

Cost analysis of vestibular schwannoma screening with contrast-enhanced magnetic resonance imaging in patients with asymmetrical hearing loss

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Abstract

Background: Vestibular schwannomas are a rare cause of asymmetrical hearing loss, and routine screening with magnetic resonance imaging can be costly. This paper reports results on vestibular schwannoma screening at our institution and compares the cost of screening to a utility of hearing benefit.

Method: All screening examinations with magnetic resonance imaging performed for asymmetrical hearing loss between 2006 and 2011 were retrospectively reviewed. The cost per new vestibular schwannoma diagnosis was calculated. The cost per patient for those who benefitted from intervention was estimated based on rates of hearing preservation reported in the literature.

Results: Forty-five (4.3 per cent) of 1050 screening examinations with magnetic resonance imaging performed for asymmetrical hearing loss were positive for vestibular schwannoma, and the cost per new diagnosis was \$11 436. The estimated screening cost per patient for those who benefitted from surgery or radiation was \$147 030, while US federal compensation for unilateral hearing loss was \$44 888.

Conclusion: Although we achieved a lower screening cost per new diagnosis than reported in the current literature, there remains disparity between the screening cost per benefitted patient and the ‘benefit’ of hearing.

Key words: Vestibular Schwannoma; Screening; Magnetic Resonance Imaging; Hearing Loss; Cost Analysis

Introduction

Asymmetrical hearing loss is frequently encountered in patients who present with hearing complaints. Among the broad differential diagnosis, which includes many treatable and non-treatable causes, vestibular schwannoma is a rare cause, with studies reporting 2.1–3.7 per cent prevalence among patients who present with asymmetrical hearing loss.^{1–3} However, correct diagnosis of vestibular schwannoma is often clinically significant because of the potential for a definitive treatment. Radiation and surgical resection are the current mainstream treatments, and these have been shown to positively improve patients’ quality of life.^{4–7}

Different strategies have been proposed to reduce the cost of screening for vestibular schwannoma, such as the incorporation of auditory brainstem response^{8–10} or use of non-contrast magnetic resonance imaging (MRI) sequences.^{11–14} However, contrast-enhanced MRI is considered by many as the ‘gold standard’ in diagnosing vestibular schwannoma because of its high sensitivity and specificity.^{15,16} At our institution, a dedicated internal auditory canal contrast-enhanced

MRI protocol is used for vestibular schwannoma screening.

This study aimed to: (1) report the results of vestibular schwannoma screening with contrast-enhanced MRI of the internal auditory canal at our Veterans Affairs institution; (2) investigate the imaging cost per diagnosed and per treated vestibular schwannoma, respectively; and (3) determine whether contrast-enhanced MRI screening is cost-effective in patients with asymmetrical hearing loss by comparing the cost of screening to a novel utility of hearing benefit in terms of US dollars. This represents a unique cost–benefit analysis not currently present in the literature.

Materials and methods

This retrospective review was initiated in 2009 and involved examination of all patients who underwent MRI of the internal auditory canal at the Veterans Affairs Greater Los Angeles Healthcare System between 2006 and 2011. All procedures contributing to this work complied with the ethical standards of the relevant national and institutional guidelines.

Our internal auditory canal MRI protocol includes sagittal T1-weighted, axial T2-weighted, fluid-attenuated inversion recovery ('FLAIR') and post-contrast axial T1-weighted images of the whole brain, as well as thin-section, pre-contrast axial T1-weighted, and post-contrast axial and coronal T1-weighted images of the internal auditory canal.

To obtain the clinical history, we queried the electronic medical record system of the Veterans Affairs institute to identify all internal auditory canal MRI scans performed from 2006 to 2011. The records (in free-text format) were processed using the General Architecture for Text Engineering ('GATE') natural language processing system.¹⁷ Records with terms of interest were identified. These terms were variants of the phrase 'asymmetrical hearing loss'. Patients with a known history of vestibular schwannoma were excluded from this study. A chart review was performed on the patients with newly diagnosed vestibular schwannoma, and age, indication, symptom duration, tumour size and treatment decision were recorded.

The total cost of the screening MRI examinations was determined using the US Medicare reimbursement rate for internal auditory canal MRI with and without contrast (Current Procedural Terminology code number 70553). The total cost was divided by the number of diagnosed patients and the number of patients treated with surgery or radiation, to determine the cost per diagnosis and per treated patient. In order to estimate the cost per 'benefitted' patient, we factored in a percentage of patients with hearing preservation related to a definitive treatment based on the literature.

Results

A total of 1631 screening internal auditory canal MRI examinations were performed between 2006 and 2011 (excluding patients with previous history of vestibular schwannoma). Indication information was available for data mining in 1388 of the 1631 radiology reports; 243 reports returned no history or indication. Of the 1388 reports with indications, 1050 (75.6 per cent) contained variants of 'asymmetrical hearing loss'. Other common reasons for ordering the screening examination included vertigo and dizziness.

Of all 1631 examinations, 47 patients were newly diagnosed with vestibular schwannoma, yielding a 2.9 per cent overall positive rate. Of these 47 patients, 45 presented with asymmetrical hearing loss, and 2 presented with vertigo. None of the 243 studies without indication yielded a positive study. The positive rate in the asymmetrical hearing loss group specifically was 4.3 per cent (45 out of 1050). Of note, one patient who presented with asymmetrical hearing loss was diagnosed with bilateral vestibular schwannomas. **Table I** summarises the profile of the 45 patients with asymmetrical hearing loss who were newly diagnosed with vestibular schwannoma.

Of these 45 patients, only 7 underwent a definitive treatment; 2 underwent surgical resection and 5

TABLE I
PATIENT PROFILE*

Parameter	Median	Range
Age at diagnosis (years)	66	30–88
Symptom duration (years)	6	0.5–30
Tumour size (long axis; mm)	8	2–27

*For the 45 patients with asymmetrical hearing loss newly diagnosed with vestibular schwannoma (46 tumours).

underwent radiation therapy. The indications for these patients included worsening hearing loss and notable tumour growth. The other 38 patients who neither received resection nor radiation underwent conservative management and underwent follow-up MRI studies at 6-monthly intervals for the first year and every 1–2 years thereafter.¹⁸

The Medicare global non-facility limiting charge for internal auditory canal MRI is \$490.10.¹⁹ The total cost of screening MRI was \$799 353 ($\490.1×1631), and the cost per newly diagnosed vestibular schwannoma was \$17 008 ($\$799 353 / 47$). In patients with asymmetrical hearing loss as the indication, the total cost of screening MRI was \$514 605 ($\490.1×1050), and the cost per newly diagnosed vestibular schwannoma was \$11 436 ($\$514 605 / 45$).

The US Department of Labor federal employee compensation for complete hearing loss in 1 ear is 52 weeks of compensation, or \$44 888 for the year 2013, according to the national average wage index on the Social Security Administration website.²⁰

The previously reported rates of serviceable hearing preservation are 44–74 per cent with radiosurgery and 35–47 per cent with resection.^{21–24} If we used a mid-point of these numbers (roughly 50 per cent) to estimate the per cent of benefit with intervention, the estimated screening cost per asymmetrical hearing loss patient who benefitted from a treated schwannoma in our cohort would be \$147 030 ($514 605 / (7 \times 0.50)$).

Discussion

The positive rate for all indications in our study (2.9 per cent) was similar to, and for asymmetrical hearing loss specifically (4.3 per cent) was higher than, previously reported figures (2.1–3.7 per cent).^{1–3} The screening of our veteran patient population resulted in a higher median age at diagnosis (66 years) than previous studies (51–55 years).^{1,25,26} Meanwhile, the median size of tumours detected (8 mm) was slightly smaller than that reported by others (10 mm).^{2,26}

In this cohort, only 16 per cent (7 of 45) of the newly diagnosed vestibular schwannoma patients who presented with asymmetrical hearing loss received definitive treatment over the 4–9 year follow-up period. This number appears to be lower than previous studies.^{18,27} Barring potential differences in sampling and patient preferences, it is noteworthy that many veterans at

our Veterans Affairs institution have a history of noise exposure, and the routine auditory screening offered to these patients may have contributed to an earlier detection of vestibular schwannoma, and therefore potentially less need for urgent intervention. Additionally, a smaller tumour size has been associated with better hearing preservation and less severe complications following radiosurgery or resection.^{28,29}

Despite offering routine auditory screening in a population closely associated with noise exposure (which may detect a higher rate of asymmetrical hearing loss than screening in an average population, and which potentially decreases the yield of screening MRI), we were able to maintain our positive rates, which were similar to or better than the rates reported in the literature. Although the rates reported in this study may have been slightly falsely elevated because of the number of studies without indications, the authors attribute the overall success to the adequate clinical pre-screening of the referring physicians.

Wilson *et al.* reported an average cost of \$61 650 per newly diagnosed vestibular schwannoma patient when MRI was incorporated for screening patients with asymmetrical hearing loss.³ The cost figure we generated (\$11 436) is significantly lower, which is mostly because of the lower cost of MRI at the Veterans Affairs institution. As the MRI cost continues to decrease, the cost-effectiveness of MRI in vestibular schwannoma screening will likely increase.

The screening cost per patient for those who suffered from hearing loss due to vestibular schwannoma and who benefitted from a definitive treatment such as radiosurgery or resection remains considerably higher for two main reasons. Firstly, not all patients with vestibular schwannoma are candidates for definitive treatment, and secondly, not all treated patients benefit from the intervention.

- **Magnetic resonance imaging (MRI) remains the ‘gold standard’ in screening for vestibular schwannomas; however, it is costly**
- **This paper reports a lower cost per vestibular schwannoma diagnosis with MRI screening at our institution than previously reported**
- **Nevertheless, the estimated cost per benefitted patient was higher than the benefit of hearing as defined by US federal compensation**
- **This disparity may be narrowed if MRI cost is reduced and patient outcome is improved**

The estimated screening cost per vestibular schwannoma patient who benefitted from radiation or surgery (\$147 030) remains significantly higher than the US Department of Labor federal employee compensation for complete hearing loss in one ear (\$44 888). Note that this cost includes only the diagnostic portion. When the costs of treatment and post-operative

care are also included, this increases the discrepancy further. Although definitive treatment of vestibular schwannoma theoretically halts tumour growth and progressive hearing loss, most patients do not experience frank hearing improvement with the intervention. This may be related to the indolent course of some vestibular schwannomas and the multifactorial nature of hearing loss. Potential complications from radiation or surgery also remain an intangible cost to the patients and the healthcare system.³⁰

Both the current literature and our analysis show that routine screening for vestibular schwannoma with MRI may be too costly as far as hearing is concerned. Nevertheless, vestibular schwannoma does potentially cause other debilitating conditions, such as vertigo, and can even cause death.⁴ Further investigation into the combined cost of diagnosis and management, and patient outcome, as well as continued refinement of the screening algorithm and of interventions, are needed to shape an effective clinical approach for vestibular schwannomas.

Conclusion

This is the first study to compare the screening cost of MRI for vestibular schwannoma to a utility function that quantifies the expected benefit. This utility function is based on the US Department of Labor federal employee compensation for complete loss of hearing in one ear. Based on this analysis, the current Veterans Affairs cost of screening per diagnosis of vestibular schwannoma in patients with hearing loss, when accompanied by adequate clinical pre-screening, is noticeably lower than previously reported. However, the overall cost–benefit of screening remains largely affected by subsequent disease management and patient outcome. In this particular cohort, there was a significant disparity between the estimated cost of screening per benefitted patient and the ‘benefit’ of hearing. This disparity will likely narrow if the MRI cost is decreased and patient outcome is improved. Further investigations addressing other debilitating outcomes caused by vestibular schwannoma will likely reveal additional benefits of screening and may reduce the disparity. This analysis also allows physicians and patients to substitute in other utility or benefit measures for hearing, if they deem the figures of the US Department of Labor too low.

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