



Predictive Factors of Post-Operative Hearing Loss Following Vestibular Schwannoma Surgery



Ahad Sabab*

Adelaide Medical School, University of Adelaide, Australia

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*Corresponding author: Ahad Sabab, Medical School, University of Adelaide, North terrace Adelaide, SA 5005, Australia, Tel: 0413508789; Email: ahad.sabab@student.adelaide.edu.au

Abstract

Vestibular Schwannoma (VS), are benign tumours of Schwann cell origin, that are located within close proximity to cranial nerve VIII (vestibulocochlear nerve). The current management of VS is by microsurgery or radiosurgery and they can lead to post-operative hearing loss (POHL), a very common complication. There are many factors that neurosurgeons can assess, which can indicate the likelihood of developing POHL. Pre-operatively, tumour size, PTA range, MRI findings, pre-operative tinnitus, hearing loss duration >1-year, abnormal auditory brainstem response and unhealthy internal auditory canal fundus are all associated with increased likelihood of POHL. Post-operatively, only speech discrimination score (SDS) and PTA is associated with POHL. Surgical approach also dictates the probability of hearing loss and in general, microsurgery, especially middle fossa approach, has lower incidence of POHL.

Keywords: Vestibular schwannoma; Predictive factors; Post-operative hearing loss; Microsurgery; Radiosurgery; Middle fossa approach; Retrosigmoid approach; Translabyrinthine approach; PTA

Introduction

Vestibular Schwannoma (VS), also known as Acoustic Neuroma, Acoustic Neurinoma and Acoustic Schwannoma, are benign tumours that are located within close proximity to cranial nerve VIII (vestibulocochlear nerve). These tumours originate from Schwann cells, which are cells that form a protective layer around nerves. VS has an annual incidence rate of 1 per 100,000 people per year and 8% of brain tumours diagnosed in adults are VS. Overall, this makes VS a relatively common brain tumour and one that every Neurosurgeon will encounter at some point in their practice.

There are a myriad of clinical symptoms associated with VS, with the most common being, unilateral hearing, unilateral tinnitus, vertigo, ataxia and headaches [1]. The diagnosis of VS is through neuroimaging via MRI scans. Due to the current ease of access to MRI scans, it is used extensively in medical practices and as a result, the incidence of VS has been increasing [2].

Currently there three main modes of treatment for VS and they are, microsurgery (operative), radiosurgery and observation. The 3 main approaches used in microsurgery for VS resection are, middle fossa approach, translabyrinthine approach and retrosigmoid approach. Whereas, in radiosurgery, Stereotactic radiosurgery and Gamma-knife radiosurgery are the main approaches employed.

VS and its close proximity to cranial nerve VIII, makes VS treatment very challenging. As a result it is common to see

complications such as, damage to, facial nerve, vestibulocochlear nerve and blood vessels intra-operatively [3]. There are also many post-operative complications that can arise as a consequence of VS surgery, such as headaches, hearing loss, tinnitus, just to name a few [4]. The aim of this review is to collate some of the predictive factors for post-operative hearing loss (POHL), following VS surgery.

Pre-Operative Factors

There are multiple pre-operative factors that have been associated with POHL, after VS surgery. Tumour size is one of the strongest predictors of POHL, with studies indicating that the incidence of hearing loss being, low in small tumours (<1.5cm), but, high in large tumours (>3cm) [5-9]. Studies conducted by Rohit et al. [5] and Ferber et al. [10], found statistically significant correlation ($p < 0.05$) between pre-operative Pure Tone Audiometry (PTA) and POHL. Rohit et al. [5] found, the group with preserved hearing had a pre-operative PTA of 23.44dB and the hearing loss group had pre-operative PTA of 29.17 [5].

Findings on neuroimaging has also been studied to determine their ability to predict POHL. Cochlear enhancement on T1-weighted spin-echo image has shown to be well correlated with total hearing impairment post-operatively [11]. In a study by Dubrulle et al. [11], 13 participants had cochlear enhancement pre-operatively, and following VS surgery, all of the participants had total hearing impairment.

The correlation between age and POHL is a highly debated topic, with strong evidence, both for and against the prognostic capability of patient's age [5,8,12]. For example, Rohit et al. [5] found, no statistically significant correlation between age and POHL, while, Abboud et al. [8] did find significant correlation [5,8]. Such variation in results are primarily due to the age cut-offs used by each study.

There are many other pre-operative factors that have been correlated with POHL. This include pre-operative tinnitus, hearing loss duration >1-year, abnormal auditory brainstem response and unhealthy internal auditory canal fundus [10,13,14].

Choice of Surgery

The choice of surgery has a great impact on the likelihood of patients experiencing POHL. Microsurgery and radiosurgery are the 2 main modes of intervention for patients with VS. They both have similar level of disease control, with no statistically significant ($p > 0.05$) difference between them [15,16]. However, POHL is reduced in microsurgery compared to radiosurgery and a study by Karpinos et al. [15] found hearing loss to be 42.5% in microsurgery and 85.6% in radiosurgery [15]. More detailed studies comparing microsurgery and radiosurgery found that, incidence of POHL depends not only on surgical mode, but also, the tumour size [17-19]. VS with size <1.5cm are classified as small and microsurgical resection of this tumours are associated with lower incidence of hearing loss [17,18]. On the other hand, VS with size >3cm (classified as large) and volume >10cm³, with tolerable/asymptomatic mass effect, microsurgery and radiosurgery, both had the same incidence of POHL [19].

As discussed above, there are 3 different microsurgical approaches for VS resection and they are, middle fossa, translabyrinthine and retrosigmoid approach. Middle fossa approach is the safest approach and in the case of small tumours, there is only minimal hearing loss observed [16]. Retrosigmoid approach is considered the 2nd best approach for preventing POHL. Ansari et al. [16] found that, when the VS size was <1.5cm (small size), middle fossa approach was always superior to retrosigmoid approach in minimising POHL, but, when VS size was >1.5cm (medium – large size), both middle fossa and retrosigmoid approach had the same incidence of hearing loss [16]. Unlike retrosigmoid approach, where hearing is sometimes preserved, translabyrinthine approach is associated with complete hearing loss.

Radiosurgery is generally associated with higher incidence of POHL [15,17-19]. In radiosurgery, a low radiation dose has been correlated with lower incidence of POHL [20]. When the cochlea is exposed to <5.3Gy radiation dose, the incidence of POHL is low, but significant increase in incidence is observed when the radiation dose is >5.3Gy [21]. However, a dose of 5.3Gy is too low to control and reduce tumour growth. In a study by Franzin et al. [12], radiation dose of approximately 13Gy was suggested for treating VS, since it maintained a good balance between minimising post-operative hearing loss and disease control [12]. This is further supported by Kim et al. [22] who showed that a radiation dose >13Gy was associated with a significantly higher probability of hearing loss.

Post-Operative Factors

Unlike pre-operative factors, there are only two post-operative factors that are associated with predicting POHL. Speech discrimination test is method of analysing auditory function. Based on the performance of the patient, they are assigned a speech discrimination score (SDS). In a study by Woodson et al. [18], 90% of the patients who had a SDS >70%, immediately after operation, remained in this category in a 2 year follow up and 88% remained in this category in a 5 year follow-up. While this does not suggest that the patients didn't have any POHL, it does indicate that, post-operatively, if the SDS is high, the patient will most likely remain in this category without (further) deterioration in hearing, in the long term.

Deterioration in PTA is another post-operative indicator for POHL [23]. In a study, patients who had ≥5dB deterioration in their PTA within 6 months post-surgery, had ≥15dB deterioration in a 5 year follow-up. Similarly, patients who had <5dB deterioration in their PTA within 6 months post-surgery, had <15dB deterioration in a 5 year follow-up [23].

Conclusion

While VS not associated with mortality, due to the post-operative complications, it can be a burden to the patient, both physically and emotionally. For this reason, it is important to treat the VS, while minimizing the risk of complications that can hinder the quality of life. The indicators of POHL above can be used to assess the likelihood of developing hearing loss and use this knowledge to not only communicate the risks and benefits to the patient, but also, to determine the best treatment option for the patient.

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