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Modern Surgery - Chapter 22. Diseases and Injuries of Nerves

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XXII. DISEASES AND INJURIES OF NERVES.

1. Diseases of Nerves.

Neuritis, or **inflammation of a nerve,** may be limited or be widely distributed (multiple neuritis). The first-mentioned form will here be considered. The causes of neuritis are traumatism, wounds, overaction of muscles, gout, rheumatism, syphilis, fevers, and alcoholism.

Symptoms.—The symptoms of neuritis are as follows: excessive pain, usually intermittent, in the area of nerve-distribution. The pain is worse at night, is aggravated by motion and pressure, and occasionally diffuses to adjacent nerve-areas or awakens sympathetic pains in the opposite side of the body. The nerve is very tender. The area of nerve-distribution feels numb and is often swollen. Early in the case the skin is hyperesthetic; later it may become anesthetic. The muscles atrophy and present the reactions of degeneration; that is, the muscles first cease to respond to a *rapidly* interrupted, and next to a *slowly* interrupted, faradic current; faradic excitability diminishes, but galvanic excitability increases. When, in neuritis, faradism produces no contraction, a slowly interrupted galvanic current which is so weak that it would produce no movement in the healthy muscle causes marked response in the degenerated muscle. In health the most vigorous contraction is obtained by closing with the — pole; in degenerated muscles the most vigorous contraction is obtained by closing with the + pole. When voluntary power returns, galvanic excitability declines; but power is often nearly restored before faradic excitability becomes manifest (Buzzard).

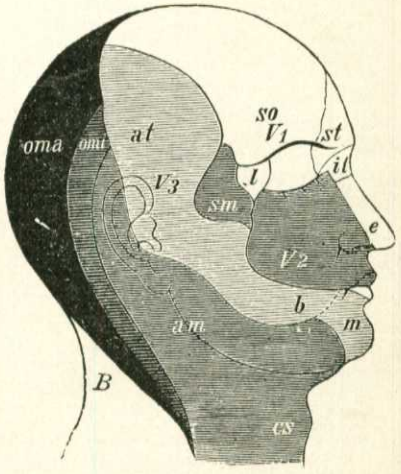


Fig. 293.—Distribution of the cutaneous sensitive nerves upon the head: *oma*, *omi*, The occipit. maj. and minor (from the N. cervical. II and III); *am*, N. auricular magn. (from N. cervic. III); *cs*, N. cervical. superfic. (from N. cervic. III); V_1, first branch of the fifth (*so*, N. supraorbit.; *st*, N. supratrochl.; *it*, N. infratrochl.; *e*, N. ethmoid.; *l*, N. lachrymal.); V_2, second branch of the fifth (*sm*, N. subcutan. malæ seu zygomaticus); V_3, third branch of the fifth (*at*, N. auriculo-tempor.; *b*, N. buccinator; *m*, N. mental.); *B*, posterior branches of the cervical nerves (Seeligmüller).

Treatment.—The treatment of neuritis consists of rest upon splints, and the use of an ice-bag early in the case and a hot-water bag later. Blisters over the course of the nerve are of value, especially in traumatic neuritis. Massage and electricity must be used to antagonize degeneration. A descending galvanic current allays pain to some extent. Deep injections of chloroform or cocain may allay pain. Treat the patient's general health, especially any constitutional

disease or causative diathesis. The salicylate of ammonium or phenacetin may be given internally. In some cases nerve-stretching is advisable.

Neuralgia is manifested by violent paroxysmal pain in the trajectory of a nerve. This disease, unless it is excessively severe and persistent, is treated, as a rule, by the physician. Neuralgia of stumps and scars is a surgical condition, and is due to neuromata, or entanglement of nerve-filaments in a cicatrix. Tic douloureux and other intractable neuralgias require careful removal of any cause of reflex irritation. Causal reflex irritation may arise from disease of the stomach, eyes, uterus, nose, throat, etc. Tic douloureux has been treated by removal of the Gasserian ganglion; removal of Meckel's ganglion; ligation of the common carotid artery; neurectomy of terminal branches of the fifth nerve; division of motor nerves; massive doses of strychnin (Dana and purgatives (Esmarch). The distribution of the fifth nerve, the seat of pain in tic douloureux, is shown in Fig. 293.

Treatment of Neuralgia of Stumps.—Excise the scar; find the bulbous end of the nerve and cut it off. Senn tells us to section the nerve by V-shaped cuts, the apex of the V being toward the body, and to suture the flaps together. Senn's method will prevent recurrence. In some cases reamputation is performed. In entanglement of a nerve in a scar remove a portion of a nerve above the scar and also the neuroma in the scar.

2. Wounds and Injuries of Nerves.

Section of Nerves (as from an incised wound).—After nerve-section the entire peripheral portion of the nerve degenerates and ceases structurally to be a nerve in a few weeks, but after many months, or even years, the nerve may regenerate. The proximal end degenerates only in the portion immediately adjacent to the section; it rapidly regenerates, and a bulb or enlargement composed of fibrous tissue and small nerve-fibers forms just above the line of section; this bulb adheres to the perineural tissues. The entire distal end degenerates, but new axis-cylinders form in this segment by proliferation of the nuclei on the sheath of Schwann. Union of a divided nerve is brought about by the projection of axis-cylinders from the proximal end or from each end and the fusion of these cylinders. The nearer the two ends are to each other, the better the chance of union.

Symptoms.—Pronounced changes occur in the trajectory of a divided nerve. The muscles degenerate, atrophy, and shorten, and develop the reactions of degeneration. When union of the nerve occurs the muscles are restored to a normal condition. If the nerve contains sensory fibers, complete anesthesia (to touch, pain, and temperature) usually follows its division; but if a part is supplied by another nerve as well as by the divided one, anesthesia will not be complete. Trophic changes arise in the paralyzed parts. Among these changes are muscular atrophy; glossy skin; cutaneous eruptions; ulcers; dry gangrene; painless felons; falling of the hair; brittleness, furrowing or casting off of the nails; joint-inflammations; and ankylosis. Immediately after nerve-section vaso-motor paralysis comes on, and for a few days the paralyzed part presents a temperature higher than normal. The diagnosis as to which nerve is cut depends upon a study of the distribution of paralysis and anesthesia.*

* See Bowlby on "Injuries of Nerves."

The Symptoms of Division of Nerves.—*Brachial Plexus.*—If one or more cords of the brachial plexus are divided, motor paralysis and anesthesia appear in the limb, the extent of the paralysis and the area of the anesthesia depending upon the cord or cords involved. It should be remembered that the inner cord of the brachial plexus gives origin to the ulnar nerve, the inner and outer cords give branches which fuse to form the median nerve. The posterior cord gives origin to the subscapular, the circumflex, and the musculospiral nerves. The outer cord gives origin to the external anterior thoracic and the musculocutaneous, as well as to the outer trunk of origin of the median.

Evulsion of the brachial plexus is sometimes effected by an injury, when the arm is not lost. Algernon T. Bristow ("Annals of Surgery," Sept., 1902) reports 3 cases of this rare injury, and has collected 24 undoubted instances. One of his own cases was operated upon the third day after the accident. In this case there was complete paralysis of the upper extremity, with the exception of the sensory area of the intercostohumeral and the circumflex nerves. The accident had been inflicted by the patient's forearm becoming entangled in a rope, which was pulled upon by a steam winch. On reaching the hospital he felt severe pain, referred to the arm. There was much swelling in the inner portion of the subclavian triangle, the left pupil was contracted, and it seemed likely that the nerves had been evulsed close to the intervertebral foramina. From the fact that sensation was preserved in the skin of the convexity of the shoulder, down to the insertion of the deltoid, Bristow concluded that some fibers of the posterior cord of the plexus had escaped division; but when the operation was performed, this conclusion was found to be erroneous. An incision was made, and it was found that the plexus had given way at the point where the four cervical nerves and the last dorsal unite to form the three trunks. In order to reach the lower ends, it was necessary to saw the clavicle and divide the two pectoral muscles; and the torn ends of the nerve-trunks were found underneath the clavicle. Suturing was performed. The ends of the sawn clavicle were sutured together, the wound was closed and dressed, and the arm was put up in Sayres's dressing.

This article of Bristow's is of extreme interest. He discusses the injury to the sympathetic and the reason that sensation was preserved over the area usually supplied by the circumflex. After the performance of this operation sensation over the entire upper arm returned. We agree with Bristow that after such an injury early operation is the only thing that offers any prospect of the return of function. I myself once operated upon a patient that had developed paralysis, motor and sensory, after violent stretching of the arm. In the light of Bristow's case, I assumed that evulsion of the plexus had probably taken place. Incision disclosed the fact that the plexus was intact, but was surrounded with dense scar-tissue. This tissue was removed, so as to loosen the nerves; but I have lost track of the patient, and do not know the result. My patient was operated upon many months after the injury. It is well to bear in mind that in an injury of the supraclavicular division of the brachial plexus there will probably be palsy of the great serratus muscle.

Posterior Thoracic Nerve.—Division of this nerve causes paralysis of the serratus magnus muscle, which is made evident by eversion and rotation of the scapula when the arm is taken forward.

Suprascapular Nerve.—Division of this nerve produces some anesthesia

over the scapula and paralysis of the supraspinatus and the infraspinatus muscles.

Circumflex Nerve.—Division of the circumflex nerve produces paralysis of the deltoid muscle, so that it becomes impossible to lift the arm to a right angle with the body. There is some slight retention of power in the anterior fibers, which are supplied by the anterior thoracic nerve. The skin over the lower part of the muscle is usually anesthetic.

Musculocutaneous Nerve.—Division of this nerve produces paralysis of the biceps and of the brachialis anticus muscles. This palsy becomes especially evident when the forearm is supinated, because in this position the supinator longus can no longer act as a flexor of the elbow. There is anesthesia of the radial side of the forearm, anteriorly and posteriorly.

The Musculospiral or Radial Nerve.—Division of this nerve high up, near the plexus, causes paralysis of the extensor muscles of the elbow and the wrist, of the supinators, and of the long extensors of the thumb and fingers. When

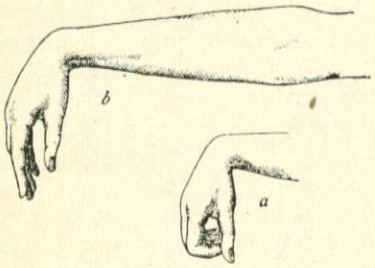


Fig. 294.—Paralysis of musculospiral nerve after fracture of the humerus ("wrist-drop"); but when fingers have been flexed into palm, *a*, they can be extended *b*, at first interphalangeal joints by lumbricals and interossei, which are supplied by the ulnar and median nerves (Erichsen).

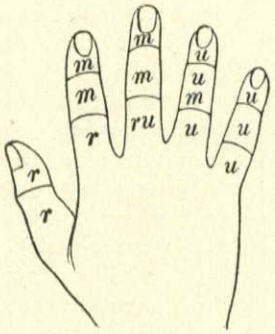


Fig. 295.—Distribution of sensory nerves on the backs of the fingers: *r*, Musculospiral or radial nerve; *u*, ulnar nerve; *m*, median nerve (Krause).

divided near the middle of the humerus, the triceps usually, but not invariably, escapes. If the injury is below the branch going to the supinator longus, that muscle will escape; otherwise it will become paralyzed. The extensor palsy causes wrist-drop and loss of the power of extending the first phalanges of the fingers and thumb; and, as Gowers has pointed out, flexion is reduced to one-third of the normal, the flexors having lost power "from the loss of antergic support." As a rule, in musculospiral palsy there is loss of supination. Sensibility is sometimes greatly affected, and sometimes very slightly. Anesthesia rarely occurs in the upper arm; and even in the hand sensation may be normal, or nearly so. Fig. 294 shows the position of the parts in musculospiral palsy and Figs. 295 and 298 the sensory distribution of the nerve.

The Median Nerve.—After division of the median nerve there is paralysis of the pronators; the flexor carpi radialis; the finger flexors, except the ulnar portion of the deep flexor; the abductors, and the flexors of the thumb; and the two radial lumbricales. The forearm can be placed in a position midway

between pronation and supination; but further pronation cannot be voluntarily effected. In executing flexion of the wrist, a strong deviation toward the ulnar side takes place. The thumb is in a position of extension and adduction, and cannot be brought into apposition with the finger-tips. The second phalanges of the fingers cannot be flexed on the first, and the distal phalanges of the first and second fingers cannot be voluntarily flexed. The corresponding phalanges of the third and fourth fingers can be flexed, this being accomplished by the unparalyzed ulnar half of the deep flexor. Flexion of the first phalanges is still possible, as it is accomplished by means of the interossei. The extensor action of the interossei muscle upon the middle and distal phalanges, being unopposed, may eventually cause subluxation. The sensory distribution of the median nerve is shown in Figs. 295, 296, 297, and 298. It is the sensory nerve of the radial side of the palm, the front of the thumb, the first

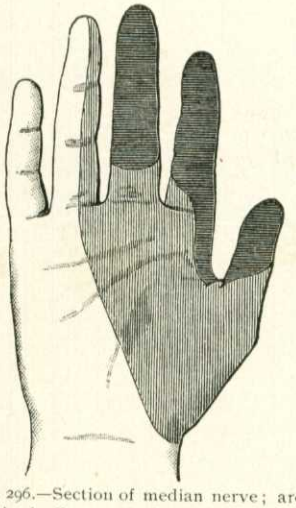


Fig. 296.—Section of median nerve; areas of anesthesia (heavy shading) and of dysesthesia (light shading) on palmar surface of hand (Bowlby).

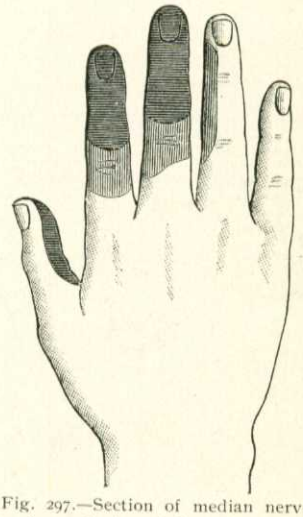
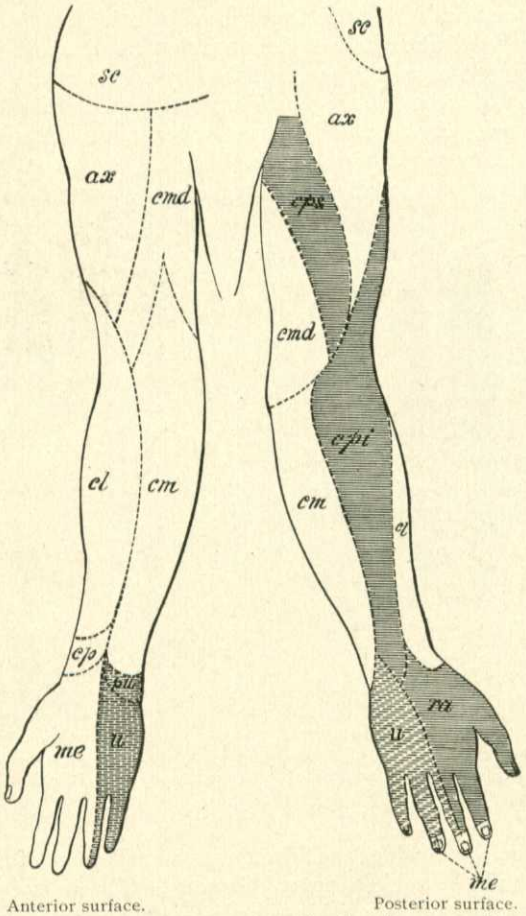


Fig. 297.—Section of median nerve; regions of anesthesia and dysesthesia on dorsal surface of hand (Bowlby).

and second fingers and half of the third finger, and the back of the last phalanx of the index and the middle finger (Gowers). The sensory changes after median paralysis are quite variable—sometimes widespread and complete, at other times trivial, and occasionally absent. Gowers says that if there is anesthesia it is usually of the palmar surface, and may also occur on the dorsal aspect of the ends of the first two fingers.

The Ulnar Nerve.—When the ulnar nerve is divided, there is paralysis of the flexor carpi ulnaris, of the ulnar portion of the deep flexor, of the muscles of the little finger, of the adductor pollicis, and of the inner end of the flexor brevis pollicis (Gowers). It becomes impossible to adduct the thumb, and the majority of the movements of the little finger are abolished. Flexion of the fingers is impossible at the first joints, and extension is impossible at the other joints; but, as Gowers points out, the loss is slighter in the first two fingers than in the others, because the lumbricales of the first two fingers are supplied by the

median nerve. Interosseal flexion is impossible; and the opponents of the interossei, acting without normal antagonism, contract and produce what is known as a *claw-hand* (Fig. 299), a condition in which the first phalanges are overextended and the others are flexed. The sensory loss in ulnar paralysis is extremely variable. The sensory distribution is to the ulnar side of the hand,



Anterior surface. Posterior surface.

Fig. 298.—Distribution of the cutaneous nerves to the shoulder, arm, and hand. The region of the N. radialis is represented by the unbroken hatched line, that of the N. ulnaris by the broken hatched lines. *a*, Anterior, *b*, posterior surface; *sc*, Nn. suprascapular (plexus cervicalis); *ax*, chief branch of N. axillar.; *cps*, *cpi*, Nn. cutanei post. sup. and inf. (from N. radialis); *ra*, terminal branches of N. radialis; *cm*, *cl*, Nn. cutanei medius (also to the plexus) and lateralis (chiefly to the N. medianus); *cp*, N. cutan. palmar., N. rad.; *cmd*, N. cutan. medialis; *me*, N. medianus; *u*, N. ulnaris; *epu*, N. cutan. palm. ulnaris (Henle).

both back and front, involving the little finger, the ring-finger, and the ulnar half of the middle finger (Figs. 295, 298, and 300).

Lumbar Plexus.—The lumbar plexus supplies the cutaneous surface of the lower portion of the abdomen, of the front and the sides of the thigh, and of the inner portion of the leg and foot (Fig. 301). It innervates the flexors and

adductors of the hip-joint, the extensors of the knee, and the cremaster muscle. The branches sent to the leg are the obturator and the anterior crural nerves.

Sacral Plexus.—The sacral plexus supplies the extensors and rotators of the hip, the knee-flexors, and all the muscles of the foot; also the skin of the gluteal region, the back of the thigh, the outer portion and the posterior part of the lower leg, and most of the foot (Gowers) (Fig. 301). Its chief branches are those to the external rotators of the hip—the gluteal nerve, the small sciatic, and the great sciatic.

The Anterior Crural Nerve.—When this nerve is divided, the extensor

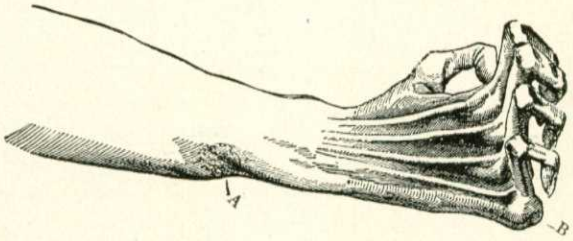


Fig. 299.—Paralysis of ulnar nerve from wound at A; contracture of common extensor with posterior luxation of first phalanges; B, head of metacarpal bone (Duchenne).

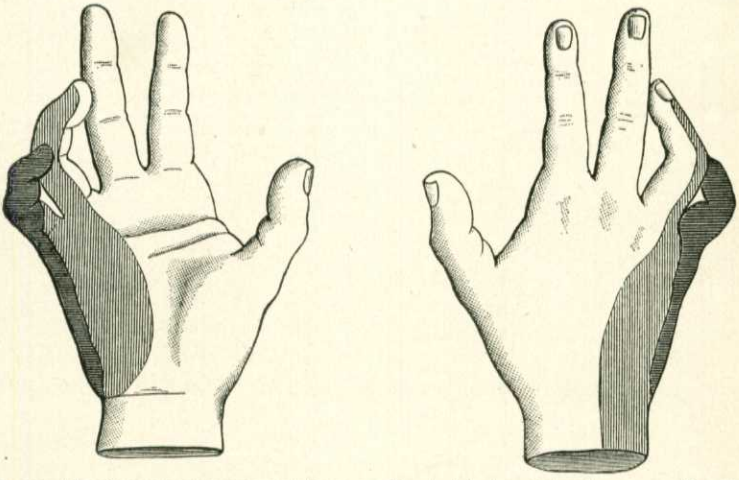


Fig. 300.—Showing sensory loss and ordinary position in injuries of the ulnar nerve (Bowlby).

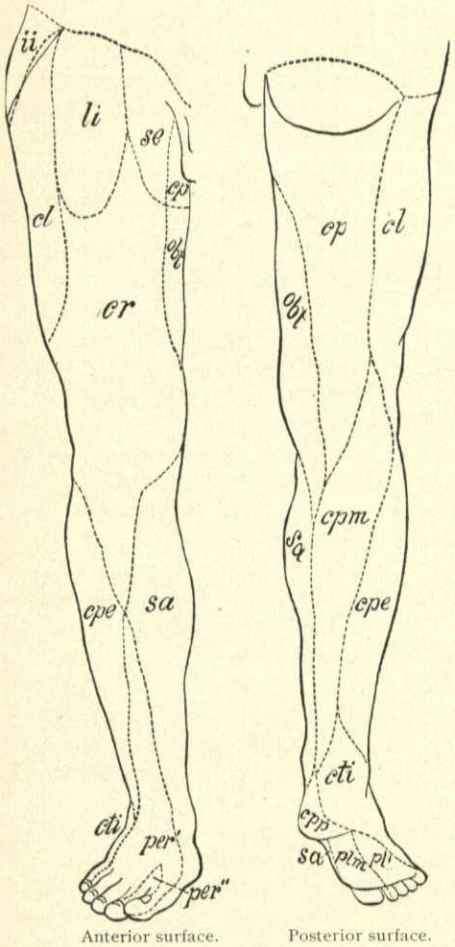
muscles of the knee are paralyzed. The psoas muscle is not affected, even if the nerve is divided within the abdomen; but high division may produce paralysis of the iliacus muscle. In anterior crural palsy the skin is anesthetic over almost the entire thigh, the inner surface of the leg and foot, and the inner sides of the first and second toes (Fig. 301).

The Obturator Nerve.—In obturator palsy the adductor muscles of the thigh are paralyzed, and, in consequence, the patient is unable to cross one leg over the other. Gowers points out that external rotation of the thigh is also interfered with.

The Superior Gluteal Nerve.—The division of this nerve paralyzes the

gluteus medius and the gluteus minimus muscles, and there is "loss of abduction and circumduction of the thigh" (Gowers).

The Small Sciatic Nerve.—Division of this nerve paralyzes the gluteus maximus muscle, and produces anesthesia of the upper half of the calf of the leg and of the middle third of the back of the thigh (Gowers) (Fig. 301).



Anterior surface. Posterior surface.

Fig. 301.—Distribution of the cutaneous nerves of the lower extremity: *ii*, N. ilio-inguinal. (plex. lumb.); *li*, N. lumbo-inguinal. (to the genitocrural, plex. lumbal.); *se*, N. spermat. ext. (to the genitocrural); *cp*, N. cutan. post. (plex. ischiad.); *cl*, N. cutan. lateral. (plex. lumb.); *cr*, N. cruralis (plex. lumbal.); *obt*, N. obturator. (plex. lumb.); *sa*, N. saphen. (plex. lumbal.); *cpe*, N. commun. peron. (N. peron. tibial.); *cti*, N. commun. tibial.; *per'*, *per''*, N. peronæi ram. superfic. et prof.; *cpm*, N. cutan. post. med. (plex. ischiad.); *cpp*, N. cut. plant. propr. (N. tib.); *plm*, *pll*, N. plantar. medial. et lateral. (N. tib.) (Henle).

The Great Sciatic Nerve.—If this nerve is divided near the sciatic notch there is a paralysis of the flexor muscles of the leg. These muscles, as Gowers points out, are also extensors of the hip. There is likewise paralysis of all the muscles below the knee. If, however, the injury is below the upper third of the thigh, there is no paralysis of the flexors of the leg. If the nerve is damaged on a level below the small sciatic, there is anesthesia of the outer portion of the leg, of the sole of the foot, and of most of the dorsum of the foot (Fig. 301).

The External Popliteal Nerve.—When this nerve is damaged, there is paralysis of the tibialis anticus muscle, the extensor longus digitorum, the extensor brevis digitorum, and the peronei; and the patient is unable to flex the ankle and extend the first phalanges of the toes. When he tries to walk, he cannot lift the foot from the ground; and eventually there is the development of talipes equinus (Gowers). The anesthesia is manifest on the outer portion of the anterior surface of the leg, and also on the dorsum of the foot (Fig. 301).

The Internal Popliteal Nerve.—Damage to this nerve paralyzes the posterior tibial muscle, the flexor longus digitorum, the muscles of the calf, the popliteus muscle, and the muscles of the plantar surface of the foot. The toes become flexed at the two distal joints, and extended at the proximal joints. Walking

is greatly interfered with. There is loss of the power of rotating the flexed leg inward, if the damage is above the branch to the popliteus muscle; and extension of the ankle-joint is lost. As the consequence, talipes calcaneus develops (Gowers). The anesthesia is variable, but usually involves the sole of the foot, and the outer surface and lower portion of the back of the leg (Fig. 301).

The Plantar Nerves.—Division of the internal plantar nerve paralyzes the short-toe flexor, the two inner lumbricales, and the plantar muscles of the great toe, except the adductor (Gowers). There is anesthesia of the inner portion of the sole of the foot, and of the plantar surface of the three inner toes and of half of the fourth toe (Fig. 301).

Division of the external plantar nerve causes paralysis of the muscles of the little toe, of the adductor of the great toe, of all the interossei, of the two outer lumbricales, and of the flexor accessorius (Gowers). There is anesthesia of the skin of the outer half of the sole of the foot, of the little toe, and of half of the fourth toe (Fig. 301).

Treatment.—In all recent cases of nerve-section, suture the ends of the divided nerve. In 123 cases of primary suture, 119 were cured in from one day to one year (Willard). The return of sensation may be rapid or may be slow; muscular power returns more slowly than sensation. If the patient is not seen until long after the accident, incise and apply sutures (secondary sutures); if the nerve cannot be found, extend the incision, find the trunk above and trace it down, and find the trunk below and follow it up. In 130 cases of secondary suture, 80 per cent. were more or less improved (Willard). Even after primary suture loss of function is bound to occur for a time. After secondary suture sensation may return in a few days, but it may not return until after a much longer period; in any case muscular function is not restored for months. After partial section of a nerve the ends should be sutured. In performing secondary suture it may be necessary to effect "lengthening" in order to approximate the ends. Transplantation of a portion of nerve is sometimes practised. Transplantation is bridging the gap by means of a portion of nerve from one of the lower animals or from a recently amputated human limb. Nerve-transplantation may fail utterly; it may be followed by great improvement; but absolute and perfect restoration of function cannot be obtained. R. Peterson * has made a study of the 20 recorded cases of nerve-transplantation. Eight of the operations were primary and 12 were secondary. The periods after the injury at which operation was performed varied from forty-eight hours to a year and a quarter. Four of the 8 primary cases improved. Eight of the 12 cases of secondary operation showed improvement in motion or sensation. The distance between the nerves did not seem to affect the results. No case recovered completely, but in one case sensation returned completely and only the abductors of the thumb remained weak. In most cases benefited sensation returned by the tenth day and motion within two and a half months. In one of the successful cases, that of A. W. Mayo Robson,† the spinal cord of a rabbit was used.

Pressure upon nerves may arise from callus, scars, a dislocated bone, a tumor, or pressure from an external body.

The **symptoms** may be anesthetic, paralytic, or trophic.

* Amer. Jour. of Med. Sciences, April, 1899.
† Amer. Jour. of Med. Sciences, April, 1899.

The **treatment** is as follows: Remove the cause (reduce a dislocated bone, chisel away callus, excise a scar, etc.); then employ massage, douches, exercise, and electricity.

Dislocation of the Ulnar Nerve at the Elbow.—This condition is very rare. It may occur as a complication of a fracture or a dislocation, or as an uncomplicated condition. It may be produced by violence or by muscular effort, which ruptures the fascia the function of which is to retain the nerve back of the inner condyle of the humerus. In some cases the symptoms are slight and transitory, the nerve functionating well in its new situation. As a rule, there are pain, numbness, or anesthesia of the ulnar trajectory, some stiffness of the elbow, and stiffness of the little finger and ring-finger. The nerve can be felt in front of the inner condyle of the humerus. In some cases neuritis follows, with trophic changes.

Treatment.—Expose the nerve by an incision, incise the fibrous tissue back of the inner condyle, and press the nerve into the bed prepared for it and hold it in place by sutures of kangaroo-tendon passing through the triceps tendon. Wharton advises suturing also "the margin of the fascial expansion of the triceps tendon superficial to the nerve."*

Contusion of Nerves.—The **symptoms** of contusion of nerves may be identical with those of section. Sensation or motion, or both, may be lost. The case may recover in a short time, or the nerve may degenerate as after section.

The **treatment** at first is rest, and later electricity, massage, frictions, and douches.

Punctured Wounds of Nerves.—The **symptoms** of punctured wounds of nerves may be partly irritative (hyperesthesia, acute pain, and muscular spasm) and partly paralytic (anesthesia, muscular wasting, and paralysis).

The **treatment** after the puncture has healed is the same as that for contusion.

3. Operations upon Nerves.

Neurorrhaphy, or Nerve-suture.—When a nerve is completely or partially divided by accident, it should be sutured. The instruments required are an Esmarch apparatus, a scalpel, blunt hooks, dissecting forceps, hemostatic forceps, curved needles or sewing needles, a needle-holder, and catgut, silk, or kangaroo-tendon. In primary suture render the part bloodless and aseptic. Enlarge the incision if necessary. If the ends can readily be approximated, pass two or three sutures through both the nerve and its sheath and tie them (Figs. 302 and 303). If the ends cannot be approximated, stretch each end and then suture. Remove the Esmarch band, arrest bleeding, suture the wound, dress antiseptically, and put the part in a relaxed position on a splint. After union of the wound remove the splint and use massage, frictions, electricity, and the douche. The operation in some instances fails, but in many cases succeeds. In some few cases sensation returns in a few

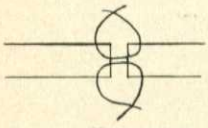


Fig. 302.—Nerve-suture.

* A report of fourteen cases of dislocation of the ulnar nerve at the elbow, by H. R. Wharton, Amer. Jour. of Med. Sciences, Oct., 1895.

days, but in most cases does not return for many weeks or months. Sensation is restored before motor power. *Secondary suture* is performed upon cases long after division of a nerve. The part is rendered aseptic and bloodless; an incision is made; the bulbous proximal end is easily found and loosened from its adhesions; the shrunken distal end is sought for and loosened (it may be necessary to expose the nerve below the wound and trace its trunk

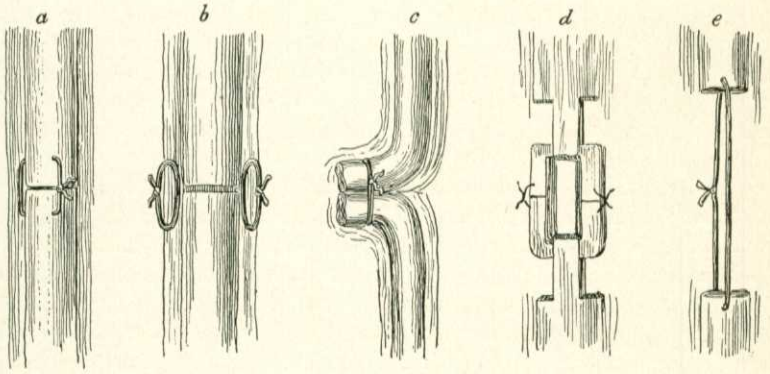


Fig. 303.—Nerve-suture: *a*, Direct; *b*, perineurotic; *c*, paraneurotic; *d*, *e*, neuroplasty (Senn).

upward); the entire bulb of the proximal end is cut off; about one-quarter of an inch of the distal end is removed (Keen); each end is stretched, and the ends are approximated and sutured together. If stretching does not permit of approximation, adopt the expedient shown in Fig. 303, *d*, or in Fig. 304, or graft a bit of nerve from a recently amputated limb or from a lower animal (it makes no difference as to whether the grafted nerve were motor, sensory, or mixed). A. W. Mayo Robson has succeeded in grafting the spinal cord of a rabbit in the median nerve of a man. The restoration of function was almost complete. Allis suggested shortening the limb by excising a piece of bone, and the operation has been carried out successfully by Keen, Rose, and others. Letiévant attaches the cut end of the peripheral portion of a divided nerve to an adjacent uncut nerve. Assaky uses the suture *à distance*, composed of catgut passing from end to end and serving as a bridge for reparative material (Fig. 303).

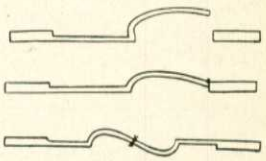


Fig. 304.—Suture of a nerve by splitting the ends (Beach).

Neurectasy, Neurotomy, and Neurectomy.—*Neurectasy*, or nerve-stretching, may be applied to motor, sensory, or mixed nerves. A nerve can be stretched about one-twentieth of its length. Neurectasy has been employed for neuralgia, neuritis, muscular spasm, hyperesthesia, anesthesia, painful ulcer, perforating ulcer, and the pains of locomotor ataxia. The operation, which was once the fashion, seems to benefit some cases, but it is not now thought so highly of as formerly. The incision for neurectasy is identical with the incision for neurectomy or neurotomy of the same nerve. *Neurotomy*, or section of a nerve, is only performed upon small and purely sensory nerves. It is performed chiefly for peripheral neuralgia

or for some other painful malady. It is useless, because sensation soon returns. Paget saw complete return of sensation in four weeks after division of the median nerve. Corning endeavors to prevent this regeneration by inserting oil between the ends. He uses oil of theobroma containing enough paraffin to make the melting-point 105° F. The oil is melted, is injected around the nerve, and cold is applied. The nerve is now sectioned with a canaliculated knife, the ends are separated widely, more oil is injected, and cold is again applied. The theory is that this oil, which is solid at the temperature of the body, devitalizes the nerve at the point of section and acts as a barrier to the passage of regenerating fibers. This method has been applied especially in cervicobrachial neuralgia.* *Neurectomy*, or excision of a portion of a nerve-trunk, is only applicable to sensory nerves and to painful affections.

Sympathectomy.—*Jonnesco's Operation.*—It has long been known that division of the sympathetic nerve in the neck may produce important changes in the eye and in the cerebral circulation. In 1893 Jaboulay divided the sympathetic on each side, for the purpose of treating epilepsy. The removal of the ganglia of the sympathetic was proposed by Baracz; and the operation was first performed by Jonnesco, in 1896, for epilepsy. The operation is performed by some surgeons for epilepsy, for exophthalmic goiter, and for glaucoma. In operating for glaucoma, the superior cervical ganglion on each side is removed, as it is from this that the sympathetic fibers that pass to the eye are derived. If the operation is done at all, it should be a bilateral operation.

The operation is used in epilepsy on the theory that there is an anemic condition of the brain in this disease, which is corrected by producing a hyperemia; and that the hyperemia improves cerebral nutrition. The operation in epilepsy is largely theoretical, although Jonnesco claims 12 per cent. of cures in a large number of operations. In exophthalmic goiter there seems to be some distinct evidence that the operation may be beneficial. Personally, I have not employed it in epilepsy; and, at the present time, I should not be inclined to do so. In exophthalmic goiter, if any operation is necessary, I should perform partial thyroidectomy; but in progressive glaucoma, which is always so absolutely hopeless, the operation is a justifiable procedure and occasionally seems to have a distinct influence in retarding the development of the disease.

The incision should be made along the posterior margin of the sternocleidomastoid muscle. I have become convinced, in performing two operations of this kind and through studies made upon the dead body, that the ganglion may be more easily reached from behind the sternocleidomastoid than from in front of it. The internal jugular vein and the carotid artery are lifted upward and forward; and the superior ganglion will usually adhere to the under portion of the carotid sheath, and be lifted up with it. Theoretically, it is not necessary to open the carotid sheath in this operation; but, practically, this had better be done, so that one may, without any possibility of doubt, distinguish between the pneumogastric and the sympathetic nerve. The moment the nerve is cut, the pupil on that side will contract.

Stretching of the Sciatic Nerve.—Some surgeons stretch the sciatic

* Medical Record, Dec. 5, 1896.

nerve by anesthetizing the patient and holding the leg and thigh in line, strong flexion being made upon the hip, the entire lower extremity being used as a lever (Keen). This method, which has caused death, inflicts needless damage, and stretching after an incision has been made is safer and better. The instruments required are a scalpel, hemostatic forceps, dissecting forceps, a dissector, retractors, and a scale with a handle and a hook. The patient lies prone, the thighs and legs being extended. An incision four inches in length is made a little external to the middle of the thigh, and going at once through the deep fascia; the biceps muscle is found and is drawn outward; the nerve is discovered between the retracted biceps on the outside and the semitendinosus on the inside, resting upon the adductor magnus muscle. The nerve, which is caught up by the finger, is first pulled down from the spine and then up from the periphery, and finally the hook of the scale is inserted beneath the trunk and the nerve is stretched to the extent of forty pounds. Very rarely is even a single ligature needed. The wound is sutured and dressed. If the incision is made at a higher level below the gluteofemoral crease, the sciatic nerve will be found just by the outer border of the biceps.

Neurectomy of the Infra-orbital Nerve.—The instruments required in this operation are a scalpel, dissecting forceps, aneurysm needle, hemostatic forceps, blunt hooks, a dissector, and metal retractors. The patient lies upon his back, the head being a little raised by pillows. The surgeon stands to the outside of and faces the patient. A curved incision one and a half inches long is made below the lower border of the orbit. The nerve lies in a line dropped from the supra-orbital notch to between the two lower bicuspid teeth. The nerve is found upon the levator labii superioris muscle. A piece of silk is passed under the nerve by an aneurysm needle and firmly fastened. The upper border of the incision is drawn upward; the periosteum of the floor of the orbit is elevated and held by a retractor; the roof of the infra-orbital canal is broken through; the nerve is picked up far back with the blunt hook and is divided with scissors, and the entire nerve is drawn out by making traction upon the silk. The bleeding in the orbit is checked by pressure. The wound is stitched without drainage.

Neurectomy of the Supra-orbital Nerve.—Before sterilizing the parts shave off the eyebrow. The instruments required and the position of the patient are as for the operation upon the infra-orbital nerve. A curved incision one inch long discloses the nerve as it emerges from the supra-orbital notch or foramen at the junction of the inner and middle thirds of the eyebrow. The nerve is pulled forward and cut off above and below.

Neurectomy of the Inferior Dental Nerve.—The instruments are the same as for any other neurectomy, and in addition a chisel, a mallet, and a rongeur forceps. Make a curved incision around the angle of the jaw. Lift the supra-maxillary branch of the facial nerve downward (Kocher). Separate the masseter muscle with a periosteum-elevator and slight touches with the knife. Chisel an opening in the center of the ascending ramus (Velpeau's rule). This opening exposes the beginning of the dental canal. If necessary, the opening may be enlarged with a rongeur. Pull the nerve out with a hook and remove a piece from it.

Extracranial Operation for Neuralgia of the Fifth Nerve.—The operation for removal of the Gasserian ganglion is difficult, bloody, and

dangerous. Removal of portions of the pain-haunted nerve-trunks sometimes cures the condition and often ameliorates it for a considerable time. The serious operation of removing the ganglion may be performed if peripheral operations fail or in violent and intractable cases of long standing in which pain is felt in more than one branch. Removal of nerves by ordinary neurectomy often gives comfort for a few months, but rarely gives prolonged relief. If we seek striking benefit by an extracranial operation, it must be thoroughly done.

Rose's Method of Neurectomy.*—This operation is a modification of the Braun-Lossen method and is employed when the second division of the fifth nerve is the seat of pain. Besides the instruments laid out for any ordinary operation, the surgeon requires chisels, fine saws, blunt hooks, periosteum separators, silver wire (No. 22), and drills. The infra-orbital nerve is exposed by an incision, a ligature is tied around it, the roof of

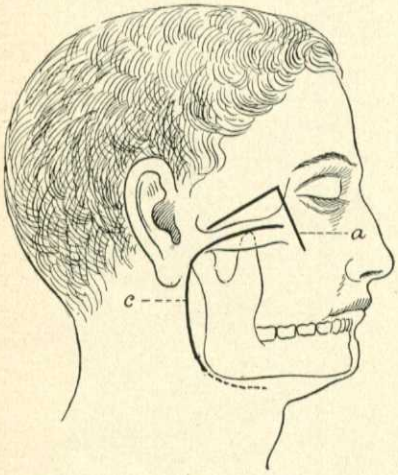


Fig. 305.—*a*, The Braun-Lossen incision; *c*, Rose's incision for reaching the sphenomaxillary fossa (Rose).

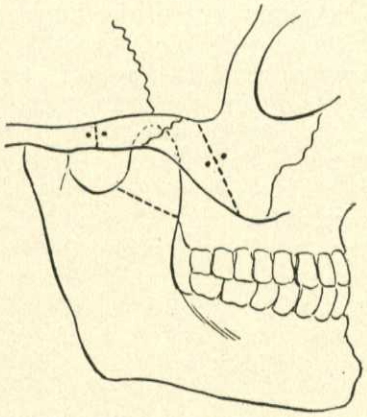


Fig. 306.—Lower jaw and zygoma. Drill-holes and saw-cuts are shown (Rose).

the infra-orbital canal is opened by a chisel, and the nerve is traced back as far as possible. The wound is then packed temporarily with gauze. The next step in the operation is to open a way into the sphenomaxillary fossa (Fig. 305). The knife is inserted slightly below the external angular process of the frontal bone, is carried back along the zygoma, down in front of the ear to just above the angle of the jaw, and then forward for two inches. This flap, which is composed of skin and subcutaneous fat only, is dissected forward, and Steno's duct and branches of the facial nerve are not damaged. The flap is wrapped in gauze and temporarily stitched to the side of the nose. The zygoma is exposed by a transverse incision. At the root of the zygoma two holes are drilled one-fourth of an inch apart and two more holes one-fourth of an inch apart are drilled through the zygomatic process of the malar line. The zygoma is then divided by a

* See article by Wm. Rose, Practitioner, March, 1900.

saw (Fig. 306). The posterior saw line runs between the two drill-holes at the root of the zygoma. The anterior cut passes between the two anterior drill-holes. The direction of the first cut is directly downward. The direction of the second cut is downward and forward from above. The arch is freed and detached downward and backward. The exposed tendon of the temporal muscle is retracted backward. The removal of a little fat exposes the pterygomaxillary fossa. The internal maxillary artery is exposed, two ligatures are applied, and the vessel is divided between them. The finger feels for the sphenomaxillary and pterygomaxillary fissures. The external pterygoid muscle is separated from the greater wing of the sphenoid and from the root of the external pterygoid process. On the edge of the greater wing of the sphenoid a long prominence is usually detectable. It overhangs the sphenomaxillary fossa and should be cut away by the use of a chisel. The superior maxillary nerve is lifted on a blunt hook, is grasped with forceps, and is twisted off as near the ganglion as possible (Fig. 307). The distal end is drawn upon and the nerve, having been previously loosened, is drawn back through the infra-orbital canal. The zygomatic arch is wired in place, the temporal fascia is sutured with buried sutures, and the skin-wound is closed. If the pain involved not only the second division, but also the third division, the operation previously described should be performed first, and the third division should be attacked a few weeks later. The third division is reached by removing the coronoid process. The inferior dental and lingual nerves are found, and are traced up to the foramen ovale, and are twisted off close to the ganglion, and the distal portions are removed.

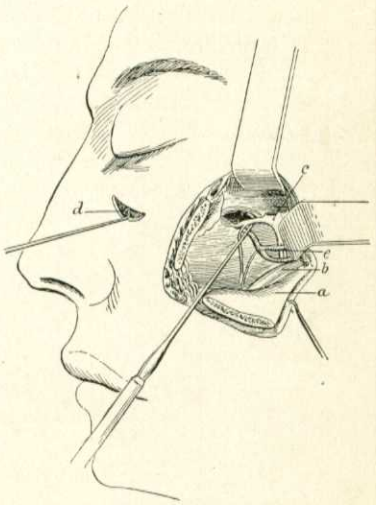


Fig. 307.—*a*, The zygomatic arch, turned down after sawing; *b*, tendon of the temporal muscle retracted; *c*, superior maxillary nerve and Meckel's ganglion; *d*, infra-orbital nerve emerging from canal; *e*, internal maxillary artery.

Removal of the Gasserian Ganglion.—This operation is dangerous, bloody, and difficult, and is only undertaken in very severe cases of tic douloureux, and in cases upon which less grave procedures have failed. The operation usually cures the pain if the patient recovers from the actual procedure. The mortality is from 10 to 15 per cent. Carson collected 100 cases, Murphy and Neff 42 cases. The mortality in this group of 142 cases was 15 per cent. Most of the cases reported by Murphy and Neff were operated upon during or after 1899, and in this group the mortality was 10 per cent. ("Progressive Medicine," March, 1903). In Lexer's series of 201 cases, referred to below, the mortality was 17 per cent. In many cases a perfect cure is obtained. In some few the pain returns upon the side operated upon. Occasionally it arises on the side not operated upon. In some cases ulceration of the cornea follows operation. Such ulceration may

be trivial, may result in opacity, or may destroy the eye. Paralysis of the abducens occurs in some cases. The hemorrhage may be so profuse as to require packing of the wound and suspension of the operation for a few days. Lexer ("Arch. f. klin. Chir.," Bd. lxv, H. 4) gives a table of 201 cases. Of the survivors, 93.4 per cent. were apparently cured. In two-thirds of the cases the trouble was right-sided. In 10 the operation was temporarily abandoned because of hemorrhage. The experience of surgeons in general is that after the removal of the ganglion there is apt to be some atrophy of the tongue and the eye usually becomes insensitive and watery.

The Hartley Operation for Removal of the Gasserian Ganglion.—This operation was first performed by Hartley in 1891, five months before Krause performed it. The surgeon is provided with the instruments for osteoplastic resection of the skull. Krause and others employ a surgical engine. Special retractors, various hooks, scalpels, a dry dissector, dissecting and hemostatic forceps, and an electric forehead-light are required. Long strips of gauze must be

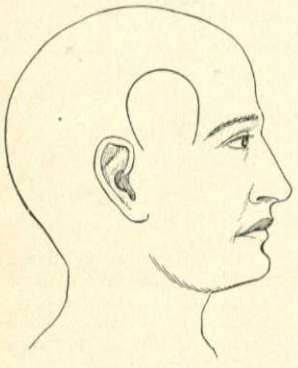


Fig. 308.—Hartley's osteoplastic flap in removal of Gasserian ganglion (Tiffany).

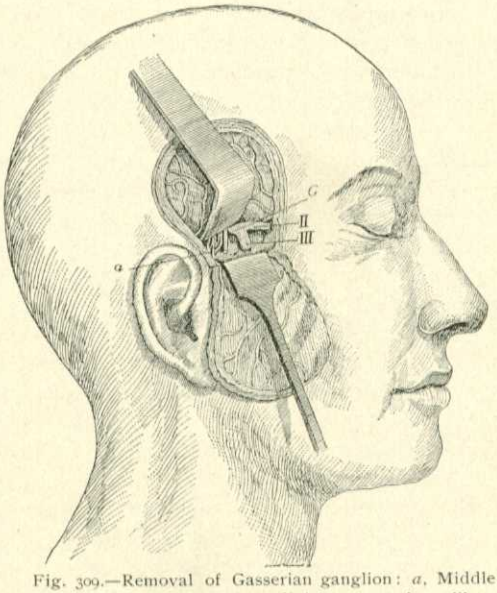


Fig. 309.—Removal of Gasserian ganglion: *a*, Middle meningeal artery; II, ophthalmic division; III, submaxillary division; *G*, ganglion (Krause).

ready for packing in case of hemorrhage. The patient is placed recumbent, with head turned to the opposite side. The application of a provisional ligature or clamp to the external carotid artery is advocated by some, but this step will not control the venous bleeding, which is the most harassing hemorrhage encountered. A large osteoplastic flap is formed in front of the ear (Fig. 308), and is broken out. Hemorrhage is arrested. It may be found that the meningeal artery has been ruptured. If this accident has happened, and the vessel lies in a bony canal, plug with Horsley's wax. If the vessel is bleeding upon the dura, ligate by passing suture-ligatures around it. If it is torn off at the foramen spinosum, pack with iodoform gauze, and postpone the conclusion of the operation for forty-eight hours. It may be necessary at any stage of this formidable operation to pack the wound and postpone completion for two

days. Some surgeons (Krause, Bergmann) ligate the meningeal artery as a routine procedure; but this operation is often difficult and requires much time. If the unligated vessel is divided, the hemorrhage can be arrested by gauze packing or by plugging the foramen spinosum. The head and body of the patient should now be elevated. This allows the brain to drop posteriorly and renders forcible retraction unnecessary, and, further, it lessens venous bleeding (Lexer). The next step is to lift up the dura and with it the brain (Fig. 309). Find the inferior maxillary nerve and clamp it with hemostatic forceps. Find the superior maxillary nerve and clamp it. Loosen the nerve from their beds with a dry dissector. Twist the clamp-forceps so as to reel up the nerves. This pulls out the ganglion intact with the motor root and the root of origin, as far back as the pons (Krause's method). Arrest bleeding; close the flap; sew the lids of the affected side together; and cover the eye with a watch-crystal.

Cushing has modified the Hartley operation so as to permit of extradural manipulation below the arch made by the middle meningeal artery and thus lessen the danger of laceration of the artery ("Jour. Amer. Med. Assoc.," April 28, 1900). He trephines the wall of the temporal fossa very low down, opens into the skull below the arch of the meningeal vessels, and thus avoids the meningeal at the foramen spinosum of the sphenoid bone and the sulcus arteriosus of the parietal bone.

Horsley's Intradural Method.—An opening is made into the middle fossa of the skull, the dura is opened, and the ganglion is found and removed. This operation is easier than the extradural method, but is believed to be more dangerous.

The Frazier-Spiller Operation of Intracranial Neurotomy of the Sensory Root of the Trigeminus.—If experience shows that after division of the sensory root the nerve does not regenerate, and it seems probable that it does not, the operation must be regarded as a valuable addition to our resources. In this operation the zygoma is temporarily resected. The temporal fossa is exposed, the bony wall is trephined, and the trephine opening is enlarged by the use of a rongeur. The dura is separated and the ganglion and its sensory root exposed. The dural envelope of the ganglion is opened, is separated, and the sensory root is exposed. The sensory root is then picked up on a blunt hook and divided. It is frequently possible, Frazier tells us, to separate the sensory root from the motor root.

Abbe's Operation of Intracranial Neurectomy.—Ligate the external carotid artery of the diseased side, make a vertical incision over the middle of the zygoma down to the bone. An opening into the skull is made by a mallet and gouge, and this opening is enlarged by a rongeur until it is one and one-half inches in diameter. The dura is lifted from the middle fossa and the nerves are exposed. Each nerve-trunk is clamped, is divided near its foramen of exit, and is separated from the ganglion by cutting or by twisting with the forceps. A strip of sterile rubber tissue, one and one-half inches in length and three-fourths of an inch in width, is laid over the round foramen and the oval foramen and is pressed into place by gauze. In a few moments the gauze is withdrawn and the ganglion is allowed to descend upon the rubber tissue. The wound is then closed. (See Robt. Abbe, in

"Annals of Surgery," Jan., 1903.) The rubber tissue is used to block the foramina of exit and prevent future emergence of regenerating nerves.

Operation for Facial Paralysis of Extracerebral Origin (Facio-accessory Anastomosis and Faciohypoglossal Anastomosis).—Operation for this condition was first performed in 1895. (See "Remarks on the Operative Treatment of Facial Palsy of Peripheral Origin," by Chas. A. Ballance, Hamilton A. Ballance, and Purves Stewart, "Brit. Med. Jour.," May 2, 1903; and also the "Surgical Treatment of Facial Paralysis by Nerve Anastomosis," by Harvey Cushing, "Annals of Surgery," May, 1903.) The procedure first employed by Ballance was, after noting by galvanism that muscular fiber still remained, to expose the facial nerve at its point of exit from the stylomastoid foramen, to cut the nerve-trunk across as high up as possible, to expose the spinal accessory, and to suture the distal end of the facial into the trunk of the spinal accessory. The spinal accessory was half cut through to make a bed for the end of the facial. The paper above referred now recommends end-to-side anastomosis between the divided facial and the hypoglossal. The authors have operated five times for facial palsy, and Faure, Kennedy, Cushing, and Keen have done similar operations. The conclusions of the Ballances and Stewart are as follows ("Brit. Med. Jour.," May 2, 1903):

"1. Peripheral facial palsy is remediable by facio-accessory anastomosis, but the extent of recovery appears to be limited to associated movements in conjunction with the shoulder. In most cases the previous deformity disappears when the face is at rest.

"2. For reasons above stated we would in future recommend faciohypoglossal anastomosis rather than facio-accessory.

"3. The cases most suitable for operation are those in which the paralysis has lasted so long that no recovery is to be expected—say, facial palsy lasting six months without any sign of recovery. In our opinion the sooner the operation is done after this date, the better.

"4. A suppurative causal condition producing an infective neuritis renders the prognosis after operative treatment less favorable than in cases due to trauma."