Vibration-induced nystagmus and Head Impulse Test screening for vestibular schwannoma. Our experience of 56 cases

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KEY POINTS

1.Our population represents a common clinical scenario in which auditory profiles do not determine eligibility for further evaluation.

2.Mean VOR gain in the VS group, was significantly lower on the affected side in the three canal planes.

3.Refixation saccades in the affected horizontal canal had a significantly higher latency and velocity in the VS group.

4. When we categorized the presence of the VIN with mastoid stimulation, we yielded sensitivities of 81.8% and specificities of 73.9% for detecting VS.

5.The VIN test causes minor discomfort with high diagnostic accuracy and should be considered before referring for further imaging.

INTRODUCTION

Vestibular schwannomas (VS) make up approximately 8% of brain tumours and are found in about 1 in 100,000 persons annually11Hojjat H., Svider P., Davoodian P., Hong R., Folbe A., Eloy J.A., et al: To image or not to image? A cost-effectiveness analysis of MRI for patients with asymmetric sensorineural hearing loss. Laryngoscope 2017; 127: pp. 939-944.

Asymmetric sensorineural hearing loss (ASNHL) and tinnitus are the major presenting symptoms in these patients. There is currently insufficient evidence to recommend a strategy that relies entirely on asymmetry at any single auditory pure-tone threshold.

Despite its vestibular nerve origins, the role of vestibular function testing in VS is poorly defined. Analysis of vestibular functioning with caloric testing or Vestibular Evoked Myogenic Potentials (VEMPs) to diagnose VS has yielded high sensitivity and low specificity results22Chiarovano E, Darlington C, Vidal PP, Lamas G, de Waele C. The role of cervical and ocular vestibular evoked myogenic potentials in the assessment of patients with vestibular schwannomas. PLoS One. 2014 Aug 19;9(8):e105026.. Semicircular canal function analysis, using video head-impulse testing (vHIT), have demonstrated a reduced Vestibulo-Ocular Reflex (VOR) gain in VS33Taylor RL, Kong J, Flanagan S, Pogson J, Croxson G, Pohl D, Welgampola MS. Prevalence of vestibular dysfunction in patients with vestibular schwannoma using video head-impulses and vestibular-evoked potentials. J Neurol. 2015 May;262(5):1228-37.. Nevertheless, the role of the vHIT as a clinical screening tool for VS remains undefined.

The Vibration-induced nystagmus (VIN) test is a simple and reliable method for detecting vestibular asymmetry44Park H, *Lee Y*, Park M, *Kim J*, *Shin J*. Test-retest reliability of vibration-induced nystagmus in peripheral dizzy patients.*J Vestib Res.* 2010;20(6):427-31.. In the present study, we investigated the role of vHIT and VIN in diagnosing VS in a population of patients with ASNHL.

2. METHODS

Patient Selection

Patients with ASNHL (interaural asymmetry of [?]15 dB HL at two contiguous frequencies or [?]10 dB HL at any two frequencies between 2,000 Hz and 8,000 Hz,) were included in this prospective case-control study. Patients with previous otologic surgeries, acoustic trauma, and previous vertigo symptoms were excluded.

Patients evaluation

Patients underwent a neuro-otologic examination, audiometry and vHIT (Otometrics; Denmark), as previously reported11Martin-Sanz E, Esteban J, Vaduva C, Sanz R, Lopez-Escamez JA. High-frequency sensorineural hearing loss associated with vestibular episodic syndrome. ClinOtolaryngol. 2017 Aug;42(4):856-859., 22Martin-Sanz E, Diaz JY, Esteban-Sanchez J, Sanz-Fernández R, Perez-Fernandez N. Delayed Effect and Gain Restoration After Intratympanic Gentamicin for Menière's Disease. Otol Neurotol. 2019 Jan;40(1):79-87..

VIN protocol

VIN testing was completed using the V.VIB 3 F Stimulator (Synapsis, Inc., Marseille, France). This stimulator is a mechanical off-axis rotating vibrator with a vibration amplitude of 1 mm and a cylindrical contact surface 2 cm in diameter.

VIN testing was applied to the mastoid process and in the lower part of the SCM muscle. Growing stimulus frequencies of 30, 60, and 100 Hz were applied for 10 s each. Rest periods of 30 s were used between each stimulus application.

The maximum velocity of the slow phase (MVSP) components of nystagmus evoked by each stimulation was determined with a 2D video-based system (Ulmer VNG, v. 1.4, SYNAPSIS, Marseille, France).

Tumour size

The diameter across the meatal axis was obtained using IMPAX software (AGFA Healthcare, Mortsel, Belgium). A gadolinium enhanced T1 sequence was used. Slice thicknesses ranged from 0.5 mm to 3 mm.

Statistical analyses

Statistical analyses were performed using SPSS Statistics ver. 20.0.

One-way ANOVAs were used to assess mean hearing threshold by frequency. The relationships between tumour volume, VOR gain, and MVSP of VIN were analysed by linear regression analysis.

A receiver operating characteristic (ROC) curve was used to determine the cut-off values for VOR gain, latency, and velocity of the refixation saccades and MVSP of the different VIN stimulation levels.

Sensitivity and specificity were calculated based on the presence of nystagmus in any of the VIN protocol stimulation sites or refixation saccades in the vHIT register.

RESULTS

Auditory results

Twenty-three control subjects (8 women, 15 men; mean age, 63.39±2.23 years) were identified. Another 33 patients with VS were included (14 women, 19 men; mean age, 59.67±2.24 years). (Fig.1).

No significant differences were observed between the case and control groups for any of the auditory thresholds tested.

vHIT results

Mean VOR gain in the VS group, was significantly lower on the affected side in the three canal planes (p=0.08, p=0.00 and p=0.01 for horizontal, posterior and superior semicircular canal, respectively) when both case and control groups were compared. Refixation saccades in the affected horizontal canal had a significantly higher latency and velocity in the VS group (p=0.0001). (Table 1).

Categories were then established for the variables VOR gain, latency, and velocity of the saccades, to determine the best model for predicting the probability of VS. (Table 2).

VIN results

The MVSP of nystagmus evoked in each stimulation were significantly decreased in the control group when compared to those in the VS patients, except for ipsilateral SCM stimulation at 100 Hz, which was not statistically significant. Higher MVSP values were registered with either ipsilateral or contralateral mastoid stimulation than with other stimulation modes ($p<0.05$).

We did not observe any significant differences between the ipsilateral and contralateral stimulation parameters in either the mastoid or SCM between the case and control groups.

The areas under the curve and the sensitivity and specificity for each cut points, are shown in Table 2.

There were no significant differences in sensitivity among the different sites or stimulation sides ($p > 0.05$). The sensitivity and specificity were highest (81, 8% and 73, 9%, respectively) when calculated based on the presence of a VIN with any mastoid stimulation (Figure 2).

Vertical VIN was detected in just 5 of 33 (15.5%) patients tested. No subjects from the control group developed vertical VIN. Vertical VIN sensitivity and specificity were not calculated due to small numbers of patients.

Correlation with tumour diameter

The MVSP of VIN cases upon stimulation of the 30 Hz ipsilateral and contralateral mastoid processes were linearly correlated with tumour size ($p = 0.000$ [R^2 =0.368] and p=0.02 [R^2 = 0.409], respectively). VIN stimulation and VOR gain values did not have any statistically significant correlations with tumour size.

DISCUSSION

Key findings

In the present study we evaluated a clinically applicable screening test for VS in patients with ASNHL, a highly prevalent clinical condition.

We identified a significantly lower mean VOR on the affected side for vHIT test in the VS group. An analysis of saccade velocity or latency in the present study revealed high specificity (87 and 91%, respectively) but low sensitivity (51%).

When we categorized the presence of the VIN with mastoid stimulation, we yielded sensitivities of 81.8% and specificities of 73.9%.

Comparison with other studies

A significant difficulty in establishing the sensitivity and specificity of MRI for VS, is that the prevalence of VS is consistent across adult populations, while the prevalence of ASNHL is highly variable. Efforts have been made to establish auditory criteria for the selection of patients who require further evaluation.

Pena[10] reported that a criterion of 45 dB results in a low specificity for detecting VS. In a retrospective chart review, Saliba11Saliba 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 Feb;268(2):207-12. observed that 74 patients with VS (diagnosed by MRI) had the greatest asymmetry at 3 kHz.

Our vestibular findings echo those observed by Blödow22Blödow A, Helbig R, Wichmann N, Wenzel A, Walther LE, Bloching MB (2013) Video head impulse test or caloric irrigation? Contemporary diagnostic tests for vestibular schwannoma. HNO 61:781–785 who, using only horizontal vHIT, reported a reduced gain of 0.76 ± 0.28 and sensitivity of 41.0% in a group of 46 VS patients. Similarly, Taylor et al[4]reported a high prevalence of vestibular abnormality among VS patients. They included patients with VS and symmetrical hearing (21.4% of the study population), which could explain some differences with our study regarding the prevalence of vestibular dysfunction.

Although several authors have studied VIN in patients with VS33Lee JM, Kim MJ, Kim JW, Shim DB, Kim J, Kim SH. *Vibration-induced nystagmus in patients with vestibular schwannoma: Characteristics and clinical implications.* Clin Neurophysiol. 2017 Jul;128(7):1372-1379. , none have investigated the potential role of the VIN test as a screening tool for VS in an ASNHL population.

Lucke44*Lucke K.* [A vibratory stimulus of 100 Hz for provoking pathological nystagmus (author's transl)]. *Z Laryngol Rhinol Otol.* 1973 Oct;52(10):716-20 Legends Figure 1. Asymmetric NSHL patients were initially included. Patients with previous otologic surgeries, acoustic trauma, and previous vertigo symptoms were excluded of the study; NSHL: Neurosensorial hearing loss Figure 2. Bar graph representing sensitivity and specificity for every vibration mastoid stimulation. The presence of the vibration induced nystagmus represents the sensitivity. The absence of the vibration induced nystagmus in the control group represents the specificity. A: 30 Hz ipsilateral mastoid vibration; B: 60 Hz ipsilateral mastoid vibration; C:100 Hz ipsilateral mastoid vibration Table 1. Mean VOR gain for horizontal, posterior and superior semicircular canal in both Control and Vs groups. VS: vestibular Schwannoma Table 2. The ROC curves and the areas under the curves with sensitivity and specificity results for each of its cut points. AUC: Area under the curve; HSC: Horizontal canal; PSC: posterior semicircular canal; SSC: superior semicircular canal was the first to describe a correlation between vibratory stimulation and vestibular lesions, concluding that VIN reflects peripheral vestibular imbalances.

Strengths and Clinical applicability

In this study, our population of patients represents a common clinical scenario in which auditory profiles do not substantially determine eligibility for further evaluation.

Under normal conditions, a small difference in vestibular excitability does not alter central vestibular symmetry. In contrast, stronger stimulation enhances the small imbalance in central vestibular symmetry that already exists between both labyrinths. . This allows for the VIN to be used to detect small asymmetries. This property is, in our opinion, the main strength of the VIN test, and may be taken advantage of to detect VS, as our results suggest.

This test causes only minor discomfort for the patient, and has high diagnostic accuracy, and should be considered before referring such patients out for further imaging. Further studies that include additional clinical variables may further increase both the sensitivity and specificity of the VIN test, thus improving the detection of VS in ASNHL patients.

Study limitations

The experimental paradigms used, including selection biases, may be a source of study limitations. We did not include patients without VS or hearing loss, nor did we include control subjects with vertigo antecedents. Both groups also contained some individuals with uncommon clinical VS presentations. Consideration of such individual differences should be accounted for when applying this protocol more broadly.

6. REFERENCES

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