Surgery of the Upper Respiratory System

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Chapter 11: Surgery of the Ear

Surgery for Acoustic Neurinoma

Recently otolaryngologists have become interested in the operation pioneered by William F. House, for the removal of acoustic tumors.

A small acoustic neurinoma (2 cm), without coexisting loss of serviceable auditory function, is best removed by way of the translabyrinthine route. The operation is performed in a relatively short time and is attended with low morbidity and mortality rate.

A total resection of a small acoustic neurinoma can be accomplished through the translabyrinthine route with a 75% chance for preservation of facial nerve function. This is in contrast to a figure which is usually reported as below 20% when the tumor is approached from the posterior route. The intrameatal portion and petrous extensions of the tumor can be resected only through the translabyrinthine route. The importance of total removal cannot be overemphasized, for the mortality rate in patients with recurrent acoustic neurinomas rises sharply.

Total removal of a larger acoustic neurinoma (4 cm and larger) by way of the translabyrinthine route may not be practical, for the exposure of that portion of the tumor adherent to the brain stem and the exposure of vital arteries and cranial nerves may be difficult and hazardous. When the tumor is large the translabyrinthine approach may be used for resection of the intrapetrous portion of the tumor, dissection of the intrapetrous and intracranial portions of the facial nerve, decompression of the tumor, and resection of the posterior surface of the petrous pyramid to the sigmoid portion of the lateral sinus in order to facilitate the suboccipital approach.

To complete the removal of the tumor the suboccipital craniotomy is performed 1 to 2 weeks following the translabyrinthine procedure. This two-stage resection for large acoustic neurinomas is the safest and offers the patient the best chance for survival, preservation of the facial nerve, and complete removal of the tumor.

The diagnosis and successful resection of an acoustic neurinoma is dependent upon a team effort. The team should include an audiologist, roentgenologist, otoneurologist, neurosurgeon, and otolaryngologist. Once the diagnostic procedures have been completed, the case should be reviewed at a meeting of all members of the team. It is my experience and that of my colleagues that all acoustic neurinomas should be approached first by the translabyrinthine route. The neurosurgeon should be present for the intracranial portion of this operation, or at least to inspect the field following the total resection of a small acoustic tumor. If the suboccipital approach is required as a second-stage procedure, the otolaryngologist should be present for that portion of the operation having to do with the facial nerve. Often he can be of valuable assistance with the identification and dissection of the lateral portion of this nerve.
**Diagnosis**

Advances in audiology have contributed considerably to the diagnosis of acoustic neurinomas. Since there is no specific pattern of audiological findings, complete testing is necessary. For the most part this evaluation will either exclude the possibility of the presence of an acoustic tumor or present evidence which should initiate the stimulus to embark upon other diagnostic studies.

**Audiologic Testing.** For proper organization and simplicity it is best to divide the audiologic testing into six categories. Approximately 50% of patients with acoustic tumors will present positive findings in all of them. These categories are as follows:

1. **Testing with whispered and spoken voice.** With the patient's unaffected ear masked with a Barany noise apparatus, phonetically balanced words are spoken at a distance of 1 foot from the patient. A moderate or marked loss of discrimination will be quite apparent. If the hearing loss is great, the use of a speaking tube is of value in detecting discrimination loss.

2. **Testing with a tuning fork.** If an acoustic neurinoma is present, it is obvious that the Weber test will show lateralization to the uninvolved ear. The reaction to the Rinne test should be positive, but should show a reduced bone and air conduction time. A marked increase of the bone conduction time is indicative of tone decay. The Bing test, which is performed by placing the tuning fork over the mastoid process and intermittently occluding the external auditory canal, is of value. With a conductive hearing loss the patient notices very little or no difference in the hearing with the canal occluded, but with a sensorineural hearing loss he will usually state that bone conduction is louder when the ear canal is occluded. The tuning forks often give an excellent indication as to the presence of recruitment. This test is performed by lightly brushing 512, 1024, and 2048 tuning forks. With any significant hearing loss the patient will usually not hear one or all of these tuning forks. Unless the hearing loss is very severe, the patient will hear a tuning fork which has been moderately tapped with a rubber hammer. A positive reaction for recruitment is evident if the patient withdraws from the sound or states it is too loud or uncomfortable when the tuning fork, which has been struck by a sharp blow with the rubber hammer, is placed next to his ear.

3. **Audiogram.** Johnson and House, in their evaluation of pure-tone air-conduction threshold tests, in a series of 46 patients with acoustic neurinoma, found that there was no specific pattern associated with the tumor; 67.4% of the patients demonstrated a high-tone hearing loss, 24% a flat-tone loss, 4.38% a low-tone loss, and 4.3% a trough-shaped loss. Seventy-five percent of patients with acoustic neurinomas will have a type 3 or 4 Bekesy tracing. In a large series of these patients, at least 5% will have normal hearing. This is understandable, for the tumor does not involve or exert pressure on the cochlear nerve, nor does it interfere with the blood supply to the cochlea. Normal hearing or a slight hearing loss is not necessarily indicative of a small tumor.

4. **Recruitment.** Recruitment (determined by the alternate binaural loudness balanced test), which may or may not be present, is useful in differentiating cochlear from retrocochlear disease. As a general rule there is no recruitment when a neural lesion is present. Approximately 10% of patients with acoustic neurinomas, however, will have complete
recruitment. Many others will demonstrate partial recruitment. This is quite understandable since an acoustic tumor may interfere with hearing, either by pressure on, or with involvement of, the cochlear nerve producing a neuro-type loss. On the other hand, the tumor may interfere with the blood supply to the cochlea and thus produce an end-organ lesion.

5. SISI (short increment sensitivity index) test. This should be performed in all patients suspected of having an acoustic tumor. In the test a steady ring is administered at 20 decibels above the threshold and increased at 1 decibel increments. As a rule a cochlear lesion will respond to a 1-decibel increase in loudness. On the other hand, approximately 70% of patients with acoustic tumors will not respond and have a low (0 to 20%) Sisi score.

6. Discrimination score. A speech test should be conducted using the standard Spondee and PB words. In approximately 70% of acoustic neurinoma patients the discrimination score will be at a 30% or lower level. Approximately 20% of the patients will show fairly good discrimination (60 to 100%). The remaining 10% will demonstrate a discrimination score between 30 and 60%.

Vestibular Testing. Approximately 95% of patients with acoustic neurinoma will show some evidence of vestibular dysfunction. Vertigo is usually not the presenting complaint associated with an acoustic neurinoma. Some symptoms suggestive of vestibular dysfunction can be elicited in approximately 80% of the patients; the remaining 20% will have no history of vertigo. A small percentage of patients will give a history of episodic vertigo. At least 6% of the patient’s with a positive history of vestibular dysfunction will admit only to a sensation of unsteadiness rather than that of true vertigo.

Caloric Test. The minimal caloric test is the first test used to determine vestibular function, for it is less apt to produce side effects than are the others. If the results of this testing show no abnormality on either side and equal response on both sides, additional testing is not indicated. The minimal caloric test is performed with the patient’s head inclined backward at an angle of 60 degrees; 20 cc of water (at a temperature of 80°F) are instilled into the external auditory canal in 20 seconds. If there is no response to this test, then an icewater (Kobrak) test is performed. Icewater (5 cc) is instilled into the external auditory canal with the patients head inclined backward at a 60-degree angle. If there is no response, then 10 cc and finally 20 cc of icewater are instilled into the ear canal. No response to 20 cc of icewater is indicative of nonfunction.

Electronystagmography. Electronystagmography is of some value, but there are no consistent characteristic findings for localization of lesions. It will more readily demonstrate spontaneous nystagmus. Tracings are obtained after irrigating the ear canal with water both above and below the normal body temperature. The degree and type of response is recorded. The greatest value of electronystagmography is that it produces a permanent record which can be referred to, especially for comparison with future testing.

Trigeminal Nerve. The corneal reflexes are said to be absent in approximately 60% of patients with acoustic neurinoma. With careful testing, at least some slight degree of decreased facial sensation can be elicited in 30% of the patients. As a general rule there is normal fifth nerve function when the size of the tumor is less than 2 cm.
**Facial Nerve.** Less than 10% of patients with acoustic neurinomas will show either decreased function or irritability of the facial nerve. A loss of sensation in the posterior wall of the external auditory canal is rather difficult to evaluate. When pronounced, it should increase the index of suspicion that there is a lesion involving or compressing the facial nerve.

Hyperacusis is not a common finding. This may be confused with positive recruitment.

Pulec and House report that two thirds of patients with confirmed acoustic tumors had decreased taste function as determined by the electric taste-tester. Most of these patients were not aware of this loss, and only 8% showed a noticeable decreased taste.

The tear test (Schirmer) provides an evaluation of the parasympathetic fibers which accompany the facial nerve from the superior salivary nucleus. The test is performed (Pulec) with two strips of filter paper 1 cm in width. Each is folded 5 mm from one end and placed over a lower lid. Normally 2 cm of filter paper will be saturated with tears in 1 minute. The unaffected side, of course, serves as a good control. Approximately 60% of the patients will show decreased tearing on the side of the lesion.

**Other Cranial Nerves.** Involvement of the ninth and tenth cranial nerves will be manifested by a decreased palatal or pharyngeal reflex and a vocal cord paralysis on the side of the lesion. Weakness or paralysis of the tongue musculature represents an involvement of the twelfth cranial nerve.

Involvement of the ninth, tenth, eleventh, and twelfth cranial nerves is evidence that the tumor has increased in size in an inferior and posterior direction and in the region of the jugular foramen. Cerebellar signs are rare; when manifest they signify the presence of a large tumor. The signs usually associated with cerebellar compression are past-pointing, a disturbance in the gait, or dysdiadochokinesia. As the size of the lesion increases, there may be signs of brain-stem compression, herniation of the cerebellar tonsils into the foramen magnum, increased cerebrospinal fluid pressure with resultant papilledema, and visual disturbance.

**Spinal Fluid and Perilymph Protein Determination.** An acoustic neurinoma does not necessarily cause a rise in the protein level of the spinal fluid. In 25% of the patients the spinal fluid protein value is less than 50 mg per 100 cc of fluid. Usually a normal protein level in a patient with an acoustic neurinoma denotes a relatively small tumor.

For perilymph protein determination, perilymph fluid is aspirated through a perforation made in the foot plate of the stapes. This test should not be performed if other evidence points to a positive diagnosis of an acoustic tumor or when the hearing is normal or slightly decreased. In a patient with an acoustic neurinoma the perilymph protein level is usually well in excess of 1000 mg per 100 cc.

**X-ray Study.** Of all the diagnostic procedures, radiographic evaluation is the most valuable. Routine x rays of the petrous bone should be taken if there is even a slight degree of suspicion that the patient has an acoustic tumor. These should include petrous views by way of the orbits, views at right angle to the long axis (Stenvers views), and 30-degree angle fronto-occipital projections (Chamberlain-Towne views). Normally the diameter fox the
internal auditory canal is quite variable (2.5 to 11 mm), and there may be a 1- to 2-mm variation between the right and left sides. On the other hand, asymmetry between the two sides in a normal person is uncommon, and thus a 1-mm difference between the diameter of one internal auditory meatus and that of the other is significant, providing there is clinical evidence of the presence of an acoustic tumor. When a difference exists, laminograms or polytomography of the petrous bone are indicated. These will outline more clearly the differences in the diameters of the internal auditory canals and the areas of bone destruction.

If the index of suspicion of the presence of an acoustic tumor is high, contrast studies are indicated. This is especially true since the internal auditory canals are normal in 5% of persons with acoustic tumors. The myelography of the posterior fossa is by far the preferable contrast study. A pneumoencephalogram is indicated when the tumors are large.

**Treatment**

**Middle Cranial Fossa Approach.** This approach is similar to that used to approach the trigeminal ganglion. A window, approximately 4 cm square, is made in the squamous portion of the temporal bone. The temporal lobe dura is retracted superiorly after reducing the spinal fluid pressure. The greater superficial petrosal nerve is identified as it exists from the hiatus facialis on the anterior surface of the petrous pyramid. The bone over this nerve is removed by using a diamond bur and constant suction irrigation. The dissection is continued in a posterior direction, until the geniculate ganglion is identified. The bone superior to the facial nerve, medial to the geniculate ganglion, is removed in a similar fashion, until the internal auditory canal is identified. The roof of the internal auditory canal is removed, exposing the tumor.

This operation is technically difficult, for there is a fair chance of injury to the facial nerve as it is unroofed. The bony dissection is accomplished in an area between and very close to both the cochlea and the labyrinth. Injury to the internal auditory artery is another hazard and will result in loss of both auditory and vestibular function.

**Translabyrinthine Approach to the Cerebellopontine Angle.** **Anatomy.** The key to the translabyrinthine operation is a thorough knowledge of the anatomy of the petrous bone and its surrounding structures.

The figure shows the anatomic relationships after the mastoid, middle ear, and labyrinth have been dissected. The important landmarks indicating the location of the horizontal portion of the facial nerve are the cochleariform process, incudal fossa, and the horizontal semicircular canal.

The ampullar ends of the horizontal and superior semicircular canals are close neighbors. The superior semicircular canal often extends above the level of the tegmen mastoideum. The common crus is deep and elusive. The posterior semicircular canal is found just posterior and at right angles to the horizontal semicircular canal.

The vertical portion of the facial nerve is found by a careful and thorough dissection of the superficial group of antero-inferior mastoid cells. The incudal fossa and digastric ridge are also useful landmarks.
The position of the sigmoid portion of the lateral sinus in relation to the labyrinth is variable. An anteriorly positioned sinus usually indicates underdevelopment of the mastoid cells and adds to the complexity of the operation.

The sinodural angle must be dissected. The tegmen over the dura of the posterior and middle fossae is identified. Citelli’s angle, at the junction of the dural plates of the posterior and middle fossae is the landmark, in the mastoidectomy defect, for the superior petrosal sinus.

The superficial and deep groups of the antero-inferior mastoid cells are carefully dissected to determine the level of the jugular bulb and for location of the digastric crest.

A view of the posterior and middle cranial fossae is seen in the figure. Of note are the branches of the middle meningeal artery, the sigmoid portion of the lateral sinus with the beginning of the jugular bulb, the superior and inferior petrosal sinuses, the anterior and posterior surfaces of the petrous pyramid, and the internal auditory meatus.

The translabyrinthine approach for small tumors is through the triangle bound by the superior petrosal sinus, the lateral sinus, and the jugular bulb.

The surgeon should have a clear mental picture of the components of the internal auditory meatus. A simple method of doing this is to visualize the internal auditory meatus as being divided into an upper and lower half by the horizontal crest (crista transversa).

The antero-inferior quadrant is occupied by the cochlear nerve. As would be expected from the middle ear anatomy, the facial nerve enters the meatus directly above in the anterolateral quadrant.

Behind the facial nerve, in the postero-superior quadrant, is the superior vestibular nerve with its branches to the utricle and horizontal and superior semicircular canals. There is a vertical crest between the superior vestibular nerve and the facial nerve.

The inferior vestibular nerve enters the meatus in the postero-inferior quadrant. It supplies the utricle. The nerve to the posterior semicircular canal usually enters behind the inferior vestibular nerve in a separate foramen.

*Technique of Operation.* The incision is similar to that for any postauricular mastoidectomy. Inferior and superior extensions over the mastoid tip and squamous portion of the temporal bone are made in accord with the pneumatization of the mastoid.

It is imperative to obtain wide exposure of the root of the zygomatic portion of the temporal bone and the superior wall of the external auditory canal.

A simple mastoidectomy should include exposure of the entire tegmen mastoideum, lateral sinus plate, sinodural angle, mastoid tip with digastric ridge, horizontal semicircular canal, and short process of the incus.
The superficial group of antero-inferior mastoid cells usually leads directly to the facial nerve. Other landmarks for identification of the vertical portion of the facial nerve are the incudal fossa, horizontal semicircular canal, and the digastric ridge.

At this point a small fenestra is made in the horizontal semicircular canal in order to obtain perilymph for a protein determination.

The superior and posterior semicircular canals are identified and entered. Whether or not to remove the incus at this point is controversial. Some surgeons prefer to leave it in place to protect the horizontal portion of the facial nerve. Others remove it in order to keep an eye on the nerve and also to identify the cochleariform process. As the semicircular canals are dissected the vestibule is encountered.

While dissecting the medial aspect of the labyrinth and vestibule, the periosteum lining the posterior wall of the internal auditory canal is encountered. This is followed laterally and slightly anteriorly until the posterior end of the horizontal crest is identified. This important landmark positively identifies the superior and inferior vestibular nerves. Above and slightly anterior to the superior vestibular nerve is a triangular projection of bone which has been mentioned previously. This provides differentiation of the facial nerve in relation to the superior vestibular nerve.

The remaining bone is carefully removed from the dura of the posterior fossa. This dissection is somewhat tedious and is best done with a diamond bur and constant irrigation-suction.

Quite often the tumor can be seen before the dura is incised. It is of a yellowish, fatty consistency and may be accompanied by cysts of various sizes. The dura is carefully incised with angulated dural knives. A biopsy specimen is taken for frozen-section diagnosis.

The capsule of the small tumor is dissected posteriorly, superiorly, and inferiorly, by using various elevators, forceps, middle-ear scissors, and small cottonoids.

Prior to dissecting the tumor anteriorly, the vestibular nerve concerned (usually the superior) is sectioned laterally. The facial nerve must be positively identified before dissecting the anterior aspect of the tumor. The identity of the facial nerve is confirmed by the use of an electrical nerve stimulator (Richards Manufacturing Co).

The vestibular nerve is sectioned medially and the tumor removed. The antero-superior cerebellar artery is often seen and should not be disturbed. Bleeding from the internal auditory artery and other small vessels may at times be troublesome. This is treated by packing with absorbable gelatin sponge (Gelfoam) or oxidized cellulose gauze (Oxygauze), cottonoids saturated with thrombin solution, or by cauterization, using a #20 insulated suction tip.

Prior to closure of the wound, the dural defect is temporarily packed with cottonoids and the bony mastoid labyrinthectomy defect irrigated with bacitracin solution (50,000 units of bacitracin in 200 cc of normal saline) to remove all debris and bony fragments. Hemostasis is imperative.
The mastoid labyrinthectomy defect is obliterated with subcutaneous adipose tissue obtained from the left side of the abdomen. The mastoid incision is closed with drainage. The adipose tissue serves to prevent postoperative contamination and leakage of spinal fluid. This tissue rapidly revascularizes.

*Postoperative Course.* The postoperative course is similar to that of a mastoidectomy. The patient should be carefully observed for early signs of central nervous system complications. The usual duration of hospitalization is one week.

**Suboccipital Translabyrinthine Approach.** Resection of large acoustic neurinomas, in excess of 4 cm in diameter, is rather difficult and hazardous by way of the translabyrinthine route. It is difficult to identify the antero-inferior cerebellar artery, and that portion of the tumor attached to the brain stem must be approached at right angles. Therefore, injury to the lower cranial nerves is likely. As a result, my colleagues and I have adopted a two-stage technique for resection of large tumors.

The first-stage operation consists of a dissection and tagging of the facial nerve, decompression of the posterior fossa, and partial resection of the acoustic neurinoma. Of prime importance is the identification of the facial nerve. This is sometimes difficult when the tumor is large, for the nerve can be displaced and may be broadened and thinned by pressure from the tumor. The tumor is carefully resected from the posterior aspect of the facial nerve, both in the internal auditory canal and intracranially. As much of the tumor is removed as is necessary for decompression of the posterior fossa. This is for the most part an intracapsular resection. It is important to remove as much bone as is possible on the posterior surface of the petrous pyramid in order to facilitate the dissection during the second-stage operation.

At the termination of the translabyrinthine operation, a narrow strip of blue rayon is placed on the posterior surface of the facial nerve. This is extremely useful as a "tag" for identification of the facial nerve during the second-stage procedure. The labyrinthectomy and mastoidectomy defects are obliterated with an adipose autograft, and the mastoid incision is closed without drainage.

The second-stage suboccipital operation should be performed as soon as the patient has recovered from the first-stage procedure. An interval of 1 to 2 weeks is usually required. During the second operation, the remainder of the tumor is dissected from its attachment to the lower cranial nerves, cerebellum, and brain stem. The rayon strip is identified and removed from the posterior surface of the facial nerve. The nerve stimulator, with a long insulated probe, is invaluable when outlining the course of the facial nerve from the brain stem to the internal auditory meatus. Once the course has been ascertained that portion of the tumor, which may extend forward and be attached to the fifth cranial nerve, can be readily resected.

A temporary facial paralysis may follow the resection of a large tumor. Anesthesia of the cornea is often present with large tumors. The cornea is thus in great danger of injury. The administration of antibiotic eye ointment is essential, beginning with the immediate postoperative period. If there is no evidence of return of facial nerve function in 3 to 5 days, a lateral tarsorrhaphy is indicated.
Surgery of the Auricle

Congenital Lop Ears

The term "congenital lop ears" covers a variety of anomalies of the external ear. Attempts to classify these various types of ear problems are confusing because one deformity may differ slightly from another and yet shade ever so slightly into still another category. There are, however, five basic defects, each with variations, which the surgeon will observe when analyzing congenital lop ear. These are:

1. Poor definition or absence of a component part of an ear, most often the anthelix.
2. An excess of cartilage in the concha either uniformly, superiorly, or inferiorly.
3. Abnormally small ears (microtia).
4. Excessive size of the ears (macrotia) or of a component part of the ears.
5. Disparity in the size or shape of one ear as compared with the other.

Many surgical techniques have been devised and advocated for the correction of these defects. That no one surgical procedure is a "cure-all" can be attested by the number available. Each surgeon, therefore, should have a workable knowledge of a few basic procedures which he can vary to correct the unique defects of any particular ear.

The minimum age for surgical correction of lop ears should be around 4 to 5 years. Prior to this age, most children are not conscious of any deformity. At any earlier age the auricular cartilage may not be mature enough to make the procedure technically feasible.

Preoperative Preparation. Unless the patient is in his late teens, general anesthesia will prove invaluable. Local anesthesia can be used with older patients. Xylocaine with epinephrine is infiltrated circumferentially around the ear and around the external auditory meatus. This works quite nicely with a well-premedicated patient.

After the patient is "prepped," he is draped so that contamination of an ear, either prior to the operation or following it, is avoided. This can be accomplished by placing a sterile stockinette, with holes cut for the ears, over the patient's head. A sterile sheet is placed under the head. After one ear has been operated upon, sterile batting applied while working on the second. Many surgeons now prefer to use sterile adhesive drapes which are applied easily and provide a view of the patient's features.

Various Surgical Techniques. Space does not permit mention of the many procedures that have been devised for correction of the numerous auricular defects. Three widely used techniques will be described. A variation of one of these techniques will usually suffice to correct most cases of lop ears adequately. The surgeon's ability to use the right procedure for the right case and his own innovations will make the difference between mediocre and good results.

Mattress Suture Otoplasty (Mustarde Technique). This is a simple method which has recently become quite popular.
The ear is folded into the desired position and straight needles are passed through the apex of the "new" anthelix. The needles are tipped with methylene blue and withdrawn, leaving a series of dots along the posterior surface of the apex of the new anthelix. An elliptical excision of skin is made on the posterior aspect of the ear down to perichondrium. The skin is undermined 5 to 10 mm in all directions.

Using #4-0 white silk or braided dacron, with an atraumatic needle, at least four mattress sutures are placed in position to bridge a gap in the cartilage. These are tied when all the sutures are in place. The degree of tightening of the sutures determines the contour of the anthelix. The skin is closed with interrupted sutures of #5-0 nylon.

This is a simple procedure which will correct a poorly developed anthelix, but other techniques or variations of this technique may be necessary in patients with abnormalities of the conchal cartilage, grossly enlarged ears, or disparity of ear size.

*Cutting, Thinning, and Tubing the Cartilage.* This technique was described by Converse and associates in 1955. An elliptical piece of postauricular skin is excised to expose the auricular cartilage posteriorly. The anthelix is outlined with straight needles introduced anteriorly when the ear is positioned into proper alignment. The needles are tipped with ink and withdrawn. The cartilage is incised along the inked lines provided by this maneuver. It should be noted that the superior incision does not joint the lateral incision. Another incision is also made along the lateral border of the conchal cartilage. The auricular cartilage between these incisions is thinned with a wire brush, then folded back and sutured to the proper width. This technique can be combined with the excision of conchal cartilage when necessary.

*Linear Incisions and Fish-Scaling.* Luckett, in 1910, advocated "breaking the spring" of the cartilage with a single linear incision to help form a new anthelix. This procedure is seldom used today for occasionally it produces a sharp crease in the ear rather than the natural-appearing, rounded anthelix desired. This method was modified later by others who preferred multiple partial-thickness incisions parallel to the new anthelix. Those experienced with this technique can produce a normal-appearing anthelix.

Another method for "breaking the spring" of the auricular cartilage, involving multiple gouges in the posterior aspect of the cartilage, was introduced by Holmes in 1966. This operation is performed by making rows of interdigitating pieces of cartilage with only partial thickness. According to Holmes, this adequately breaks the spring and forms a surface area for fibrosis to occur so that the ear will remain in this position, once the stay sutures are removed.

*Surgery of the Lobule.* Excessive lobule size may be decreased by a simple wedge incision. The protruding lobule may be corrected at the time of an otoplasty by a "W" excision of postauricular skin.

*Dressing and Postoperative Case.* Dressing and packing of the ear is most important to prevent the formation of hematomas and to hold the ears relatively immobile during the initial healing phase. Cotton, impregnated with either an antibiotic ointment or tincture of benzoain, is packed into the convolutions of the ear and covered carefully with cotton fluff. The postauricular incision is covered with petrolatum gauze and the proper amount of cotton
fluff. Cotton pads are then placed over the ears and a mild compression dressing is taped into place to remain for 5 to 7 days. The ear should be examined for hematomas the day following the operation.

**Excision of Auricular Lesions**

A natural-appearing or cosmetically acceptable external ear following trauma or surgical removal of a tumor is the result of a gentle surgical technique plus a basic knowledge of flaps, grafts, and pedicles.

The most commonly excised tumors of the external ear and auricle are squamous cell and basal cell carcinomas. Excision of these lesions is usually performed with the area locally anesthetized. A small tumor presents no difficulty since it may be excised by a simple V incision which is closed primarily. As the size of the lesion increases it becomes more difficult to approximate the edges of the helix; when closure is difficult two additional small V incisions are most helpful. A 1-cm margin should be obtained around the lesion. The results of a frozen section should be checked before the wound is closed.

In some instances up to one third of the auricle may be excised in this manner without disturbing the contour of the ear.

For larger defects, the surgeon must resort to local flaps and pedicles. For complete or nearly complete loss of the auricle there is no good method of total reconstruction. Numerous procedures have been employed, but none have given consistently good, cosmetically acceptable results in even the most skilled hands. This is a problem that remains sorely in need of a solution.

The surgeon may use one of a variety of flaps, pedicles, or grafts for reconstruction. When partial loss of the auricle does not permit primary closure.

**Postauricular Flap.** This flap, also known as an auriculomastoid flap, can be used in a number of ways. The flap can be based posteriorly and outlined to fit the defect of the auricle. It is sutured in place with a strip of cartilage graft from the opposite ear, or nasal septum, embedded to conform to the helix. After 3 weeks, the base of the flap is severed and the flap is raised and sutured in place to form the posterior surface of the auricle.

**Chondrocutaneous Flap.** For a similar lesion, Millard has described an ingenious method which employs a composite flap using cartilage from the ear being operated upon to re-form the rim of the helix. The flap is based on the anterior auricular skin and has intervening scar tissue which makes a delay imperative. After a 2-week delay, the flap is raised again, and a piece of cartilage, 0.33 cm in width, is excised and left attached to the skin. This is fashioned to form a cartilaginous support for the length of the reconstructed helix. The distal skin is sutured into place to form the posterior surface of the auricle. A split-thickness graft is needed to complete the posterior surface of the auricle and to resurface the donor site.

**Advancement of a Helical Flap for Superior Auricular Defects.** This procedure is advantageous for relatively small- to medium-sized superior marginal defects. It has a
cosmetic advantage in that duplication of the helix is not attempted. Instead, the remaining helix is advanced superiorly. A composite advancement is fashioned with the incision carried just anterior to the remaining helix and through the sides of the defect. The flap is based on the postauricular skin which must be freed from the posterior surface of the aural cartilage. It is then advanced and sutured. If the decrease in vertical height is noticeable, the height of the opposite ear may be reduced by the wedge-incision technique.

**Scalp Flap for Superior Auricular Defects.** If the hairline permits, this procedure is useful for the repair of the superior auricular defects. A local scalp flap is raised superiorly, and autogenous cartilage is embedded. The freshened edges of the auricle are sutured to the flap. After an appropriate delay (usually 3 weeks), the scalp flap is excised and sutured in place to re-form the contour of the ear. The scalp is closed primarily and a split-thickness skin graft is needed for the posterior surface of the auricle.

**Tubed Pedicle Flap.** The tubed pedicle flap can be used for subtotal or total loss of the helix. Based posteriorly near the auricle, the flap can be delayed and attached to the remaining auricle to form a helix. This procedure requires multiple steps and often the results are not entirely satisfactory.

**Preauricular Flaps.** These are superiorly based flaps which are rotated 90 degrees without delay. The donor site is closed primarily. They have proven satisfactory for correction of defects of the anterosuperior area of the auricle.

**Special Problems**

**Excision of Preauricular Cysts.** Preauricular cysts are common congenital cystic structures located anterior to the base of the helix. The small, intermittently draining sinus tract can usually be probed without difficulty. These cysts produce very few symptoms until the become infected. Prophylactic excision is indicated.

The external tract is ligated with a silk suture. A triangular flap is then raised exposing the cystic system. This conglomerate of cyst, fibrosis, and subcutaneous tissue is removed along with the duct. The triangular flap is then sutured into place.

**Chondritis Following a Burn.** The progress of a burned ear should be followed very closely. The usual time for onset of chondritis is 3 to 5 weeks following the accident. Dull pain heralds the onset; usually the pain increases in severity. The ear develops inflammation and edema causing its protrusion from the head. Fluctuance develops and drainage may occur spontaneously.

Dowling attributes a decrease of from 19 to 29% of chondritis of the auricle, occurring in association with all burns of the face, to open-air treatment and the use of Sulfamylon.

The cartilage involved with chondritis should be excised along with the overlying skin. If possible, the underlying skin, upon which a graft may be placed, should be preserved. The incidence of recurrence is high and, when this takes place, additional auricle must be excised. Chondritis of the ear usually is attended with at least some degree of auricular deformity.
The Cauliflower Ear. This is the "boxer's ear" in which scar contraction has occurred following trauma and hematoma formation.

Prevention is, of course, the best treatment. The blood and serum in an acute hematoma of the auricle should be evacuated as soon as feasible. A problem arises in that the hematoma may continue to re-form. To avoid this, a pressure dressing should be applied. One method is to tie through-and-through sutures over moist cotton; this will provide firm pressure and prevent the reaccumulation of serum and blood. Cotton, impregnated with tincture of benzoin, is then tucked into all the spaces of the auricle, and a pressure dressing is applied.

Temporal Bone Resection

Block resection of the temporal bone, with or without a radical neck dissection, as pioneered by John S. Lewis, has increased the 5-year survival rate for carcinoma involving the temporal bone. Prior to instigation of this method of therapy the treatment consisted of a radical mastoidectomy followed by radiation therapy, with a resultant 5-year cure rate of less than 10%. The osteonecrosis and injury to the intracranial structures (pons and medulla), following a full course of radiation therapy to the temporal bone, were often devastating.

Temporal bone resection, with or without preoperative radiation therapy, has increased the 5-year survival rate to approximately 30% (Lewis, 1966). The preoperative radiation therapy, however, should not exceed 4000 r.

Pathology of Carcinoma Involving the Ear

Carcinoma of the external ear and outer ear canal is most frequently of the basal cell variety (in two thirds of cases) and most often is found in the elderly white male. Basal cell carcinoma of the auricle, which is located well away from the external auditory canal, is not a serious disease and can be treated by radiation therapy or local excision as is prescribed for similar lesions in other areas of the head and neck. A lesion with 1 cm of the external auditory canal is a much more serious disease and must be treated by radical surgery. The extensive lymphatics in this region account for the seriousness of this disease (Miller).

Squamous cell carcinoma is the most common type of tumor found in the deep external auditory canal, middle ear, and mastoid. It is more prevalent among females than among males and occasionally is associated with chronic otitis media.

Adenocarcinoma of the temporal bone arising from the parotid, ceruminous glands, or middle ear mucosa, is rather rare. Numerous other malignant tumors have been reported in this area. The most common are rhabdomyosarcoma, malignant melanoma, and spindle-cell sarcoma.
**Signs and Symptoms of Carcinoma Involving the Temporal Bone**

1. *Pain* can result from secondary external otitis or otitis media, but may be due to invasion of bone by tumor.

2. *Hearing loss* is a common symptom and is due to either obstruction of the external auditory canal by the tumor, the presence of tumor or secondary infection involving the tympanic membrane or middle ear, or the extension of disease into the inner ear. It is thus important to differentiate between a conductive and perceptive hearing loss.

3. *Bleeding* from the external auditory canal can be the first and only symptom of disease. Severe hemorrhage from the external auditory canal is encountered with the rhabdomyosarcoma.

4. *Otorrhea* associated with a long history of chronic otitis media occasionally precedes the onset of carcinoma. Usually, however, the otorrhea is caused by secondary otitis externa or otitis media. A biopsy of the external auditory canal should be performed in those cases of chronic otitis externa which do not respond to the usual conservative measures, especially when granulation tissue is present.

5. A *facial nerve paralysis* may occur when the disease extends to the middle ear and beyond. Rather extensive disease can be expected when facial nerve paralysis complicates a malignant lesion in this region.

6. *Vertigo* is usually indicative of extension of disease to the inner ear, but may be the result of secondary infection.

7. *External swelling* can be present and is due to extension of disease into the parotid gland or the sternocleidomastoid muscle.

**Diagnosis of Carcinoma Involving the Temporal Bone**

Routine x-rays of the mastoid bone will show evidence of bone destruction in approximately 40% of the cases. Polytomography of the temporal bone has somewhat increased this percentage. It must be kept in mind that the exact extent of disease cannot be determined until the time of operation.

The functions of the facial, auditory, and vestibular nerves should be carefully studied. Any evidence of extension of disease beyond the confines of the temporal bone must be evaluated. The surgeon should search carefully for enlarged cervical lymph nodes.

The diagnostician must be careful not to be fooled by a pathologic report indicating no malignant disease as ascertained from a study of granulation tissue or of a polyp overlying the lesion itself. A repeat biopsy is indicated if there is any suspicion of malignant tumor.

It can be assumed that there is disease in the middle ear if the lesion in the external auditory canal has extended to the region of the tympanic membrane. The tympanic
membrane may remain entirely normal when the tumor extends around the annular ligament to the middle ear.

**Radiation Therapy of Carcinoma Involving the Temporal Bone**

It is the considered opinion of most radiotherapists that any form of radiation therapy to a carcinoma which has invaded the bone is of little value. Most reports in the literature indicate a 5-year survival rate of less than 10% for patients with carcinoma of the temporal bone treated by radiation therapy. The complications of a full course of radiation therapy for temporal bone carcinoma have been mentioned.

Postoperative radiation therapy is indicated for those patients who had had one or more surgical procedures prior to the temporal bone resection. The amount of postoperative supravoltage radiation should not exceed 4500 r.

Preoperative radiation therapy is indicated for patients with more advanced disease in whom the cancer extends to the dura. These patients have severe pain that is difficult to control, even with narcotics. The amount of preoperative supravoltage radiation should not exceed 4000 r.

**Indications for Temporal Bone Resection**

Positive indications for temporal bone resections are:

1. Disease of recent onset.
2. Evidence of slight bone destruction.
3. More advanced disease in a patient who has received preoperative radiation therapy.

**Preoperative Care**

At least six units of whole blood should be in readiness prior to this extensive operation. The patient's scalp is shaved completely if the entire auricle is to be removed, otherwise the shaved area can be limited to the preauricular region, the scalp over the squamous portion of the temporal bone, and the region behind the mastoid bone.

**Anatomic Considerations**

The surgeon must have a thorough knowledge of the vascularity surrounding the temporal bone. The sigmoid portion of the lateral sinus lies posteromedial to the mastoid bone and extends inferiorly to the jugular bulb at the base of the skull. The superior and inferior petrosal venous sinuses are also important landmarks during this dissection. Medial to the petrosal bone is the cavernous sinus. The carotid artery is located inferior, anterior, and medial in the petrous pyramid and fortunately is less vulnerable to injury during a temporal bone resection that are the other vascular structures.

It is usually necessary to sacrifice the facial nerve when the temporal bone is resected. The condylar process of the mandible and parotid gland are also included in the resection. The cochlea and semicircular canals are transected or resected during the procedure. A radical
neck dissection is performed if there is evidence of cervical metastasis or if evidence of carcinoma in the inframastoid lymph nodes is found on frozen section at the time of the operation.

The location of the hypoglossal and vagus nerves at the base of the skull should be kept in mind during the operation in order to avoid their injury.

**Surgical Technique**

In general there are two variations of the primary incisions, depending upon whether or not there is to be partial preservation of the auricle. The peripheral auricle can be preserved when the tumor lies deep in the external auditory canal.

The entire auricle must be sacrificed when the tumor is present in the region of the concha.

After elevating the flap over the tip of the mastoid bone and the sternocleidomastoid muscle, a careful search for lymph nodes is conducted. The nodes are removed and sent to the pathology department for frozen-section diagnosis. A radical neck dissection is included with the operation if the lymph nodes show evidence of tumor involvement. Skin flaps are elevated anteriorly over the parotid gland, superiorly over the squamous portion of the temporal bone, posteriorly over and behind the mastoid bone, and inferiorly to expose the sternocleidomastoid and digastric muscles. The incisions for rotation and advancement of the flaps, to be used for repair of the defect when the entire auricle is removed, are not made until the temporal bone resection has been completed.

The squamous portion of the temporal bone is carefully inspected for evidence of bone destruction. The bone incision in this area is made with a rotating cutting bur. This incision begins anteriorly over the root of the zygomatic portion of the temporal bone, and extends superiorly to a point at least 4 cm above the level of the temporal line. The posterior limit of the bone incision, which extends across the squamous bone superiorly, is continued to a vertical line drawn from behind the mastoid bone. The posterior bone incision is made along this vertical line. The squamous bone can be removed, either piecemeal with a rongeur or in one piece by making a bone incision above the temporal line.

It is not uncommon for carcinoma to involve a portion of the dura in the region over the roof of the epitympanum. The area of involvement is excised with a wide margin and repaired with temporal fascia.

The attachments of the sternocleidomastoid and digastric muscles to the mastoid bone are severed. The jugular vein, carotid artery, and vagus, hypoglossal and facial nerves are exposed. A ligature is placed around both the internal carotid artery and the internal jugular vein to be tightened if either vessel is inadvertently opened during the temporal bone resection.

The beginning of the sigmoid portion of the lateral sinus is identified by additional bone removal in the postero-inferior aspect of the defect made by resection of the squamous portion of the temporal bone. The entire sigmoid portion of the lateral sinus is exposed and
dissected posteriorly, away from the temporal bone, so that it will not be injured as the temporal bone is removed.

The head and neck of the condylar process of the mandible are exposed and an incision is made through the neck of the mandible with a Stryker or Gigli saw. The condylar process above this incision is resected, exposing the glenoid fossa. Beginning in the antero-inferior aspect of the defect made by resecting the squamous portion of the temporal bone, an incision is made through the root of the zygomatic portion of the temporal bone with a rotating cutting bur, Kerrison forceps, or Stryker saw. The middle meningeal artery, or one of its branches, is usually present in this location and must be carefully avoided. The bone dissection is continued inferiorly across the glenoid fossa exposing the eustachian tube. There then remains a thin segment of bone between the line of dissection and the carotid canal.

The parotid gland, along with the facial nerve, is resected at this point. On occasion, when the tumor involves only the outer half of the external auditory canal and the surgeon is certain that there is no extension of disease around the annular ligament into the middle ear, it may be possible to preserve the continuity of the facial nerve. In such a case the facial nerve is clearly exposed at the stylomastoid foramen and a superficial and deep lobe parotidectomy is performed.

The styloid process is identified and transected near its base. The muscles attached to the base of the styloid process and the inferior surface of the temporal bone are transected at this time. A vertical bone incision is made in the glenoid fossa, exposing the eustachian tube.

The spinal fluid pressure must be reduced prior to dissecting the dura from the anterior and posterior surfaces of the petrous bone. This is accomplished by using either an intravenous sodium mannitol solution or an indwelling spinal catheter, or by making a small linear incision through the dura over the temporal lobe. A purse-string suture is then placed around this incision and the catheter is inserted for drainage of spinal fluid. Approximately 40 cc of spinal fluid are removed. Dissection of the dura in the region of the superior petrosal sinus is rather difficult. A tear in the superior petrosal vein is repaired with silver clips or silk sutures.

The dura of the temporal lobe is retracted medially and superiorly, exposing the petrous bone to the level of the internal auditory meatus. A curved osteotome is placed medial to the arcuate eminence and immediately lateral to the internal auditory meatus on the anterior surface of the petrous pyramid. An incision is made in a posterior and inferior direction, with extreme care, and only through bone, in order to avoid injury to the internal carotid artery.

The inferior surface of the temporal bone is exposed. A chisel is placed medial to the digastric groove and a bone incision is made in a superior direction. At this point the temporal bone should be free with the exception of a small area of bony attachment in the region of the glenoid fossa. The attachments are easily severed with a straight osteotome.

As the remaining soft tissue attachments of the temporal bone are incised and the temporal bone is removed, one or more tears may be made in the dura, resulting in spinal fluid leakage. Subcutaneous adipose tissue is obtained from the abdominal wall and used to repair the defects in the dura and also to obliterate the cavity resulting from the temporal bone
resection. The catheter is removed from the dura of the temporal bone and a purse-string suture is tied.

At this point a radical neck dissection is carried out if indicated. If available a second team of surgeons should be called in to perform this operation. A radical neck dissection is usually unnecessary with resection of a temporal bone carcinoma for metastasis to the neck occurs in only 16% of uncontrolled cases. Almost all patients die of local disease with possible extension into the brain.

The hypoglossal nerve is identified, dissected free, and transected peripherally, so that it can be re-directed and sutured to the peripheral end of the transected facial nerve. The results of hypoglossal facial anastomosis are quite gratifying, for a good facial tone is obtained and there is motion of the face when the patient attempts to move the tongue or swallow.

**Postoperative Management**

In the past, cerebral fluid leakage has been a serious complication with the additional hazards of meningitis and brain abscess. The incidence of these complications has been markedly reduced with the use of adipose autografts.

If postoperative hemorrhage occurs, the site of bleeding may be a lateral sinus or the superior petrosal sinus. Bleeding is easily detected for it will either saturate the dressing or cause swelling, as the blood infiltrates the subcutaneous spaces.

Infection is a likely complication because of the length of time required for the operation and the existing secondary infection superimposed on the carcinoma. It is wise to place the patient on intravenous antibiotic therapy to cover both gram-positive and gram-negative organisms for a period of at least 5 days following the operation.

A facial nerve paralysis is managed as has been mentioned previously.

Varying degrees of vertigo will persist for 3 to 6 weeks postoperatively unless the labyrinth was functionless prior to surgery. A careful explanation of the cause of this vertigo, along with antivertiginous medication, will be beneficial.

For a patient in whom the tumor was not completely resected, postoperative radiation therapy is instituted as soon as wound healing is complete. The use of cryosurgery for treatment of residual or recurrent disease may be of value.