Video head impulse test results suggest that different pathomechanisms underlie sudden sensorineural hearing loss with vertigo and vestibular neuritis: Our experience in fifty-two patients

1 | INTRODUCTION

Vestibular neuritis (VN) is a most common disorder that has a comorbid presentation with acute vestibular syndrome (AVS) in the absence of cochlear symptom. Sudden sensorineural hearing loss (SSHL) with continuous vertigo (SHLV) that lasts more than 1 day is another disorder of AVS. VN and SHLV can be easily differentiated by reference to their clinical features, namely without or with cochlear involvement. Although VN and SHLV are considered as two different disorders, their pathophysiology can be explained by similar mechanisms.

Although the mechanisms underlying SSHL remain unclear, the most widely acknowledged theories implicate vascular ischaemia and viral infections. The inner ear and cranial nerves VII and VIII are supplied by different branches of the internal auditory artery (IAA; Figure 1), and vascular lesions at different segments of this artery lead to cochlear and/or vestibular symptoms. In contrast to SSHL, the most important aetiology underlying VN is viral infection.

Recently, a quick and convenient tool, the video head impulse test (vHIT), was developed to measure and quantitatively analyse the function of each semicircular canal. vHIT can easily and accurately analyse the degree of function of each canal in patients with SHLV and VN, and may also further our understanding of the pathomechanisms underlying these two disorders. Thus, this study enrolled patients with either SHLV or VN, as diagnosed based on clinical symptoms and signs. vHIT was performed in all patients to investigate whether SHLV and VN share a similar aetiology.

2 | MATERIALS AND METHODS

2.1 Ethical considerations

Anonymised case note data were used and had no impact on patients. Formal ethical approval was not required.

2.2 Setting

2.2.1 Study design and subjects

We performed a retrospective chart review of patients who were selected from Department of Otolaryngology at Shanghai Jiao Tong University Affiliated Sixth People’s Hospital, from August 2016 to September 2017. A total of 22 patients with VN were diagnosed based on a history of spontaneous, consistent vertigo and physical examinations suggesting severe unilateral peripheral vestibular dysfunction. Diagnoses of 30 patients with SHLV were based on the diagnostic criteria for SSHL and accompanying vertigo that lasted for more than 24 hours.

2.2.2 vHIT protocols

All patients underwent vHIT on the first or second visit, usually within 2 days to 2 weeks after onset of acute vertigo.

An ICS Impulse® 3.0 vHIT device (Otometrics A/S, Taastrup, Denmark) was used for all vHIT tests, and the standard protocol of Halmagyi et al. was adhered to. vHIT-G is calculated as the ratio of the compensated slow phase eye velocity to the head pulse velocity using...
a “wide window” from the beginning of the impulse until the head velocity returns to (or crosses) 0°/seconds.7 Overt and covert saccades are also important for evaluation of impairments in the functions of the semicircular canals and to help determine the accuracy of vHIT-G.

2.2.3 | Variables

For each patient, a detailed history was obtained and standard bedside examinations were performed.

2.3 | Statistical analysis

All statistical analyses were performed with SPSS software (ver. 22.0; IBM Corp., Armonk, NY, USA). The rate of abnormalities was compared between SHLV and VN patients using independent-samples t tests. Normally distributed vHIT-G data were compared using independent-samples t tests and post hoc tests. The gender between two groups was compared using chi-square test. P values <0.05 were considered to indicate statistical significance.

3 | RESULTS

3.1 | Clinical features

The clinical and demographic characteristics of the SHLV and VN patients are summarised in Table 1. Of the 30 patients with SHLV, the mean duration of vertigo was approximately 4.3 days; 1 patient (3.3%) complained of positional vertigo and exhibited downbeat nystagmus, 5 (16.7%) had a positive horizontal head impulse test (h-HIT), and 2 (6.7%) and 7 (23.3%) had abnormal signs on the Romberg and Fukuda tests, respectively. Of the 22 VN patients, 12 (54.5%) exhibited spontaneous nystagmus, 18 (81.8%) had a positive h-HIT, and 5 (22.7%) and 14 (63.6%) had positive Romberg and Fukuda tests, respectively.

3.2 | Audiology

Of the 22 VN patients, only 2 cases showed mild high-frequency hearing loss. In the SHLV group, eight patients had no response at 100 dB HL, at four frequencies (500, 1 k, 2 k and 4 k Hz), while the average hearing levels at these four frequencies in the ipsilesional ears in the remaining 22 patients were 59.29 ± 30.14, 60.50 ± 31.54, 62.90 ± 34.17 and 67.22 ± 28.35 dB HL, respectively. The average hearing levels at 500, 1 k, 2 k and 4 k Hz in the ipsilesional ears of the VN patients were 20.42 ± 9.16, 20.42 ± 10.10, 18.75 ± 11.90 and 26.67 ± 18.26 dB HL, respectively.

3.3 | vHIT

In the two groups of patients, the mean vHIT-G values for the anterior semicircular canal (AC), horizontal semicircular canal (HC) and posterior semicircular canal (PC) are shown in Table 2. The vHIT-G values of the AC and HC in the corresponding affected canals significantly differed between the SHLV and VN groups (P < 0.05), with the VN patients showing lower vHIT-G values than the SHLV patients; the vHIT-G values of the PC did not differ between the groups.

Asymmetry values among the bilateral HC, AC and PC were calculated in the VN and SHLV groups (Table 3). There were significant differences in the bilateral HC and AC between the SHLV and VN groups (P < 0.05), but not in the bilateral PC.

Keypoints

- Sudden sensorineural hearing loss with vertigo and vestibular neuritis are two disorders that could be caused by similar pathomechanisms.
- A quick and convenient tool, the video head impulse test (vHIT), was developed to measure and quantitatively analyse the function of each semicircular canal.
- Auditory and vestibular function in the two disorders, using PTA and vHIT, could help determine whether these disorders have similar degree of severity and scope of affected semicircular canals.
- The affected semicircular canals and severity of functional loss in the canals differed between the SHLV and VN groups by assessing the vestibulo-ocular reflex (VOR) gain (vHIT-G) and asymmetry values.
- vHIT results were different in VN and SHLV groups, which may underlie different aetiologies of VN and SHLV.

![FIGURE 1](image-url) The blood supply and frequency distribution of inner ear. AICA: anterior inferior cerebellar artery; IAA: internal auditory artery; AVA, anterior vestibular artery; PVA: posterior vestibular artery; *anacusia type of sudden deafness with three semicircular canals dysfunction; **anacusia type of sudden deafness with posterior semicircular canal dysfunction; ***high-frequency descending type of sudden deafness with posterior semicircular canal dysfunction.
TABLE 1  Clinical and demographic characteristics of the SHLV and VN patients

|                | SHLV (n = 30) | VN (n = 22) | P-value |
|----------------|--------------|-------------|---------|
| Gender (male/female) | 6/24         | 12/10       | 0.01    |
| Age (mean ± SD)       | 50.73 ± 16.64 | 43.14 ± 13.57 | 0.085   |
| Affected side (left/right) | 19/11        | 13/9        |         |

SHLV, sudden sensorineural hearing loss with vertigo; VN, vestibular neuritis.

TABLE 2  vHIT-G values of the AC, HC and PC in the SHLV and VN patients

|                | SHLV         | VN          | P-value |
|----------------|--------------|-------------|---------|
| AC             | 0.77 ± 0.23  | 0.54 ± 0.25 | 0.001   |
| HC             | 0.98 ± 0.35  | 0.60 ± 0.37 | <0.001  |
| PC             | 0.53 ± 0.28  | 0.58 ± 0.25 | 0.481   |

AC, anterior semicircular canal; HC, horizontal semicircular canal; PC, posterior semicircular canal.

TABLE 3  Bilateral HC, AC and PC of the SHLV and VN groups

|                | SHLV         | VN          | P-value |
|----------------|--------------|-------------|---------|
| LL/RL          | 17.38 ± 16.40 | 55.32 ± 61.16 | 0.002   |
| LA/RA          | 22.69 ± 17.02 | 39.95 ± 22.34 | 0.003   |
| LP/RP          | 36.59 ± 28.66 | 40.82 ± 28.13 | 0.600   |

LL, left lateral; RL, right lateral; LA, left anterior; RA, right anterior; LP, left posterior; RP, right posterior.

3.4  Functions in the AC and/or HC-superior vestibular nerves and the PC-inferior vestibular nerves

vHIT itself cannot separate semicircular canal injury from vestibular nerve; therefore, the functions of the semicircular canal(s)-vestibular nerve branch(es) were evaluated together using vHIT-G. In the SHLV group, 2 patients (6.7%) had isolated AC- and HC-superior vestibular nerve dysfunction, 10 (33.3%) had isolated PC-inferior vestibular nerve dysfunction and 15 (50%) showed dysfunction of all three canals-vestibular nerves. In the VN group, of the seven patients (31.8%) who exhibited superior vestibular nerve dysfunction, three cases involved the HC, one involved the AC and four involved both AC and HC semicircular canals. Additionally, 2 patients (9.1%) with functional loss of the PC were classified as having inferior vestibular nerve dysfunction and 13 (59.1%) cases involved dysfunction of both the superior vestibular nerve and the inferior vestibular nerve.

4  DISCUSSION

Sudden sensorineural hearing loss with vertigo and VN are two different auditory and/or vestibular disorders that can be easily differentiated based on their clinical symptoms. Although these two disorders are thought to have different aetiologies, they could be explained by similar pathomechanisms, namely a vascular pathology that theoretically underlies both disorders. If this is true, the severity and scope of semicircular canal impairment would be similar between the two disorders. Thus, the present study assessed auditory and vestibular function in the two disorders, using PTA and vHIT, and sought to determine whether these disorders have similar aetiologies.

5  STRENGTHS OF THE STUDY

The present study found that the affected semicircular canals and severity of functional loss in the canals differed between the SHLV and VN groups. In the SHLV group, dysfunction typically included profound deafness or high-frequency hearing loss in conjunction with decreased function in the PC, suggesting that the entire basilar membrane (or basal turn) and PC were affected. In the present study, all three semicircular canals were typically affected equally in the VN group. Unlike the SHLV group in the present study, a vascular pathology could not explain the isolated vestibular function loss without cochlear damage seen in the VN patients with functional loss in either the AC, HC, or all three canals.

The present study also showed that asymmetry of the vHIT VOR can be used to evaluate the function of semicircular canals and may be more accurate than vHIT-G. Our results indicate that the PC in SHLV patients was vulnerable to injury, whereas the functions of all three semicircular canals in VN patients were susceptible to injury, which suggests that SHLV and VN do not have a common aetiology.

For making a diagnosis of VN, decreased function of semicircular canal is a necessary criterion. In the present study, spontaneous nystagmus only presented in 12 and h-HIT were abnormal in 18 of 22 patients with VN. When the static compensation is completed, spontaneous nystagmus will disappear, but abnormal h-HIT will still exist. This could explain the difference between spontaneous nystagmus and h-HIT. Additionally, vHIT revealed 2 patients had isolated posterior semicircular canal affected, who should exhibit normal h-HIT. vHIT can quantitatively evaluate the function of all semicircular canals, therefore can provide more information for the diagnosis of VN.

6  COMPARISONS WITH OTHER STUDIES

Semicircular canal function in acute vestibulopathy can also be assessed by caloric tests, which are mainly used for horizontal canal testing. A study of 19 patients with SSHL that employed caloric tests reported that 8 (42.1%) had normal findings and 11 (57.9%) had abnormal findings; however, vertigo was not assessed. In the present study, the averaged vHIT-G value for the HC was 0.98 in the SHLV patients. Therefore, caloric tests are not sufficient to assess the vestibular functions of patients with SHLV.
Similar to caloric and rotational chair tests, vHIT reflects the function of the entire semicircular canal VOR pathway but cannot identify whether a peripheral vestibular sensory organ or vestibular nerve is damaged. The diagnostic value of vHIT is high (sensitivity of 87.9% and specificity of 94.8%) for VN, and other types of acute vertigo and its positive predictive and negative predictive values have been reported as 85.3% and 95.8%, respectively. vHIT, as a high-frequency measure tool, is a useful complement to caloric and rotational tests.

7 | CONCLUSIONS

The present study showed that vHIT results were different in VN and SHLV groups, which may underlie different aetiologies of VN and SHLV; thus, further study will be necessary to confirm these results and determine the different aetiologies.

CONFLICT OF INTEREST

None to declare.

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Clinical outcomes of exclusive transcanal endoscopic tympanoplasty with tragal perichondrium in 129 patients

1 | INTRODUCTION

Tympanic membrane perforation is typically repaired through tympanoplasty using grafts, which may be fat, areolar tissues overlying the temporals fascia and tragal perichondrium-cartilage island or true temporals fascia. Among all, temporals fascia is the most widely used material for its great accessibility and high success rate. Despite the high graft take rate of more than 90%, this technique is commonly performed through postauricular or endaural approaches. However, both approaches may cause postoperative complications, such as wound pain, numbness, auricular haematoma, cosmetic concerns and perichondritis. Therefore, transcanal tympanoplasty was developed to reduce these complications.

In recent decades, the endoscope has also been widely used in ear surgeries, such as myringoplasty, tympanoplasty and...