Four-handed Resection of Vestibular Schwannoma Using Subcapsular Technique: Operative Technique and Single Institutional Experience of 734 Cases

Celine D Hounjet, BSc, MD[1]; Ana Sofia Alvarez, MD[1]; Patrick R Toyota, BSc, MD[1]; Hannah Schoenroth, MSc[1]; Serge Makarenko, MD, FRCSC[1]; Brian Westerberg, MD, MHSc, FRCSC[1]; Ryojo Akagami, MD, MHSc, FRCSC[1]; [1]University of British Columbia

Introduction

Four-handed surgical technique utilizing a diploscope has gained traction in recent years for improved educational opportunity, reduced surgical time, and reduced morbidity and mortality. Additionally, subperineural or subcapsular technique for VS resection has been more recently recognized as a safe and effective approach to this pathology, however, it remains somewhat controversial due to the "subtotal" nature of leaving the tumoral capsule in situ. We aim to summarize the experience of a single surgical team composed of a fellow-ship trained neurosurgeon and otolaryngologist with resident assistance who have completed a total of 734 cases utilizing both a 4 handed surgical technique and subcapsular dissection with neuromonitoring, primarily through a retrosigmoid craniotomy to resect VS at a tertiary care centre.

Methods

A chart review was completed on 734 patients who underwent resection of a vestibular schwannoma between July 1, 2001 and Oct 1, 2024.

For all cases, standardized protocols are applied; most cases were approached through a retrosigmoid craniotomy. Positioning for this approach is described.

OR Set Up

Figure 1 includes OR set up for both R and L sided cases

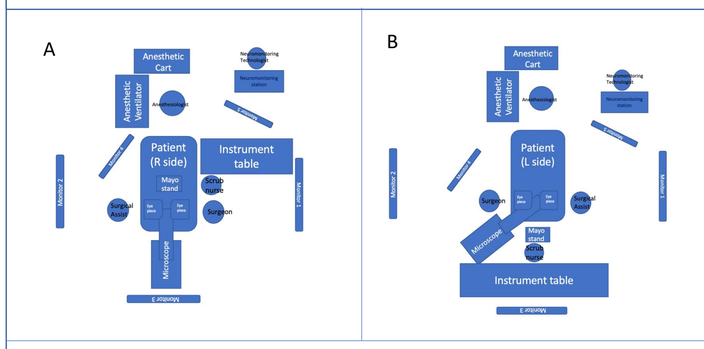

Figure 1.
A. OR set up for R-sided lesion. The microscope is positioned at the head of the bed and the scrub nurse stands to the R hand of the primary surgeon. The mayo stand is placed over the patient within reach of the surgeon and scrub nurse. **B.** OR set up for L-sided lesion. The scrub nurse remains at the head of the patient/R hand of the surgeon and again, the mayo stand is placed within reach. Monitor 1 displays neuromonitoring. Monitor 2, 4, and 5 display the operative field for observers, the scrub nurse, and the neuromonitoring team. Monitor 3 displays the vital signs. The surgical assist is primarily a resident or fellow.

Neuromonitoring

Neuromonitoring will include CN VII MEPs (cortical stimulation[2]), CN V and VII free running EMG, BAERs (if hearing is present), and 4 limb MEPs and SSEPs[3]. Additionally, a stimulator probe is used intraoperatively to detect nerve fibers and to perform supramaximal stimulation following resection of the tumour[4]. Additional monitoring of lower cranial nerves will be utilized as needed depending on the size of the lesion.

Positioning

All patients are positioned supine with a shoulder wedge. Extensive padding of bony prominences is performed and patients are secured to the operating table with cross hip heavy cotton tape. The ipsilateral shoulder is taped inferiorly. The head is secured in a Sugita headframe with chin tuck, rotation to the contralateral side, and vertex down. To preserve contralateral venous outflow, a jugular bulb is placed on the contralateral side and measurements of ICP are optimized during positioning[1] (Figure 2).

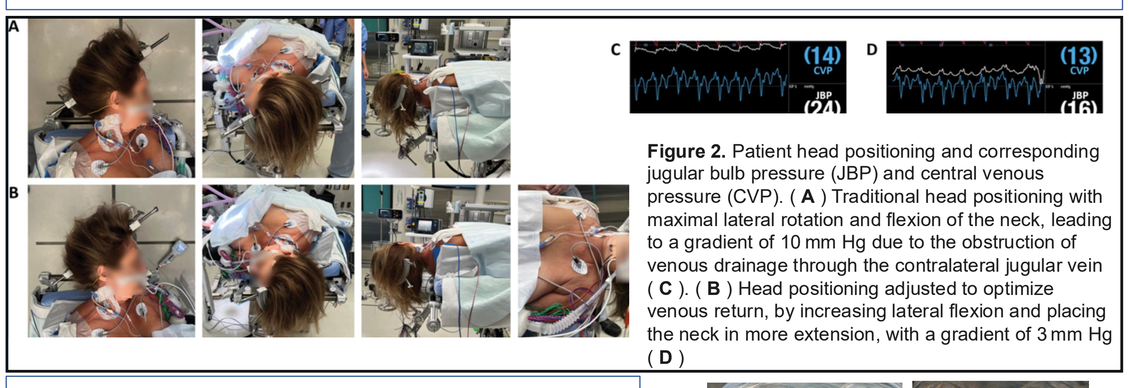

Figure 2. Patient head positioning and corresponding jugular bulb pressure (JBP) and central venous pressure (CVP). (**A**) Traditional head positioning with maximal lateral rotation and flexion of the neck, leading to a gradient of 10 mm Hg due to the obstruction of venous drainage through the contralateral jugular vein (**C**). (**B**) Head positioning adjusted to optimize venous return, by increasing lateral flexion and placing the neck in more extension, with a gradient of 3 mm Hg (**D**)

Craniotomy

A standard C-shaped retrosigmoid incision is planned. The retroauricular scalp is opened in two layers. Auricularis posterior and sternomastoid are transected and reflected anteriorly with the scalp as a myocutaneous flap (Figure 3, A). The remaining muscle layers are then opened as a second muscle flap which is reflected inferiorly (Figure 3, B). The craniotomy is fashioned with an electric high-speed drill in the usual fashion. At the end of the case the scalp is closed in a layer wise fashion (Figure 3, C).

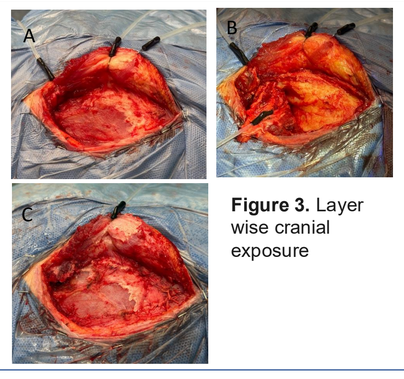

Figure 3. Layer wise cranial exposure

Surgical approach

Subcapsular or perineural tumour dissection is performed. All dissection is performed sharply with microscissors. Dissection occurs in the direction of the nerve, toward the IAC with minimal traction. As planes are identified between the tumour and cerebellum, brainstem, and nerves, gel foam is placed and can be left in situ at the end of the case. This avoids the trauma of removing coagulated cottonoids from neural tissue at the end of the case. Keratoma dissectors are utilized for the intracanalicular portion of the resection after the IAC is drilled.

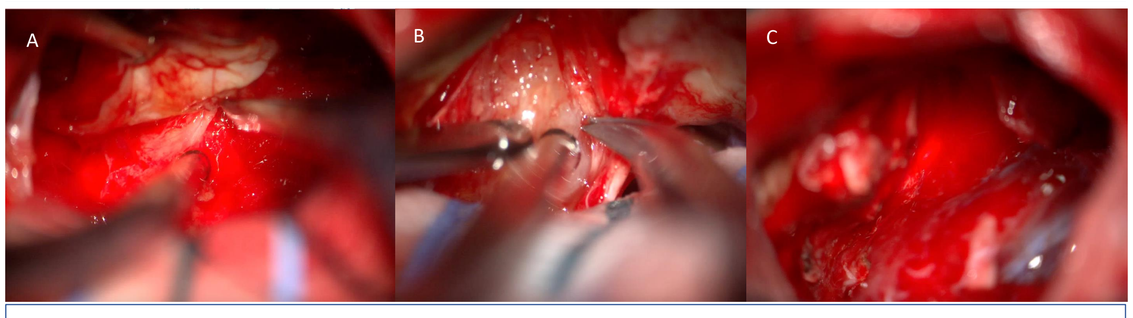

Figure 4. A. Demonstrates extracanalicular subperineural sharp dissection with microscissors. **B.** Microsurgical dissection of intracanalicular tumour off of CN VII after the IAC has been drilled. **C.** Residual perineural capsule left in situ after tumour resection is complete.

Perioperative Care

Minocycline is utilized as a perioperative antibiotic for its potential neuroprotective properties. Patients receive 200mg PO prior to surgery and are continued on 100mg PO BID post-operatively for 10 days[5]. Post-operative MRIs are obtained at 4-6 wk follow-up.

Results

Follow up was > 10 years for 434 patients. Gross total or near total resection was achieved in 635 cases (86.5%).

Demographics	
Gender, n (%)	
Female	446 (63.4)
Male	258 (36.6)
Age (years)	
Mean	49.5
Median	50
Range	13-81

Table 1. Patient demographics

Tumour Characteristics	
Side, n (%)	
Left	339 (48.4)
Right	361 (51.6)
Size	
Mean Volume	7.8 cm^3
Volume Range	0.3 – 37.7 cm^3
Mean avg. Diameter	2.5 cm

Table 2. Tumour characteristics. Excludes recurrences and residual tumour reoperations. Size calculated using 4/3*pi*r^2 where r=D/2 and D=avg of 3 dimensional measurements in AP, SI and ML orientations on MRI IAC CISS sequences

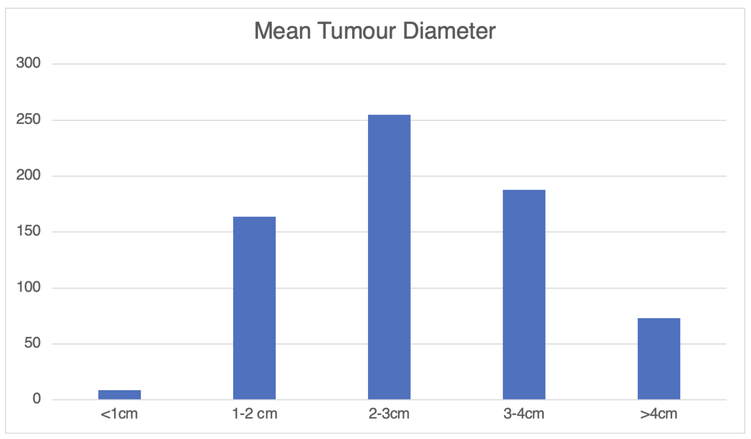

Figure 5. Mean tumour diameter = avg of 3 dimensional measurements in AP, SI and ML orientations on MRI IAC CISS sequences

Surgical Outcomes, n (%)	
Surgical Approach	
Retrosigmoid	672 (90%)
Translabyrinthine	59 (7.9%)
Partial labyrinthectomy petrous apicectomy	15 (2%)
Extent of Resection	
Gross or Near Total	635 (86.5%)
Subtotal	106
Hearing Preservation	
Attempted	304
Successful	115 (38%)
Facial Nerve Preservation	
HB-1	437 (64.9%)
HB-2	168 (25%)
HB-3	49 (7.3%)
HB-4	8 (1.2%)
HB-5	8 (1.2%)
HB-6	1 (0.15%)
Total	673
HB-1 + HB-2	605 (89.9%)
Complications	
CSF leak/hydrocephalus	15 (2.2%)
Other CN deficit	2 (0.3%)
Meningitis	1 (0.15%)
Hospital acquired infection	5 (0.74%)
Hemorrhage/Post Op Hematoma	5 (0.74%)
Air embolus	2 (0.3%)
Other major complication	7 (1%)
Mortality	2 (0.3%)
Recurrence	
Requiring repeat surgery	25 (3.7%)

Table 3. Surgical approach and outcomes. Facial nerve outcomes were excluded for those that had pre-existing facial weakness that did not worsen post-operatively. Hearing preservation was attempted in all patients with a measurable BAER waveform, even if hearing was diminished at baseline. Recurrence/reoperation rates are for patient followed up to 26 years. Major complication is defined as complication that alters standard post-operative course through medication administration and/or operative or procedural intervention. These included corneal abrasion, spontaneous pneumothorax, MI, ARDs, and hyponatremia.

Discussion and Conclusion

Herein we describe a comprehensive explanation of our approach to vestibular schwannoma resection at a single institution, which is safe and effective. Through employing the above techniques, we have achieved resection rates and post-operative outcomes superior to those described in the literature. We recommend the use of four-handed surgical technique for educational and technical advantages. Our outcomes condone the use of sub-perineural dissection with low rates of recurrence. ICP monitoring with a jugular bulb catheter is utilized to optimize venous outflow to improve venous pressure and theoretically improve intraoperative venous bleeding, in addition to reducing ICP. Minocycline reduces the rates of early facial nerve palsy, however, it may not prevent delayed facial nerve palsy although further study is required. In conclusion, the combination of the above techniques can be utilized to advantage with optimal outcomes.

Contact

Celine Hounjet
University of British Columbia
chounjet@mail.ubc.ca
1-604-704-8994

References

1. Brakel B, Wang J, Kam J, Huttunen H, Dhaliwal B, McEwen J, Westerberg B, Makarenko S, Akagami R. Use of Jugular Venous Pressure to Optimize Outcomes of Vestibular Schwannoma Resection: A Review of the Literature and Proof of Concept. J Neurol Surg B Skull Base. 2024 May 31;86(4):403-408. doi: 10.1055/a-2324-9978. PMID: 40620634; PMCID: PMC12227251.
2. Dong CC, Macdonald DB, Akagami R, Westerberg B, Alkhani A, Kanaan I, Hassounah M. Intraoperative facial motor evoked potential monitoring with transcranial electrical stimulation during skull base surgery. Clin Neurophysiol. 2005 Mar;116(3):588-96. doi: 10.1016/j.clinph.2004.09.013. PMID: 15721072.
3. MacDonald DB, Dong CC, Uribe A. Intraoperative evoked potential techniques. Handb Clin Neurol. 2022;186:39-65. doi: 10.1016/B978-0-12-819826-1.00012-0. PMID: 35772897.
4. Schmitt WR, Daube JR, Carlson ML, Mandrekar JN, Beatty CW, Neff BA, Driscoll CL, Link MJ. Use of supramaximal stimulation to predict facial nerve outcomes following vestibular schwannoma microsurgery: results from a decade of experience. J Neurosurg. 2013 Jan;118(1):206-12. doi: 10.3171/2012.10.JNS12915. Epub 2012 Nov 9. PMID: 23140153.
5. Janicki R, Warren D, Westerberg B, Akagami R. Minocycline as a neuroprotective perioperative antibiotic in skull base tumours and prevention of delayed facial nerve palsies (in acoustic neuromas), a before and after study. 2007. Skull base. DOI: 10.1055/s-2007-981791