The resurrection of vestibular neurectomy: a 10-year experience with 115 cases

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Between 1925 and 1945, Walter Dandy and Kenneth McKenzie performed more than 700 posterior fossa eighth nerve sections and vestibular neurectomies to treat the intractable vertigo accompanying Ménière's disease. During the past 10 years, with the aid of microsurgical techniques and the approach to the posterior fossa through the temporal bone, vestibular neurectomy has undergone a resurgence of popularity. When hearing is to be preserved, vestibular neurectomy is the surgical treatment of choice for patients who fail to undergo a remission of the vertigo attacks of Ménière's disease. This report reviews 115 consecutive vestibular neurectomies performed from 1978 to 1988 for the treatment of Ménière's disease.

In 1978, retrolabyrinthine vestibular neurectomy (RVN), a procedure in which the posterior fossa is entered anterior to the sigmoid sinus and behind the labyrinth, was introduced. During the last 3 years, the approach to the posterior fossa has been a small dural opening behind the sigmoid sinus; this approach is known as the combined retrolabyrinthine retrosigmoid approach. There have been no cases of facial paralysis and no serious complications connected with this technique. A high incidence of headache (50%) resulted when the posterior wall of the internal auditory canal was drilled away for better exposure. Transient cerebrospinal fluid (CSF) leaking occurred in 7% of the patients undergoing RVN; however, no CSF leaks occurred when the combined retrolabyrinthine retrosigmoid approach was used. In the RVN series, wound infection occurred in 20% of the cases until perioperative antibiotics reduced the rate to 3%. The results in terms of curing or improving vertigo have been excellent (94%), and hearing has been preserved to within 20 dB preoperative levels in 76% of the cases. Until a cure for Ménière's disease is found, microsurgical posterior fossa vestibular neurectomy remains the best treatment.

KEY WORDS • vestibular neurectomy • Ménière's disease • vertigo

TODAY, vestibular neurectomy is accepted as the procedure of choice to preserve hearing and relieve intractable vertigo associated with unilateral vestibular disorders that are refractory to medical management. Frazier, in 1904, was the first to perform an eighth nerve section through the posterior fossa to relieve symptoms of vertigo in Ménière's disease. Twenty-one years later, in 1925, Dandy began performing eighth nerve sections. Cutting only the superior half of the eighth nerve (vestibular fibers) was introduced by McKenzie in 1931. In 1932, Dandy performed the first of his 624 vestibular neurectomies, the largest series in the world. After his death, peripheral destructive procedures of the labyrinth became popular and have remained so until recently; unfortunately, hearing is lost with this technique. The first microsurgical vestibular neurectomy was performed by William House in 1961 through a subtemporal approach. In this procedure, the roof of the internal auditory canal (IAC) is drilled away and the vestibular nerve transected. Because of the technical difficulty and associated complications, few middle fossa nerve sections were performed in the United States.

In 1978, while removing a ninth nerve neurilemoma from the posterior fossa through a transmastoid retrolabyrinthine approach, Silverstein and Norrell discovered a clear cleavage plane in the eighth nerve between the cochlear and vestibular nerves. Gross and microscopic laboratory studies confirmed that vestibular neurectomy could be performed routinely through a retrolabyrinthine approach. This report presents the indications, anatomical findings, and evolution of the microsurgical approach to the posterior fossa vestibular neurectomy.

Indications and Contraindications for Vestibular Neurectomy

Although classic unilateral Ménière's disease is the most common indication, vestibular neurectomy can be useful for other labyrinthine disorders (for example,
traumatic labyrinthitis). Patient's choice is a strong consideration in the decision of when to operate. Some patients may have one or two severe attacks of Ménière's disease a month and not have their lifestyles sufficiently affected to warrant a major surgical procedure to correct the problem. Other patients with only two or three attacks a year can be so severely affected that they live in constant dread of the next recurrence. Before surgery can be considered, objective evidence of unilateral inner ear disease should be provided by audiogram, electronystagmography, and electrocochleography.

Contraindications to vestibular neurectomy include bilateral vestibular disease, poor medical condition, ataxia or other indications of possible significant central nervous system involvement, and vertigo arising from a patient's only hearing ear. Vertigo from an ear with very poor hearing (that is 80 dB speech reception threshold and < 20% discrimination) is usually more appropriately treated with a transcocchlear eighth nerve section. A previous endolymphatic sac operation is not a contraindication, nor is old age when the patient is healthy and has good balance function. Vestibular neurectomy has been performed successfully in patients over 70 years old with excellent results and little additional morbidity; however, elderly patients usually take longer to regain good balance function postoperatively than do younger individuals.

Anatomy: Vestibular, Cochlear, and Facial Nerves

The anatomy (Fig. 1) is described assuming the patient is supine with the head turned away from the surgeon. At the labyrinthine end of the IAC, six separate branches of the seventh and eighth cranial nerves enter the temporal bone: the facial nerve, nervus intermedius, superior vestibular nerve, saccular nerve, posterior ampullary nerve, and cochlear nerve. The transverse (falciform) crest, which lies in a perpendicular plane, divides the lateral IAC into superior and inferior compartments. A bridge of bone (Bill's bar) separates the superior half of the IAC into an anterior-superior quadrant containing the facial nerve and nervus intermedius and a posterior-superior quadrant containing the superior vestibular nerve. Anteriorly, and inferior to the falciform crest, lies the cochlear nerve, hidden from the surgeon by the inferior vestibular nerve. The posterior ampullary nerve lies in a separate canal (the singular canal) which enters the IAC in the posterior-inferior quadrant, approximately 2 mm medial to the falciform crest. This reliable landmark is the point at which drilling stops when the posterior wall of the IAC is being surgically removed. Thin-section computerized tomography of the labyrinth is routinely obtained to visualize the exact location of the singular canal. The inferior vestibular nerve is formed when the saccular nerve joins the posterior ampullary nerve just medial to the falciform crest.

The superior vestibular nerve innervates the superior semicircular canal, horizontal semicircular canal, saccule, and utricle. The inferior vestibular nerve innervates the saccule and the posterior semicircular canal. The cochleovestibular (CV) cleavage plane at the labyrinthine end of the IAC separates the cochlear and vestibular nerves. It lies in the superior-inferior plane, with the vestibular nerves occupying the posterior half of the IAC. The superior and inferior vestibular nerves fuse between the falciform crest and the porus acusticus. Laterally, within the IAC is a constant, well-delineated cleavage between these two nerves.

At the distal end of the IAC, the cochlear nerve lies anterior to the inferior vestibular nerve. The cochlear and inferior vestibular nerves fuse within the IAC just medial to the falciform crest. The cochlear and vestibular nerves then rotate 90° so that the cochlear nerve lies caudal and inferior to the vestibular nerve as it enters the porus acusticus. From a medial vantage point, the rotation in the left ear is clockwise; in the right ear, it is counterclockwise. Most of the rotation occurs within the IAC; only slight rotation occurs in the cerebellopontine angle (CPA) (Fig. 2). The cochlear nerve exits the brain stem caudal and slightly dorsal to the vestibular nerve. The 90° rotation of the cochlear...
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Fig. 2. Cadaver specimen of the right eighth cranial nerve. Note the 90° rotation of the cochlear nerve (CN) and the vestibular nerve (IVN). A triangular marker (arrow) is inserted in the cochleovestibular cleavage plane. The posterior portion of the eighth cranial nerve is shown. The anterior portion faces away from the surgeon. SVN = superior vestibular nerve.

Fig. 3. Orientation of the cochlear and vestibular fibers. Note the vestibular fibers oriented together in the superior position of the eighth nerve. Vest. = vestibular nerve; Coch. = cochlear nerve; P.I. = nervus intermedius. (Reproduced from Rasmussen AT: Studies of the VIIIth cranial nerve of man. Laryngoscope 50:667-683, 1940.)

and vestibular nerves is not recognized in modern neurosurgical publications.13

After the vestibular and cochlear nerves fuse within the IAC, the CV cleavage plane usually persists grossly and histologically. The vestibular fibers remain segregated and are cephalad or superior; the cochlear fibers are caudal or inferior. Occasionally, inferior vestibular fibers will run with the cochlear nerve, while the efferent cochlear fibers run with the inferior vestibular nerve (Fig. 3). Near the labyrinth, the CV cleavage plane runs in a superior-inferior direction and, because of rotation, in an anterior-posterior direction in the CPA. In the CPA, the CV cleavage plane appears grossly as a fine septum along the eighth cranial nerve in 75% of the patients.

In the lateral IAC, the facial nerve is positioned in the anterior-superior quadrant, anterior to the superior vestibular nerve, running to a ventral-caudal position as it exits the brain stem. The facial nerve remains ventrally positioned and hidden by the eighth cranial nerve along much of its entire course. In the IAC, the facial nerve is connected to the superior vestibular nerve by the Rasmussen facial-vestibular anastomosing fibers and, in the CPA, the facial nerve lies adjacent to, but distinct from, the eighth nerve. Although it remains hidden from the surgeon’s view by the eighth cranial nerve, the facial nerve can easily be seen by gentle retraction of the superior vestibular nerve in the IAC or the eighth nerve in the CPA. The facial nerve exits the brain stem 3 mm ventral and usually caudal to the eighth nerve root entry zone. In the IAC, the seventh nerve appears whiter than the eighth nerve; in the CPA, it appears more gray.

The nervus intermedius, which may consist of a single nerve or multiple bundles, runs between the seventh and eighth nerves through their entire course. The nervus intermedius enters the brain stem closest to the eighth nerve and usually delineates the CV cleavage plane on the anterior surface of the eighth nerve. The flocculus of the cerebellum covers 5 mm of the eighth cranial nerve at the brain stem.

Operative Approaches for Vestibular Neurectomy

Middle Fossa Approach

From 1963 to 1978, the middle fossa (subtemporal) approach was exclusively used to section the vestibular nerve. Results for vertigo relief were good, but the procedure was formidable, anatomical landmarks were difficult to visualize, and complications such as facial nerve weakness or deafness did occur.12 Patients over 60 years of age were generally not candidates. The procedure was technically difficult and carried a high risk of complications, thus many patients who had significant disability were not enthusiastically offered a middle fossa vestibular neurectomy.

Posterior Fossa Approaches

Retrolabyrinthine Approach. In 1978, the two senior authors developed the retrolabyrinthine approach to the posterior cranial fossa for vestibular neurectomy,10,11 Although retrolabyrinthine vestibular neurectomy (RVN) was previously used as an approach for trigeminal nerve section,4 its application for selective vestibular nerve section had not been described.

A simple mastoidectomy is performed, and the lateral sinus and posterior fossa dura just behind and in front
of the sinus are exposed. The endolymphatic sac is widely exposed, and the bone overlying the posterior semicircular canal is identified. The sigmoid sinus is collapsed with a retractor, and anterior to the sigmoid sinus the dura is incised in a C shape based on the labyrinth (Fig. 4). Intravenous mannitol (1.5 gm/kg to a maximum of 100 gm) is given when the drilling begins, which allows a wider exposure of the CPA during surgery. Using the Nicolet Pathfinder,* auditory responses are monitored from the brain stem, cochlea, and eighth cranial nerve. Facial nerve monitoring is performed with a stimulator monitor.†

Intraoperative monitoring of auditory evoked responses was found to enhance the surgeon’s ability to preserve hearing and allows the surgeon to inform the family immediately after surgery that hearing will probably be unchanged. After the CV cleavage plane is visualized under high-power magnification, a longitudinal incision is made in the plane; the cochlear and vestibular fibers are separated, and the vestibular nerve is transected. Several landmarks are helpful in finding the CV cleavage plane. The vestibular nerve often appears gray while the cochlear nerve appears whiter; the cochlear fibers are more numerous, averaging 31,000, whereas the vestibular fibers average 18,000. A fine blood vessel frequently courses on the surface between the cochlear and vestibular fibers. A mirror can be used to view the anterior surface of the eighth nerve, since the CV cleavage plane is sometimes more visible from this surface. The nervus intermedius, which usually lies in the CV cleavage plane, can also be seen anteriorly. The superior half of the eighth cranial nerve is transected when a CV cleavage plane cannot be readily identified. Most vestibular fibers will be cut and most cochlear fibers will be spared using this technique. The dura is closed with three or four interrupted 4-0 silk sutures and the mastoid cavity is filled with abdominal adipose tissue.

Retrosigmoid/Internal Auditory Canal Approach. In 1985, the retrosigmoid/IAC (RSG/IAC) approach was used in an attempt to perform a more complete vestibular neurectomy near the labyrinth, to improve vertigo relief and hearing preservation, and to decrease the incidence of cerebrospinal fluid (CSF) leak. Because the cleavage plane between the cochlear and vestibular fibers is more completely developed within the IAC, a more complete and selective vestibular neurectomy can be performed by cutting the nerve within the IAC. In this procedure, a posterior fossa craniotomy is performed immediately behind the lateral sinus, and the cerebellum may be gently retracted to give exposure to the seventh and eighth cranial nerves and the IAC. The posterior wall of the IAC is removed to the singular canal, thereby exposing the branches of the eighth cranial nerve. The superior vestibular nerve and the posterior ampullary nerve are sectioned. The inferior vestibular fibers that innervate the saccule are not divided because of their close association with the cochlear.

TABLE 1
Vertigo results following vestibular neurectomy for Ménière's disease*

<table>
<thead>
<tr>
<th>Vertigo Result</th>
<th>RVN</th>
<th>RSG/IAC</th>
<th>RRVN</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of cases</td>
<td>67</td>
<td>15</td>
<td>14</td>
<td>96</td>
</tr>
<tr>
<td>cured</td>
<td>82%</td>
<td>87%</td>
<td>93%</td>
<td>84%</td>
</tr>
<tr>
<td>improved</td>
<td>10%</td>
<td>13%</td>
<td>7%</td>
<td>10%</td>
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<tr>
<td>unchanged</td>
<td>8%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
</tbody>
</table>

* The follow-up period was 2 years or greater. RVN = retrolabyrinthine vestibular neurectomy; RSG/IAC = retrosigmoid/internal auditory canal approach; RRVN = combined RVN and RSG/IAC.
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The saccule has no known vestibular function in man, so sparing these fibers does not result in postoperative vertigo attacks.

This procedure offers several advantages over the RVN technique. No abdominal fat is needed to fill the defect, thus the procedure can be performed on thin patients. Since the exposure does not enter the mastoid, patients who have had chronic mastoiditis or a sclerotic mastoid or patients with an anterior-lying sigmoid sinus can be candidates for the RSG/IAC approach.14,16

Combined Retrolabyrinthine/Retrosigmoid Approach

The combined retrolabyrinthine/reotosigmoid vestibular neurectomy (RRVN) evolved in 1987,15 incorporating the advantages of both the RVN and the RSG/IAC approaches. It allows the surgeon to assess the CV cleavage plane in the posterior fossa and to decide where the neurectomy should be performed. If a good CV cleavage plane exists, the vestibular nerve will be sectioned in the CPA. If no cleavage plane is identified, then the dura is reflected off the temporal bone, the IAC is opened with a diamond burr, and the superior vestibular and posterior ampullary nerves are divided, as in the RSG/IAC approach (Fig. 7). The mastoid air cells are sealed with bone wax, the dura is closed in a watertight fashion, and the surgical defect is filled with abdominal adipose tissue.

Operative Results

Of 115 cases of vestibular neurectomy for Ménière’s disease reviewed, 67 operations were RVN, 15 RSG/IAC, and 33 RRVN. The follow-up period was at least 2 years. No patient developed Ménière’s disease in the opposite ear. The overall cure rate for vertigo was 84%, with an additional 10% significantly improved. The results were similar with each surgical approach. The vertigo cure rate was 82% for patients who underwent RVN, 87% for RSG/IAC, and 93% for RRVN (Table 1). Hearing results were good with each approach. The postoperative pure-tone average has remained within 20 dB of the preoperative level in 71% of cases for the patients who underwent RVN, 67% for RSG/IAC, and 91% for RRVN (76% overall). The discrimination score remained within 20% postoperatively in 70% of cases for the patients who underwent RVN, 47% for RSG/IAC, and 82% for RRVN (69% overall) (Table 2).

Complications encountered with all approaches are listed in Table 3. In cases with RVN, CSF leaks occurred in 7% of the cases because a tight closure of the posterior fossa dura was not possible. The CSF leaks were managed with the placement of a continuous...
The complications encountered in vestibular neurectomy for Ménière’s disease are listed in Table 3. The incidence of headache (9%) has been greatly reduced using RRVN. One patient (3%) had a CSF leak with a wound infection and one had a complete sensorineural hearing loss postoperatively. The wound infection rate was 3%.

**Discussion**

The original RVN has proved to be an excellent procedure with minimal complications. However, a better procedure was contemplated for several reasons: the inability to determine a definite CV cleavage plane in 25% of the cases, 24% of patients having a further sensorineural loss and some having a conductive loss postoperatively, the complications of CSF leaks (7%) or wound infection (3%), and the inability to expose the IAC, if needed, to see a better CV cleavage plane.

The ideal procedure would be one in which an intraoperative decision could be made as to whether the vestibular nerve section should be made in the CPA or within the IAC, depending upon the presence or absence of a distinct CV cleavage plane; the hearing would less likely be affected, and CSF leaks could be avoided by a better dural closure. The RSG/IAC approach introduced in 1985 appeared to offer these advantages. The superior vestibular nerve could routinely be separated from the facial and inferior vestibular nerves in the IAC, but it was difficult to separate the inferior vestibular nerve from the cochlear nerve near the porus acusticus without causing a sensorineural hearing loss. This problem was solved by avulsing the posterior ampullary nerve and leaving the saccular nerve intact. This allowed a complete denervation of the vestibular labyrinth without compromising auditory function. The dura could be closed completely, thus avoiding the problem of CSF leaks.

The only difference between the standard RVN procedure and the RRVN procedure introduced in 1987 is that, in the latter, a limited mastoidectomy is performed skeletonizing the LVS, and the dural incision is made behind, rather than anterior to, the LVS. Once the CSF is released, the cerebellum falls away from the temporal bone and allows good exposure of the CPA without cerebellar retraction. The distance from the dural opening to the eighth cranial nerve is about 1 cm farther than in the RVN exposure. Exposure with the RRVN approach allows the surgeon to remove the posterior wall of the IAC, if needed, to section the vestibular nerve. Because of the approach angle to the CPA, opening the IAC is not possible with the standard RVN approach. The use of stay sutures to elevate and retract the LVS forward allows easier and greater exposure of the CPA without cerebellar retraction. Less bone is removed over the cerebellum in the RRVN procedure than in a RSG/IAC craniotomy. Since most of the mastoid bone is left intact, there is less chance of conductive hearing loss caused by adipose tissue herniating into the middle ear or bone dust fixing the stapes bone. The RRVN appears to offer advantages over both the RVN and the RSG/IAC procedures. Since lumbar drain for 2 to 5 days to control CSF pressure. Lumbar drainage has been used for the past 8 years, and no patient has required a second operation to eliminate a CSF leak. The wound infection rate has been drastically reduced since perioperative antibiotics have been administered. No antibiotics were used in the first 40 RVN cases, and the infection rate was 20%. All infections were superficial and responded rapidly to local treatment and oral antibiotics, but this rate was regarded as unacceptably high. The use of intravenous nafcillin in a three-dose regimen (2 gm preoperatively, 2 gm intraoperatively, and 2 gm 6 hours postoperatively) has reduced the infection rate to 3%. In cases of penicillin sensitivity, clindamycin (600 mg) is used in a similar dosage schedule. No cases of meningitis have been encountered. No facial paralysis or death has occurred. Postoperative unsteadiness was expected (as seen after labyrinthectomy), but it improved with central compensation and was generally well tolerated and accepted.

Complications of RSG/IAC vestibular neurectomy have been infrequent (Table 3); however, severe chronic postoperative headache has been a problem. In 50% of the patients, the headaches have been difficult to control with nonnarcotic analgesics. The headaches appear to decrease in severity over a 2-year period. Four (27%) of the 15 patients still have severe headaches requiring continuous medication after 2 years. The headache is usually unilateral (ipsilateral to surgery), most severe in the temporal region, and frequently retro-orbital. The cause for the headache has remained a mystery, particularly since this approach has been used successfully for fifth nerve section or vascular decompression and is quite similar to the suboccipital approach often used for acoustic neurinoma surgery. The postoperative headaches remain a major concern and have tempered our enthusiasm for the classic RSG/IAC vestibular neurectomy.

The complications after RRVN are listed in Table 3. The incidence of headache (9%) has been greatly reduced using RRVN. One patient (3%) had a CSF leak with a wound infection and one had a complete sensorineural hearing loss postoperatively. The wound infection rate was 3%.
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less bone is removed in the RRVN procedure, the surgical time is reduced. The watertight closure of the dura reduces the chance of a CSF leak, as found in RVN. Thus far, the hearing results have been better than those of either RVN or RSG/IAC approaches. The results in curing vertigo have been excellent (93%). The RRVN approach represents a further evolution of the procedure and is an improvement over both RVN and RSG/IAC vestibular neurectomy.

Acknowledgments

The authors thank Beth Schiffner and Sherry Depue for their technical assistance and Beth Lin and Patricia Terrill for their help and critical review of the manuscript.

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Manuscript received May 9, 1989. Accepted in final form October 3, 1989.

This paper was presented at the Annual Meeting of the American Association of Neurological Surgeons, Washington, D.C., on April 3, 1989.

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