Radiographic findings in young adults with asymmetric sensorineural hearing loss☆

Hiba Z. Khan[a], Catherine Y. Park[a], Michelle A. Lim[a], Amado J. Beltran[a], Douglas Farquhar[b], Myron Yencha[c], Gregory G. Capra[d],*

[a] Rosalind Franklin University of Medicine and Science, North Chicago, IL, United States of America
[b] Department of Otolaryngology, University of North Carolina-Chapel Hill, Chapel Hill, NC, United States of America
[c] Department of Otolaryngology, Lovell Federal Health Care Center, North Chicago, IL, United States of America
[d] Department of Otolaryngology, Naval Medical Center Portsmouth, Portsmouth, VA, United States of America

A B S T R A C T

Purpose: To evaluate radiographic findings in US Navy recruits found to have asymmetric sensorineural hearing loss (ASNHL) during routine medical screening.
Materials and methods: Retrospective analysis of US Navy recruits receiving screening audiometry and medical suitability evaluation from January 2011 to October 2016. Single-institution, institutional review board-approved study of US Navy recruits screened for hearing loss over a six-year period. All recruits with ASNHL were evaluated by an otolaryngologist and received diagnostic radiographic evaluation. Audiometric and imaging results were retrospectively reviewed for this population and compared to common screening criteria.
Results: ASNHL was identified in 674 of 228,504 total recruits screened. This population was 91% male and between 17 and 29 years old (mean age 21.1). Six-hundred fifty-three (97%) met criteria for further ASNHL evaluation. Subjective hearing loss was reported in only 6% of patients. Six-hundred sixty-one (99%) received magnetic resonance imaging of the internal auditory canals. Intracranial pathology was identified in 43 (6.3%) patients and 2 (0.3%) had a causative intracranial lesion corresponding to ASNHL. No patients were found to have a vestibular schwannoma.
Conclusions: In a population of healthy young adults with audiometric proven ASNHL, 0.3% had radiographic proven intracranial pathology explaining the hearing loss. Intracranial masses may be less likely to cause ASNHL in this population; further research is needed to determine appropriate MRI screening methods for young adults with ASNHL.

1. Introduction

With no prevalent etiology, asymmetric sensorineural hearing loss (ASNHL) may be caused by a variety of factors. This includes prolonged or sudden noise exposures, as well as causative lesions within the brain and the internal auditory canal, cerebellopontine angle or temporal bone [1]. Therefore, pursuing further imaging and workup of ASNHL is a decision based on risk factors and medically imperative indicators of ASNHL [2].

The principal purpose of imaging in ASNHL is to identify possible intracranial lesions. The historical analysis of these tumors has advanced from relying on medical history and physical examination to imaging technology. As assessment tools have progressed from computerized axial tomography (CT) scans, to auditory brainstem response, and finally to magnetic resonance imaging (MRI) with gadolinium contrast, identifying intracranial lesions has become increasingly

sensitive [3].

However, of the audiograms that identify ASNHL, few are classified as vestibular schwannomas on MRI in the general population [4–6]. Further, MRI is an expensive diagnostic tool with often limited accessibility [3]. Therefore, in addition to predisposing risk factors, the audiogram is a useful screening method for evaluating the need for MRI. However, with no standardized definition of an ASNHL threshold that necessitates MRI, screening has become an inefficient and expensive utilization of the health-care system [2,3].

Historically, conducting further imaging and workup of ASNHL has been practitioner dependent. While large hearing loss margins on audiogram may be easily referred for imaging, borderline cases with reliable explanations (occupational noise exposures, childhood otologic illness) for ASNHL are less straightforward. Thus, the criteria used to refer patients for MRI are dependent on a clinician's own definition of ASNHL thresholds, combined with patient lifestyle and risk factors [2].

```
┌─────────────────────────┐
│  228,504 recruits screened │
│      for hearing loss      │
└─────────────────────────┘
            │
┌─────────────────────────┐
│  701 met ASNHL criteria  │
│  requiring Otolaryngology │
│        evaluation         │
└─────────────────────────┘
            │                    ┌─────────────────────────┐
            ├────────────────────│  27 did not meet criteria for │
            │                    │          inclusion          │
            │                    └─────────────────────────┘
┌─────────────────────────┐
│   674 met criteria for   │
│  inclusion into the study │
└─────────────────────────┘
            │
┌─────────────────────────┐
│    661 (99%) had an MRI   │
└─────────────────────────┘
```
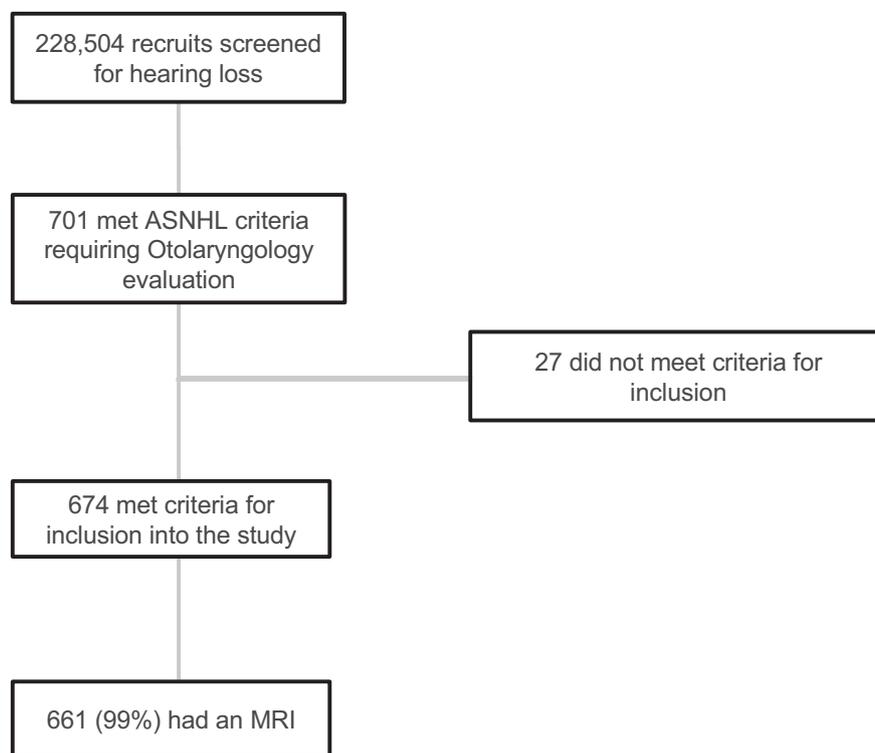
Fig. 1. Flow chart of patient recruitment.

As such, the role of clinical context is a significant factor in pursuing imaging referrals. Zapala et al. analyzed the influence of age, sex and noise exposure history on pure-tone hearing asymmetries [2]. This analysis is a significant indicator of the overall impact of age, sex and noise exposure on ASNHL and confirms the need for a well-rounded clinical history before pursuing further imaging workup.

Nine definitions of ASNHL have been evaluated for vestibular schwannoma (VS) in past literature. Saliba et al. [7] applied these nine definitions to a cohort and found that an asymmetry of greater than or equal to 15 dB at 3000 Hz was associated with the greatest likelihood ratio for positive VS in MRI when compared to the other eight definitions. Tolisano et al. [8] recently found 2000 Hz asymmetries to be more specific to the military population with prior military related noise exposure. These conclusions are significant for further defining ASNHL. However, it is also imperative to consider the significance of clinical context as outlined by Zapala et al. [2]. Further, the literature focuses on older middle-aged populations, without an in-depth analysis of ASNHL in young adult populations [2,3,7,8]. Yet, younger populations are increasingly exposed to loud noises via personal music devices [9]. Therefore, it is necessary to explore how a large, young adult cohort can alter the process of screening.

As such, the primary objectives of this study were: (1) to estimate the true prevalence rates of ASNHL in a young adult population; (2) to identify the true prevalence of MRI positive intracranial causative lesions as the source of ASNHL; (3) to evaluate adherence rates of standardized screening protocols.

2. Patients and methods

Our retrospective case series was approved by the governing institutional review board of the James A. Lovell Federal Health Care Center (FHCC). Eligible patients aged between 17 and 29 years underwent routine audiometric screening at FHCC between January 2011 and October 2016 for the indication of routine military requirements to meet enlistment standards. Those patients with sensorineural or mixed hearing loss determined to have a significant ASNHL component to

their hearing thresholds based on a comprehensive audiogram by a licensed audiologist and subsequently referred for otolaryngology evaluation with and without radiographic imaging were included in this study. Exclusion criteria included prior military experience beyond six-weeks of recruit training to avoid military occupational noise exposure being a confounding element.

2.1. Outcomes assessment

Electronic medical records were reviewed. Audiologic data captured included type and degree of hearing loss, laterality, average asymmetry of hearing loss, frequency of hearing loss, and whether the patient met criteria for ASNHL based upon nine accepted criteria within the literature which were presented in the Saliba et al. article [7]. Further data obtained included demographic data, presence or absence of subjective hearing loss, and prior noise exposure, and otologic history such as personal or family history of hearing loss. Finally, radiographic results were included in this study.

2.2. Statistical analysis

The primary outcome measures for the study were the audiometric and radiographic results of the screening MRI performed on each individual. Secondary outcomes included demographic data and whether the individuals met standardized screening criteria commonly utilized in otolaryngology practice. Descriptive statistical analysis was conducted in STATA 15 (StataCorp, College Station, TX).

3. Results

A total of 228,504 patients were screened in just under six years for hearing loss using basic pure-tone audiometry. After initial screening 701 patients (0.31%) were found to have abnormal hearing meeting criteria for ASNHL work-up. Twenty-seven patients, though, did not meet criteria for inclusion into the study due to age or duration of military experience, while a total of 674 patients met criteria for

Table 1

Characteristics of patients meeting criteria for asymmetric sensorineural hearing loss screening.

Patient demographics	Total	
	No.	%
Age (years)	n = 674	
18–20	305	45%
20–25	298	44%
25–30	71	11%
Mean age	21.1	
Male sex	613	91%
Subjective hearing loss complaint	39	6%
Chronic noise exposure history	551	84%
Sudden noise exposure	34	5%
Gun use (any exposure)	399	67%
Loud music (chronic)	158	27%
Audiometry		
Asymmetric sensorineural hearing loss side	n = 667	
Right	210	33%
Left	447	67%
Bilateral (no significant asymmetry)	10	1%
Left ear hearing status	n = 667	
Normal	190	28%
Sensorineural hearing loss	467	70%
Mixed hearing loss	8	1%
Conductive hearing loss	2	0%
Left ear frequency of hearing loss (Hz)	n = 659	
Normal hearing	182	28%
Less than 3000 Hz	27	4%
3000 Hz or greater	391	59%
Above and below 3000 Hz	59	9%
Right ear hearing status	n = 667	
Normal	376	56%
Sensorineural hearing loss	283	42%
Mixed hearing loss	7	1%
Conductive hearing loss	1	0%
Right ear frequency of hearing status	n = 663	
Normal hearing	375	57%
Less than 3000 Hz	28	4%
3000 Hz or greater	226	34%
Above and below 3000 Hz	34	5%

inclusion (Fig. 1). After examination, an MRI was ordered to rule-out an intracranial source for ASNHL in 99% of patients. Table 1 shows patient demographics, otologic history, and audiometric results including left sided predominant hearing loss in our subjects.

In some cases, complete data and audiometric results were not available beyond a diagnosis, laterality, and MRI results. For the audiometric data available, it was noted that 97% of patients met any criteria for ASNHL and were appropriately referred for imaging. For the specific criteria this study found that the criteria set forth by AMCLASS and Cueva, were the most likely to be in agreement with further ASNHL work-up. However, the guidelines proposed by the AAO-HNS were the least likely to have resulted in a referral (Table 2).

Radiographic results were available for 661 patients, of which 93%

Table 2

Percentage of patients meeting common asymmetric sensorineural hearing loss criteria as referenced by Saliba et al. [7].

Hearing loss criteria met	Percent of total subjects (%)
Meets any criteria	97
Saliba	38
Department of Health	64
Sunderland	84
AAO-HNS	14
Oxford	46
Seattle	42
Nashville	74
AMCLASS	97
Cueva	92

Table 3

Abnormal findings identified with magnetic resonance imaging with gadolinium contrast.

MRI findings	Number of patients
Enhancement of eighth cranial nerve[a]	1
Enlarged vestibular aqueduct	1
Tortuous anterior inferior cerebellar artery	1
Non-specific T2 hyperintense foci white matter	5
Cortical dysplasia (possible low-grade primary neoplasm)[b]	1
Pineal cyst	2
Arachnoid cyst	16
Pituitary macroadenoma	1
Arnold-Chiari I malformation	3
Anterior clinoid process bone lesion	1
Primary frontal bone lesion	1
Chronic rhinosinusitis	15

[a] Recommend repeat imaging in 6-months.
[b] Recommend repeat imaging in 3-months.

had no radiographic abnormality. Of the patients with an abnormality, most patients had no identifiable causative lesion explaining their ASNHL (Table 3). However, two patients (0.3%) had a possible source for their diagnosis. One patient was noted to have an enlarged vestibular aqueduct. The other patient was found to have asymmetric prominence of the cisternal portion of the eighth cranial nerve without contrast enhancement, which was attributed to a developmental variance, viral neuritis, or an atypical schwannoma. In addition, one patient was incidentally found to have cortical dysplasia possibly representing a low-grade primary brain neoplasm. In both cases, repeat imaging was recommended at six and three-month intervals respectively. In no cases was a vestibular schwannoma definitively diagnosed.

4. Discussion

Greater than 30,000 individuals are trained annually at Naval Station Great Lakes Recruit Training Command. The United States Navy (USN), much like the other Department of Defense (DOD) services, requires that each individual with the potential for enlistment must undergo a routine medical screening, which includes screening audiometry by a trained audiology technician. None of these recruits have any military occupational noise exposure, and for the large majority an audiometric abnormality is rarely found. However, for the few that do show audiometric abnormalities, further audiometric screening by a licensed audiologist is required. Based on the results of this formal audiometric evaluation, the audiologist determines if a true abnormality exists and whether further work-up is warranted. If deemed an ASNHL based upon non-standardized screening criteria, the recruit is then referred for an MRI and sent to an otolaryngologist for medical disposition at a single institution.

The reason for such thoroughness in otherwise healthy and asymptomatic individuals is the potential cost burden of disease to the DOD and the potential impact that a pre-existing medical condition may have on the ability for DOD members to perform the mission of the military. At the same time this thoroughness provides a unique opportunity to evaluate a subset of the population, young adults representative of much of their civilian American counterparts, before their health has been influenced by the type of military occupational noise exposure Tolisano et al. [8] describe. Furthermore, with 99% of the individuals having received an MRI with gadolinium contrast, our study was provided a unique opportunity to surveil this population with regards to the prevalence of intracranial lesions that has yet to be published with such robust data. Lastly, our study was able to analyze the frequency with which our audiologists met commonly used criteria for ASNHL work-up and thus verify appropriate referral patterns [7].

During our study, one would have expected to identify a causative lesion in at least some patients. Particularly given the audiologic

findings, VS would be the most likely culprit identified, which historically account for 6% of all intracranial tumors and a cadaveric prevalence rate of 0.8–2.4% [8,10–13]. However, not a single vestibular schwannoma was conclusively identified in 661 MRIs performed despite appropriate referrals in 97% of cases. This is in contrast to other studies, which studied older, symptomatic populations. Cueva [3] found that in screening 312 patients with ASNHL, 9.94% of patients had a causative lesion. Of these 7.69% were found to be a VS. Although these values are higher than other studies which found VS incidence rates closer to 1.5–5.0% of screened populations, it is perhaps surprising that despite the thoroughness of the USN's screening of prospective recruits with ASNHL, the closest our study was to a diagnosis of VS was non-specific enhancement of the eighth cranial nerve in only one patient [3,14]. That said, screening MRIs did lead to the diagnosis of one causative abnormality in the form of a unilateral enlarged vestibular aqueduct in a single patient, which has been reported to be the most common childhood inner ear radiographic anomaly [15].

With the sheer number of MRI results, it was to be expected that other incidental abnormalities would be identified during our study. The most common diagnosis was arachnoid cyst in 2.4% of our patients, which is in agreement with a study by Al-Holou et al. [16] that identified arachnoid cysts in 1.4% of their population. Typically these lesions are asymptomatic, but larger arachnoid cysts can present with headaches and seizures, rather than hearing loss [17]. In no case in our study was hearing loss attributed to an arachnoid cyst based on radiographic findings related to size and location. Thus, this information was not recorded and any symptoms associated with these patients' arachnoid cysts were felt to be beyond the scope of the study. Finally, chronic rhinosinusitis (CRS) was diagnosed in 2.3% of cases. Although it is not known in this study how many of these patients met the clinical diagnosis of CRS, historical numbers suggest that 12% of the US population suffers from CRS annually [18].

Another focus of our study was to identify the appropriateness of screening methods in this study's population; an often debated subject of its own [3,7,10,19,20]. For instance, one author found that greater than or equal to 15 decibel (dB) difference in at least two or more frequencies or 15% difference in speech discrimination scores offered the most sensitivity in finding retrocochlear pathology [3]. In contrast Saliba et al. [7] created the "Rule 3,000" after they compared nine commonly used screening methods for ASNHL. Despite their differences, though, the development of most screening methods did have in common two key aspects. First, the average age of those screened in these studies and identified to have vestibular schwannomas in other studies tended to be in the fourth to sixth decade of life (average age range 38–58 years); an age much older than our population, which had a mean age of 21.1 years [3–5,7,8,10,11,14]. Second, as acknowledged by many authors most patients presented with symptomatic, unilateral hearing impairment or associated tinnitus and imbalance [10]. In contrast, only 6% of patients had symptoms to suggest a retrocochlear pathology may be present in our study. Arguably few if any of our population would ever have been identified let alone screened for retrocochlear pathology in normal circumstances. Despite a difference in our study population, it is again notable that 97% of those screened did meet at least one commonly used screening criteria for ASNHL work-up.

Accepting that other studies were able to identify a significant number of VS in their patients, while we discovered none, one can question the utility of performing screening MRIs for a young adult population such as ours. When reviewing the data, we found that the majority of our population lacked subjective hearing loss and most had noise exposure which could explain the presence of an ASNHL diagnosis. Eighty-four percent of patients reported at least chronic noise exposure and 5% admitted to sudden noise exposure in the form of acoustic trauma. However, it has been acknowledged that in some cases symptoms may not be present in the preclinical stage of disease despite clinical evidence of asymmetric hearing loss [5,10]. Therefore, to exclude such patients from screening MRIs with abnormal audiograms

simply because they do not have symptoms, yet have a reasonable source for hearing deficits, would be considered outside of medical standards. Perhaps, then, investigation into the most cost-effective strategy when studying a young adult population is warranted. In an era when our youth are subject to increasing amounts of chronic noise exposure, one might suggest taking this risk factor into consideration when applying screening methods. Our patient population admitted to chronic loud noise exposure, when asked, in 84% of cases (Table 1). Only 5%, though, admitted to sudden noise exposure. Yet, if further queried by the clinician, 67% admitted to gun use on more than one occasion and 27% admitted to listening to loud music regularly either through concerts or personal listening devices. Therefore, screening may begin with novel audiometric criteria that focuses on the lower frequencies to better screen for noise induced hearing asymmetries. Tolisano et al. discuss this very point when it comes to military veterans with known military noise exposure [8]. However, when considering whether to perform an MRI, one should also consider the cost of missing or delaying a diagnosis in these patients, particularly in a population that may have a preclinical tumor that is small and more amenable to either surgery or radiotherapy, is significant.

The value of early detection of vestibular schwannomas cannot be understated. The literature acknowledges that early detection of small tumors is possible with near 100% sensitivity [13]. This means that small tumors are easily identified thus making post-operative hearing preservation a realistic outcome and other cranial neuropathies less likely [13,21]. Furthermore, early detection also allows for more treatment options, such as stereotactic radiosurgery [5].

Perhaps equally important, patients with delayed or missed diagnoses have a greater chance of permanent deafness or other cranial neuropathies that are irreversible [3,22]. These are considered life-altering events that greatly impact quality of life. For the DOD, the monetary impact is significant. The cost to train military members can be in the tens or hundreds of thousands of dollars, which does not account for the cost of lost lives or equipment that could occur if a mission is impacted by one's inability to perform a mission safely or to appropriate standards to minimize risk. In the scheme of things, some would argue that the debate has long been settled that MRI is the most cost-effective strategy not just for the general population but especially so for the DOD [3,10,20]. However, could more be done? Wilson et al. [22] argue that serological testing may provide better insight into the source of ASNHL while avoiding the cost of MRI. Although no serological studies were routinely performed in our study, it is an option that may help to limit the cost burden in the future when used selectively [23].

Arguably, the real issue should be more about instituting novel imaging protocols for low risk patients, which are more cost effective. Multiple studies have shown non-contrast enhanced T2 weighted images to have 100% sensitivity in detecting tumors as small as 2-mm for half the cost and time of traditional contrast enhanced studies [1,10,13,20,21]. Some, though, would argue there is a risk of missing sub-centimeter tumors or recalling patients to repeat contrasted studies in some cases [5,10,22]. Nonetheless, formally instituting imaging protocols for low-risk individuals would benefit the DOD financially.

As with any retrospective study, there are limitations with the data. First, a true prevalence rate of ASNHL cannot be determined as it relates to those patients meeting this study's inclusion criteria. Although, it is informative to know that 0.31% of patients screened had been referred for ASNHL, it is not possible to determine how many patients would have been otherwise excluded from our population studied. Additionally, due to the inherent nature of the study, no long-term follow-up is available. In particular this is important for possible cases that may later identify themselves as a causative lesion for a patient with ASNHL, as was the case with our one patient that had enhancement of his eighth cranial nerve but lacked follow-up imaging. Although it would not substantially change our findings by only adding one case of a vestibular schwannoma, some would argue that the cost to

the individual if this case was missed, associated cost of treatment, and indirect costs incurred by the USN would more than justify the imaging of the 660 other individuals. Further, this data represents a snapshot in time over a 6-year period that possibly does not represent the true prevalence of intracranial pathology within this population. In addition, there is an obvious selection bias of our cases in that over 90% of individuals are male. Therefore, this does not necessarily represent the true population, but is more in accordance with the male predominance seen within the armed services. Future research of this population would also benefit from more complete information such as race, home of origin of these individuals, and the exact noise exposure experienced by the subjects to make broader conclusions. Nonetheless, this data is valuable because it is the largest study providing insight into the hearing status of a subset of the American population that has been inundated recently with increasingly worse noise exposure through the use of personal listening devices, occupational noise exposure, and recreational gun use. Finally, it contains a large volume of imaging information of the young adult population with ASNHL not yet published in the literature.

5. Conclusion

In this study of a young adult population with no prior military occupational noise exposure, less than 1% of individuals were found to have ASNHL of which 0.3% had radiographic evidence of intracranial pathology possibly explaining the hearing loss. The research also showed that despite non-standardized screening criteria, licensed audiologists appropriately referred patients in 97% of cases for evaluation. Although our data suggests that intracranial masses may be less likely to cause ASNHL in this population, it also suggests that further research is needed to determine the appropriate audiometric and MRI screening methods necessary for low-risk, young adults with ASNHL.

References

[1] Hojjat H, Svider P, Davoodian P, Hong R, Folbe A, Eloy JA, et al. To image or not to image? A cost-effectiveness analysis of MRI for patients with asymmetric sensorineural hearing loss. Laryngoscope 2017;127:939–44.
[2] Zapala DA, Criter RE, Bogle JM, Lundy LB, Cevette MJ, Bauch CD. Pure-tone hearing asymmetry: a logistic approach modeling age, sex, and noise exposure history. J Am Acad Audiol 2012;23:553–70.
[3] Cueva RA. Auditory brainstem response versus magnetic resonance imaging for the evaluation of asymmetric sensorineural hearing loss. Laryngoscope 2004;114:1686–92.
[4] Anderson TD, Loevner LA, Bigelow DC, Mirza N. Prevalence of unsuspected acoustic neuroma found by magnetic resonance imaging. Otolaryngol Head Neck Surg 2000;122(5):643–6.
[5] Lin D, Hegarty JL, Fischbein NJ, Jackler RK. The prevalence of "incidental" acoustic neuroma. Arch Otolaryngol Head Neck Surg 2005;131(3):241–4.
[6] Margolis RH, Saly GL. Asymmetric hearing loss: definition, validation, and prevalence. Otol Neurotol 2008;29(4):422–31.
[7] Saliba I, Bergeron M, Martineau G, Chagnon M. Rule 3,000: a more reliable precursor to perceive vestibular schwannoma on MRI in screened asymmetric sensorineural hearing loss. Eur Arch Otorhinolaryngol 2011;268:207–12.
[8] Tolisano AM, Burgos RM, Lustik MB, Mitchell LA, Littlefield PD. Asymmetric hearing loss prompting MRI referral in a military population: redefining audiometric criteria. Otolaryngol Head Neck Surg 2018;158(4):695–701.
[9] Henderson E, Testa MA, Hartnick C. Prevalence of noise-induced hearing threshold shifts and hearing loss among US youth. Pediatrics 2011 Jan;127(1):e39–46.
[10] Fortnum H, O'Neill C, Taylor R, Lenthall R, Nikolopoulos T, Lightfoot G, et al. The role of magnetic resonance imaging in the identification of suspected acoustic neuroma: a systematic review of clinical and cost effectiveness and natural history. Health Technol Assess 2009;13(18):1–154.
[11] Kleijwegt M, Ho V, Visser O, Godefroy W, van der Mey A. Real incidence of vestibular schwannoma? Estimations from a national registry. Otol Neurotol 2016;37:1411–7.
[12] Tos M, Stangcrup SE, Caye-thomasen P, Tos T, Thomisen J. What is the real incidence vestibular schwannoma? Arch Otolaryngol Head Neck Surg 2004;130:216–20.
[13] Carrier DA, Arriage MA. Cost-effective evaluation of asymmetric sensorineural hearing loss with focused magnetic resonance imaging. Otolaryngol Head Neck Surg 1997;116(6):567–74.
[14] Newton JR, Shakeel M, Flatman S, Beattie C, Ram B. Magnetic resonance imaging screening in acoustic neuroma. Am J Otolaryngol 2010;31(4):217–20.
[15] Arjmand EM, Webber A. Audiometric findings in children with a large vestibular aqueduct. Arch Otolaryngol Head Neck Surg 2004;130:1169–74.
[16] Al-Holou WN, Terman S, Kilburg C, Garton HJ, Muraszko KM, Maher CO. Prevalence and natural history of arachnoid cysts in adults. J Neurosurg 2013;118(2):222–31.
[17] Mazurkiewicz-Beldzinska M, Dilling-Ostrowska E. Presentation of intracranial arachnoid cysts in children: correlation between localization and clinical symptoms. Med Sci Monit 2002;8(6):462–5.
[18] Orlandi RR, Kingdom TT, Hwang PH, Smith TL, Alt JA, Baroody FM, et al. International consensus statement on allergy and rhinology: rhinosinusitis. Int Forum Allergy Rhinol 2016(Suppl. 1):S22-209.
[19] Chau JK, Cho JJW, Fritz DK. Evidence-based practice: management of adult sensorineural hearing loss. Otolaryngol Clin North Am 2012;45:941–58.
[20] Linker SP, Ruckenstein MJ, Acker J, Gardner G. An accurate, cost-effective approach for diagnosing retrocochlear lesions utilizing the T2-weighted, fast-spin echo magnetic resonance imaging scan. Laryngoscope 1997;107:1525–9.
[21] Abele TA, Besachio DA, Quigley EP, Gurgel RK, Shelton C, Harnsberger HR, et al. Diagnostic accuracy of screening MR imaging using unenhanced axial CISS and coronal TWWI for detection of small internal auditory canal lesions. Am J Neuroradiol 2014;35(12):2366–70.
[22] Wilson YL, Gandolfi MM, Ahn IE, Yu G, Huang TC, Kim AH. Cost analysis of asymmetric sensorineural hearing loss investigations. Laryngoscope 2010;120:1832–6.
[23] Cueva RA. In reference to cost analysis of asymmetric senorineural hearing loss investigations. Laryngoscope 2013;123:2077.