Chapter 191: Surgery of the Posterior Cranial Fossa

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Adequate exposure for skull base neoplasms involving the posterior fossa requires precise management of the temporal bone. The modern era for skull base surgery and transtemporal techniques began in 1961 when William House introduced the operating microscope and multidisciplinary-team-surgery for removal of acoustic neuromas. With the vastly reduced mortality and facial nerve preservation rates of the translabyrinthine (TL) approach for acoustic neuromas (ANs), House established the TL approach as the procedure to which all other microsurgical approaches to the cerebellopontine angle (CPA) are compared (Glasscock, 1979). Subsequently, multiple approaches to the CPA have been developed to permit the surgeon to tailor the procedure to a particular patient's pathology and physiology status.

This chapter details the basic approach, specific indications, techniques, and special features of the TL, retrosigmoid (RS) or suboccipital, retrolabyrinthine (RL), transcochlear (TC), transotic (TO), middle fossa (MF), and extended middle-fossa (EMF) approaches for skull base neoplasms involving the posterior fossa. Table 191-1 summarizes the basic indications and drawbacks of the various approaches for resection of these tumors. In addition, the chapter reviews the surgical approaches for skull base lesions that are adequately managed by drainage procedures. A method for selecting the surgical approaches in ANs suitable for hearing preservation is presented, and general principles of patient management and treatment of complications of posterior fossa tumor surgery are outlined.

Table 191-1. Indications, advantages, and disadvantages of surgical approaches for resection of posterior fossa skull base neoplasms

Approach	**Indications**	**Advantages**	**Disadvantages**
Translabyrinthine	Large, medium or small CPA tumor	Wide exposure not limited by tumor size Facial nerve identified at CPA and fundus of IAC Immediate repair of facial nerve is possible Bone removal is extradral Limited cerebellar retraction	Total hearing loss

Retrosigmoid (suboccipital)
- CPA tumors without extensive IAC involvement
  - Hearing preservation possible in small lesions without extensive IAC involvement
  - Wide exposure not limited by tumor size
    - IAC fundus not exposed in hearing preservation cases
    - Cerebellar retraction may produce hydrocephalus
    - Intradural drilling may result in severe headaches

Retrolabyrinthine
- Selected CPA lesions without IAC involvement
- Biopsy of CPA lesions
  - Hearing preservation possible
  - Bone removal is extradural
  - No cerebellar retraction
    - Limited exposure

Transcochlear
- Extensive lesions of petrous apex and clivus
  - Wide exposure of skull base with access to clivus, vertebral, and basilar arteries and full exposure of petrous carotid artery
    - Temporary facial nerve paralysis
    - Total hearing loss

Transotic
- Same as transcochlear
- Some advocate use in ANs with unfavorable venous anatomy
  - Same as translabyrinthine
  - No facial nerve transposition
    - Facial nerve in IAC and mastoid segments limits exposure
    - Total hearing loss

Middle fossa
- Small intracanalicular tumors with minimal CPA involvement and good hearing
  - Hearing preservation possible
    - Small tumors only
    - Poor access to inferior IAC
    - Poor access to CPA

Extended middle fossa
- Petroclival lesions involving posterior and middle fossa with good hearing
  - Hearing preservation possible
    - Temporal lobe retraction.

Translabyrinthine Approach

Basic approach

A transmastoid labyrinthectomy and skeletonization of the sigmoid sinus and posterior fossa dura permit identification of the facial nerve with wide exposure of the internal auditory canal (IAC) and CPA (Fig. 191-1).

Indications

The TL approach is the principal approach for all lesions of the CPA and IAC. This technique is ideal for medium and large ANs because hearing preservation is unlikely by any approach in tumors larger than 2.0 cm and because this approach carries the highest rate of preserved facial nerve function. Small ANs without serviceable hearing are also removed by the TL approach.

The approach is suited for any neoplasms requiring exposure of the CPA, including meningiomas, nonacoustic neuromas, gliomas, chordomas, and skull base chondrosarcomas. In addition, if serviceable hearing is not present, the TL approach is useful for complete facial nerve decompression and vestibular neurectomy.

Technique

This section details patient positioning, preparation, monitoring, and tumor removal for the TL approach. The same techniques are used for the other approaches except where otherwise specified. The patient is positioned supinely with the head turned to the opposite side. Head-holding pins or supports are not used. Electromyography (EMG) electrodes for intraoperative facial nerve monitoring are inserted into the orbicularis oris. Perioperative antibiotics, steroids, and diuretics are not used routinely. However, bacitracin (50.000 units/L) is used in the irrigation solution. Hyperventilation is usually sufficient for brain relaxation.

The curved postauricular incision is made with the apex 3 cm posterior to the postauricular crease. The soft tissue and periosteum are elevated from the mastoid and adjacent occipital bone and self-retaining retractors are inserted.

The bony exposure is accomplished in three stages, which are performed with the operating microscope, drill, and continuous suction irrigation (House, 1979). The majority of the drilling is performed with cutting burrs; however, diamond burrs are used for portions of the procedure in which drilling is performed on the dura or venous sinuses. Stage one is the complete mastoidectomy. Posteriorly the bone is removed beyond the sigmoid sinus, and the sinus is skeletonized. The extent of bone removal posterior to the sinus and decompression of the posterior fossa depends on the size of the tumor; greater posterior removal provides greater exposure of the CPA. Superiorly the middle fossa plate is identified and thinned; anteriorly the facial nerve is identified in its vertical segment but left covered with bone for protection against inadvertent burr trauma.

The second stage is the complete labyrinthectomy. The horizontal, superior, and posterior semicircular canals are systematically removed. Particular care is required along the inferior border of the horizontal canal because of the proximity of the facial nerve and along the ampulated end of the posterior canal because this end lies medial to the facial nerve.

The third stage of the bone removal is the actual decompression of the middle and posterior fossa dura and removal of bone around the IAC. The bone overlying the posterior fossa is removed with cutting and diamond burrs except for an island of bone over the sigmoid sinus (Bill's island). The mastoid emissary vein must be transected to permit retraction of the sinus and posterior fossa dura; therefore, bleeding from the emissary must be controlled either with sutures, cautery, or bone wax. The petros ridge, which is the junction between the middle fossa and posterior fossa dura, must be removed. The superior petrosal sinus, which lies under the petrous ridge, is sometimes adherent to the bone; and the resulting bleeding is controlled with bipolar cautery or extradural packing with Surgicel. The entire middle fossa and posterior fossa dura adjacent to the mastoid are exposed.

The final stage of bone removal is skeletonization of the IAC. The orientation of the IAC is roughly parallel to the external auditory canal (EAC); thus, the fundus of the canal is just medial to the floor of the vestibule, which was exposed with the labyrinthectomy. In contrast, identification of the porus requires extensive bone removal as the IAC is dissected medially. The basic principle of exposing the IAC is that all bone removal should be accomplished before opening the dura, and complete bone removal requires decompression of 270 degrees around the circumference of the canal to avoid any obscuring ledges of bone. By completing bone removal before opening the dura, the risk of accidental injury to the nerves of the IAC is minimized. The inferior border of the IAC is skeletonized first. This edge of the canal is identified by gradually enlarging a trough between the inferior edge of the vestibule and the jugular bulb. The cochlear aqueduct is usually identified as the dissection proceeds anteromedially. This structure becomes the inferior limit of the dissection, thereby protecting the lower cranial nerves from injury. After the inferior border of the IAC has been identified, the bone overlying the porus acusticus is thinned with cutting and diamond burrs. The superior border of the IAC is identified last, as the facial nerve is more susceptible to injury in this area. A burr size that will fit between the middle fossa dura and the superior border of the IAC is used to expose the superior border. The entrance of the facial nerve into the IAC can be positively identified just medial to a vertical crest of bone, Bill's bar, along the superior aspect of the fundus. At this point the bony exposure is completed and tumor removal can begin (Fig. 191-2).

Tumor removal

In small lesions, the tumor is exposed by opening the dura of the IAC. Attention is focused on the fundus of the IAC, and the superior vestibular nerve is transected by placing an instrument lateral to Bill's bar and reflecting the nerve inferiorly. This maneuver protects the facial nerve and identifies the lateral plane between the facial nerve and the tumor. Sharp and blunt dissection can proceed with scissors and angled hooks from lateral to medial but without actually placing traction on the facial nerve. In some small tumors, the dissection can be completed entirely without debulking.

In large tumors CPA exposure is necessary. Intracapsular tumor debulking is completed before the tumor is dissected directly from the facial nerve. In essence, a large tumor is reduced to a small tumor. The dural flaps are developed carefully to avoid injury to the underlying petrosal vein or even branches of the anteroinferior cerebellar artery that can reach the dura. The incision is midway between the sigmoid sinus and the porus acusticus. The incision is carried directly to the porus where it is continued in a curve around the porus. Debulking must be accomplished to positively identify the facial nerve medially and to complete the dissection of the tumor from the brainstem. Vessels that do not actually enter the tumor are reflected away, and the posterior aspect of the tumor is incised. Intracapsular debulking is accomplished with small dissection forceps, scissors, or with the House-Urban rotatory dissector. Some surgeons at other institutions prefer to use the laser or ultrasonic aspirator for debulking. Such intracapsular debulking permits the tumor to collapse on itself for easier manipulation during dissection of the tumor from the facial nerve. The arachnoid sheath that binds the tumor to the nerve anteriorly is released with small hooks. In tumor dissection it is important not to push the tumor medially into the CPA, as this maneuver stretches the nerve at its lateral fixed bony attachment. The tumor and capsule is removed by separating it completely from the facial nerve. Once the tumor debulking is completed and the facial nerve is identified medially, attention is focused on the fundus of the IAC. Final tumor dissection proceeds in the manner described previously for a small tumor. In this manner the majority of the tumor has been removed while the facial nerve has been protected in the dura of the IAC.

After tumor removal the eustachian tube is closed by removing the incus, transecting the tensor tympani tendon and filling the eustachian tube and aditus ad antrum with Surgicel and temporalis muscle. The dural defect is approximated with sutures, and the mastoidectomy defect is filled with strips of abdominal fat. The ends of the strips are placed through the dural defect to plug the dural opening. The wound is closed in layers, and a compressive dressing is applied.

Special features

The TL approach provides wide and direct access to CPA tumors with minimal cerebellar retraction. The versatility of this apporach for both large and small tumors makes it the most common approach for resection of ANs. The TL approach was used in over 95% of the 3000 ANs removed at the House Ear Clinic.

The fundamental advantage of the TL approach, particularly in medium and large tumors, is that it permits positive identification of the facial nerve, laterally at the fundus and medially at the brainstem. Thus the tumor can be dissected from either direction with optimal control of the facial nerve. Such medial and lateral identification of the nerve has permitted a rate of anatomic preservation of the facial nerve in over 98.5% of the 759 ANs removed at the House Ear Clinic between 1984 and 1989 (Arriaga et al, 1991). Furthermore, if the facial nerve is transected, as occurs in cases of CPA facial nerve neuroma, the tympanic and mastoid portions of the nerve are available for rerouting and reanastomosis or grafting.

Properly performed, with wide exposure of the middle and posterior fossa, the TL approach provides equal exposure of the CPA, as any other neurosurgical approach; however, the direct route of exposure of the CPA eliminates the need for cerebellar support (retraction).

The disadvantage of this approach is that hearing cannot be preserved. Although significant attention has been focused on hearing preservation in AN surgery, this is only a consideration in a small minority of patients. In a recent series of 300 consecutive cases of ANs, "only a maximum of 5% of patients, using the broadest criteria, could be candidates for hearing-conserving surgery" (Thomsen et al, 1989). The advent of gadolinium-enhanced magnetic resonance imaging (MRI) scanning has resulted in an increased percentage of ANs, which are diagnosed at a small size before hearing is affected. Thus, hearing conservation procedures are becoming a more frequent consideration.

Retrosigmoid (Suboccipital) Approach

Basic approach

Transmastoid decompression of the sigmoid sinus and a retrosigmoid craniotomy permit access to the CPA tumors without disturbing the labyrinth. Intradural removal of the posterior aspect of the IAC permits direct access to the medial two thirds of the IAC (Fig. 191-3).

Indications

Because the principal advantage of this approach is hearing preservation, this is an excellent technique for ANs of the CPA with serviceable hearing and limited involvement of the IAC. Nonacoustic neoplasms of the CPA that do not involve the IAC, such as meningiomas, can be approached in this fashion with an opportunity for hearing preservation.

Technique

The soft tissue of the ear are reflected anteriorly, and the muscles are widely reflected from the retromastoid region. A complete mastoidectomy is performed and the sigmoid sinus is skeletonized and decompressed. The posterior semicircular canal is skeletonized, and the posterior fossa dura up to the posterior semicircular canal is exposed. This area of exposed dura identifies the location of the posterior semicircular canal if the posterior lip of the IAC must be removed later in the procedure. A bone flap is removed posterior to the sigmoid sinus with the otologic drill; this flap is preserved for replacement at the conclusion of the procedure.

The dura is incised posterior to the sigmoid sinus, and care is taken not to injure the underlying vessels that may be adherent to the dura. The cerbellum is exposed and supported with retractors to allow visualization of the tumor in the CPA. The neurosurgical techniques for tumor removal at the brainstem are the same regardless of the approach chosen. If the tumor bulk is too large to permit proximal identification of the facial nerve, debulking of the tumor is performed. Once the debulking has been accomplished, the tumor is dissected from the facial nerve toward the porus acusticus (Fig. 191-4).

If the tumor extends into the IAC, the posterior lip of the canal is removed with diamond burrs. A dural flap is created lateral to the porus and reflected medially. Drilling of the posterior lip of the IAC is continued until the lateral extent of the tumor is visualized. The anatomic boundary of exposing the posterior IAC and preserving hearing is the posterior

semicircular canal. The area of dura previously exposed just posterior to the posterior canal alerts the surgeon to the precise location of the posterior canal when the posterior lip of the IAC is removed. Once the lateral limit of the tumor has been identified, tumor removal is accomplished in the same manner as with the TL approach.

Unlike the TL approach in which Bill's bar permits definitive identification of the facial nerve at the fundus, in the RS approach the surgeon relies primarily on the facial nerve monitor for identifying the nerve lateral to the tumor. Once the location of the nerves is known both medially and laterally, the tumor usually can be removed with preservation of the facial nerve. In cases attempting hearing preservation, obviously, the cochlear nerve must also be preserved. Particular care is taken to preserve the blood supply to the IAC as hearing preservation depends on an intact blood supply.

After tumor removal, the dural defect is reapproximated and the mastoid and IAC are obliterated with abdominal fat. The bone flap is replaced, and the wound is closed in separate layers. A compressive dressing is applied.

Special features

The RS approach, in selected cases, offers an opportunity for hearing preservation with success rates varying from 30% to 65%, depending on the selection criteria used for hearing preservation surgery (Gardner and Robertson, 1988; Harner et al, 1990; Kemink et al, 1990). This approach is used at the House Ear Clinic in CPA tumors smaller than 1.5 cm with good hearing and limited involvement of the IAC. The principal limitation of this approach is that the fundus of the IAC is not directly visualized. This approach is being used more frequently as small tumors of the CPA are diagnosed with enhanced MRI and minimal auditory symptoms.

Tumor extending to the fundus is a contraindication to the RS approach for hearing preservation. With the RS approach, tumor removal in the fundus is accomplished "by feel" with hooks or mirrors. This approach risks leaving residual tumor or damage to the facial nerve.

Bill's bar in the fundus of the IAC, cannot be used to identify the facial nerve laterally in the RS approach; thus, this step is more difficult in the RS approach and relies more heavily on the nerve monitor. Although the rates of facial nerve preservation are comparable between the TL and RS techniques, the literature supports better facial nerve preservation with the TL approach. Reported series of RS tumor removals (Defriese et al, 1984; Harner et al, 1990; Samii et al, 1985) have not exceeded the 98.5% rate of facial nerve preservation in the House Ear Clinic series of 759 ANs removed predominantly by the TL approach.

A 10% incidence of severe postoperative headaches have been reported with this approach (Silverstein et al, 1991). This symptom is likely related to the intradural spread of bone dust, which occurs as a result of drilling the posterior lip of the IAC. Unlike the TL approach, the drilling must be intradural in the RS approach.

Another objection to this approach has been the need for cerebellar retraction. By skeletonizing the sigmoid sinus and reflecting it anteriorly with "tacking" sutures in the dura,

cerebellar retraction can be minimized. However, medium and large lesions still require significantly more cerebellar retraction than is necessary with the TL approach.

Middle Fossa Approach

Basic approach

A temporal craniotomy permits exposure of the IAC after identification of the superior semicircular canal and geniculate ganglion (Fig. 191-5).

Indications

This approach is ideally suited for intracanalicular ANs. It provides limited exposure for lesions involving the CPA, and greater than 1 cm CPA involvement is a relative contraindication to this approach. Decompression of the IAC in cases of acoustic tumors in only-hearing ears can be accomplished in this fashion (Gadre et al, 1990).

Technique

The middle fossa approach has been described in detail in a separate chapter in this volume. The basic surgical exposure is illustrated in Fig. 191-6, A and B. Mannitol and furosemide are used in addition to hyperventilation for brain relaxation.

Special features

Intracanalicular tumors, particularly those in the lateral portion of the IAC, are amenable to this approach in cases suitable for attempted hearing preservation. Because the approach has been limited to small lesions, the theoretical problem of limited access to the posterior fossa in case of bleeding has not been an issue.

The success of preservation of measurable hearing in selected patients is 59%; however, the limiting factor is the cochlear blood supply (Shelton et al, 1990). Just as in the RS hearing preservation cases, the rate of cochlear nerve preservation is substantially higher than actual hearing preservation. The approach is not recommended in patients over 65 years because in these patients the dura is more adherent and fragile.

Retrolabyrinthine Approach

Basic approach

A wide mastoidectomy with skeletonization of the posterior semicircular canal permits access to the CPA with preservation of the seventh and eighth nerves (Fig. 191-7).

Indications

The principal indication for this approach is vestibular nerve section for intractable vertigo (see Chapter 183) or for neurotomy in tic douloureux (Brackmann and Hitselberger, 1978). As an approach for posterior fossa neoplasms, the RL approach affords adequate

exposure and hearing preservation in selected cases of arachnoid cysts, meningiomas, and metastatic lesions of the CPA. In situations that require a tissue diagnosis before proceeding with definitive surgery, the RL approach permits wide exposure with minimal morbidity for "exploration" of lesions of the CPA.

Technique

The incision and soft tissue exposure are identical to that of the TL approach. Mannitol and furosemide are used for brain relaxation. A complete mastoidectomy is performed. The fossa incudis and the lateral and posterior semicircular canals are identified. The facial nerve is skeletonized but kept covered with bone.

Because the exposure with this approach depends on collapsing the sigmoid sinus posteriorly, bone is completely removed from the sigmoid sinus and the subocciput posterior to the sinus. Extensive exposure of the retrosigmoid dura is necessary for adequate exposure with this approach. The middle fossa dura is exposed and the petrous ridge is removed to increase the exposure.

The dura is opened as a flap that begins just medial to the sigmoid sinus and preserves the endolymphatic sac. The flap is held anteriorly with sutures, and tumor dissection can be performed in the posterior fossa (Fig. 191-8).

Once the CPA is entered and cerebrospinal fluid is released, the cerebellum falls away. Thus, cerebellar retractors are not necessary to expose the cranial nerves in the CPA; instead, the sigmoid is collapsed posteriorly with a fenestrated suction.

When tumor removal is completed, the dura is closed with sutures. The defect is obliterated with abdominal fat. Closure is performed in layers and a compressive dressing is applied.

Special features

The indications for this approach in tumor removal are limited. If exposure of the IAC is not needed for a small neoplasm of the CPA, however, this approach can preserve hearing and avoids the greater degree of cerebellar retracton required for the RS approach.

Transcochlear Approach

Basic approach

As an extension of the TL aproach, additional exposure of the skull base is obtained by displacement of the facial nerve and removal of the cochlea to provide surgical access to lesions of the petrous tip and clivus (Fig. 191-9).

Indications

Petroclival meningiomas and epidermoids of the petrous tip are the principal lesions for which this approach has been applied (House et al, 1978). However, extensions of this approach have been used in glomus jugulare tumors, temporal bone carcinomas, and extensive nonacoustic neuromas of the CPA.

Technique

The incision; soft tissue exposure; and complete mastoidectomy, labyrinthectomy, posterior and middle fossa dura decompression, and skeletonization of the IAC are performed as in the TL approach.

The facial nerve is decompressed from the stylomastoid foramen to the geniculate ganglion. After sectioning the chorda tympani nerve via an extended facial recess approach and transecting the greater superficial petrosal nerve, the facial nerve can be transposed posteriorly. Transposition of the nerve removes the obstacle to extending the exposure anteriorly. The TC approach has been modified to include transection of the EAC and two-layered closure of the meatus. This modification permits removal of the posterior wall of the EAC, thus allowing wider anterior exposure in the areas of the jugular bulb and internal carotid artery. Next, the incus and stapes are removed. The cochlea is removed, thus exposing the carotid artery anteriorly, the jugular bulb and inferior petrosal sinus inferiorly, and the superior petrosal sinus superiorly. The bony exposure leaves a dura covered window extending from the superior petrosal sinus to the inferior petrosal sinus and reaching the clivus medially (Fig. 191-10).

The same principles of tumor removal are used as with the other approaches to the CPA. However, the position of the facial nerve in relation to the tumor and the proximity of the basilar artery make certain aspects of tumor removal with the TC approach different from other approaches to the CPA. Unlike in AN surgery, tumors of the petrous apex and clivus are characterized with the facial nerve on the posterior surface of the tumor. Thus the nerve must be dissected free of the tumor and protected. The position of the vertebrobasilar arterial system must be considered. As tumor dissection proceeds medially, the basilar artery will be anterosuperior and the vertebral artery posteroinferior. Extensive tumors that cross the midline are removed by reflecting the vessels posteriorly from the tumor capsule. The surgical defect is filled with abdominal fat, the wound is closed in layers, and a compressive dressing is applied.

Special features

The approach provides direct access to the base of implantation and blood supply of tumors arising from the petrous tip and petroclival junction. Temporary facial nerve paralysis occurs uniformly with the posterior transposition of the facial nerve required by this approach. Such paralysis is most likely the consequence of devascularization of the perigeniculate segments of the nerve caused by transection of the greater superficial petrosal nerve and its accompanying vessels. Satisfactory recovery of facial nerve function is the rule.

Transotic Approach

Basic approach

This approach is similar to the modified TC approach in which the EAC is closed and the posteriro EAC removed. The distinction of this approach is that the facial nerve is skeletonized but left in its bony canal in the surgical field.

Indications

The transotic approach is indicated in lesions of the CPA extending inferiorly into the jugular foramen or anteriorly into the clivus. Some proponents of this approach use the additional exposure anteriorly in cases of high jugular bulbs or anteriorly placed sigmoid sinuses in small to medium ANs (Jenkins and Fisch, 1980). Surgeons of the House Ear Clinic have found that the TL approach with wide decompression of the sigmoid sinus and posterior fossa dura provides adequate exposure of the IAC and CPA, even in large acoustic tumors with unfavorable venous anatomy.

Technique

Through a postauricular incision the ear is reflected anteriorly, and the external auditory meatus is transected and closed in two layers. Essentially the same procedure as that described in the TC approach is performed, with the exception that the facial nerve is not completely freed from the fallopian canal. Rather, the nerve is skeletonized and left in its canal. At the conclusion of the exposure, the facial nerve is suspended, traversing the surgical field with a bony cover. The tympanic ring is removed with systematic exposure of the jugular bulb, jugular foramen, and carotid canal. By working around the facial nerve, the surgeon has access to lesions of the IAC, CPA, clivus, and jugular foramen (Fig. 191-11). Closure is performed with obliteration of the defect with abdominal fat.

Special features

This approach combines the added exposure provided by removal of the tympanic ring and access medial to the facial nerve with the added safety of not transposing the facial nerve.

The TO approach also offers an alternative management of the anterior sigmoid or high jugular bulb in cases of cerebellopontine angle tumor removal in which hearing preservation will not be attempted. Leaving the facial nerve in situ is an attractive means of avoiding excessive manipulation of the facial nerve; however, leaving the nerve without transposition requires added vigilance by the surgeon, as dissection proceeds medial to the plane of the facial nerve. Furthermore, exposure is limited at the brainstem because the labyrinthine segment of the facial nerve and the contents of the IAC are not transposed.

Extended Middle Fossa Approach

Basic approach

Through a wide temporal craniotomy, the temporal bone surrounding the otic capsule is systematically removed. This approach exposes lesions extending from the posterior fossa through the tentorium and incisura and anteriorly up to the region of foramen lacerum and the posterolateral aspect of the cavernous sinus (Fig. 191-12).

Indications

This approach is indicated in extensive petrous ridge and petroclival lesions involving the temporal bone, but which still have serviceable hearing. Petrous ridge lesions with extension through the tentorium into the middle fossa are especially amenable to this approach.

Technique

The patient is positioned in the supine position with the head turned. Mannitol and furosemide as well as hyperventilation are used for brain relaxation. The widest temporal craniotomy that will stil accept the House-Urban middle fossa dura retractor is performed. The middle-fossa retractor is inserted and the temporal lobe is progressively retracted to permit identification of the middle meningeal artery anteriorly, the petrous ridge posteriorly, and the petroclival junction medially. The IAC is uncovered using the standard middle fossa technique as described previously. The extension in the exposure is accomplished by removing the petrous ridge and posterior aspects of the temporal bone up to the labyrinth. Anteriorly, the temporal bone is removed up to the foramen lacerum and internal carotid artery (see Fig. 191-6, C0. The area of Meckel's cave is now clearly identified and the posterolateral portions of the cavernous sinus are accessible.

Special features

This approach permits safe removal of extensive lesions (especially meningiomas) of the middle and posterior fossa that have not directly involved the otic capsule or IAC. Preservation of hearing and the facial nerve is possible with this technique despite wide access to the lesion.

Approaches for Skull Base Lesions Requiring Drainage

As described in Chapter 188, cholesterol granulomas are nonneoplastic lesions that may expand the petrous apex and produce symptoms related to the nerves of the posterior fossa. Similarly, mucoceles of the petrous apex may produce symptoms by their expansion. Both lesions are adequately treated by surgical drainage.

Translabyrinthine

If hearing and vestibular function are absent, this approach provides the most direct route for aeration from the mastoid through the surgical defect to the petrous apex (Gherini et al, 1985). Usually, however, this approach is not appropriate because patients often have excellent hearing in spite of large cholesterol granulomas.

Middle cranial fossa

This approach does permit hearing preservation; however, it requires temporal lobe retraction for expansion, and there is not a readily available space for drainage of the cyst and permanent aeration of the apex.

Infralabyrinthine

After a complete mastoidectomy, the sigmoid sinus is decompressed, the posterior semicircular canal and jugular bulb are identified, and the infralbyrinthine air cells are followed into the petrous apex. The cyst is incised, drained, and stented open into the mastoid (Fig. 191-13) (Gherini et al, 1985). This approach may be technically impossible in a patient with a high jugular bulb. Furthermore, although reexploration is possible in the face of an occluded stent, revision requires formal revision of the transmastoid approach.

Transcanal infracochlear

The EAC is transected and a superiorly based tympanomeatal flap is elevated. The bony external meatus is widened, and the air cell tract between the jugular bulb and carotid artery is followed into the petrous apex. This approach permits dependent drainage of the petrous apex into the middle ear (Fig. 191-14). If the drainage tube becomes obstructed, it may be revised through an office myringotomy. The principal disadvantage of the transcanal infracochlear approach is the prolonged healing required for the EAC and the need for direct exposure of the petrous carotid artery (Giddings et al, 1991).

Selection of Surgical Approach

The rationale for selecting a particular surgical approach in ANs is similar for other posterior fossa neoplasms. The principal goal is tumor removal with minimal postoperative morbidity. Accordingly, the surgical approach should be tailored to a particular patient's pathology and functional status. The notion that a single approach should be used in all lesions of the posterior fossa is not only counterintuitive but also subjects patients to unnecessary morbidity. In cases without serviceable hearnig, the TL approach provides wide and direct access to the CPA with maximal facial nerve safety, minimal cerebellar retraction, and a low incidence of severe postoperative headache.

Patients with small tumors and good hearing have three options for surgical removal: the TL approach that destroys hearing, the MF approach in young patients with small, mainly intracanalicular tumors, and the RS approach in small tumors of the CPA that do not extend to the fundus of the IAC.

Realistic patient counseling is necessary regarding hearing conservation procedures. Gardner and Robertson (1988) rigorously reviewed the literature on hearing preservation in AN surgery. Of 621 cases of attempted hearing preservation up to 1987, the "success rate" was 33%. Reported "successful" hearing preservation rates often refer only to measurable hearing; the rate is far less if "useful hearing" (SRT < 30 dB and speech discrimination > 70%) or "serviceable hearing" (SRT > 50; speech discrimination > 50%) is considered. Furthermore, long-term follow-up studies reveal that 56% of these patients experience significant loss of the preserved hearing over time (Shelton et al, 1990).

After discussing the risks and benefits of the various surgical approaches, many potential candidates for hearing preservation choose the TL approach, with its slightly higher rate of facial nerve preservation, than the hearing conservation procedures.

In meningiomas and tumors that do not affect the IAC and have not affected hearing, the extended middle-fossa approach is used if both posterior and middle fossa exposure is necessary. The RL approach is used for limited lesions of the CPA only, whereas the RS would be applicable for more extensive lesions of the posterior fossa. Extensive anteromedial exposure is needed for lesions of the clivus. Hearing preservation is usually not feasible in such lesions, and the TC or TO approach may be used.

Patient Management and Surgical Complications

Comprehensive management of patients with skull base neoplasms of the posterior fossa requires a team of specialists familiar with the particular needs of this patient group. In addition to neurotologists and neurosurgeons, designated internists, anesthesiologists, radiologists, ophthalmologists, and critical care nurses are essential components of the care of these patients with very specialized needs.

Preoperative management

Preoperative antibiotics are not routinely used in uncomplicated cases. Osmotic agents and diuretics for brain relaxation are usually not used in the TL approach; however, the RL, RS, MF, and EMF approaches require such techniques to minimize the need for retraction.

Intraoperative monitoring

Facial nerve monitoring is used routinely in all cases of posterior fossa neoplasms. Continuous monitoring is performed with EMG electrodes and monitoring equipment with instantaneous visual and loudspeaker output. An audiologist is a member of the operative team to assist with interpretnig monitoring signals and stimulating the facial nerve when required to identify nerves intraoperatively.

Auditory brainstem response monitoring is not routinely used. Because this modality provides only delayed feedback to the surgeon, it cannot affect intraoperative decision making or tissue manipulation in a meaningful way. The advent of direct eighth nerve recording systems may make available to the surgeon in hearing preservation cases a practical "real-time" feedback system.

Postoperative care

The compression mastoid dressing applied in the operating room is left in place until the fourth postoperative morning. The patient is observed in the neurologic intensive care unit for 2 days after surgery and then transferred to the general ward. Limited activity is begun on the first postoperative morning, and ambulation usually begins on the third or fourth postoperative day.

Complications

Anteroinferior cerebellar artery

Tumor manipulation at the brainstem may result in changes in vital signs. Such changes are related to ischemia, which is usually in the distribution of the anteroinferior cerebellar artery. Manipulation is temporarily stopped until vital signs changes have resolved. Vital sign alterations that do not resolve or recur with any tumor manipulation are an indication to terminate the procedure. Complete interruption of this vessel may result in Atkinson's syndrome, infarction of the lateral tegmental pons, which is often fatal (Atkinson, 1949).

Cerebrospinal fluid leaks

In the TL approach, cerebrospinal fluid (CSF) leakage through the wound is rare with meticulous closure. The incidence of CSF rhinorrhea is less than 10% and usually responds to replacement of the compression mastoid dressing. The routine obliteration of the eustachian tube has nearly eliminated this problem. In the rare case of persistent leakage (1 case in a recent series of 230 acoustic tumor procedures), additional abdominal fat saved from the initial procedure is placed into the area of leakage and a compression dressing is replaced.

In the RS approach, the mastoidectomy is also obliterated with fat. In some institutions, the mastoid is not routinely entered, and fluid communication is possible through exposed air cells, which ultimately permit fluid leakage through the eustachian tube. Aggressive bone wax over mastoid air cells is necessary to avoid leaks; in cases of persistent leaks, additional fat obliteration of the mastoid and "waxing" of air cells is usually successful.

Meningitis

Any procedure that exposes the subarachnoid space can be complicated by postoperative meningitis. In the experience of the House Ear Clinic, the incidence of meningitis has been less than 5%. The diagnosis is suspected in a toxic-appearing patient with a stiff neck, recent headache, and fever. Appropriate spinal fluid studies confirm the diagnosis. The mean time of onset of meningitis in patients with AN has been 8 days postoperatively. Aggressive medical management of this complication has successfully avoided any serious complications from meningitis except for a delayed hospital discharge (Brow, 1979). We continue to prefer not to use prophylactic antibiotics because (1) the risk of meningitis is low, (2) there is no proven efficacy in reducing postoperative meningitis in posterior fossa skull base surgery, (3) infections may be masked by the short-term prophylactic regimen, and (4) there is a danger of causing a resistant infection, particularly

if a CSF leak occurs postoperatively.

Facial nerve

Facial nerve transection is ideally managed by immediate repair or with an interposition graft (Arriage and Brackmann, 1991). In the TL approach, access to the middle-ear and mastoid portions of the nerve can provide a longer distal segment to assure a tension-free anastomosis (Barrs et al, 1984). In cases where direct repair is not possible or where an intact nerve does not resume function within 1 year, the facial-hypoglossal anastomosis provides reliable facial reanimation (Luxford and Brackmann, 1985). Temporalis muscle transfer is an alternative technique for reanimation of the paralyzed face, which is attractive because of its immediate effects.

Ophthalmologic

The combination of facial paralysis and corneal insensitivity, which are both more likely in cases of large tumors, predisposes the cornea to significant trauma. Patients who are expected to have prolonged facial paralysis (> 6 months) are managed with a brow lift and eyelid spring. In cases of partial facial weakness or when the paralysis is expected to be short term, aggressive medical treatments including lubricating drops, ointments, contact lenses, moisture chamber protection and nightly taping of the affected eye are undertaken (Levine, 1979).

Summary

The modern skull base surgical team can choose from a variety of microsurgical approaches for resection of posterior fossa neoplasms. The approach should be tailored to the patient's particular pathology and physiologic status. Realistic counseling of patients is critical for informed decisions concerning surgical approaches and possible cranial nerve sequellae. Skull base surgery is a team endeavor, and the full array of experts familiar with the specific needs of these patients is necessary for a successful outcome.