Prevention and Management of Cerebrospinal Fluid Fistula After Transtemporal Skull Base Surgery

John P. Leonetti, M.D.,¹ Douglas Anderson, M.D.,² Sam Marzo, M.D.,¹ and George Moynihan, M.D.¹

ABSTRACT

The incidence of cerebrospinal fluid (CSF) fistula after transtemporal skull base surgery can range from 4% to 19%. The risk of CSF leak may be related to tumor size and location, the extent of the dural defect, and the technical aspects of the wound reconstruction. Prevention of meningitis depends on the early detection and management of CSF leakage. Five hundred eighty-nine patients underwent a variety of transtemporal surgical approaches for the extirpation of skull base tumors at our institution from July 1988 to October 1999. The medical records were reviewed retrospectively to identify the tumor histology, size, and location, as well as the surgical approach, defect reconstruction technique, and the incidence of postoperative CSF leak. The risk of CSF fistulae was greatest in using the retrosigmoid approach (8%) and lowest in those who underwent a translabyrinthine approach (4%). Tumor size had no bearing on the incidence of the CSF leak and the overall incidence of meningitis was 1.0%. This article outlines our institutional objective for the prevention and management of CSF fistula after transtemporal skull base surgery. Illustrative cases will be presented.

KEYWORDS: Cerebrospinal fluid fistula, transtemporal approach, meningitis

Transtemporal approaches are often used in the extirpation of tumors originating from structures within the jugular foramen, middle ear, petrous apex, internal auditory canal, cerebellopon-

tine angle, foramen magnum, and the infratemporal fossa.¹ The risk of cerebrospinal fluid (CSF) leakage, after dural violation, remains a potentially life-threatening complication that may occur in the

Skull Base, volume 11, number 2, 2001. Reprint requests: John P. Leonetti, M.D., Department of Otolaryngology–Head and Neck Surgery, Loyola University Medical Center, 2160 S. First Avenue, Maywood, IL 60153. ¹Departments of Otolaryngology–Head and Neck Surgery, and ²Neurological Surgery, Loyola Center for Cranial Base Surgery, Maywood, Illinois. Copyright © 2001 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662. 1531-5010,p; 2001,11,02,087,092,ftx,en;sbs00208x.

management of neoplasms located in any of these regions.² This article reviews our experience with postoperative CSF fistulae by evaluating a variety of transtemporal surgical approaches used in a series of 589 patients.

RELATED ANATOMY

The degree of temporal bone pneumatization is highly variable and is, perhaps, the most critical anatomic factor related to postoperative CSF leakage. Air cell tracts have been classified as mastoid, perilabyrinthine, apical, peritubal, and accessory.³ The supralabyrinthine and infralabyrinthine portions of the perilabyrinthine air cells allow for easy egress of CSF through the mastoid antrum, middle ear, and eustachian tube. Inadequate dural repair after any transtemporal approach will result in CSF wound collection, CSF otorhinorrhea, or both clinical manifestations.

The perilabyrinthine region is further subdivided into the supralabyrinthine and infralabyrinthine areas. The supralabyrinthine area is composed of three tracts. The first two tracts, the posterosuperior and posteromedial, run parallel to each other along the posterior medial surface of the petrous bone. The subarcuate cell tract extends from the mastoid into the subarcuate fossa.⁴

The infralabyrinthine pneumatization consists of the hypotympanic and retrofacial air cell tracts. The hypotympanic air cell tract extends from the hypotympanum to the area inferior to the labyrinth. The retrofacial air cell tract courses medial to the descending portion of the facial nerve, toward the infralabyrinthine region.

The petrous apex can be divided into the peritubal and apical regions. The peritubal area surrounds the osseous portion of the eustachian tube. This area consists of the anterosuperior and anterolateral air cell tracts. The anterosuperior tract extends from the epitympanum, between the genu

of the facial nerve and middle cranial fossa dura, and leads to the eustachian tube. The anterolateral tract extends from the eustachian tube to the horizontal portion of the carotid canal.

The apical area of the petrous bone is composed of three air cell tracts. The hypotympanic tract courses between the carotid canal and cochlea to reach the apical area of the petrous bone. The peritubal tract is an extension of the eustachian tube air cells into the apical area, while the perilabyrinthine tracts lead to the apical area from either the supralabyrinthine or infralabyrinthine areas.⁵

Nonanatomic factors that may influence the risk of CSF leakage include the method of dural repair, the presence of increased intracranial pressure, a history of prior radiation therapy, and the type of wound closure.⁶ The histology, size, and location of the tumor resected are less likely to impact the incidence of postoperative CSF leakage.

METHODOLOGY

The medical records of 589 patients who underwent transtemporal skull base surgical resection of an intradural or transdural tumor at our institution between July 1988 and October 1999 were retrospectively reviewed. Surgical data were retrieved from operative reports, tumor histology was identified from pathology reports, and all other perioperative information was collected from hospital medical records.

RESULTS

Patient Data

All patients were referred to our tertiary medical center for the surgical treatment of their disease. Of the 589 patients, 319 were female and 270 were

male. The age range was 8 to 76 years, with a mean age of 56.4 years.

Surgical Approach

The translabyrinthine and retrosigmoid approaches were most commonly used. Sixty-three patients underwent a combination of transtemporal approaches for tumor removal. A summary of the techniques used is shown in Table 1.

Wound Closure

The detailed methods for wound closure varied according to surgical approach. The presigmoid dural defect, after a translabyrinthine approach, was packed with adipose strips after antral occlusion with a bone wax, bone pate plug. The musculo-periosteal flaps were approximated in a vertical or T-shaped fashion, and the scalp was repaired with a running-locking suture technique or staples.

The transcochlear and infratemporal fossa defects were repaired in the same manner as the translabyrinthine defects in addition to direct eustachian tube packing with temporalis muscle, bone wax, and bone pate.

Our method for internal auditory canal closure after retrosigmoid transmeatal surgery has been described in detail.⁷ The retrosigmoid dura was repaired primarily, or with a fascial dural patch.

The intracranial pressure is increased (Valsalva) to check the completeness of the dural repair. If the dural closure is watertight, and no CSF is seen in the antrum, bone pate is placed over the dural repair, followed by adipose tissue, and standard wound closure as described earlier. If the dural repair is complete, and CSF collects in the antrum via the perilyabyrinthine cells, but the hearing was lost during tumor removal, the eustachian tube and middle ear are occluded via the facial recess. If CSF drainage is noted, and hearing was preserved, the dura is reopened, and the internal auditory canal is more aggressively packed with bone wax, bone pate and a muscle plug.

The middle fossa approach was used only in 3 patients in this series. Temporalis fascia was draped over the exposed internal auditory canal and wound closure was performed in a standard manner.

Lumbar-subarachnoid drainage, which was used in a majority of patients who underwent a combined approach or a retrosigmoid approach, was rarely used in the other patients. The drains were used intraoperatively and for 24 to 48 h postoperatively.

All wounds were covered with a rather tight compressive dressing, which was kept in place for 3 to 5 days. When present, CSF wound collection was usually noted within 24 h of dressing removal, and when noted, CSF rhinorrhea occurred before hospital discharge in all but 3 patients. All patients were instructed, by means of standardized reading material and discharge nurse discussions, to refrain from strenuous activities and heavy lifting (>15 lb) for 3 weeks after surgery.

Table 1 Transtemporal Surgical Approaches (n = 589)

Approach	n
Translabyrinthine	209
Retrosigmoid	191
Infratemporal	71
Combined	63
Transcochlear	52
Middle fossa	3

Tumor Histology

Acoustic neuroma was the most common tumor encountered in this series. A variety of neoplasms such as lipoma, hemangioma, epidermoid, facial neuroma, prostate cancer, melanoma, and meta-

Table 2 Tumor Histology (n = 589)

Tumor	n	%
Acoustic neuroma	455	77
Meningioma	61	10
Paraganglioma	42	7
Other	31	6

static breast cancer made up the remainder of lesions treated. A summary of the tumor histology is displayed in Table 2.

Tumor Size

Most of the tumors removed in this series were 2 to 3 cm, in greatest diameter, as measured by computed tomography (CT) scan or magnetic resonance imaging (MRI). Tumor sizes for all patients are presented in Table 3.

CSF Leakage

CSF fistula was defined as wound collection, otorrhea, wound leakage, or rhinorrhea, as noted by physical examination. In general, fluid sampling and nuclear medicine studies were not necessary to confirm the presence of CSF leakage. The risk of CSF leak was highest in the retrosigmoid and combined approaches and least in the translabyrinthine and middle fossa approaches. The incidence of CSF leakage related to surgical approach is shown in Table 4.

Table 3 Tumor Size (n = 589)

Size (cm)	n	%
<1.0	133	23
1.1–2.0	101	17
2.1–3.0	231	40
>3.0	124	20

Table 4 CSF Fistula Related to Surgical Approach (n = 589)

Approach	n	Leak (n)	Leak (%)
Retrosigmoid	191	15	7.8
Infratemporal	71	5	7.0
Combined	63	4	6.3
Transcochlear	52	3	5.7
Translabyrinthine	209	8	3.8
Middle fossa	3	0	0.0

Meningitis

Thirty-five of 589 (or 6%) of the patients undergoing transtemporal skull base approaches experienced a postoperative CSF leak. Three of these 35 patients developed bacterial meningitis, and another 3 patients who did not demonstrate CSF fistula suffered from meningitis. All patients with meningitis were treated with intravenous antibiotics, and no patients experienced any additional permanent untoward sequelae.

Management of CSF Leakage

Fifteen of the 35 postoperative CSF leaks presented as a wound fluid collection, and all these patients were treated with aspiration of the fluid, replacement of the compressive dressing, and 2 to 3 days of lumbar subarachnoid drain placement with bed rest. Two of these patients required wound revision with additional adipose packing. The remaining 13 patients healed without untoward sequelae. Twelve patients developed CSF rhinorrhea. All patients in this group were immediately returned to the operating room for reclosure of the internal auditory canal if hearing was preserved (2 patients) or eustachian tube and middle ear obliteration if hearing was not saved (10 patients). Six patients developed both CSF wound collection and rhinorrhea and all 6 were managed as outlined above. One patient had CSF otorrhea from a torn external auditory canal and one patient

developed otorrhea from an iatrogenic eardrum perforation. Both patients required wound revision with oversew of the ear canal. The CSF leak management is summarized in Table 5.

DISCUSSION

A variety of surgical approaches have been perfected that allow the safe extirpation of lateral skull base and posterior fossa tumors.⁸ The risk of CSF leakage after some of these approaches can be as high as 20%.⁹ The development of meningitis, related to postoperative CSF leak, can be life-threatening.

Transtemporal exposure for tumor removal will result in violation of many air cell tracts that predispose to the formation of CSF leakage. In an extensive review of 723 acoustic tumor resections, Rodgers et al.¹⁰ concluded that "technical factors account for postoperative CSF leak and meningitis after translabyrinthine acoustic tumor removal." Perilabyrinthine air cell tracts allow for egress of CSF after retrosigmoid-transmeatal exposure to the internal auditory canal.^{3,7} Finally, transsigmoid dural resection for jugular foramen tumors during extensive infratemporal fossa approaches may result in postoperative CSF leakage.¹¹

A thorough analysis of all potential factors that might influence the incidence of CSF leakage is beyond the scope of this article. The purpose of this review was, rather, to evaluate a variety of commonly used lateral skull base approaches with respect to the development of postsurgical CSF leakage and to offer our current methods for preventing and managing this untoward sequelae.

The incidence of CSF leakage in this series of 589 patients ranged from 3.8% in the translabyrinthine approach to 7.8% in the retrosigmoid approach. As only three patients underwent a middle fossa approach, the 0% CSF leak rate is not included in our comments. Meticulous air cell tract occlusion, dural repair, dural packing, eustachian tube blockage and wound repair are critical technical factors to reduce the risk of CSF fistulae. The importance of compressive dressings, lumbar-subarachnoid drainage and bed rest is less commonly agreed upon as impacting the occurrence of CSF leakage. Our techniques of wound closure and postoperative patient activity level are tailored according to the surgical approach employed.

The management of CSF fistula after transtemporal surgery can involve intradural or extradural techniques.¹²⁻¹⁴ In general, we prefer to manage CSF wound collection with aspiration, replacement of a compressive dressing, lumbar-subarachnoid drainage, and bed rest. Only 2 of

Table 5 Management of 35 Patients with Postoperative CSF Leak

Presentation	N	Management	Result
Wound collection	15	Aspiration	2 pts needed wound revision
		Dressing	13 no additional leakage
		Lumbar-subarachnoid	
		Drainage	
Rhinorrhea	12	IAC closure (if hearing +)	No additional leakage
		wound revision (if hearing -)	
Wound collection and rhinorrhea	6	Same as rhinorrhea group	No additional leakage
Otorrhea	2	EAC oversew with wound revision	No additional leakage

CSF, cerebrospinal fluid; IAC, internal auditory canal; EAC, external auditory canal.

15 patients treated in this manner required additional wound revision surgery. Twelve patients presented with CSF rhinorrhea and 6 patients developed rhinorrhea and wound fluid collection. Sixteen of these patients were managed by wound revision with eustachian tube and middle ear occlusion; 2 patients underwent repacking of the internal auditory canal. None of these 18 patients developed additional CSF leakage. CSF otorrhea required external auditory canal oversew in 2 patients.

CONCLUSION

An understanding of temporal bone pneumatization patterns and meticulous wound closure are critical toward reducing the incidence of CSF fistula after transtemporal surgery. Thirty-five (6%) of the 589 patients discussed in this review developed CSF leakage, 3 of whom suffered meningitis.

ACKNOWLEDGMENT

The authors thank Amy Donohue for her meticulous preparation of this manuscript.

REFERENCES

1. Leonetti JP, Reichman OH, Izquierdo RW. The Contemporary Management of Skull Base Neoplasms. *Insights in Otolaryngology*. Vol 5. St Louis, MO: CV Mosby; 1990:1-6
2. Bryce GE, Nedzelski JM, Rowed DW. Cerebrospinal fluid leaks and meningitis in acoustic neuroma surgery. *Otolaryngol Head Neck Surg* 1991;10: 81-87
3. Smith PG, Leonetti JP, Grubb RL. Management of CSF otorhinorrhea complicating the retrosigmoid approach to the cerebellopontine angle. *Am J Otol* 1990;11:178-180
4. Allam AF. Pneumatization of the temporal bone. *Ann Otol* 1969;78:78-49
5. Curtin H, Som P. The petrous apex. *Otolaryngol Clin North Am* 1995;28:473-496
6. House JL, Hitselberger WE, House WF. Wound closure and CSF leak after translabyrinthine surgery. *Am J Otol* 1982;4:126-128
7. Leonetti JP, Anderson DE, Newell DJ, Smith PG. Posterior internal auditory canal closure following the retrosigmoid approach to the cerebellopontine angle. *Am J Otol* 1993;14:31-33
8. Leonetti JP, Smith PG, Reichman OH, et al. Neurotologic considerations in the treatment of advanced clival tumors. *Otolaryngol Head Neck Surg* 1992;107:49-56
9. Mangham CA. Complications of translabyrinthine vs. suboccipital approach for acoustic tumor surgery. *Otolaryngol Head Neck Surg* 1998;99:396-400
10. Rodgers GK, Luxford WM. Factors affecting the development of cerebrospinal fluid leak and meningitis after translabyrinthine acoustic tumor surgery. *Laryngoscope* 1983;103:959-962
11. Kletzker GR, Smith PG, Backer RJ, Leonetti JP. Neurotologic and skull base surgery. In: Krespi Y, Ossoff R, eds. *Complications in Head and Neck Surgery*. Philadelphia: WB Saunders; 1993:73-96
12. Persky MS, Rothstein SG, Breda SD. Extracranial repair of cerebrospinal fluid otorhinorrhea. *Laryngoscope* 1996;101: 134-136
13. Wax MK, Ramadan HH, Ortiz O. Contemporary management of cerebrospinal fluid rhinorrhea. *Otolaryngol Head Neck Surg* 1997;116:442-449
14. Li JC, Leonetti JP, Mokarry V. The concept of transtympanic injection of fibrin caulk. *Arch Otolaryngol Head Neck Surg* 1993;119:854-857