or have penetrated the space occupied beneath the tumor. Under such circumstances the opening in the spine should be enlarged in an upward direction.

3. Where the upper needle pulsates and the cerebrospinal fluid flows under normal or increased pressure and the rate of flow is more rapid than from the lower needle which pulsates little or not at all, open the dura.

4. If the cerebrospinal fluid issues from both needles with the same rate of rapidity, the upper needle pulsates and the lower one does not, one concludes that a tumor is situated between the needles; the dura may be opened.

5. If no fluid at all issues from the upper needle while from the lower it appears first under pressure and then slackens, the conclusion is justified that the upper needle has either entered the tumor or the lipoidol. Under such conditions after slightly enlarging the opening of the bone in an upward direction, the dura can be opened.

In conjunction with the Jirasek two-needle test, the Queckenstedt test may be carried out. To obtain exact results the needles must be of the same length (about 5 to 7 cm.) of the same width, equally ground, perfectly smooth within and without and manufactured of the same material. They must be inserted in

exact relationship to the region explored with the patient in a horizontal position. Jirasek has observed no ill effects following his test. In arachnoiditis, Jirasek's test is not applicable neither should it be resorted to in cases of hypotension of the cerebrospinal fluid or blood, nor can it be applied in cases where a second tumor separates the spinal from the cerebral system. Jirasek used this test in thirty-one cases. Fifteen of the patients were afflicted with tumors and sixteen suffered from other intravertebral diseases. In spinal tumors he obtained definite information in fourteen out of fifteen cases. In the one remaining case, the result was indefinite and in no instance gave the test misleading information. While no test is infallible, Jirasek's two-needle test is certainly of distinct value in diagnosis of intraspinal tumors and as a guide to proper operative procedures.

When the two-needle test is positive, one can immediately open the dural sac and arachnoid; when it is doubtful or negative, the dura and a visceral leaf of the arachnoid is opened by the Elsberg method. No matter where the tumor is located, it is gently drawn aside by means of a hook, tape or by injecting water at the base of the tumor. Where the neoplasm is located in the intramedullary portion of the spinal cord, one or two posterior nerve roots which are hindering the operative procedure have to be divided. Cocain-block as recommended by Frazier is of definite value, especially in intramedullary tumors. The question of whether to operate in one or two stages has to be decided according to the location of the tumor, its size, outline, depth, nature, etc. If the operation is performed in one stage, it is essential to carefully watch the blood-pressure during the operation and the action of the heart and to interrupt the operation at once if alarming symptoms threaten.

According to Jirasek, probing of the subdural and epidural spaces is more dangerous than informative when the operation progresses well. However, probing is of special importance when multiple tumors are suspected. Jirasek points out that the practice of certain American surgeons who recommend an examination of the penetrability of the spaces above the removed tumor by means of the Queckenstedt test at the conclusion of the operation may not give definite information particularly when much of the cerebrospinal fluid has been lost during the operation. The dura is closed with silk thread. Before closure, however, one must ascertain whether the conditions of pressure are normal (Cairus). When the spinal cord is very edematous following the removal of tumors, the dura is left open; also no closure of the dura is attempted when there is danger of bleeding in the bed of the tumor or when the tumor cannot be removed in its entirety or in cases of malignant tumors, particularly when they are to be subjected to radiation therapy. It is better to resort, in such instances, to a decompressive laminectomy. The admonition of von Eiselsberg (1926) that such decompressive operation is not justifiable is opposed by Jirasek because of his experience that not all cerebrospinal fluid fistulae proved fatal.

The muscles should be united with two rows of sutures. Following the operation the patient must remain in a horizontal position. Extension of the head and lower extremities is resorted to only when the bodies of the vertebrae are damaged. In patients where the operation was not of great severity, Jirasek allows them to get up after about 10 days or a fortnight. Otherwise the confinement is prolonged. In cases where fortification of the spinal column is indicated by reason of loss of support, one may resort to spinal fusion of the Albee type or to the Weigner-Jirasek method of arthrodesis of the intervertebral joints.

In inoperable malignant tumors in this locality particularly where patients suffer from constant pains which cannot be relieved by other means, myelotomy is recommended by Spiller. This is best performed at the level of D IV-D V

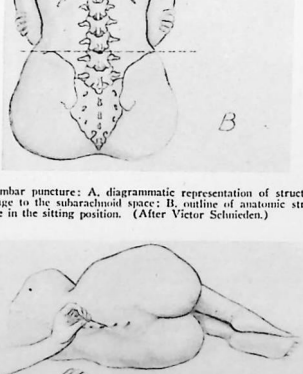


FIG. 947. Lumbar puncture: A, diagrammatic representation of structures traversed by needle in its passage to the subarachnoid space; B, outline of anatomic structures concerned in lumbar puncture in the sitting position. (After Victor Schmieden.)

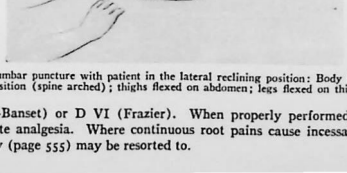


FIG. 948. Lumbar puncture with patient in the lateral reclining position: Body in ventroflexed position (spine arched); thighs flexed on abdomen; legs flexed on thighs.

(Robineau-Banset) or D VI (Frazier). When properly performed the results are complete analgesia. Where continuous root pains cause incessant suffering, ramicotomy (page 555) may be resorted to.

Lumbar Puncture

The technic of puncturing the lumbar subarachnoidean space for diagnosis or therapy is practically the same as that for spinal anesthesia. The patient may be either in the sitting or obliquely reclining posture. (Figs. 947-948.)

Step 1. The skin is thoroughly prepared and the immediate area infiltrated with a few drops of 1% novocain solution. The tip of the spinous process of the fourth lumbar vertebra is marked by the left index finger.

Step 2. The surgeon now introduces a special graduated exploratory needle at a point about 1 cm. to the right and just below the tip of the spinous process; the needle is made to penetrate slowly in a direction forward, inward toward the median line and slightly upward into the interlaminous space between the fourth and fifth lumbar vertebrae. (Fig. 947.) The entrance of the needle into the subarachnoid space should be recognized by the lessened resistance. The needle usually traverses a distance from skin to subarachnoid space of about 2½ to 3 inches. When the needle enters the subarachnoid space, clear cerebrospinal fluid will appear either in droplets or in a stream. A suction syringe needle may be employed instead of the exploratory aspirating needle.

Step 3. The free-flowing cerebrospinal fluid is caught in a suitable sterile receptacle (preferably three sterile test tubes) and not more than from 20 to 30 cc. is withdrawn at a time. The needle is then withdrawn and the puncture site closed with sterile zinc oxide plaster or collodion.

Cistern Puncture

This procedure resembles in part a lumbar puncture but the space entered is that portion of the subarachnoid space termed the cisterna basalis. It is utilized mainly for diagnostic purposes and for administering therapeutic serum in meningitis.

Step 1. Shave the "nape" of the neck from the external occipital protuberance downward. Surgically prepare the skin of this area. Place the patient on his side and flex the neck. Have an assistant hold patient's head firmly.

Step 2. Visualize a line which passes backward from the glabella through the external auditory meatus thus clearing the upper limits of the foramen magnum. Palpate the spine of the axis, and infiltrate the area immediately above it with a 1% novocain solution. Insert the exploratory needle just above the spine of the axis and in the midline. Cautiously advance the needle along the line of direction previously visualized. At a depth of 1 to 1½ inches the "snap" of the dura indicates that the subarachnoid space has been entered. Once through the dura further advancement must be absolutely prevented.

Step 3. Spinal fluid escapes as in a lumbar puncture and the subsequent procedures are the same.

PILONIDAL CYSTS

Postanal Dermoid

The condition is also referred to as pilonidal sinus, pilonidal fistula, sacral dermoid, postanal fissure and sequestration dermoid. Pilonidal cysts are formations containing hair which occur at the base of the spine around the sacrum. The condition is congenital. A small fistula or sinus often connects these cysts with the skin. The sinus opening very often occurs between the end of the coccyx and the anal canal, coursing upward toward the lower end of the sacrum or coccyx. Its location has occasionally been responsible for the wrong diagnosis of fistula in ano. In some cases there are numerous openings leading into cystlike cavities. These sinuses are prone to infection and when once infected are very troublesome. Patients, as a rule, are unaware of the existence of the condition until infection becomes manifest, usually between the second and third decades of life. Lateral openings are often found discharging pus. Incision and drainage, curetment and cauterization are often resorted to, to cure the condition but they prove ineffective. Complete excision is called for to obtain a cure.

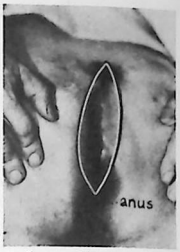


Fig. 949. Pilonidal cyst. Outline of incision embracing all pathologic tissue.

Both sexes are affected but it is more frequent in males. It is rare in negroes. Short hairs are often seen projecting from the openings. A probe or palpation will rarely give a true picture of the extent of the condition. Cysts and cavities are usually deep-seated, the sinuses lying close to the periosteum; the cavities are often multiple.

Palliative measures, as stated, are useless to effect a cure. Prior to operation, explore the sinuses; inject the tracts with methylene blue.

Preceding surgery the proposed operative site should be given special cleansing attention for several days. A very excellent solution for this purpose is that of Scott (Mercurochrome 10; acetone 50; alcohol (95%) 275; distilled water, 175).

Operation. General anesthesia, low spinal or occasionally block infiltration.

Step 1. Make two lateral elliptical incisions as shown in Fig. 949. Extend these incisions to the depths sufficiently to embrace the entire affected area en bloc. See to it that not the slightest vestige of cyst remains; if left behind, recurrence will be the rule.

Step 2. Primary union may now be attempted. All dead spaces must be obliterated. This may be secured where the cyst is small, the wound clean and asepsis assured.

Tension on the sutures is often excessive; however, the wound may become infected, calling for immediate removal of the sutures.

In the vast majority of cases, the best results are obtained by judicious packing of the wound and superimposed closure of the tegumentary segments.

I prefer to dissect down to the bone and undercut the flaps bringing these into easy apposition and thus shortening the time of healing.

Rigid asepsis is imperative. I prefer to lock up the bowels for a few days to avoid possible soiling.

OPERATIONS ON TENDONS AND TENDON SHEATHS

TENOTOMY

This consists of division of a tendon transversely. Tenotomy is used mainly when a tendon is too short, giving rise to deformity. The operation may be performed either by the

(a) open method or by the
(b) subcutaneous operation.

Open Tenotomy

Thoroughly expose the parts to be divided by a liberal incision running parallel with the tendon. Tenotomy knives are used for the purpose. The section of tendon to be severed is divided and the wound closed.

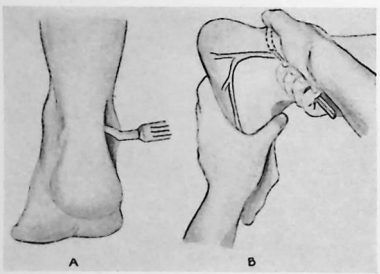


Fig. 950. A, Subcutaneous tenotomy of the tendo Achillis. Note that the tenotome is introduced parallel to the direction of the tendon from its anterior surface. B, The cutting edge of the tenotome is now directed perpendicularly to the tendon; the tendon is made tense by dorsoflexing the foot and it is then divided through by sawing motion as indicated. Note that the thumb palpates the subcutaneous position of the blunt edge of the tenotome. (After Kirschner.)

Subcutaneous Tenotomy

Small narrow bladed tenotomes are used for the purpose. Short, narrow bladed instruments, sharp or probe pointed are used, depending upon existing conditions.

Subcutaneous tenotomy is preferred because of

1. lessened danger of infection and
2. elimination of scar.

Introduce the tenotome through the skin down to the tendon to be divided. Withdraw it. Introduce a blunt pointed knife along the track thus made, turn the cutting edge toward the tendon to be divided; put the latter on the stretch and with a sawing motion divide the tendon. When important structures are placed in jeopardy by the subcutaneous method the open procedure should be resorted to.

Tenotomy of the Tendo Achillis

Step 1. Place the patient face downward and antiseptically prepare the limb to be operated on. Palpate the position of the tendon to be severed, locating its most accessible part.

Step 2. Introduce a sharp pointed tenotome anterior to the tendon (Fig. 950 A). Turn the cutting edge of the tenotome toward the tendo Achillis. Flex the foot, making the tendon tense. Avoid perforating the tendon while introducing the knife.

Step 3. Divide the tendon by a see-saw motion, avoiding injury to the skin (Fig. 950 B).

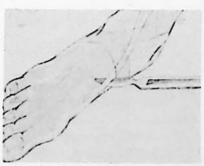




Fig. 951 Fig. 952

Fig. 951. Tenotomy of the tibialis anticus tendon proximal to its insertion and distal to the cruciate ligament.

Fig. 952. Open tenotomy of the tibialis posterior tendon above the internal malleolus avoiding the posterior tibial vessels.

Step 4. Withdraw the knife. Dress and maintain the foot and leg in its corrected position.

Tenotomy of the Tibialis Anticus

Abduction and plantar flexion show the position of the tendon which is divided near its insertion into the internal cuneiform bone. A tenotome is introduced through the skin a short distance from the proximal edge of the tendon. Turn the knife toward the tendon; divide it (Fig. 951). Withdraw the knife; dress the wound.

Tenotomy of the Tibialis Posticus

Divide the tendon about 1½ inches above the internal malleolus. Recognize the tendon by abduction and plantar flexion of the foot (Fig. 952). It is usually divided together with the tendon of the flexor longus digitorum. Avoid injury to the posterior tibial vessels.

Peronei Tendons

These tendons are divided just above the base of the external malleolus. The operation is done subcutaneously; the tenotome is introduced close to the fibula between the tendons and the bone.

Biceps Cruris

The division of this tendon is performed by an open operation in order to avoid the external popliteal nerve which is exposed to injury while doing the subcutaneous operation (Fig. 953). The incision is carried in the direction of the tendon just above its insertion into the fibula.

Semitendinosus and Semimembranosus

These are divided just above the knee joint. The operation is usually performed subcutaneously.



Fig. 953. Course of the biceps cruris muscle and the location for its tenotomy.

Sternomastoid (Torticollis)

1. Subcutaneous and
2. open operation.

1. SUBCUTANEOUS OPERATION

This operation leaves no visible scar; its chief drawback lies in the fact that important structures may inadvertently be injured. The sternal head of the muscle is easily managed; a tenotome is introduced to it beneath the skin; incise the tendon from before backward; the clavicular portion should also be divided (Fig. 954).

2. OPEN OPERATION

This procedure avoids the danger of injury to contiguous structures, but leaves a visible scar. Rotate the head toward the sound side. Beginning at the outer edge of the sternal attachment of the muscle, an incision 1 or 1½ inches in length is made. Divide the tendon completely, including any restraining fascial bands. Careful hemostasis (Fig. 955). Overcorrect (Lorenz); immobilize the head in plaster of Paris, sandbags or other apparatus. Retain the position by an extension apparatus or collar.

Torticollis may also be remedied by muscle lengthening (the well-known Thomas operation) or by myomectomy (Mikulicz's operation) which consists of excising the lower two-thirds of the sternocleidomastoid muscle preserving the upper third to avoid injury to the spinal accessory nerve.

Lengthening of Tendons

This becomes necessary when loss of substance of a tendon causes its shortening. The Z-operation is one of simplicity. Figure 956 illustrates the technical details of the procedure. It consists principally of splitting the tendon longitudinally into two halves for a sufficient distance and then cutting half through on either end of the split in opposite directions. Other methods are shown in Figs. 957-958.

Shortening of a Tendon

This is usually done in various forms of paralytic talipes. Here also the Z-method may be used with the difference that the divided two halves instead of being used to lengthen the structures are shortened by cutting away the redundancy and then suturing as shown in Figs. 959-960.

TENORRHAPHY (TENDON SUTURE)

This may be either primary (recent injury) or secondary (injuries of long standing). Union of divided tendons is usually accomplished by

(a) End-to-end union.
(b) Side-to-side union.
(c) Lateral implantation.



Fig. 954

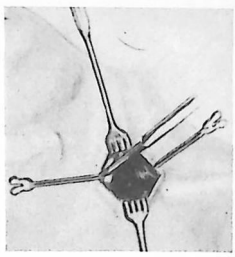
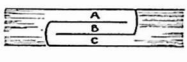


Fig. 955

Fig. 954. Torticollis, subcutaneous tenotomy. Semicircular line on illustration indicates skin incision through which tenotome is introduced to divide affected sternomastoid tendon.
Fig. 955. Torticollis, open operation; illustration depicts division of tendinous (sternal) and muscular (cleidal) portions of the muscle, over grooved directors.





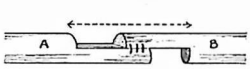




Fig. 956

Fig. 957

Fig. 956. Tendon lengthening by the Z-method.
Fig. 957. Lengthening of a tendon (Hibbs' method): above, the incisions; below, effect of incision on the tendon. The encircling ligatures prevent detachment.

End-to-end union is the most commonly used. It is the method of choice.

Step 1. Sterilize the wound.

Step 2. Incise the teguments sufficiently to allow ample access to the tendons (Fig. 961). If the proximal end of the tendon has retracted, make ample incisions to thoroughly expose it. The palm offers many difficulties. Extension of the hand renders these difficulties greater; flexion and squeezing the muscles of the forearm down and flexing of the wrist are of great aid. In subcutaneous ruptures of the tendons, exposure by incision should be practiced. Incisions for the exposure of muscles and tendons should be parallel to their course. Make the skin incision slightly to the side of a given tendon. Tendon sheaths should also be opened laterally.

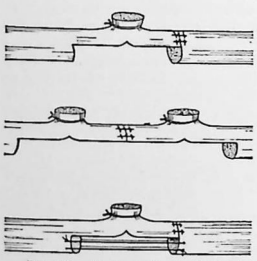


Fig. 958. Above, tendon lengthening by reflected slips; below, reinforcement of reflected slips of catgut sutures.

Step 3. Identify the tendons; grasp each end with non-crushing forceps (Allis). Devitalized, crushed tissues should be trimmed away.

Step 4. Materials for suturing the divided tendons are: round intestinal needles, catgut, silk or Pagenstecher linen. It is not essential to transfix the entire tendon; on the contrary, such sutures may cut through. Lateral sutures properly placed serve the purpose best. Two vertical lateral sutures are the simplest method of tendon approximation. Mattress sutures, reinforced by circular sutures act well. Kanavel's method of tendon suture is effective.

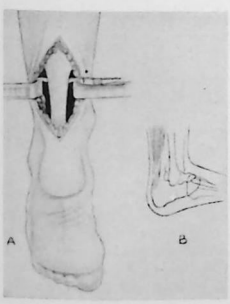


Fig. 959

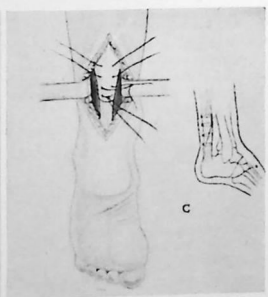


Fig. 960

Fig. 959. Tendon shortening.
Fig. 960. Tendon shortening, completed.

Step 5. Dress the wound. Relax the sutured tendons by position. Avoid pull on the suture line.

FRISCH'S METHOD OF TENDON SUTURE

This is performed as follows: Thread a fine silk suture on both ends of fine round needles. Begin the suture a few centimeters from the divided end of tendon, running a continuous suture line at the margin of the tendon to its end; here the needle emerges at the cut end of the tendon; the other end of the suture is carried along the parallel margin of the tendon (Fig. 962, a). Pass both needles through the cut end of the distal part of the tendon and continue the suture in an inverse direction. Pull both ends together and tie the knot securely. Reinforce the line of suture with interrupted sutures of fine silk or linen.

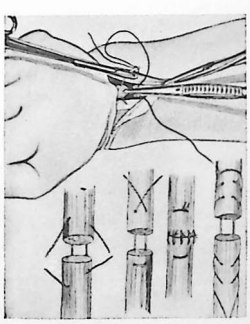


Fig. 961. Tendon suture. Above, suturing an extensor tendon of the forearm; below, different types of tendon suture (after Kirschner).

Secondary Tendon Suture

This presents greater difficulties than primary suture. The problems present are

1. To find the divided ends.
2. To overcome the shortening.

Step 1. Expose the parts with a crescentic incision. Dissect up a flap.

Step 2. Trace the muscular fibers to the injured tendon. Dissect it free. If a sheath encircles the injured tendon, open it laterally, thence trace the tendon to its divided end.

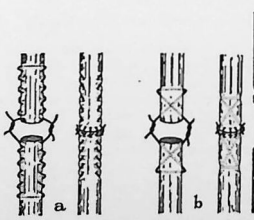


Fig. 962

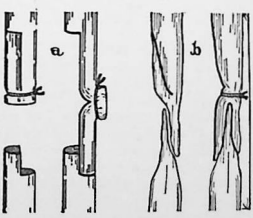


Fig. 963

Fig. 962. a, Frisch's method of tendon suture; b, simple tendon approximation.
Fig. 963. Method of uniting and lengthening tendon.

Step 3. Freshen the edges, if need be. If they cannot be approximated without undue tension, do a Z-lengthening operation (Fig. 963). Join the divided ends. Restore the tendon sheath.

Step 4. If possible, cover and protect the tendon approximation site with a thin fat reflection or transplant (Fig. 964).

Step 5. Unite the superimposed structures. Dress in a position avoiding tension on the sutures; if this is not observed, the sutures will cut out.

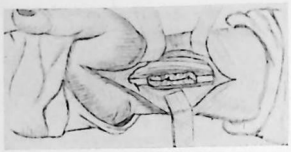


FIG. 964. Fat gauntlet about site of a tendon or nerve approximation (after Koch and Mason).

TENOPLASTY—TENDON IMPLANTATION—TENDON TRANSPLANTATION

This operation is mainly used in paralytic affections (infantile paralysis). In principle the operation consists of detaching a certain tendon from its attachment at one point and its transference and implantation at another point (bone, tendon, fascia). Each case requires special treatment. After a thorough study of a given case, tendon implantation is usually performed by tunneling the healthy tendon and pulling through it the divided end of the paralyzed tendon and suturing it in place (Fig. 965) or, insert healthy tendon into periosteum at site of insertion of affected tendon.

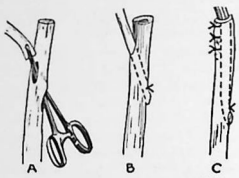


FIG. 965. Tendon transplantation (Robert Jones). A. an opening is tunneled obliquely through the healthy tendon and through this the paralyzed tendon is drawn and fixed in place with interrupted sutures. B. the free end of the receiving tendon is split longitudinally and C. wrapped around the paralyzed tendon, thus assuring better fixation.

Tendon transplantation signifies that a tendon has been totally detached from its insertion, transferred and fixed by sutures to another (paralyzed tendon) or sutured to bone, etc. Free transplantation of a tendon may also prove successful. The tendon used is usually taken from the tendo Achillis.

Tendon transplatation is indicated

1. Where it is desired to strengthen a group of muscles which have become weakened.

2. In conditions where it has become necessary to replace a muscle or group of muscles which have become paralyzed.

3. Where a balance, obstruction or opposing force is needed to counteract an overactive spastic group of muscles.

4. Where perversion of function makes it necessary to influence the tendon action; for example, changing the tendo Achillis to the outer side of the os calcis in congenital club-foot so that the ankle will not be inverted.

5. In cases of partial arthrodesis.

According to H. O. Thomas, a muscle may seem paralyzed while only overstretched and consequently weakened, as in wrist-drop. In this condition the weakened extensor muscles may have completely recovered from their original incapacity but have been stretched and ruled so completely by the flexor group that they will not act, while the flexors on account of no opposition have become contracted. Recovery may be effected by bringing the hand into a position of overextension and keeping it that way continuously for several months.

The seeming paralysis is an important point to recognize when surgical intervention is being considered. A newly transferred tendon is not strong and its point of union in its new location consists of weak scar tissue. Consequently, undue strain is likely to overstretch it, rendering it useless. The newly transplanted muscle should be treated the same as wrist-drop; this treatment should be continued, according to Jones, until "the patient is able by a voluntary effort to make it forcibly act and it can successfully withstand the action of gravity."

Tendon transplantation is indicated in cases of muscular inactivity which does not respond to other treatment. This inactivity may be due to partial or complete paralysis of one or a group of muscles or a lack of balance between muscles functioning on a certain joint, that is, one muscle or group being stronger than another. Transplantation strives to restore balance by transplanting power from the strong to the weak. So that this may be successful, it is necessary that enough strong muscles are within reach of the weaker ones. For instance, it would be useless to transplant a tendon in a condition of flail joint; the loss of power covers too large an area. Transplantation may restore function where the tendon has been lost through accident or disease and direct union is impossible. Always be sure that surgery is indicated, never operate earlier than seven or eight months after paralysis has taken place. Transplantation is used to overcome deformities as well as to restore lost function to muscles.

Partial paralysis about the ankle, characterized by talipes calcaneus, paralytic varus and equinovarus and flatfoot are the most common forms calling for operation. The unbalanced muscular condition in spastic paralysis may be caused by an increase of power in one muscle group and may or may not be accompanied by a diminishing power in the opposing group. Transplantation may also relieve contractures caused by inflammatory arthritis.

The operation should be well-planned beforehand. The muscles which have partially or completely lost their function should be definitely known as well as the source of power available to assist them. In adults this knowledge is gained by observing their voluntary movements; in the case of children they are studied while at play.

Any existing deformity should be corrected before transplantation is done, so as to insure the proper tension and transmission of power. Transplantation should not be attempted until the parts have completely recovered from the corrective operation. In cases where the deformity cannot be completely corrected on account of tendon contracture Vulpius combines tenotomy and tendon splitting at the time of transplantation.

This operation is thought to be overdone by some authors, especially in paralytic flexion of the knee where hyperextension is easily brought about. The gracilis, semitendinosus, sartorius and tensor vaginae femoris may be useful in helping the quadriceps but this assistance is not enough.

Technic. Three fundamental rules must be observed in all cases of tendon transplantation.

First: Joint pathology of any nature must be corrected before tendon transplantation is undertaken.

Second: The tendon to be transplanted must spring from as nearly a normal muscle as can be obtained.

Third: The tendon to be transplanted must reach its destination of insertion in a straight line and pass through subcutaneous fat or a tendon sheath and be inserted directly into bone.

Expose the tendons by means of longitudinal incisions made so that they may be moved over the entire exposed area. The incision should be made to one side of the tendon, not over it. V-shaped incisions require a large amount of skin dissection and often cause troublesome adhesions to form.

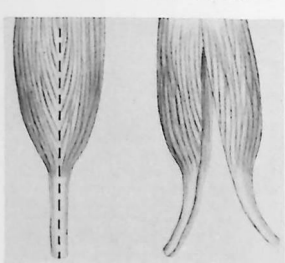


FIG. 966. Method of splitting tendon and muscle for utilization in muscle transplantation.

If the tendon from which the power is being transmitted is a long distance from the tendon on the receiving end, a second incision is made and the tendon is passed from one aperture to the other through a tunnel made with forceps. Close to a healthy, dark-red muscle is seen perhaps a yellowish-white muscle which is very hard to distinguish from the surrounding fat and which is completely paralyzed; another muscle which has atrophied from disuse may present a lighter red shade; in a third muscle, paralysis and atrophy may be manifest in streaks.

A long incision may be necessary to expose the tendon from which the power is being transmitted especially if it is deemed necessary to shape two muscles out of one. In such an instance, the split or incision should be continued well up into the belly of the muscle. This is accomplished by blunt dissection, care being taken that the muscle attached to the respective tendon segment is definitely identified. Thus two muscles are formed out of one (Fig. 966). The route by which the muscle is transmitted should be as straight as possible. For instance, when a flexor of a leg is used to transmit power to an extensor, it may be transmitted through a tunnel in the interosseous membrane.

R. Jones advocates transplanting the tendon sheath along with the tendon for

nutrition purposes and also to prevent adhesion formations to contiguous structures.

It is unnecessary to incise the fascia for the whole length of the wound when exposing tendons through long skin incisions; it is preferred to interrupt the incision in places, thus facilitating a satisfactory union.

Uniting Transplanted Tendons. Transplanted tendons are united in much the same way as divided tendons. The usual methods of transplantation are depicted in Figs. 966-967 and 968. The surfaces should be vivified and the receiving tendon made tense before sutures are applied.

Both the healthy and affected tendons are divided and the peripheral part of the healthy tendon is discarded, thus doing away with the normal function of the tendon. This is recommended only when the normal function of the healthy tendon is undesirable or if it is unimportant.

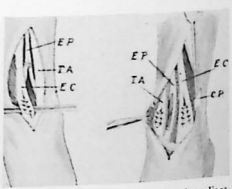


FIG. 967. Tendon transplantation for talipes equinus. E. P., extensor proprius hallucis; T. A., tibialis anticus; E. C., extensor communis digitorum.

R. Jones believes the two tendons should be united as near the insertion of the paralyzed tendon as possible to preclude the possibility of stretching. He recommends planting the healthy tendon into a suitable place in the periosteum instead of the tendon of the paralyzed muscle.

Artificial tendons of silk are used by Lange in his transplantations. Fascia lata may also be used.

When a healthy tendon is too short and where the usual methods of implantation are contraindicated, indirect transplantation may be required.

The tendon sheaths are sutured with very fine catgut; buried sutures are used to unite the deep fascia. After closing the skin, dress and apply firm retentive bandages.

Besides splints, etc., there are many ways by which the transplanted tendon is protected from over-stretching until it becomes functionally competent. Hoffa recommended shortening the paralyzed tendon, thus maintaining the limb in an overcorrected position. Dividing or lengthening the tendons which stretch the newly transplanted tendon is a commendable practice.

Aftertreatment. Following operation, the limb should be immobilized for six to eight weeks. If adhesion formation threatens the rest period should be shortened. The patient should remain in bed for four weeks. After union has taken place, some well-regulated form of physiotherapy is indicated. Passive movements and gymnastic exercises are resorted to as soon as feasible. After the patient begins to walk, he should be supplied with some form of mechanical support or a boot.

Tendon Transplantation for Talipes Equinus Due to Infantile Paralysis

The only muscles involved in this condition are the tibialis anticus and the extensor communis digitorum. The extensor proprius hallucis and the peronei

muscles may be used to transmit power to the muscles which are paralyzed (Fig. 967). It is taken for granted in all operations for talipes equinus that tenotomy or lengthening of the tendon has overcome any shortening of the tendo Achillis.

Method of Transplanting a "Slip" from the Peroneus Brevis Tendon to the Extensor Digitorum Tendon

Step 1. Make a skin incision mesially in a downward direction beginning about five fingers' breadth above the intermalleolar space, curving the lower end slightly inward. Avoid, if possible, the ends of the musculocutaneous nerve which lie in the subcutaneous tissue in the inferior portion of the wound.

Step 2. Divide the deep fascia for the whole length of the wound close to the tendons of the extensor digitorum and peroneus brevis which are readily discerned through the fascia. Dissect the extensor digitorum from its adjoining structures as shown in Fig. 968.

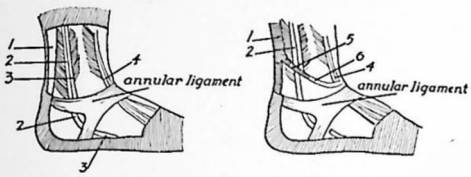


Fig. 968. 1. Tendo Achillis, 2. peroneus longus, 3. peroneus brevis, 4. extensor tendons, 5. slip from tendo Achillis, 6. tendon of peroneus brevis used as a graft.

Step 3. Make an incision about 5 inches long beginning a little below the external malleolus, parallel to and slightly behind the fibula. Divide the peronei sheath and separate the tendon of the peroneus brevis from the surrounding structures.

Step 4. Divide the tendon of the peroneus brevis up as high as possible into an anterior and posterior segment. Sever the anterior segment even with the malleolus. A tendon flap with a superior base results.

Step 5. Form a tunnel connecting the two original incisions. Keep the tunnel close to the external side of the fibula which is denuded for 2 or 3 inches. Draw the tendon flap mentioned in Step 4 through this tunnel so that it comes to rest in the front of the leg.

Step 6. While the foot is bent backward in an hyperextended position, draw the extensor communis tendon upward until it is taut and make a longitudinal buttonhole in it. Pull the peroneus brevis flap through the buttonhole from behind forward and unite as much as possible by suture.

Step 7. After carefully controlling all hemorrhage, close the wound.

Method of Transplanting a "Slip" from the Extensor Proprius Hallucis to the Tibialis Anticus

This operation may be performed independently or it may be supplementary to the procedure described above.

Step 1. (Same as Step 1 in the foregoing.)

Step 2. (Same as Step 2 in the foregoing.)

Step 3. Draw the margin of the incision toward the center. After exposing the extensor proprius hallucis and its tendon, divide the latter into an external and internal segment. Incise the external segment transversely at the lower level of the annular ligament thus obtaining a tendon flap which is fastened to the muscle above.

Step 4. Separate the tendon of the tibialis anticus; retract it upward and bend the foot backward. After making a longitudinal buttonhole in the tibialis anticus tendon, draw the free end of the hallucis tendon flap through it and fasten it as close to the insertion of the extensor tibialis anticus as possible.

Method of Transplanting a "Slip" from the Extensor Proprius Hallucis to the Extensor Communis Digitorum—Shortening of the Tibialis Anticus

Step 1. Make an incision in the midline extending downward from a point five fingers' breadth above the intermalleolar space, curving the lower end of the incision mesially and slightly upward. Incise only the skin, avoiding the ends of the musculocutaneous nerve in the subcutaneous tissue.

Step 2. After dividing the deep fascia, identify and separate the tendon of the extensor proprius hallucis which lies on the inner side of the extensor communis tendon.

Step 3. Divide the tendon of the extensor proprius longitudinally into an external and internal segment. Make a transverse incision in the outer segment even with the inferior border of the annular ligament.

Step 4. While strongly extending the foot, draw the extensor communis digitorum upward. After making a longitudinal buttonhole in this tendon, draw through it the flap made from the extensor proprius. This is firmly sutured.

Step 5. Draw back the internal margin of the wound, exposing the tendon of the tibialis anticus and make it shorter the same as the tendo Achillis as shown in Figs. 959-960 and 967 on p. 853.

Comment: Subsequent to the above operations, Robert Jones believes the removing of skin flaps is of aid in keeping the tendons free from tension. He states: "Personally I see that the deformity of the foot is overcorrected before any operation is performed; and as soon as the tendon is transplanted, as in arthrodesis, I remove an oval skin flap from the paralyzed side so large that when the edges are sewn together the foot remains fixed in an overcorrected position. The removal of the skin flap, I venture to suggest, gives us considerable help in removing strain from the transplanted tendon. The foot by this means, as I have said before, remains in the desired position in spite of any outside influences."

Royal Whitman comments as follows with reference to tendon transplantation in paralysis of club-foot:

"Tendon transplantation is most effective from the curative standpoint when but one muscle of the anterior leg group, for example an adductor or abductor, is paralyzed. The most common form of this milder type is paralysis of the tibialis anticus. As this muscle is the most powerful dorsal flexor and adductor of the foot its loss is followed by secondary equinovalgus. In Parish's operation the tendon of the adjoining extensor proprius

pollicis was simply attached to that of the tibialis anticus, but as the extensor of the great toe is a very weak muscle, its power is hardly sufficient for the double task. A more efficient procedure is to split the tendon of the paralyzed muscle. The outer half is then separated from its muscular attachment, and the distal extremity is carried laterally across the foot and is sutured to all the other tendons. The proprius pollicis is then attached to the inner half. In cases of longer standing and more marked deformity it is well to reduce the power of the abductors by cutting the tendon of the peroneus tertius from its insertion. This is then drawn beneath the other tendons and is attached to that of the tibialis anticus. All of the tendons on the front of the ankle may then be sutured to one another, so that all may act as direct dorsal flexors."

The relative strength of the muscles, as well as their function, should be considered in selecting grafts, and in prognosis also. According to Fick, it is as follows, in kilogrammeters:

Back of the Leg

The calf muscle—gastrocnemius and soleus	8.21
Tibialis posticus	0.40
Peroneus longus	0.44
Flexor com. digitorum	0.37
Flexor longus pollicis	0.82
	10.24

Front of the Leg

Tibialis anticus	1.61
Extensor proprius pollicis	0.39
Extensor longus digitorum	0.72
Peroneus brevis	0.31
Peroneus tertius	0.20
	3.23

"The importance of the calf muscle on the back, and tibialis anticus on the front of the leg, is apparent. The former is nearly four times as strong as the combined posterior group, the latter equal to all the others on the front of the leg. It has been claimed that the transplanted muscle may become hypertrophied, and that its strength may increase sufficiently to carry out its new function, but this is somewhat doubtful."

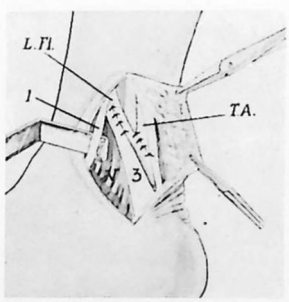
Where the calf muscles have become paralyzed and talipes calcaneus has ensued, and if the muscles are not in a hopeless condition, the applying of Thomas' principles combined with an immobilization of the leg with the foot in a plantar flexion position over a protracted period may give encouraging results. It should be tried before operation is resorted to. Some authors advocate shortening of the tendon. However, it would seem better to furnish new power to the tendon.

Method of Transferring a Tendon Flap from the Flexor Longus Digitorum to the Tendo Achillis

Step 1. Make a 4-inch incision in the midline between the tendo Achillis and the posterior margin of the tibia beginning about 1 inch below the tip of the internal malleolus; extend the incision upward (Fig. 969).

Step 2. Divide the tendo Achillis so as to form a flap of tendon about 2¼ inches long which is fastened to the os calcis below leaving the upper end free.

Step 3. Make an incision in the deep fascia parallel to and close to the back margin of the tibia. Be careful not to injure the tibialis posticus sheath and the vessels back of the flexor digitorum as well as those between it and



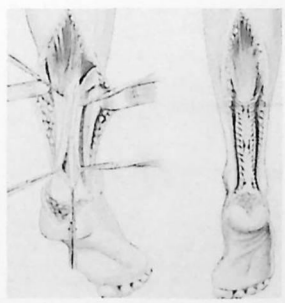


Fig. 969 Fig. 970

Fig. 969. Tendon transplantation. L. Fl., flexor longus; T. A., tendo Achillis; 1. intact portion of the tendon of flexor longus; 3. flap from tendo Achillis.
Fig. 970. Tendon transplantation. (After Berger and Banzet.)

the flexor proprius hallucis. Detach the tendon of the flexor longus digitorum opposite the internal malleolus after exposing it.

Step 4. Make a longitudinal incision in the tendon of the flexor longus digitorum so as to form an anterior and posterior segment. Make a transverse incision in the posterior segment forming a flap with a pedicle above.

Step 5. Place the ankle in a plantar flexion position, laying the tendo Achillis flap and the flexor longus digitorum flap alongside each other, and suture them together.

Step 6. Make the intact part of the tendo Achillis shorter.

Step 7. Unite the edges of the wound; apply dressings, immobilize the ankle in a plantar flexed position.

Method of Transferring a Tendon Flap from the Peroneus Longus to the Tendo Achillis

Step 1. Make a 4-inch incision in the midline between the fibula and the tendo Achillis, beginning 1 inch below the external malleolus and extending upward.

Step 2. After exposing the external margin of the tendo Achillis, form a flap about 2¼ inches long with its pedicle attached to the os calcis below.

Step 3. Make a deep fascial incision parallel to and close to the posterior border of the fibula. Expose and incise the sheath of the peronei muscles. Find the tendon of the peroneus longus lateral to the peroneus brevis tendon (Fig. 970).

Step 4. Form an internal and external segment by dividing the peroneus longus tendon; the external segment is left intact while the internal segment is incised transversely close to the malleolus forming a flap with its base above.

Step 5. Maintain the foot in a position of equinus. Place the flaps which have been formed alongside each other and suture them together.



Fig. 971. Tendon transplantation. (After Labey.)

Step 6. Make the intact part of the tendo Achillis shorter.

Step 7. Unite the edges of the incision with sutures. Apply dressings. Immobilize the ankle in a position of equinus.

Method of Transferring "Slips" from the Tibialis Posticus and Peroneus Longus to the Paralyzed Tendo Achillis (Labey)

Step 1. On the back of the leg, make a forked incision as is depicted in Fig. 971. Turn back the flaps which are identified as ABC, ABD, CBD. Pull back and save the external saphenous vein and nerve external to the tendo Achillis.

Step 2. Divide the fascia, exposing the external border of the tendo Achillis. Incise the peronei sheath.

Step 3. Make an incision in the tendon of the peroneus longus forming an anterior and posterior segment. Insert the peroneus muscle fibers into the tendon, feather-fashion, increasing the upward incision of the tendon and forming two muscular bellies; each belly is attached to a slip made of half of the tendon. Be careful so as not to injure the nerves entering the muscle. Make a transverse incision in the posterior slip of the peroneus tendon as far down as possible (Fig. 972 a and b).

Step 4. Incise the outer side of the tendo Achillis longitudinally. Draw back the edges of the incision forming a furrow. Place the mobilized posterior segment of peroneus tendon into the furrow and suture it in place. (Fig. 972 c.)

Step 5. Make a fascial incision on the internal side of the tendo Achillis. Pull the tendon outward exposing the deep fascia under which the posterior tibial vessels and nerves are visible. Make a longitudinal incision in the deep fascia internal to the vessels and nerves; draw these structures back. Expose the tibialis posticus in the deep part of the wound.

Step 6. Separate and divide the tendon of the tibialis posticus; implant a segment into the tendo Achillis identical with the peroneus longus. The

foot is held in a hyperflexed position during all of these manipulations. (Fig. 972 c-d.)

Step 7. Unite the edges of the wound (Fig. 972). Apply dressings. Immobilize the part and maintain it in a position of hyperflexion.

In some procedures the flexor proprius hallucis may be implanted into the tendo Achillis the same as the tibialis posticus; the peroneus brevis is treated the same as the longus.

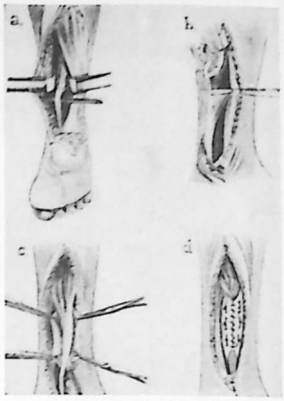


Fig. 972. Tendon transplantation. (After Labey.)

Method of Transferring Power to the Peronei by Means of a Slip of Tendon Derived from the Tendo Achillis (Labey)

This procedure is indicated where the extensor communis digitorum, peroneus longus and brevis are paralyzed and the foot takes on the position of varus.

The patient is placed in a lateroventral position on his sound side. The leg is flexed on the thigh and an assistant holds the foot.

Step 1. Make an incision in the midline between the posterior margin of the external malleolus and the external border of the tendo Achillis beginning ½ inch below a point even with the malleolus and extending upward to a point even with the middle of the calf. Carefully expose and retract the external saphenous vein and nerve.

Step 2. Expose and liberate the external margin of the tendo Achillis. Expose the muscular belly of the outer head of the gastrocnemius in the upper portion of the incision. Detach it from the soleus, while working from above downward, until a point is reached where they are definitely merged and cannot be separated. Plantar flexion of the foot relaxes the tendon.

Step 3. Divide the tendo Achillis with a knife (Fig. 973). The tendon slip

from part of the gastrocnemius above is detached from the soleus. Make a transverse incision far down on the tendon slip forming it into a flap.

Step 4. Make an incision in the fascia over the peronei muscles in the inferior three-fourths of the wound. Separate the peroneus longus and the brevis. Draw back the peroneus longus tendon. Insert the muscular fibers of the brevis into a flat tendon lying over these fibers. Through a longitudinal incision which penetrates half the muscle, draw back the margins of this incision so that the peroneus brevis now forms a furrow where the tendon of the longus is placed.

Step 5. Pull the mobilized flap of the tendon Achillis through between the peroneus longus and brevis and fix it in place securely with sutures. Twist the tendon flap while placing it so that its back surface which is uncut, is against the cut surface of the soleus thus precluding the formation of adhesions.

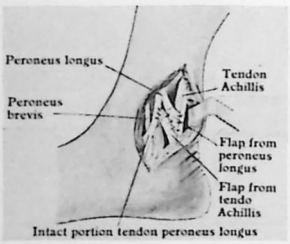


Fig. 973. Tendon transplantation. (After Berger and Banzet.)

Step 6. Unite the edges of the wound. Apply dressings. The part is immobilized, in a position of plantar flexion and outward rotation.

Method of Repairing a Lost Flexor Tendon from the Finger, by Transplantation (Von Hacker)

Step 1. Make a skin flap (Fig. 974 a) exposing the entire palmar aspect of the affected finger, in this case the middle finger.

Step 2. Make two incisions (Fig. 974 b) along the line of the extensor communis digitorum over the second metacarpal bone.

Step 3. Divide the tendon through these incisions, making a long tendon flap pedicled close to the base of the affected finger. Insert this flap through a subcutaneous tunnel to the palmar surface of the middle finger and fasten its end by suture to the periosteum of the ungual phalanx.

Step 4. Place a piece of newly removed hernial sac around the transplanted tendon and in the middle of the finger suture a piece of fibrous tissue from the destroyed tendon sheath across the tendon.

Step 5. Close the wound. Dress

GANGLION

A ganglion is a benign tumor usually occurring on the wrist or ankle; it is occasionally seen on the hand or elsewhere; its contents consist of a mucoid fluid. It is sometimes obliterated by placing it in a prominent position and striking the skin over it. The contents are then absorbed. The reparative processes are aided by the application of a snug bandage (Fig. 975).

The surgical removal of a ganglion is often a complicated procedure. Gen-

eral anesthesia should be used. Rigid asepsis is paramount, for often the tendon sheath harboring the ganglion is opened during the operation. Apply a tourniquet. An attempt should be made to remove the ganglion in toto; to accomplish this, it may frequently be necessary to ablate a portion of the tendon sheath.



Fig. 974



Fig. 975

Fig. 974. Tendon transplantation.
Fig. 975. Ganglion of the wrist.

The obliteration of the ganglion is occasionally attempted by aspirating its contents and injecting an irritant (carbolic acid, iodine, etc.) into the cyst. If this be done great caution should be exercised not to inject the sclerosing solution into the surrounding tissues.

CHAPTER 23

AMPUTATIONS AND EXARTICULATIONS

The term amputation signifies the removal of a part or of an entire given limb. Removal of a limb or a portion of a limb at a joint is spoken of as disarticulation or exarticulation.

Historical Notes. The ancients and Celsus practiced simple transverse division of an extremity. Ligation of vessels in lieu of burning oil or the cautery iron was introduced by Ambroise Paré in 1552. Petit in the eighteenth century introduced the tourniquet which made possible the control of hemorrhage and more deliberate procedures.

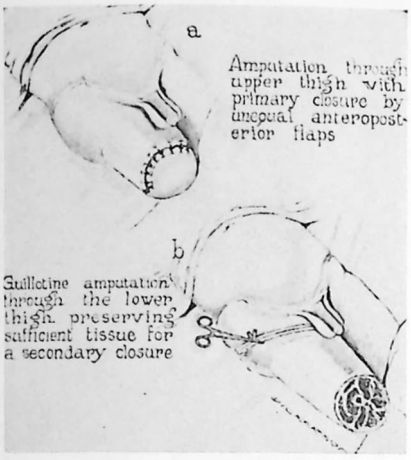


FIG. 976. Amputation through the thigh.

CLASSIFICATION

As to Time. **Primary amputation** is performed soon after the occurrence of the accident (as soon as the patient recovers from shock and before symptoms of infection supervene). **Secondary amputation** is done for removing a useless limb or after infection has supervened.

As to Skin Flaps. (Fig. 976.) **Flap amputation**, where a flap is formed: flapless amputations, where no flap is fashioned such as the amputations of

(1) Celsus and the
(2) Guillotine amputation.

As to Shape of Flap (Fig. 977).

(1) Circular.
(2) Oval or Elliptic.
(3) Racket Shaped.

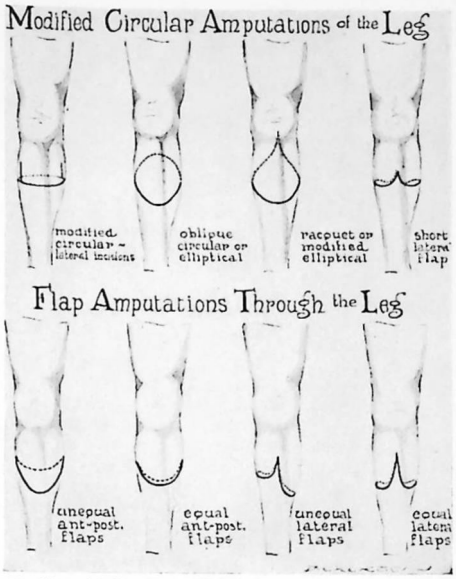


FIG. 977. Lines of incision for modified circular and flap amputations of the leg.

(4) Anteroposterior (equal or unequal length).
(5) Lateral.

As to Periosteum.

(1) Periosteal: Reflection of the periosteum, division of the bone; return of the periosteum to cover the divided end of the bone. This procedure may be followed by a sensitive stump.
(2) Aperiosteal, Bunge's Amputation: Used by most surgeons. This consists of ablation of one or two cm. of periosteum and the ends of the bone are smoothed.

As to Location.

(1) In continuity, through the bone.
(2) In contiguity, disarticulation through the joint.

As to Bone. **Osteoplastic amputation:** When a layer of attached bone covered by periosteum is placed over the divided bone ends to insure an end-bearing stump (Gritti-Stokes, Chopart).

Kinematic or Kineplastic amputations: Introduced by Vanghetti in 1896. The intent here is to direct transmission of voluntary movements from the muscles of the stump to an artificial limb. Artificial points of attachment are made from the muscles of the stump (plastic motors) from which cords transmit movements to the artificial limb. There are three divisions of motors: 1. Claw (clava); 2. Loop (ansa) and 3. Tunneled motors through the muscular masses.

G. Regoli reviewed the results reported in the literature (and a few cases of his own) of kinematic plastics according to the Vanghetti method. He observes that there are difficulties in applying the method (a) because the kinematized individuals do not exercise their muscle stumps; (b) because having undergone one (amputation) experience and generally being in receipt of a pension, they do not care to submit to another operation; and (c) because even with the best prosthesis the alterations in the muscle and other tissues do not always tend to a good functional result. It may, of course, be the other way, i.e., that a good muscular kinematic stump is not fitted with a very suitable prosthesis. Regoli is opposed to kinematic plastics in amputated tuberculous limbs. He sees no ultimate advantage and the tuberculous process in the region of the stump is stimulated. It is, however, advisable in cases of primary amputations. These are all practical difficulties which limit the application of the method.

It often happens that in these kinematic plastic operations the functional results (as regard the stump) are so good that the mutilated individual gets on very well without the prosthetic appliance. Cases of all of these kinds have been observed and reported.

Regoli reported a series of experimental kinematic plastic operations (9 altogether) carried out in dogs. Here, after an amputation, the formation of a kinematic muscle stump was attempted either without or with a band of periosteum reattached to the sectioned bone.

In all experimental animals he noticed in the muscle tissue a subacute interstitial myositis, more or less accentuated; "in the tendon tissue, a phlogistic process with connective neoformation; in the nerves nothing but a slight increase of connective tissue." These histopathologic modifications which are met in the muscles and tendons of kinematized stumps prove that kinematic plastics cause some noteworthy changes in the tissues and that such changes should be considered in estimating the probability of functional results.

AMPUTATIONS IN GENERAL

Surgical removal of an extremity or of part of it may be indicated for several reasons. The limb may be injured beyond repair (here, however, it is a matter of surgical judgment), or even, "surgical luck," for a surgeon who occasionally preserves a badly mutilated limb will get a good anatomic and even functional result. While another, with equal skill and care will not and

sooner or later he will be forced to amputate the affected limb. Severe infection or the presence of an inoperable malignant tumor leaves no alternative to amputation, if the patient can stand the ordeal.[1] In general, it is sound surgical practice to preserve any part of the body if there is any reasonable possibility that the patient's life is not thereby endangered and that at least some functioning of the part will remain. One cannot dogmatize about surgical judgment in such matters as everything depends upon the patient's general condition, the surgeon's experience and type of postoperative care that can be secured in each given case. I have seen limbs crushed and apparently maimed beyond hope, restored to almost normal function.

In every important limb amputation there are two main objectives which the surgeon must bear in mind. First, to remove the useless part with as little shock and sacrifice as possible; and second, to provide a stump which will not only cause no pain or trouble to the patient but will be most suitable for the application of an artificial limb.

The time of removal will depend upon the nature and exigency of the case. Severe hemorrhage, which cannot be arrested; a rapidly spreading infection or severe traumatism with profound shock tasks the judgment of the surgeon to its utmost. While immediate amputation is usually a pressing surgical emergency, the removal of a limb, which is the site of a malignant growth or other incurable condition, may be a matter for more deliberation and planning, in which a certain type of removal or stump formation may be executed.

The method of amputation will almost entirely depend upon the question of immediate necessity or postponed removal. There are several methods differing in their technic so as to provide different types of stumps. If the amputation is one of immediate necessity and the patient is in poor general condition one of the most rapidly executed methods must be selected and of these that which is known as the

Guillotine amputation which frequently (Fig. 976 b) is probably the best and is very often carried out, especially in military surgery. It was much used during the recent World War. In this method the limb is cut clearly through with a circular sweep of a large amputating knife; no skin or muscle flaps are provided; at the same time the bone is sawed through at the same level. A tourniquet should be used or preliminary ligation resorted to. In certain cases this operation is intended as a temporary measure only and a secondary or postponed amputation will usually follow later, if the patient survives. Although surgically such a method is open to some objections, there is often no choice as frequently the situation is a matter of life or death. In civilian surgery there may frequently be time to fashion some large muscular flaps which can be drawn together, quickly sutured, and ample drainage provided.

In postponed amputations the

Circular method (Figs. 978-979-980-981) was formerly much used, the

(1) Skin and subcutaneous tissues being divided around the whole circumference of the limb by a circular sweep of the amputating knife. These are then retracted or dissected back like a cuff and the underlying structures divided in a similar manner.

(2) The soft parts are again further retracted and the deeper muscles

[1] In selected cases of bone tumors Fred H. Albee's method of massive bone transplants is to be considered.

divided; this allows clearing of the bone and sawing it through at a higher level than the original circular incision.

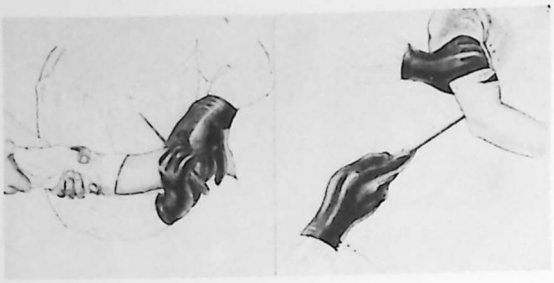


Fig. 978 Fig. 979

Fig. 978. Step 1. Technic of carrying the amputating knife in circular amputation of the arm.
Fig. 979. Step 2. Technic of carrying the amputating knife in amputation of the arm.

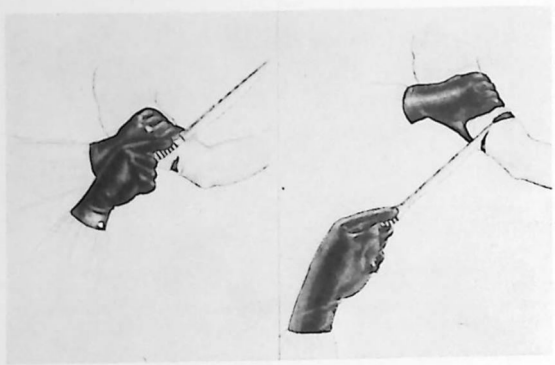


Fig. 980 Fig. 981

Fig. 980. Step 3. Position of the knife in final division of the cutaneous tegument in circular amputation of the arm.
Fig. 981. Final step. Position of the amputating knife.

(3) The end of the bone which is in the center of a conical hollow is thus covered.

(4) The blood vessels must be carefully ligated before removing the tourniquet. The stump, particularly in the lower extremities, except when fashioned with very extreme care, is not usually very shapely and after some time, owing to the shrinkage of the soft parts, the scar is likely to become attached to the bone.

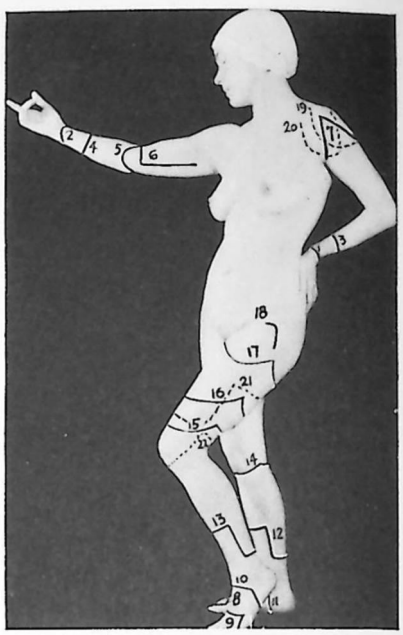


Fig. 982. Types of flaps for various amputations and disarticulations. 1. Amputation at wrist joint (dorsal incision); 2. at wrist joint (palmar incision); 3. at forearm (dorsal incision); 4. at forearm (anterior incision); 5. at elbow joint (anterior flap); 6. at arm (Teale's); 7. at shoulder joint (first method); 8. and 9. at metatarsus (Hey's); 10. and 11. at ankle (Syme's); 12. and 13. of leg posterior flap (Lee's); 14. at knee joint (Carden's); 15. of thigh (B. Bell's); 16. of thigh (Spence's); 17. at hip joint; 18. excision of hip; 19. at shoulder joint by large postero-external flap (2nd method); 20. at shoulder joint by triangular flap from deltoid (3rd method); 21. of thigh (Teale's); 22. by single flap (Carden's).

The Elliptical or Oval method is a modification of the circular method (Fig. 977). Here the incision around the limb is oval, the lower or distal portion of the flap is then dissected up so as to enable the amputation to be completed at a level a little below the proximal end of the oval incision. The free convex

border of the flap is then turned over and fitted into the concavity of the wound.

Another modification of the circular method is called the

Racket Method (Fig. 977) which is more usually practiced in amputation at lower points of the extremities and for the shoulder and hip. In it, an oval incision is made around the limb with one end pointed which, if necessary, is prolonged upward to form the handle of the so-called racket.

The Flap method of amputation is now in almost general use. The flap is made to include the skin, subcutaneous tissue, deep fascia and perhaps some muscle (Fig. 977).

Especially for the lower (weight-bearing) extremity, in and about the knee-joint, to provide a comfortable adaptable stump, the

Gritti-Stokes method (Figs. 983-984) of flap amputation is much employed. In executing this amputation a long anterior and short posterior flap



Fig. 983

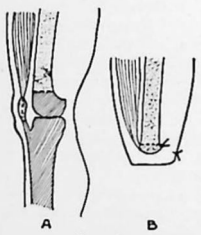


Fig. 984

Fig. 983. Incisions for Gritti-Stokes amputation.
Fig. 984. Supracondyloid femoropatellar osteoplastic amputation of the femur. (Gritti-Stokes).

is made. The amputation is done at the knee-joint where the incisions are made across the tubercle of the tibia. The patellar tendon is severed at its insertion on the tibia and preserved for future use. The anterior flap includes the patella and all other tissues down to the joint. The posterior flap is short and is not dissected up more than 2 or 3 cm. The hamstring muscles are divided just above their insertions and later sutured to the patellar ligament. The patella is turned back and its articular surface sawed off; all synovial membrane is removed. The femur is divided just above the condyles at a point where the cut end of the bone will be approximately the same size as the cut surface of the patella which is then sutured into apposition.

The nerves are shortened and injected with 95% alcohol. Excessive fat and muscle tissue are removed. The patella is sutured snugly to the cut end of the femur by interrupted chromic catgut sutures through the fascia surrounding each bone. The gracilis, sartorius, semitendinosus and semimembranosus

muscles, with the biceps on the opposite side, are fashioned to the proper length and sutured snugly to the patellar tendon; this gives them a new insertion and balances the pull of the quadriceps extensor.

There are other methods of amputation of the lower limb aiming at the formation of a desirable stump, such as for instance the Fourneau-Jordan procedure for the hip joint.

In summarizing what has been said about amputations generally, it is again stressed that sufficient soft tissues must be preserved wherever possible to cover the cut end of the bone. The skin flaps should not be too long and should be protected from gangrene by proper blood supply. It is good practice to drain an amputation stump from its most dependent point for 24 to 48 hours.

Amputation stumps are liable to special pathologic conditions. These are: (a) pain and tenderness which usually persist for some months; (b) wasting or atrophy of the severed muscles which continues until the stump becomes what is termed "consolidated"; (c) infection of the stump which may be present at the time of operation or occur after it, giving rise, sometimes, to sinuses and sequestrae; (d) a persistently painful stump is usually the result of infective neuritis or of an adherent neuro-fibroma (amputation neuroma); (this type of continued pain may be either localized or diffuse; special treatment or even reamputation may be necessary); (e) conical stump results when the soft tissue-flaps have been inadequate to cover the bone properly; (f) adherent and unsound scars usually result from inadequate or improperly placed flaps; (g) sloughing of the flaps and necrosis of the end of the bone stump occasionally occur and are due to infection; and finally, (h) contracture of the muscles around the joint above the amputation is not uncommon and is usually due to spasm following irritation and infection of the stump or a deformity following the bandaging of muscles in a bad position.

In doing an amputation the surgeon must always bear in mind the wearing by the patient of an artificial limb or other prosthesis. Stumps looked at in the light of prosthetic value are of two types: (a) those which may be expected to carry the weight of the body and (b) those which are expected to continue only the motor function of the removed limb.

In the lower extremity the artificial limb is usually secured by lateral pressure against the bony prominences such as the tuberosities of the tibia, and walking is greatly improved if the patient can bear his weight on the end of the stump.

In the upper extremity weight-bearing scarcely enters into consideration. Here it is function that counts and in doing an amputation, abduction of the upper part of the arm must, as far as possible, be guarded against. The joint above the amputation must also be kept movable and not allowed to become stiff. For these reasons it is often necessary and desirable to apply a splint to keep the muscles quiet and prevent undesirable contraction. In an amputation of the forearm the elbow is likely to be overflexed and fixed and extension may be seriously interfered with or lost if a splint is not applied. The same remark applies to an amputation below the knee.

No artificial limb or apparatus should be applied until sufficient time has elapsed to allow the tissues and structures involved in the amputation to become quite consolidated and shrunken to their full extent. Several months may be

necessary for this, although, of course, during a part of this time a temporary apparatus may be worn which will help the patient and the consolidation by active movements, apart from the generally improved mental state in moving about and learning to walk without crutches.

AMPUTATIONS IN THE UPPER EXTREMITY

CIRCULAR AMPUTATION

The circular method of amputation is the basis of all methods of ablating limbs. Amputation of the arm will be described as an example.

Anatomic Points. Retraction of the muscles after section in the upper half is unequal; in the lower half they retract equally (Fig. 985). In order to pre-

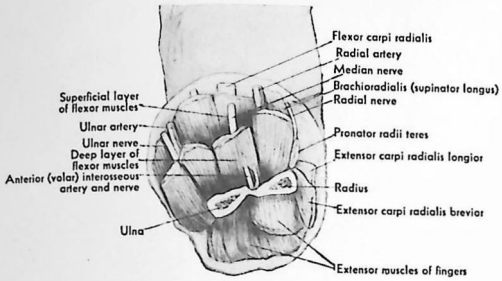


FIG. 985. Amputation about the middle of the forearm. (From Davis' Applied Anatomy.)

serve the usefulness of an upper arm stump a knowledge of the insertion and nerve supply of the deltoid, pectoralis major, and latissimus dorsi is essential.

Step 1. Block anesthesia of the brachial plexus may be used in amputation of the upper extremity. The procedure is depicted in Figs. 986-987-988. The patient is placed recumbent with the arm abducted. Apply a tourniquet near the shoulder. Grasp the arm above the proposed line of incision pulling the skin forcibly upward (Fig. 989 a). Note the point at which you propose to divide the bone and then make a circular incision (illustrations show unequal anteroposterior flaps) through the skin down to the deep fascia at a distance below this point equal to three-fourths of the anteroposterior diameter of the limb. The skin and superficial fascia are reflected upward for a distance of from one to one and a half inches. The remaining soft parts are divided to the bone (Fig. 989 b).

Step 2. A circular incision is now made through the periosteum at the level of the division of the muscles which together with the periosteum are pushed

back with a rugine for about an inch or so. At this level the bone is to be divided. Retract the soft parts with a double-tailed retractor. Divide the humerus with a saw (Fig. 989 b).

Step 3. Ligate the brachial artery and any of its visible branches before the tourniquet is removed. Identify the median, ulnar and musculo-spiral nerves. Inject them with alcohol (95%) and cut off an inch or so of each. Remove the tourniquet. Grasp any bleeding vessels and ligate them. Hot compresses will arrest oozing (Fig. 989 c).

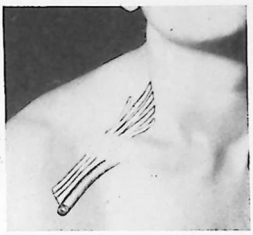


FIG. 986. Anesthesia of the brachial plexus. Relative positions of the subclavian artery and the cords of the brachial plexus in the neck and immediately below the clavicle.

Step 4. Obliterate all dead spaces with properly placed catgut sutures (Fig. 989 d). Close the stump by suturing its edges, converting the circular into a transverse wound. If deemed advisable (dead spaces, doubtful asepsis, incomplete hemostasis) provide drainage for a day or two with a tube or cigarette drain.

Comment. Where, because of the conical shape of a limb, it is difficult to reflect the tissues upward sufficiently through a circular incision, the

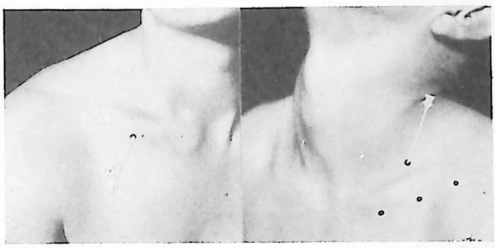


FIG. 987 FIG. 988

FIG. 987. Block anesthesia of the brachial plexus by subclavicular approach showing the point of introduction of the needle under the clavicle.

FIG. 988. Block anesthesia of the brachial plexus, supraclavicular approach. The needle is introduced above the clavicle as shown at the black point above. The points below the clavicle are for purposes of orientation.

difficulty may be promptly overcome by making lateral incisions through the soft structures. A racket incision is thus produced and the amputation

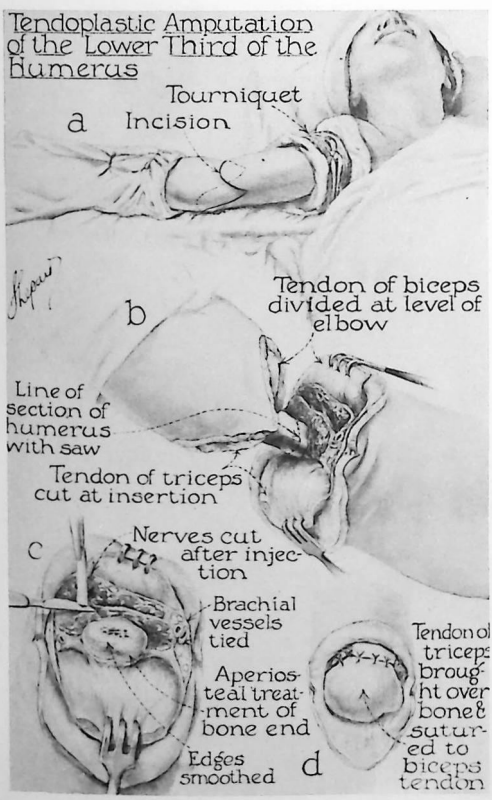


FIG. 989. Tendoplastic amputation through the humerus.

performed by two equal flaps or the oblique circular method of Kocher may be used. Fig. 989 illustrates the steps of the tendoplastic method of amputation of the lower third of the humerus and suturing the triceps to the biceps tendon.

DISARTICULATION OF THE SHOULDER JOINT

Historical Notes. To Morand is ascribed the first circular disarticulation of the shoulder joint in 1710. In 1775 LeDran the elder used an axillary flap; a posterior flap was used by Sharp in 1740 for disarticulation. Dupuytren is given credit for having developed the deltoid (external) flap. Paroisse (1800), Grosbois (1803) and Charles Bell (1808) have contributed to the development of the operation. V. Walther in 1810 used a long deltoid and a short internal flap. Guthrie in the early part of the nineteenth century employed the oval method; Scotetten used the same method in 1827. In 1865 Larrey used the external racket and Spence, the anterior racket incision. Larrey during the Napoleonic wars in one hundred disarticulations of the shoulder joint lost only ten patients! Quite a record in those days.

Control of Hemorrhage During Shoulder-Joint Disarticulation

1. **Ligation of the Vessels.** This is the simplest and most effective method. The axillary vessels are ligated under the coracobrachialis muscle. The subclavian artery may first be exposed and a temporary clamp applied. In large vascular tumors about the head of the humerus the subclavian artery may be ligated as a preliminary measure.

2. **Digital Compression of the Subclavian Artery** is unsatisfactory, because the movements of the shoulder during the operative manipulations will interfere with successful compression.

3. **Control of Hemorrhage by Elastic Constrictors.** The constrictor is made to surround the shoulder, back of the coracoid and acromion processes and there secured. However, the constrictor may slip. To obviate this, the loop of a bandage may be passed under the constrictor and the constrictor pulled toward the opposite shoulder. The tubing of the constrictor may be applied with a double turn around the shoulder and fastened by a figure of eight across the chest or under the axilla. Wyeth's pins method may also be used to prevent slipping of the constrictor. These methods are not recommended because with the Wyeth pins or figure eight elastic constriction violent hemorrhage may occur as the bone is removed. It is well to remember that when amputating for malignant disease, it is better to sacrifice too much in preference to too little and if during the operation a great deal of tissue has been sacrificed, flaps can subsequently be taken from the chest to cover the defect.

Spence's Operation or Racket Method

Step 1. The arm is slightly abducted and rotated outward. An incision is made from a point just external to the coracoid process down through the clavicular fibers of the deltoid and pectoralis major muscles, the humeral attachment of which is divided (Fig. 990). The incision is now curved outward and backward as far as the posterior border of the axilla. The incision penetrates to the bone dividing the lower part of the deltoid.

Step 2. A similar incision is made around the inner (axillary) side of the arm. Here only the skin and superficial fascia should be divided. The inner incision does not reach as low down as the outer one.

Step 3. The outer flap is now separated from the bone and joint and is re-

tracted upward exposing the head and tuberosities of the humerus (Fig. 991 a).

Step 4. The capsular muscles are divided by carrying the incision directly over the tuberosities and head of the humerus. Treves pointed out that by thorough retraction of the outer flap and close hugging of the bone with the knife, injury to the posterior circumflex artery is avoided. This is important because if injured, the vessel is not easily secured and its obliteration endangers the nutrition of the deltoid muscle and skin.

Step 5. The head of the humerus is now dislocated from the glenoid cavity (Fig. 991 b). Divide the posterior part of the joint capsule by keeping the

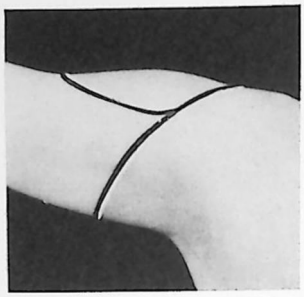


Fig. 990. Incision for Spence's disarticulation at the shoulder joint. All of the incision with the exception of the inner limb is extended down to the bone.

knife close to the bone. The remaining tissues on the medial side are divided from within outward. An assistant grasps the tissues in such a manner as to control hemorrhage by compressing the vessels. The axillary vessels are now doubly ligated and divided. Cut the axillary nerves first. Remove all synovial membrane. If this is not done, discharge of the synovial fluid will delay healing (J. Hutchinson, Jr.). Close the wound (Fig. 991 c).

Larrey's Operation

In this procedure the shoulder is disarticulated by an external racket incision.

Dupuytren's Operation

This is performed by an external U-shaped flap and a short internal flap which extends about 5 cm. below the axilla.

Fourneau-Jordan's Operation

This is performed by first applying an elastic constrictor high up. The soft parts are divided down to the bone, 3 to 4 inches below the axilla as in the typical circular amputation. The vessels are secured. A longitudinal incision is now made along the outer and posterior aspect of the limb at right

angles to the circular incision; the tissues are divided and the disarticulation completed.

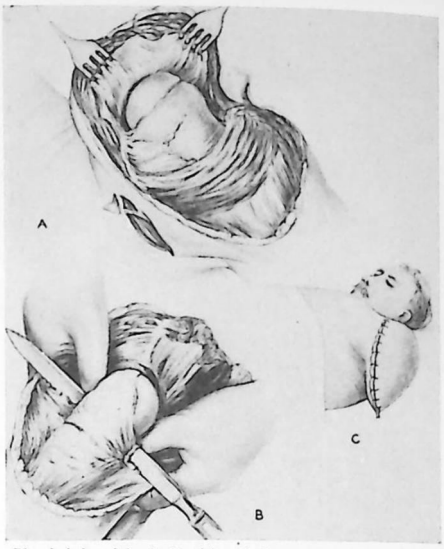


Fig. 991. Disarticulation of the shoulder joint. A. Head of humerus exposed. B. Head disarticulated. C. Closure (after Spence).

INTERSCAPULOTHORACIC AMPUTATION
(Berger's Operation)

This operation is also referred to as the fore-quarter operation and consists of the removal of the upper extremity together with the scapula and a portion of the clavicle (Fig 992).

Historical Notes. The first operation of this type is credited to Ralph Cuming, an English naval surgeon in 1808. Dixi Crosby, an American surgeon performed it in 1836. In 1837, Mussey disarticulated the sternal end of the clavicle (compressing the subclavian vessels). In 1886 Kocher performed the operation for tumor. In 1887, Berger published his extensive monograph which did much to popularize the procedure. It has since been known as Berger's operation.

Indications:

(a) Severe extensive injuries of the shoulder girdle.

(b) Malignancies of the arm, scapula and axilla.
(c) Advancing cellulitis, gangrene, etc.

Berger-Faraboeuf's Operation

The application of a tourniquet, of course, being out of the question, Berger pointed out that the success of the operation depends upon the control of hemorrhage. The form of the incision must of necessity depend on the configuration of the healthy teguments. A lanceolate incision with the antero-

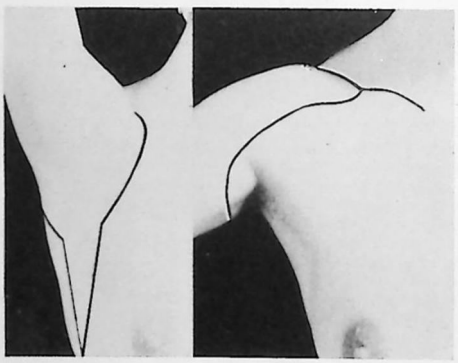


Fig. 992 Fig. 993

Fig. 992. Interscapulothoracic amputation, anterior portion of the incision.
Fig. 993. Interscapulothoracic amputation, skin incision.

inferior (pecto-axillary) and a posterosuperior (cervicoscapular) flap is the incision of choice. The operation may be divided into three stages or steps:

1. Exposure and ligation of the subclavian vessels.
2. Dissection of the flaps.
3. Removal of the limb.

Step 1. Make an incision down to the bone along the upper surface of the clavicle from the sternal end to the acromial end. Dissect off the soft parts. Berger divides the clavicle at the junction of its outer and middle thirds. The middle third of the clavicle is resected. Avoid damage to the subclavian vessels while clearing the clavicle and stripping the subclavius muscle. Keep the rugine close to the bone. The bone may be effectually divided by slipping a Gigli saw under it and sawing it through. The axillary vein will be found immediately behind the subclavius. The artery lies posterior and below the nerves. Ligate the artery and then the vein and divide them between double ligatures. Identify the scalenus anticus muscle and ligate the branches of the subclavian artery (ascending cervical, superficial cervical,

suprascapular and transversalis coli) as they pass outward in front of the muscle. Divide the brachial plexus. Before dividing, each trunk of the plexus is injected with some novocaine solution (1%).

Step 2. Formation of the Flaps: Draw the arm well away. From about the center of the incision on the clavicle mark out a flap, the convexity of which is directed toward the point of the shoulder. It passes the deltoid muscle outside the tip of the coracoid process, then curving down across the inner aspect of the arm to its junction with the posterior fold of the axilla (Fig 993).

Now, an assistant raises the arm almost vertically, pulling it forcibly upward thus exposing the back of the thorax. The scalpel is now carried downward and inward to the inferior angle of the scapula. Only the skin and deep fascia are divided. The pectoralis major is next divided in the line of the anterior incision. Open the fascia covering the axilla, examine its contents and strip the neuro-vascular structures encountered out of the way. Deepen the incision around and toward the back. Divide the latissimus dorsi. This completes the formation of the anterior flap.

The arm is now forcibly drawn across the chest, to the opposite side, to expose the back. Prolong now the clavicular incision from the tip of the acromion process over the shoulder almost vertically downward to meet the end of the first incision at the inferior angle of the scapula. Divide the trapezius throughout its entire length. Dissect the inner lip of the posterior flap exposing the vertebral border of the scapula.

Step 3. Detach the trapezius from the upper border of the clavicle and the acromion process of the scapula. Rotate the arm outward; this will expose the muscles on the ventral surface of the scapula. Divide the attachments of the levator anguli scapulae, serratus magnus, and rhomboid muscles at the vertebral border of the scapula. Draw the arm outward and so complete the separation by dividing the omohyoid muscle at the upper border of the scapula and the trapezius at the spine. Drain. Close the wound. Apply voluminous dressing.

Le Contes' Operation (1900)

This consists of disarticulating the sternal end of the clavicle instead of resecting the bone. The operation is mainly used in malignancies about the shoulder.

SPECIAL AMPUTATIONS AND DISARTICULATIONS
Amputation and Disarticulation of the Fingers

Comment: Endeavor always to retain a stump, no matter how short, provided the tendons are attached and a proper skin flap can be made. "A single finger," H. H. Lyle reminds us, "or a stump of a finger capable of some function is better than the best artificial hand." Wherever possible, amputate through the phalanx instead of doing a disarticulation (Fig. 994). When it is possible to suture the divided ends of the flexor and extensor tendons the patient will be able to move the stump. The knuckle corresponds to the head of the proximal phalanx; the joint line is, therefore, below the knuckle. Make palmar flaps; they are preferable. The scar

should be on the dorsum of the hand. Avoid having the scar adherent to the end of the stump.

Amputation of the Distal Phalanx

Flex the finger strongly. Incise as shown in the illustration. Enter the joint. Disarticulate the phalanx. The flap is made from tissues of the flexor aspect.

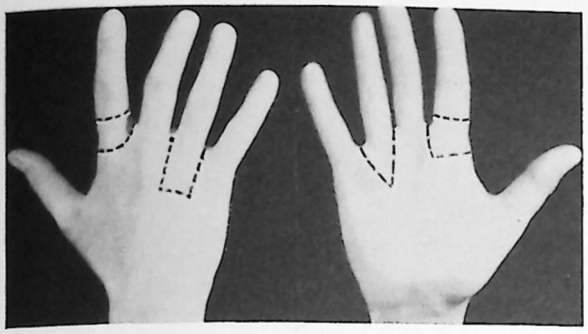


Fig. 994. Lines of infiltration of anesthetizing fluid in amputation of the fingers.

Amputation Through the Proximal or Distal Phalanges

This is performed as above. Reattach the divided tendons. Use a saw in dividing the bone. Rongeurs cause splintering.

Amputation Through the Metacarpal Bones

Here a long palmar flap should be used whenever possible. This also holds true in amputations through the wrist.

Disarticulation at the Phalango-Metacarpal or at the Metacarpo-Carpal Joints

The illustrations, Fig. 995, depict the procedures. The incisions are made on the dorsum of the hand, never in the palm. It is to be remembered that in disarticulations at the metacarpophalangeal joints a troublesome stump may result interfering with the work of the individual. Section at the distal end of the metacarpus overcomes this disability. Kocher says, "When removing the metacarpus of the thumb or the little finger it is of much importance to preserve intact the short muscles of the thenar and hypothenar eminences, because by doing so a very useful and movable stump is obtained, especially if the bone is removed subperiosteally.

"In disarticulating a finger, with or without its metacarpal bone, the transverse incision follows exactly the line of the web of the fingers; incisions must not be made higher up in the palm."

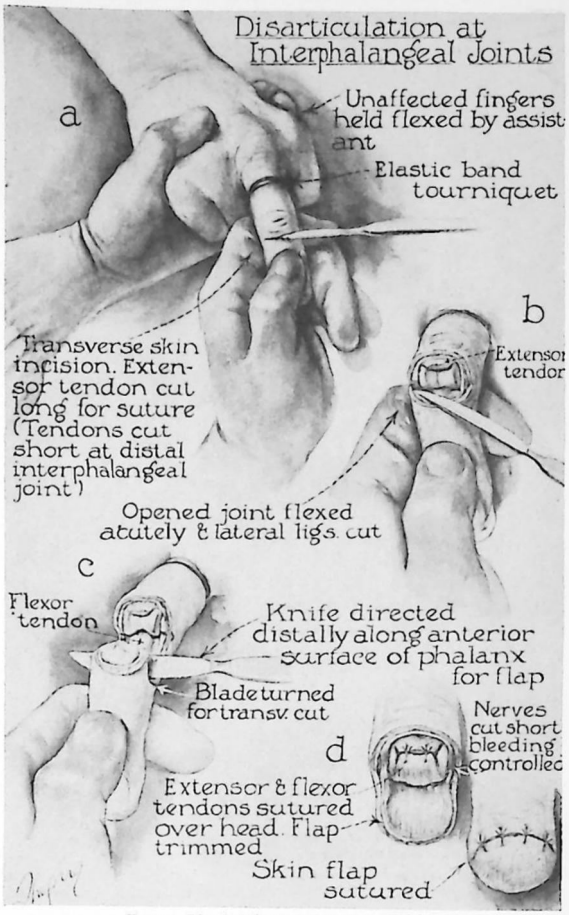


Fig. 995. Disarticulation at the interphalangeal joint.

AMPUTATION OR DISARTICULATION AT THE WRIST

This should, if at all possible, be so planned as to save the thumb, and a finger or other portion of the hand against which the thumb may be apposed.

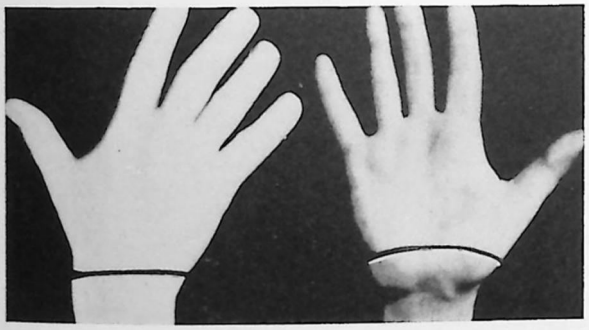


Fig. 996. Disarticulation of the wrist joint by circular incision.

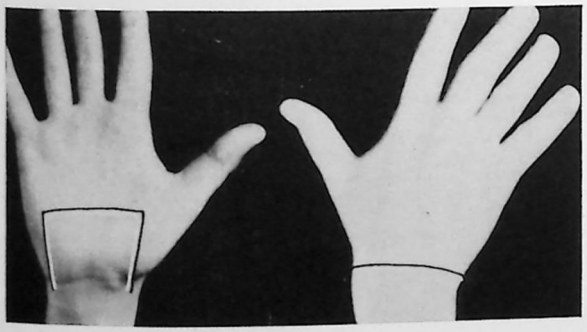


Fig. 997. Disarticulation of the wrist with a long palmar flap. Observe extent of palmar flap and position of the incision on the back of the hand. The outline of the former is quadrangular, the angles being rounded off after the flap is made.

The operation may be performed by the oblique circular method or by a double flap (Figs. 996-997). In the double flap amputation a dorsal flap is made by carrying a semilunar incision in the skin between the two styloid processes. Dissect the skin away; flex the joint forcibly; open the joint by a transverse

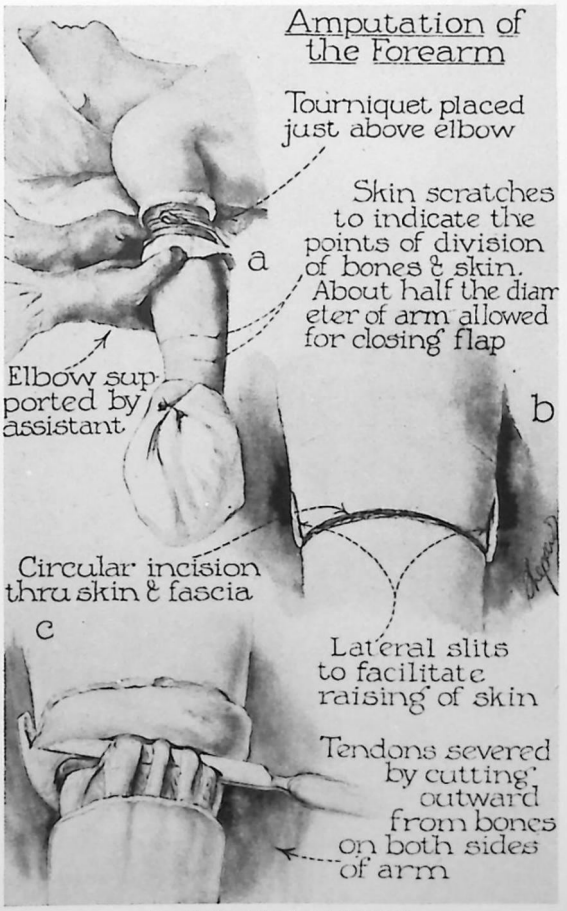


Fig. 998. Amputation through the forearm.

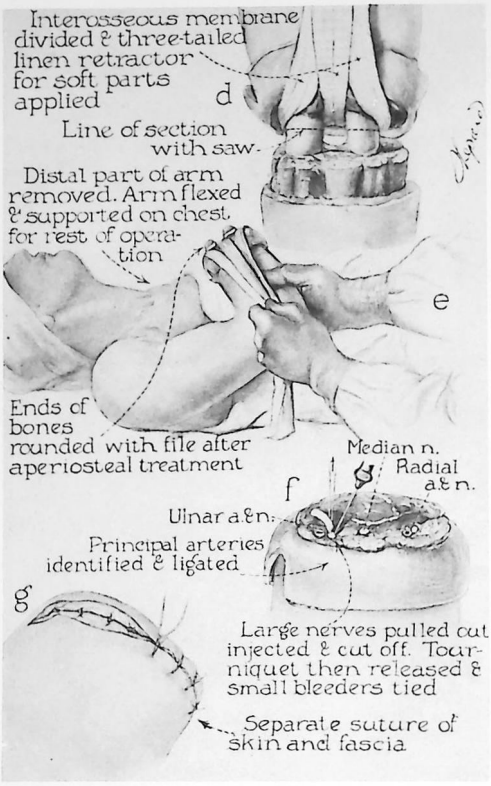


FIG. 998. Amputation through the forearm. (Continued.)

incision. Make a long semilunar palmar flap consisting of skin and deep fascia. Before removing the tourniquet, the radial and ulnar arteries are ligated. Locate the median nerve and treat it as outlined before (alcohol injection, high division). Amputations through the wrist are to be avoided according to Thomas G. Orr, as a matter of choice, because as Orr says, "An artificial hand fitted to an amputation through the carpal bones projects beyond the length of the normal hand and is unsightly and awkward. Best fitting can be obtained with an amputation at the junction of the middle with the lower third. Joint amputations are to be avoided because they produce bulbous stumps that are difficult to fit."

AMPUTATION THROUGH THE FOREARM

Choose the method which yields the longest stump. Because of the conical shape of the stump an artificial limb cannot be adjusted to the forearm alone, but must also receive support from the elbow. Aim for as great length of bone as possible. Preserve whenever possible the movements of flexion, extension, partial pronation and supination by respecting the insertion of the brachialis anticus, biceps, anconeus, triceps and pronator radii teres (Fig. 998).

The transverse circular method is best suited for amputations through the lower third of the forearm while equal anteroposterior flaps will seem best in amputations in its upper two-thirds. The illustrations depict the steps of the operation.

DISARTICULATION OF THE ELBOW

Historical Notes. Ambroise Paré is credited with having first performed this operation in 1536. Jouliet in 1848 performed the operation by the external flap method (Guerin method). The anterior flap method was developed by Brasdoe, Vacquier and Dupuytren. Velpeau used the circular method.

Anatomic Considerations (Fig. 999). The head of the radius is the guide to the joint. It can always be felt at the postero-lateral aspect of the elbow. The joint lies about a finger's breadth below the anterior crease of the elbow. Disarticulation through the elbow joint produces an undesirable, bulbous stump.

This may be done by the (a) elliptical method or (b) by a long anterior and a short posterior flap.

Circular Incision

Step 1 Make a circular incision through the skin and superficial fascia about two inches below the condyles of the humerus. Reflect the skin upward. Expose the joint.

Step 2. Extend the joint forcibly. Enter the joint through a transverse incision carried in front of the joint. Sever the lateral ligaments.

Step 3. Further extend the joint. Cause the olecranon process to project into the wound. Divide the tendon of the triceps at the tip of the olecranon process. Hemostasis. Closure of the wound.

Kocher's Operation

Step 1. Flex the forearm to an angle of 135 degrees.

Step 2. Begin with an oblique incision anteriorly over the joint line and terminate it posteriorly a hand's breadth below the summit of the olecranon process (Fig. 1000). Estes criticizes this incision by stating "the soft tissues of the anterior surface contract very markedly, those of the posterior not at

all or very little, so that a circular incision at the elbow will become by the contraction of the tissues an oval one with a long posterior flap; it is neces-

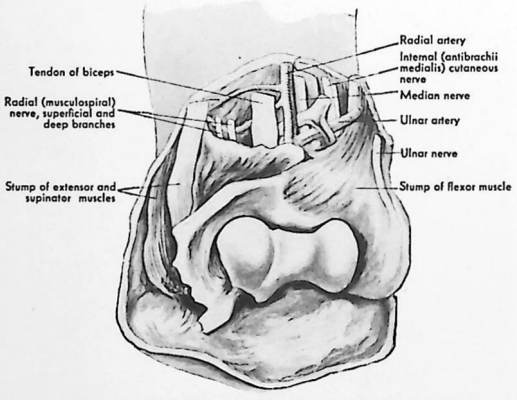


FIG. 999. Amputation at the elbow joint. (From Davis' Applied Anatomy.)

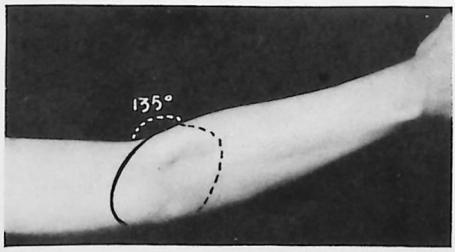


FIG. 1000. Disarticulation of the elbow joint by the oblique circular method of Kocher.

sary to bear this fact in mind so that the posterior flap may be made sufficiently long."

Step 3. Form a posterior flap comprising the integument, the insertion of the

triceps muscle, the anconeus and the periosteum. These are dissected upward until the posterior surface of the humerus is reached.

Step 4. Open the joint anteriorly by a transverse incision; expose the radiohumeral articulation from without inward (Kocher). Remove the limb.

Step 5. Hemostasis. Close the wound.

AMPUTATIONS IN THE LOWER EXTREMITY

AMPUTATIONS OF THE FOOT AND TOES

Disarticulation at the metatarsophalangeal joint is preferable to a partial amputation. The short stump left in partial amputation is often useless and a troublesome appendage.

Amputation of the Great Toe

This operation as performed corresponds to an analogous procedure on the fingers. It is best performed by a single plantar flap. Flex the toe holding it between the left thumb and forefinger. Locate the interphalangeal joint. Open into it by a transverse incision at right angles to the surface. Divide the lateral ligaments. After these and the glenoid ligaments are divided, turn the blade of the knife toward the tip of the toe, hugging the plantar surface of the phalanx. There should result a square-shaped flap. Unite the ends of the opposing tendons. Close the wound. The scar will lie above the head of the bone.

Disarticulation at the Metatarso-Phalangeal Joint

There are several methods for this procedure. Faraboeuf's operation, while not the easiest, is considered by most surgeons as the best.

Faraboeuf's Disarticulation (Interno-plantar Flap Method)

Locate the joint line. Mark out the incision (Fig. 1001). Grasp the flexed toe between the forefinger and thumb. Make a slightly curved incision down the toe until the neck of the phalanx is reached; prolong the incision over the inner side until the plantar surface is reached. Dorsiflex the toe; draw it away from the second toe; join the points of the incision. Cut down directly to the bone; divide the extensor tendon below the level of the joint. Dissect back the internal flap to the joint line. Detach the glenoid ligament from the base of the phalanx. Divide the lateral ligaments; complete the disarticulation. Hemostasis. Suture the flap into place.

Comment: It is important to remember that the incision should not be commenced above the joint line. If this be not observed the head of the metatarsal bone will prevent the flaps from proper approximation. This will necessitate the removal of a portion of the articular surface. This is to be avoided, because this portion of the bone plays an important rôle in supporting the weight of the body.

Amputations Through the Foot

Incisions here must be so planned that the scar is on the dorsum of the foot using a long plantar and a short dorsal flap, wherever possible. Save as much of the foot as possible. Measures should be instituted, so that the pull of the

tendo Achillis be counteracted to prevent the stump from assuming the equinous position.

AMPUTATIONS THROUGH THE METATARSUS

Historical Notes. The ancients practiced it. Sharp of London performed it in 1741 and Turner of Yarmouth in 1778. This procedure is to be preferred to dis-

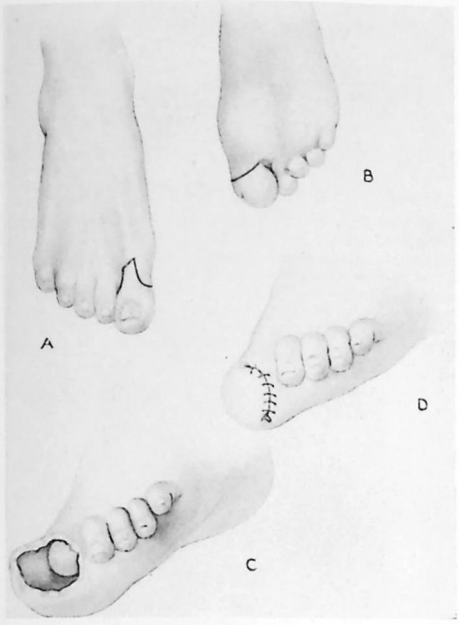


FIG. 1001. Farabœuf's disarticulation of the great toe at the metatarsophalangeal articulation. A. and B. show the anterior and posterior aspect of the line of incision. C. the toe has been disarticulated; the flaps are ready for suture. D. the flaps united. Observe that the scar faces mesially thus avoiding pressure.

articulation through the tarsometatarsal joint because the insertions of the most important muscles are retained and movements in all directions are preserved.

Sharp's Operation

Mark out a long plantar flap (Fig. 1002). Extend the foot strongly. Make the incision. Divide the extensor tendons. Dissect up the flap for a short dis-

tance above the line of division of the metatarsals. Retract. Divide the metatarsals. Bend the foot so that the divided ends of the bones protrude. Remove the bones from the flap by always cutting toward the bone, instead of away from it. Free the flap. Suture the opposing tendons over the ends of the bone. Close the wound by suturing the flap into position. The scar should be on the dorsum of the foot a short distance above the divided bones.

TARSOMETATARSAL DISARTICULATION

Historical Notes. The North American Indians practiced this operation as a means of preventing their prisoners from escaping (Ashhurst). Hey of Leeds recorded the first amputation in 1799. The first pure disarticulation was done by Lisfranc in 1815 which is in vogue at present.

Lisfranc's Operation

Lisfranc admonished that "the secret of facility in the operation lies in hitting the line of the articulation." This is best accomplished by locating the joint of the first and fifth metatarsals (Fig. 1003 [A and B]).

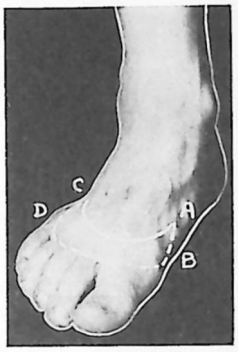


FIG. 1002. Outline of incisions in amputation through the metatarsals of the foot (Sharp's operation).

The foot is grasped by an assistant as shown in the illustration (Fig. 1003 [C, D, E, F]). The forefingers and thumb of the surgeon's left hand mark out the termination of the incision. Locate the joint line. Divide the structures on the dorsum of the foot from the base of the first to the base of the fifth metatarsal bones. Ascertain the position of the joint line by opening the first and fifth tarsometatarsal joints. Flex the foot forcibly and mark out the long plantar flap which extends forward from the points of the dorsal incision along the borders of the foot; it crosses the sole of the foot over the heads of the metatarsal bones. The flap comprises all the structures down to the bones. Put the dorsal ligaments on the stretch by forcibly depressing the foot. Open the three outer joints, then the joints between the first metatarsal and the internal cuneiform bone. Free, lastly, the head of the second metatarsal bone. This is best done by inserting the point of the knife between the two first metatarsals until by a to-and-fro motion the lateral ligaments are divided. This procedure is repeated between the second and third metatarsals. Open the joint between the second metatarsal and the middle cuneiform bone. Put the soft parts attached to the plantar surface of the metatarsal bones on the stretch. This is accomplished by pointing the toes backward (toward the heel) and pulling the heads of the metatarsals forward. By directing the knife against the bones the tense soft parts are divided. The dorsalis pedis and the two plantar arteries are ligated. The opposing tendons are sutured over the tarsus. Unite the flaps. The scar will be dorsal.



FIG. 1003. Lisfranc's amputation. A. raising the plantar flap which comprises all the structures down to the bones. The large tendon of the peroneus longus muscle can be seen crossing obliquely. B. method of grasping the foot when making the dorsal incision. (After Burghard.)

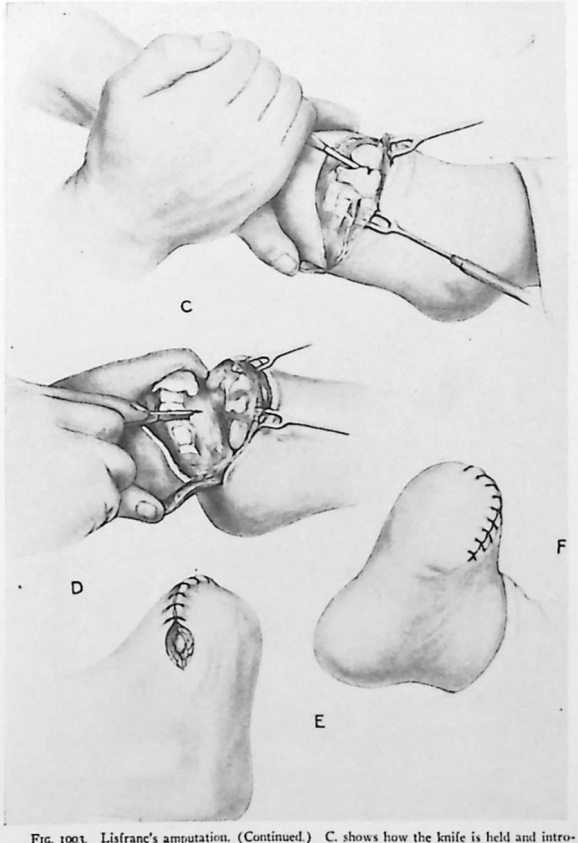


FIG. 1003. Lisfranc's amputation. (Continued.) C. shows how the knife is held and introduced between the metatarsal and internal cuneiform bones. D. shows the knife severing the peroneus longus tendon, thereby releasing the front half of the foot. E. stump seen from the inner side. F. stump seen from the outer side. (After Burghard.)

Hey's Operation

This is a modification of Lisfranc's operation and consists of sawing off the projecting portion of the cuneiform bone (Fig. 1004-g). Estes recommends Hey's procedure and believes it to be superior to Lisfranc's operation.

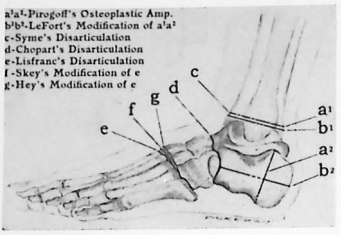


Fig. 1004. Various planes for amputation and disarticulation of the foot and ankle.

Skey's Operation

This consists of dividing the base of the second metatarsal bone and the projecting portion of the cuneiform bone (Fig. 1004-f).

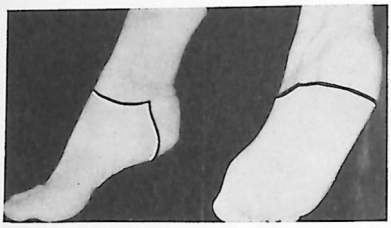


Fig. 1005. Incisions for Syme's disarticulation at the ankle joint.

Condon's Operation

This consists of disarticulating the first metatarsal and sawing the remaining bones at the same level.

Difficulties:

1. Mistakes in locating the joint line.

2. Insufficient covering for the inner aspect of the internal cuneiform.
3. Difficulty in disarticulating the head of the second metatarsal bone.

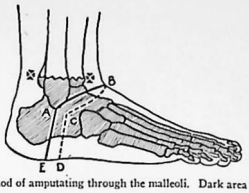


Fig. 1006. Syme's method of amputating through the malleoli. Dark area indicates parts ablated.

DISARTICULATION AT THE ANKLE JOINT

Historical Notes. Brasdor in 1774 first performed the circular method of disarticulation. This was later modified by Sabatier, Velpeau and Gunther. In 1805 J. Bell used an anterior flap. An anterior flap with sawing off the malleoli was used by Kluge; Rossi and Blandin used double lateral flaps. Antero-internal flaps were used by Jobert and Lering. Soupart, Sédillot and Guerin used internal flaps. Baudins and Soupart used external flaps. The heel-flap operation was used by Syme in 1842 while Pirogoff introduced his osteoplastic flap in 1852. Moschkowitz in 1904 introduced his osteoplastic procedure which is an osteoplastic modification of Syme's operation.

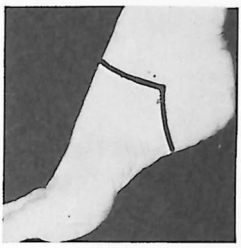


Fig. 1007. Circular incision for Pirogoff's amputation of the foot.

Chopart's Operation

This operation was performed by Chopart in 1791. It consists of a disarticulation between the astragalus and os calcis posteriorly and the scaphoid and cuboid bones anteriorly. It is performed by a long posterior and short anterior flap, similar to Lisfranc's operation previously described (Fig. 1004 d).

While much used in demonstrations, it is seldom practiced and has given way to

Syme's Operation

Step 1. Hold the foot at right angles to the leg. From the tip of the external malleolus to a point one-half inch below the internal malleolus make an anterior incision down to the bone. Continue the incision across the sole of the foot, its center slightly curved toward the heel. Unite the upper ends of the incision by an incision straight across the front of the ankle joint. This is the so-called "stirrup" incision (Figs. 1004 c, 1005-1006).

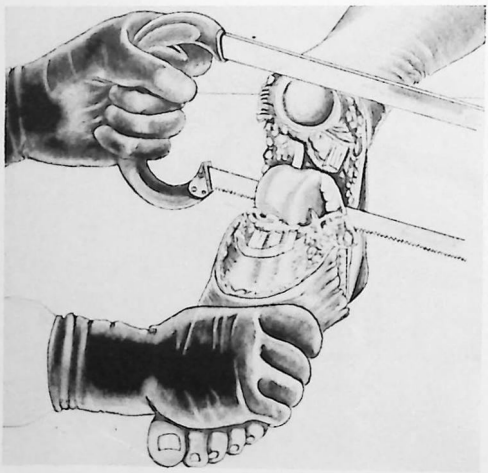


Fig. 1008. Division of the os calcis in Pirogoff's amputation of the ankle.

Step 2. Put the lateral ligaments on tension by forcibly bending the foot downward. Open the joint. Divide the lateral ligaments. Note: While dividing the soft tissues on the inner aspect of the ankle avoid injuring the posterior tibial artery. Retain as much of this vessel as possible, to insure adequate nourishment of the flap.

Step 3. Forcibly bend the foot still further, thus separating the surfaces of the

ankle-joint more and more. Expose the tendo Achillis; divide it close to the os calcis. Dissect the heel flap from the os calcis from above downward. Retain the full thickness of the flap and avoid puncturing it while it is being fashioned. Remove the foot.

Step 4. A thin piece of bone including both malleoli is sawed from the tibia and fibula.

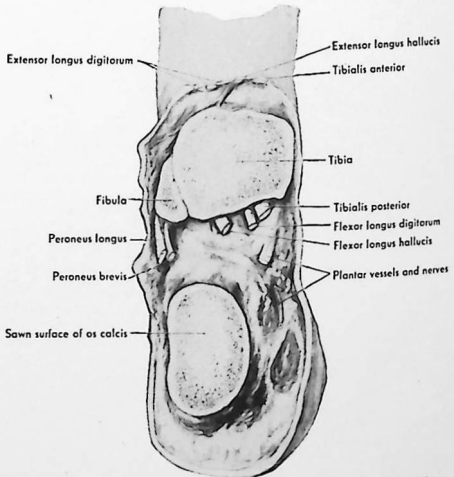


Fig. 1009. Pirogoff's amputation of the ankle. (From Davis' Applied Anatomy.)

Step 5. Provide drainage through a perforation in the flap posteriorly.

Step 6. Hemostasis. Trim away excess tissue. Suture the flap. Dress.

Comment: Do not begin the incision at the internal malleolus. This will give an asymmetrical flap which will be too long and increase the difficulties of the dissection.

Pirogoff's Osteoplastic Amputation

This consists of an osteoplastic amputation of the ankle joint by means of a heel-flap in which the posterior portion of the os calcis is retained and approximated to the sawed off surface of the tibia and fibula.

Preliminary to the operation do a tenotomy of the tendo Achillis.

Step 1. Hold the foot at right angles to the leg. Locate the joint-line.

Step 2. Make a "stirrup" incision as in Syme's operation (Fig. 1007).

Step 3. Extend the foot and divide the lateral ligaments. Do not injure the lateral posterior tibial artery.

Step 4. Divide the posterior ligament of the ankle joint at its insertion into the astragalus.

Step 5. Saw through the os calcis (Fig. 1008).

Step 6. Expose the tibia and fibula at a level above the articular surface of the tibia (Fig. 1009). Saw the bones at right angles.

Step 7. Ligate the tibialis anterior, peroneal and malleolar arteries.

Step 8. Appose the sawed surfaces accurately. Suture the structures as shown in the illustration (Fig. 1010).

Step 9. Apply a posterior splint and dressing. Flex the knee; support by pillows.

AMPUTATION OF THE LEG

Thomas G. Orr concludes that "in selecting a site for amputation through the leg, future artificial limb fitting should be kept in mind. It is now considered that amputation through the middle third, making a stump six to eight inches long, is the most desirable. It is of importance to bear in mind that a leg stump shorter than five inches cannot be satisfactorily fitted with an artificial appliance. An amputation at the old 'site of election' four inches below the knee to make a 'kneeling stump' for a peg leg is no longer recommended" (Fig. 1011).



Fig. 1010. Scheme of Pirogoff's operation. Heavy outlines and blocked out areas show skin and bone retained after other parts are ablated.

Where aperiosteal, tendoplastic or osteoplastic methods are used, the source of covering is immaterial as long as the soft parts are sutured without tension. The most generally applicable method is the oblique circular. Bier uses a large tongue-shaped anterior flap. If unequal flaps are used, the longer one is taken from the extensor surface; the shorter one from the flexor surface.

Aperiosteal Amputation of the Leg

This may be performed by the oblique circular, single or double flap methods.

Step 1. Ascertain the line of section of bone (see Figs. 1012-1013). Apply a tourniquet above the knee. Outline the skin flaps. "The deep fascia should always be included in the anterior skin flaps so that the blood supply may be disturbed as little as possible" (Orr) (Fig. 1012 a).

Step 2. Divide the muscles in a circular manner about two inches distal from the proposed point of bone section (Fig. 1012 b).

Step 3. Divide the interosseous membrane. Retract the soft parts with a three-tailed gauze retractor (Fig. 1012c).

Step 4. Divide the periosteum by a circular incision. Curve it downward for a distance of about 1 cm. Rotate the leg inward.

Step 5. Divide the bones with a saw.

Step 6. Shorten the fibula by removing about an inch of its distal end. Clear the crest of the tibia from periosteum. Saw a portion of it off, obliquely.

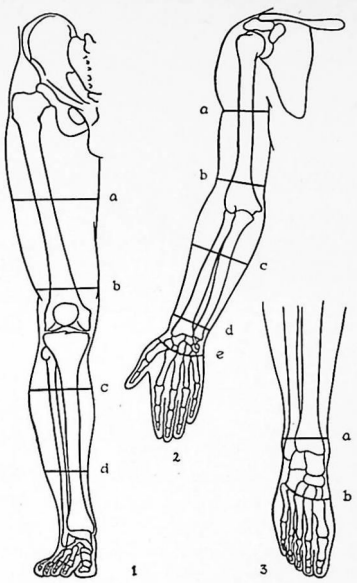


Fig. 1011. 1. Best levels for lower extremity amputations. a, Highest level permitting functioning of hip joint. b, Point of election for amputation above knee. c, Highest level permitting functioning of knee. d, Point of election for amputation below knee.
2. Best levels for upper extremity amputations. a, Highest level permitting functioning of shoulder joint. b, Point of election for amputation above elbow. c, Highest level permitting functioning elbow. d, Point of election for forearm amputation. e, Metacarpophalangeal amputation of the hand.
3. Best levels for foot amputations. a, Syme's amputation by disarticulation at the ankle and sawing off the styloid processes of the tibia and fibula. b, Lisfranc's amputation or tarsometatarsal disarticulation.

Smooth the bone edges with a rugine forceps. Scoop out the medullary canal for about one inch (Fig. 1012 d).

Step 7. Isolate the principal nerve trunks (these are O.T. tibial, saphenous,

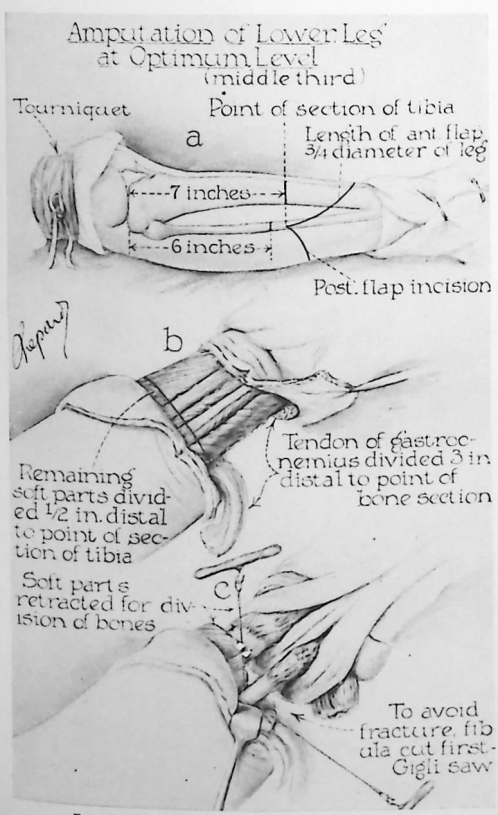


Fig. 1012. Amputation of leg at "optimum level" (middle third).

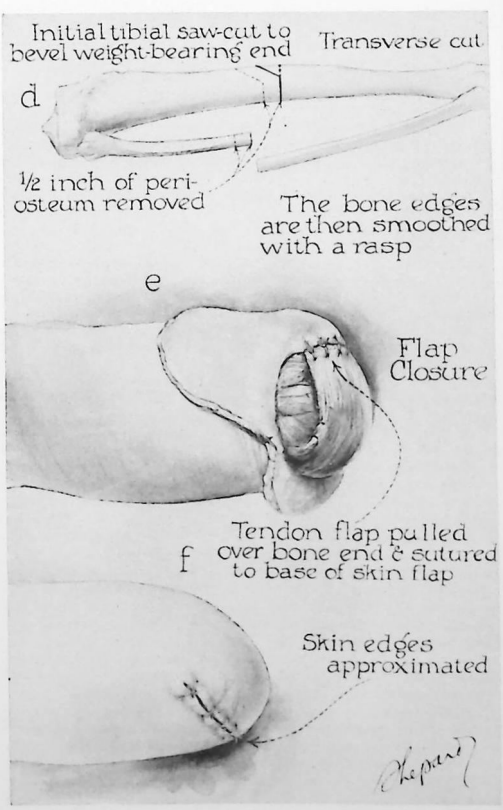


Fig. 1012. (Continued.) Amputation of leg at "optimum level" (middle third).

peroneal and sural). Inject them with 95% alcohol. Cut them short and allow them to retract. The anterior tibial vessels will be found in the interosseous membrane, the posterior tibial between the deep and superficial posterior muscles and the peroneals in the lower two-thirds of the leg behind the fibula.

Step 8. Release the tourniquet.

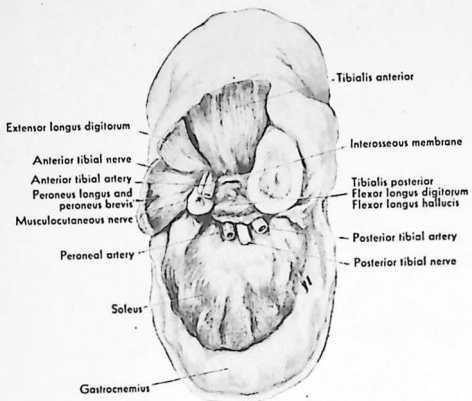


Fig. 1013. Amputation of the upper third of the leg. (From Davis' Applied Anatomy.)

Step 9. Group the muscles about the ends of the divided bones and suture them over with chromic catgut. If a fascial flap were successfully shaped, it should be brought over the muscle stump (Fig. 1012, e).

Step 10. Attend to hemostasis. Introduce a drainage tube to the muscle plane. Unite the flaps (Fig. 1012, f). Dress.

DISARTICULATION OF THE KNEE

Historical Notes. In 430 B.C. Hippocrates mentioned this procedure. In 1581 Fabricius Hildanus performed the operation at Düsseldorf. It was first performed in America by Nathan Smith in 1824. Velpeau performed it in France in 1830. In 1852 Stephen Smith introduced his method of modified, lateral flaps.

Methods:

1. Bilateral Hooded Flaps (Stephen Smith).
2. Oblique Circular Method (Bauden).
3. Anterior Flaps (Nathan Smith).
4. Circular Method (Miller).

The best of all of these is the Stephen Smith method. For the working man, this operation has no equal. For those whose chief desire is an aesthetic result, an amputation higher up should be counseled.

Stephen Smith Disarticulation

Step 1. Define the level of the knee joint and its surface anatomy.

Step 2. Commence the incision as shown in Fig. 1014, viz., in the midline on the posterior surface of the limb upon a level with the joint line. The knife is carried down vertically in the midline for about three inches; a lateral flap with its convexity downward is fashioned, its lowest point being a little over an inch below the tubercle of the tibia.

Step 3. Raise the limb and rotate it in the opposite direction and fashion the opposite flap, beginning at the tibial tubercle and extending to the vertical

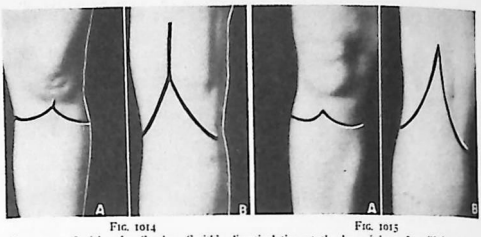


Fig. 1014 Fig. 1015

Fig. 1014. Incision for Stephen Smith's disarticulation at the knee joint. It will be noted that the incision extends slightly lower down on the inner than on the outer side.

Fig. 1015. Showing the wrong incisions for Stephen Smith's disarticulation. If the incision begins to diverge posteriorly at once there will not be enough tissue to cover the condyles of the femur.

median incision. The inner flap should be a little longer than the outer in order to afford ample covering of the large inner condyle. In the dissection of the flaps, the skin, fascia and cellular tissues are raised and the ligamentum patellae is divided. Allow the patella to remain. (Fig. 1015.)

Step 4. Flex the knee. Insert the knife between the tuberosities of the tibia and the semilunar cartilages which are left in contact with the condyles of the femur (Brenton). Sever the crural ligaments. Complete the disarticulation by dividing the soft tissues.

Step 5. Ligate the popliteal vessels. Isolate the popliteal nerve; inject it with alcohol. Sever it high and allow it to retract.

Step 6. Unite the flaps. Insert a small rubber drain in the upper angle of the wound. Apply a posterior splint. Dress. Steady with sand bags.

Comment: According to G. L. McWhorter[1] disarticulation at the knee is preferable to guillotine amputation for the reason that it is performed

[1] Technic of Disarticulation at the Knee, Surg. Clin. N. Amer., June, 1935.

at a higher level insuring healthier flaps; infected thrombi are removed from the veins and better circulation is obtained to combat infection. The stump which is left following guillotine amputation offers greater possibility of absorption, infection and sloughing of the tissues. An amputation higher up often has to follow the guillotine method. The death rate is much lower following disarticulation at the knee than after a supracondylar or thigh amputation.

In cases of purulent arthritis and osteomyelitis, Wilson recommends disarticulation highly. He states that it may be done quickly, does not produce so much shock as a supracondylar amputation, does not open new channels so that infection is spread and there is no exposure of deep bone spaces. Later on, reamputation may be done at a site chosen for an end-bearing stump.

A complete examination is necessary, in all patients with gangrene, to determine if septicemia is present and if procrastination is likely to prove fatal, or, if the condition is the result of toxemia and whether preparatory measures such as fluid administration, etc., are indicated.

The color and temperature of the skin determine the collateral circulation which is important in determining the level of amputation. If the circulation in both feet is affected and the skin above the line of demarcation is infected, the gangrenous foot may be warmer than the sound one. It is not advisable to apply a tourniquet in employing tests since this impairs circulation still further. The patency of the main arteries may be determined by the oscillometer which should be used with great care where there is a spreading infection.

Statistics compiled by Crile show the importance of the anesthetic used as regards the mortality in amputations. Out of 100 soldiers operated on for thigh amputation under ether anesthesia at a front line hospital during the World War, 66 per cent died. The mortality was approximately 20 per cent in the same number of cases operated on under nitrous oxide and spinal anesthesia. He maintains that a skilled anesthetist is very necessary and that some form of nerve-block is the only way to avoid shock.

Spinal anesthesia is contra-indicated in the presence of septic infection. Gas anesthesia seems to be superior to the other methods but must be administered skillfully. If it cannot be obtained, procaine may be used for regional block in the thigh (which see) for disarticulation at the knee or for amputation of the leg in patients not considered good surgical risks. In such patients very little morphine or none at all is administered as a preanesthetic. At a chosen site, one half of 1 per cent of procaine with adrenalin is injected in the shape of a fan in the thigh. Around the larger nerves a greater amount is injected.

McWhorter has been able to obtain a definitely lowered mortality by the use of local or gas anesthesia and the principles advocated here in the treatment of gangrene of the foot. In comparison to a parallel series of cases of amputations of the leg or thigh done by others using ether the mortality has been nearly one-half lower in his series.

McWhorter found a fascial flap modification of the Stephen Smith

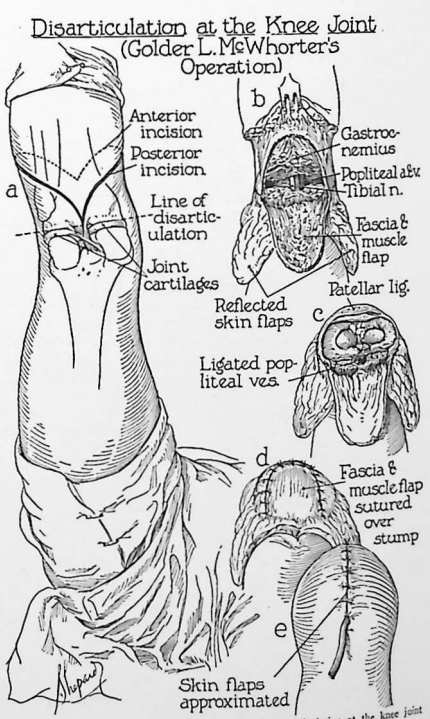


Fig. 1016. Dr. Golder McWhorter's operation for disarticulation at the knee joint

method of disarticulation at the knee satisfactory. The technic is as follows:

Step 1. A tourniquet may be applied below the level of amputation and above the gangrenous extremity thus preventing the spreading of venous, infected thrombi throughout the body by manipulation.

Step 2. Bilateral skin flaps are used (Wilson prefers a long anterior flap). Incisions are begun anteriorly and immediately below the tibial tubercle; these are directed downward and laterally on either side of the affected limb approximately 3 or 4 inches below the joint line, then curving upward posteriorly joining at the level of the joint line in the popliteal space (Fig. 1016 a). The internal flap is somewhat larger so that it may cover the larger internal femoral condyle.

Step 3. Carefully free and retract upward the skin and superficial fascia to the joint line including the lateral capsule of the joint. Retract the skin downward posteriorly over the gastrocnemius muscle so that a flap of fascia may be cut from here to cover the femoral condyles. After liberating the fascial flap which should have some muscle for vascular purposes left attached to the base of the remainder of the gastrocnemius it is incised transversely at the level of the joint line (Fig. 1016 b). Ligate the popliteal artery and vein separately. Inject the nerves with alcohol and incise at a higher level.

Step 4. Cut the patellar ligament transversely at its insertion and open the knee joint by cutting along the upper margin of the tibia leaving the cartilages attached to the femoral condyles. Flex the knee; dissect the crucial ligaments and any tendons and muscle attachments at the level of the joint line (Fig. 1016 c). Disarticulation may be done before the popliteal vessels are ligated; the fascial flap may be cut last. The latter is turned forward over the condyles and after the redundant part is trimmed away it is sutured to the incised patellar ligament and to the capsular ligament and fascia at the sides of the condyles, completely covering the end of the femur (Fig. 1016 d). Suture the skin flaps in the midline permitting a soft rubber drain to emerge posteriorly (Fig. 1016 e).

Comment: If a high amputation or disarticulation at the knee is contraindicated on account of spreading gangrene or septicemia, it may be advisable to try some other method of relieving the infection and toxemia. A low guillotine amputation seems to offer some advantages over a higher amputation in lessening time and shock but it has other disadvantages.

In patients who seem to be exceptionally poor surgical risks, McWhorter has employed two different methods which have met with a measure of success.

In the first method, a tight tourniquet is applied under aseptic conditions around the leg high above the gangrenous area and immediately below the site of future amputation. Energetic systemic treatment is given the patient for two or three days when amputation may be more safely performed.

A slight degree of pain follows the use of the tourniquet which may be largely allayed by the use of sedatives. It is virtually impossible to entirely occlude circulation by a tourniquet around the leg on account of two bones which allow circulation in the soft tissues between them and their blood vessels. The tourniquet, however, has proved valuable in checking toxemia, especially where patients have to be transported for some distance.

The second method resembles the first in its action. The popliteal artery and vein are ligated. Comparing this step with the use of the tourniquet, it has been noticed that following the tourniquet there was improvement as long as the sixth day, while after popliteal ligation the greatest improvement was on the second or third day. It is conceded that amputation or disarticulation may be done more safely after energetic systemic treatment, on the second or third day after either popliteal ligation or the tourniquet application in cases characterized by toxemia.

The experimental and clinical observations of Cannon form the basis of the above two procedures. Cannon was able to relieve shock completely after experimental crushing of a limb by clamping the blood vessels or applying a tourniquet proximal to the injury. He also noted the development of shock after removing a tourniquet from a patient with a crushed foot. In a case of shock too severe to permit movement, there was considerable improvement after a tourniquet had been applied above the crushed extremity.

AMPUTATIONS IMMEDIATELY ABOVE THE KNEE

Transcondyloid and Supracondyloid Amputations

On the whole the weight-bearing qualities of the stump are not as effectual as in disarticulation.

Methods:

1. Transcondyloid Femorotibial Osteoplastic—Ssabanejeff Operation.
2. Carden-Buchanan Operation (Transcondyloid).
3. Gritti-Stokes Operation (Supracondyloid).
4. Wilms (Transcondyloid or Supracondyloid Tendinoplastic).

The Gritti-Stokes will be described as it is most commonly used. It gives better results than the Carden-Buchanan procedure by affording end-bearing without adhesions between the bone and the skin.

Gritti (1851)-Stokes (1870) Operation

Step 1. Apply a tourniquet.

Incision: A large rectangular flap is fashioned running from a point just above the base of the condyle on one side to a corresponding point on the other side and extending downward as low as the upper part of the tuberosity of the tibia. The posterior flap is about one-third the length of the anterior flap. It is fashioned by carrying the knife straight across the back of the limb. Raise the anterior flap; divide the ligamentum patellae (Figs. 983-984, p. 868).

Step 2. Open the knee joint; divide the capsule; raise the patella with the anterior flap. Divide the tendons at the back of the joint; see that they

are divided on a level with the edge of the retracted skin. Raise the posterior flap to the line of bone section.

Step 3. Clean the bone. Retract the anterior flap over the end of the femur. Force the posterior surface of the patella out of the wound and remove its posterior articular cartilage with a thin saw. The femur is sawed through at a point where its size approximates the posterior surface of the patella. Through the tract made by the saw in the femur a large amputation knife is introduced, its cutting surface directed somewhat caudalward. With a to-and-fro motion the soft tissues including vessels and nerves are divided. A short flap thus results. The freshly cut surface of the patella is sutured snugly against the end of the femur while an effort is made to unite the hamstring muscles to the patellar ligament (Fig. 984 b). A tenotomy is then performed upon the insertion of the quadriceps muscle.

Step 4. Isolate and ligate the popliteal artery and vein. Shorten the sciatic nerve after injecting it with alcohol. Permit it to retract. Hemostasis. Obliterate dead spaces. Unite the flaps. Drain, if thought advisable. Dress.

Comment: J. W. Snyder[1] states that in a series of cases the Gritti-Stokes type of amputation was carried out at first with much concern as to the outcome, but confidence increased with experience. He continues: If we consider that the larger muscle bodies of the thigh are left undisturbed with no incision across their structures and no disturbance of their circulation some reason attends this type of procedure. The nutrient artery to the femur enters at a higher level from the profunda femoris and as division of the femur just above the condyles does not open the marrow cavity of the bone reasonable assurance of the integrity of the femur may be felt. Sloughing of the stumps of the hamstring muscles is of minor importance, the main question is the viability of the flaps and the patella itself. Apparently the rather free anastomosis about the patella is sufficient to maintain its nutrition and in no case has enough necrosis of the flaps ensued to give concern. In most of the operations the tourniquet has not been applied because of fear of producing damage to the circulation in the thigh. Snyder never felt it necessary to secure the patella to the femur with screws or nails as the tension of the quadriceps acting against the patella seems to hold the patella firmly against the femur. Secondary reinforcing sutures are however employed. If union of the patella to the femur fails to occur, the stump will not be a success from the mechanical standpoint but this has not happened in his series. His conclusions point out that this type of operation will not always be a success but the operation is much less severe on the patient than a midthigh amputation producing little if any shock when done under a spinal anesthesia and if successful it gives the patient a far more satisfactory stump.

AMPUTATION THROUGH THE THIGH

The same principles apply here as in amputation of the arm (Figs. 978-981 and 989); Circular, Oval or Long Posterior and Short Posterior flaps; Lister's operation may be used. The stump should be at least six or seven inches in length measured from the crotch. The muscles are divided about four inches distal

[1] The Southern Surgeon, April, 1935.

to the point of division of the femur (Fig. 1017). The steps of the operation (tenoplastic amputation of Kirk) are illustrated in Fig. 1018.

Disarticulation of the Hip

Historical Notes. In 1743, Ravatom proposed the operation through an external racket incision. The other consulting surgeons on the case advised against its performance. La Croix of Orleans performed it first in 1748. Perault of St. Maure, Touraine, was the second to perform it in the same year. Both operations were done on cadavers. According to Ashhurst, it was H. Thomas of London who did the first disarticulation of the hip in the Army, prior to 1717. In 1795 Kerr, of Northampton employed the oval method. Larrey used this procedure first in military practice in 1793. The first American to perform the operation was Walter Brascher of Bards-

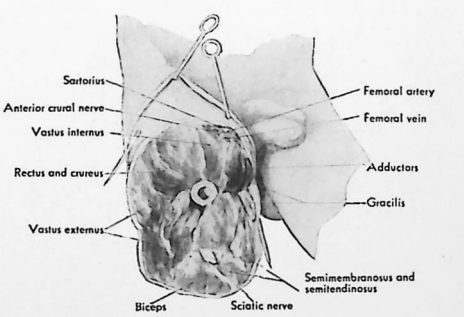


FIG. 1017. Amputation just above the middle of the thigh, showing insertion of Wyeth's pins. (From Davis' Applied Anatomy.)

town, Ky., in 1806. He performed an amputation-resection through an external racket incision.

Methods of Hemostasis. 1. Preliminary ligation of the common femoral artery or the external iliac artery.

2. Temporary digital or mechanical control of the iliac artery through an abdominal incision (McBurney).

3. Compression of the abdominal aorta (Macewen).

The object here is direct compression of the aorta. An assistant stands on a stool to the left of the patient. He forcibly pushes his clenched right fist against the anterior abdominal wall which is pressed against the aorta with the anterior abdominal wall. The fist is applied immediately below the umbilicus to the left and the assistant swings his whole body weight by crossing the right foot in front of the left. This is a simple and efficient but fatiguing method. (Fig. 664, p. 594.)

4. Compression of the vessels by a figure-of-eight tourniquet.

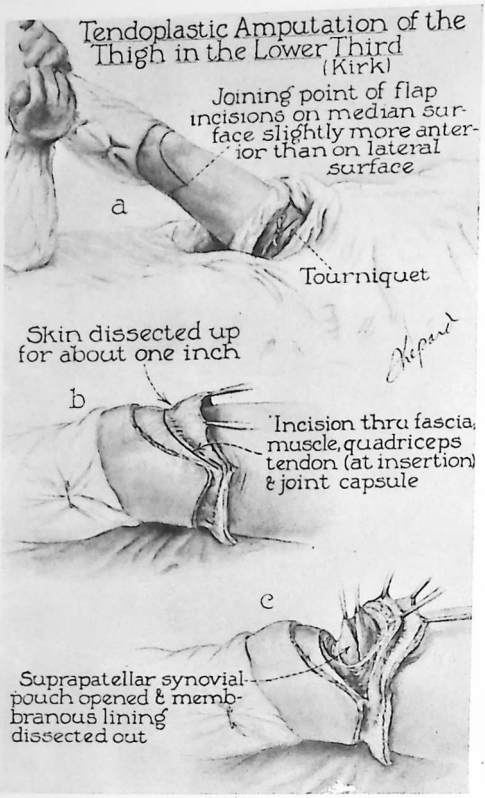


FIG. 1018. Tendoplastic amputation of the thigh in the lower third.

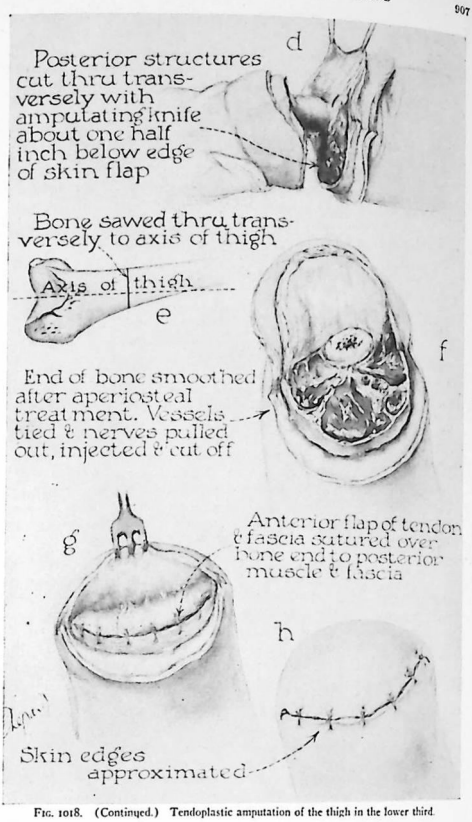


FIG. 1018. (Continued.) Tendoplastic amputation of the thigh in the lower third.

5. **Lynn-Thomas forceps tourniquet.**

The Lynn-Thomas forceps is a long instrument not unlike a gastrectomy clamp, one blade of which is passed through the soft tissues, the other blade compressing the tissues externally.

6. **Wyeth's bloodless method.** Two 10-inch pins are passed through the root of the thigh. The first one is inserted slightly below and internal to the anterior superior spine, passing superficially engaging only the skin and fascia lata. The second pin is pushed through the adductor longus. It enters one-half inch below the perineum and emerges one inch below the tuberosity of the ischium. An elastic tourniquet is wound above these pins (Fig. 1017).

7. **Mechanical Compression of the Abdominal Aorta:** An abdominal tourniquet may be used or Momburg's Constrictor may be employed.

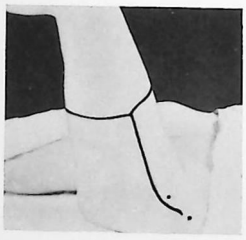


FIG. 1019. Incision for Furneaux-Jordan's disarticulation at the hip. One dot appears on the level of the crest of the ilium while the other is placed at the top of the great trochanter.

In 1908, Momburg demonstrated that Esmarch's principle may be applied to the compression of the abdominal aorta. The method consists of putting a soft rubber tube (10-15 mm. diameter) at full tension under the patient and winding it around the waist until the femoral pulse disappears. When the ends of the stretched rubber tube are secured with a clamp, secondary constrictors are applied to both thighs just below Poupart's ligament and below the popliteal spaces. When the operation is completed the abdominal constrictor is loosened and the secondary constrictors loosened one by one—the general circulation is thus gradually restored and sudden excessive strain on the heart avoided.

While in certain cases no other method will accomplish the desired end as effectually as Momburg's procedure, yet, deaths from acute dilatation of the heart, anuria, urinary suppression (transitory), etc., have been reported from its use.

Furneaux-Jordan's Method

Step 1. The patient is placed on his back with the buttocks resting on the extreme end of the table. Outline the position of the crest of the ilium and the top of the great trochanter by two dots of iodine (Fig. 1019).

Step 2. Divide the muscular attachments from the femur to the great trochanter and expose the hip joint. Separate the soft parts with a periosteal elevator, knife or scissors for the full length of the longitudinal incision.

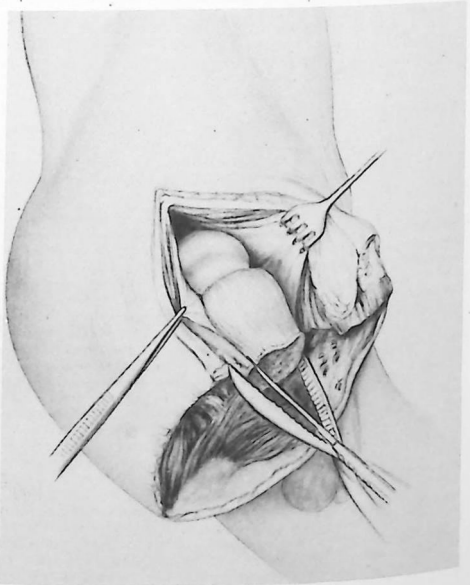


FIG. 1020. Disarticulation of the hip.

Step 3. Dislocate the femur and have it protrude through the wound (Fig. 1020). Introduce a closed forceps through the wound and force it through the tissues on the inner surface of the thigh, creating a prominence on the skin. With a scalpel divide the skin thus made to project on the tip of the forceps. Grasp in these forceps the middle of a length of rubber tubing and pull it through the wound and cut it through where it was grasped by the forceps. This leaves two portions of tubing passing completely through the

Either one should do his own splinting or have it done by a truly skilled assistant.

Often failures result from slip-shod carelessness and inexperienced after-care. Speed, not haste, is essential.

Handle tissues carefully. I have observed many self-styled "traumatic" surgeons who well deserve the appellation. There is nothing more distressing than to watch surgery recall dismemberment by a vulture.

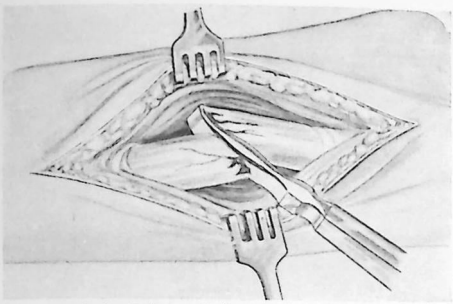


FIG. 1028. Open reduction of a fracture. The illustration shows a bone skid insinuated between the fragments of the fracture, maneuvering same into position. (After Kirschner.)

Thorough hemostasis is essential. Before closing any wound, the surgeon should train himself to enjoy a "lingering period" during which he carefully scrutinizes the field of operation and assures himself that there are no excessive oozing or bleeding areas.

One should not be a slave to any rigid rule of drainage. The case in point should suggest the type of drainage indicated.

Where there is sepsis, operation must be avoided.

COMPOUND OR OPEN FRACTURES

Operation is indicated in almost every instance where the fracture is exposed to the air through an open wound. The procedure differs according to the type of injury and condition of the patient, as well as the available facilities. The following is cited as an example:

Step 1. Anesthetize the patient. Scrub the entire limb with hot water and soap, then shave it. Remove grease by scrubbing the whole extremity with turpentine, gasoline or ether. Again scrub the limb with soap and water, followed by alcohol and some standard antiseptic solution. Grossich's method of preparing the patient excludes water. It consists simply of shaving off the hair of the affected limb which is painted with tincture of iodine. Apply an elastic constrictor.

Step 2. Obtain ample exposure of the deep wound by enlarging the skin wound. Remove all blood-clots and debris with gauze sponges, gloved finger and instruments. Trim away pieces of redundant, devitalized skin and traumatized tissues. Remove all detached bone fragments and place them in a warm aseptic solution to be reimplanted if possible or deemed advisable. Open all torn tissue spaces and muscular planes and irrigate thoroughly with mild antiseptic solution. If much dirt is ingrained into the tissues, swab the wound with benzene followed by alcohol. Institute free drainage through counter-openings where deemed advisable.

Step 3. Reduce the fracture. Fixation is accomplished by the same methods as are resorted to in simple fractures. Later, if need be, resort to open operation (Figs. 1029-1030-1144, p. 1005). Control hemorrhage by means of ligatures, forcipressure, hot packs, etc.

Step 4. Close the surface wound partially. Dress. Immobilize the affected limb in the position indicated by a given case.

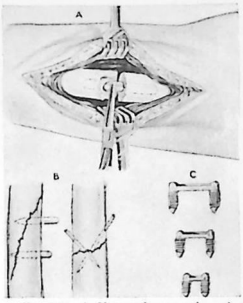


FIG. 1029. A. Here an ivory peg is used to immobilize the fragments of the fracture—the peg is introduced into the medulated canal (after Kirschner); B. other materials (ivory pegs, bolts, screws) may be used to immobilize fractured fragments; C. Jacoel's staples.

DIRECT SKELETAL EXTENSION IN FRACTURES

Traction directly upon the skeleton may be secured by nails, pins, wires and calipers. This form of extension is of special value to overcome shortening and produce alignment of fractures near the ends of bones and those in which skin areas have been injured. The lower extremity lends itself well to this procedure.

Nail extension is applied to overcome the shortening which prevents correct replacement of bone ends in recent fractures or for malunited old fractures. It is used especially in fractures of the lower limb. Fracture of the femur will be given as an example.

Step 1. Incisions are made down upon the lateral subcutaneous aspects of the femoral condyles exactly on the same level.

Step 2. A drill is carried through the head of the femur and a metal pin is passed through the drill hole. Cords are attached to the two ends of this rod and to the loop formed by them the extension weight is attached. Instead of a rod, short nails inserted on each side may be employed.

Step 3. The extension is kept up until the soft parts have been normally extended and the bone ends meet properly.

VALUE OF CLOSING COMPOUND FRACTURES BY SKIN PLASTIC

Hospitalization, suffering, deformities and deaths have been obviated by the early closing of a compound fracture. The employment of aseptic and antiseptic

first aid measures is most helpful. John E. Cannaday[1] advises the immediate application of gauze saturated with tincture of iodine, mercurochrome or picric acid solution; immobilization of the limb and the patient sent to the hospital.

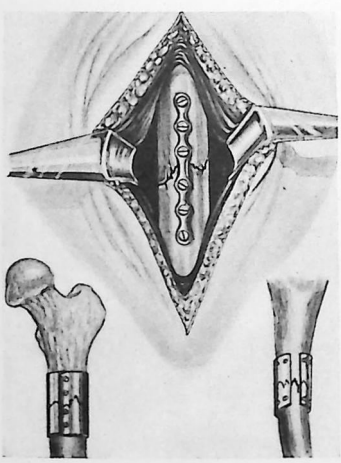


FIG. 1030. Open treatment of fracture of long bone: above, Lane plating; below, metal rings used for fixation of fractures. The metal may be perforated beforehand but a better plan is to wrap the collar around the bone overlapping the ends, then make holes in the latter into the bone. This is depicted in the lower left illustrations; however it is not easy to accomplish when dealing with triangular bones like the tibia when two plates are used as shown in the illustration in the lower right-hand corner.

If the patient is not in a state of shock, débride and disinfect the wound, remove all hopelessly injured tissue, freshen the skin edges by cutting them all the way around and reunite them with sutures, carefully. Do not turn the edges of the skin inward but join them so that they point upward resembling the apex of an inverted "V."

Plastic Methods

If the edges cannot be brought together in the usual way, Cannaday advises that long incisions be made at some distance from the opening so that the edges may be united over the bone without too much tension (Figs. 1031-1032). These incisions are preferably made through the outer fascial covering of the muscles.

[1] Annals of Surgery, April, 1929.

This promotes circulation and lessens the tendency toward edema. This may be done under local anesthesia. A prophylactic injection of antitetanic serum should always be administered. Cannaday and Henson report 90 cases of primary union out of 100 cases of compound fracture treated in the manner described. They contend this is far superior to the open method. The bone is protected



FIG. 1031

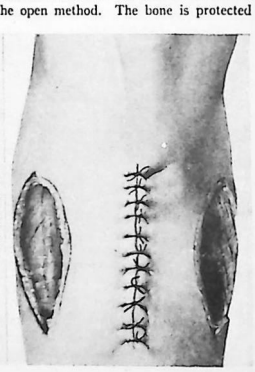


FIG. 1032

FIG. 1031. Compound fracture of the tibia with extensive exposure of bone at point of fracture.
FIG. 1032. Showing liberating lateral skin incisions, allowing suture of skin wound over point of fracture. (Cannaday.)

at the fracture site, thus preventing the formation of dense scar tissue and deformities.

IMMOBILIZATION FOR MOTILITY AND FOR FIXED JOINT

Immobilization of an injured joint demands particular attention if there is reason to suspect that the ultimate range will not be regained.

The chief factors to be taken into consideration are:

1. The best position, from a standpoint of usefulness, for a fixed joint or one with very little mobilization.

2. The movements of any joint, certain of which are easily regained while others, once lost, are difficult to regain.

3. The occupation of the patient.

Shoulder: Abduct the shoulder 90 degrees if a mobile joint is desired. Where mobility is not desired abduct the shoulder 90 degrees in a child, 75 degrees in an adult and 20 degrees forward of the coronal plane of the body and 5 degrees external rotation.

Elbow: Flex the elbow 40 degrees if mobility is desired. For a fixed joint in a woman, flex the elbow at 60 degrees; for a working man or ball player place