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Case Report

Barotrauma-Induced Perilymph Fistula: Video Head Impulse Test and High-Resolution Temporal Bones Computed Tomography Role in Evaluation and Follow-Up

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We report a case of a woman presenting with unilateral right profound hearing loss accompanied by vertigo secondary to barotrauma-induced perilymph fistula during recreational skydiving. Video head impulse test demonstrated a reduced gain in both the right horizontal and right anterior semicircular canals accompanied by frequently gathered overt corrective saccades. High-resolution computed tomography revealed an enlarged vestibular aqueduct on the affected side, a predisposing factor for the development of perilymph fistula. An exploratory tympanotomy was performed during which a perilymph leak was visualized at the round window niche. Temporal fascia patches enforced by absorbable gelatin sponges were applied to both round and oval windows. During post-surgery follow-up, the patient remained free of vestibular symptoms. An audiogram displayed mild improvement in the right ear speech reception threshold, although her hearing remained non-serviceable. The video head impulse test showed a favorable dynamic with a stepwise return to normal gain values in all semicircular canals and the disappearance of overt corrective saccades. This is the first case in which video head impulse test was employed as a valuable diagnostic tool for the evaluation and post-surgery follow-up of vestibular function in a barotrauma-induced perilymph fistula. The demonstration of an enlarged vestibular aqueduct on high-resolution computed tomography and the risk of perilymph fistula recurrence are discussed.

KEYWORDS: Perilymph fistula, enlarged vestibular aqueduct, otoneurology, video head impulse test, tympanotomy, barotrauma

INTRODUCTION

Perilymph fistula (PLF) is an abnormal communication between the inner ear perilymph and the middle ear or mastoid space. Traumatic PLF carries an estimated annual incidence of 1.5/100 000 adults of which barotrauma accounts for only 6%. Diagnosis is challenging with intraoperative visualization of perilymph leak still considered the gold standard.[1]

We report on a woman who had a unilateral profound sensorineural hearing loss (SNHL) accompanied by vertigo secondary to barotrauma-induced PLF during skydiving. The contribution of high-resolution computed tomography (HRCT) of the temporal bones and the video head impulse test (vHIT) to the patient's management and follow-up are discussed.

CASE PRESENTATION

A 43-year-old woman presented with a 4-day history of right hearing loss accompanied by vertigo that appeared immediately following skydiving. Examination revealed left beating grade 1 horizontal nystagmus, with normal otoscopy, intact facial movements, and negative fistula test. Audiometry revealed right profound SNHL with pure tone thresholds (PTT) ranging from 65 dB

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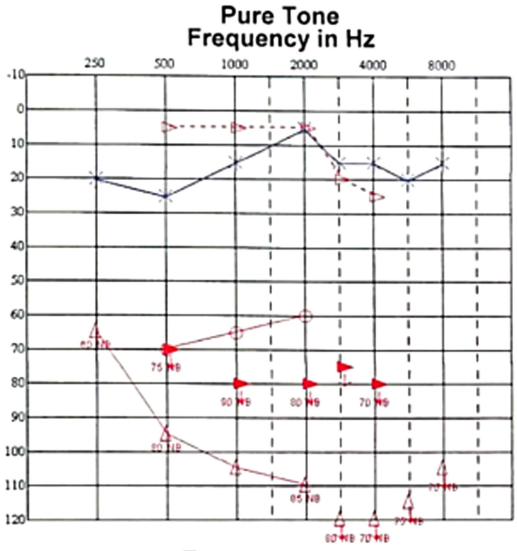


Tympanometry

	Type Peak	Comp Pressure	Volume
Rt	AD	3.7	1.0
Lt	A	1.0	0.8

Speech Audiometry

	SRT	SRT MASK	MASK Level	%Disc	MASK Level	dB
RIGHT	65	NR	60			
LEFT	15			100%		50

Figure 1. Pure tone and speech audiometry were performed at presentation.

HL at 250 Hz to complete deafness at 3000-8000 Hz. Speech reception threshold (SRT) and word recognition score (WRS) could not be tested (Figure 1).

Video head impulse test (Otometrics, Pleasanton, Calif, USA) showed a right horizontal (RH) semicircular canal (SCC) gain of 0.61 (norm 0.8) with abundant overt corrective saccades (CSs) of 90% frequency and 250°/s peak velocity. The PR (Perez and Rey) score is a measure of the temporal agreement of refixation saccades in successive head impulses: overlapping saccades result in a lower value than scattered saccades. The PR score of the RH SCC was 16, reflecting a gathered pattern.[2] The right anterior SCC gain was 0.57 (norm 0.7) with no CS (Figure 2).

High-resolution computed tomography demonstrated a 1.2 mm mid-width diameter of the right vestibular aqueduct (VA) indicating its enlargement[3] (Figure 3). The ossicular chain was intact, and the middle ear cleft was well pneumatized. Conservative treatment was

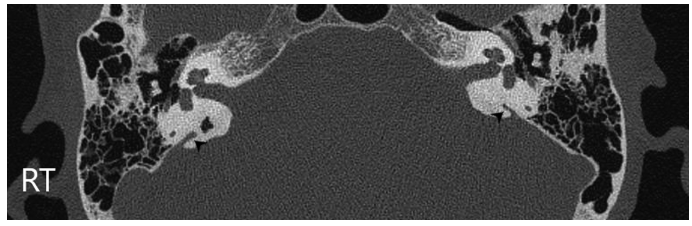


Figure 3. Axial non-contrast enhanced high-resolution computed tomography (CT) of the temporal bones. RT indicates the right side. The black arrows point to the right and left vestibular aqueducts. Note the enlarged vestibular aqueduct measured 1.2 mm on the right.

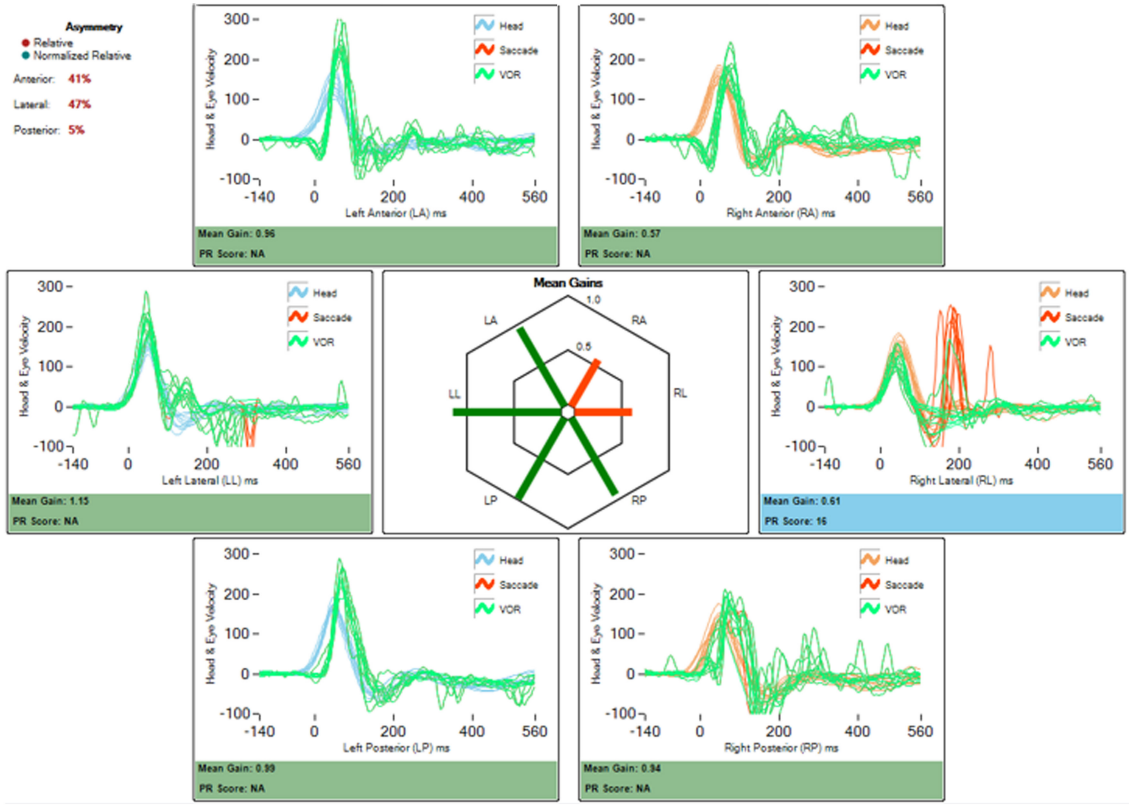
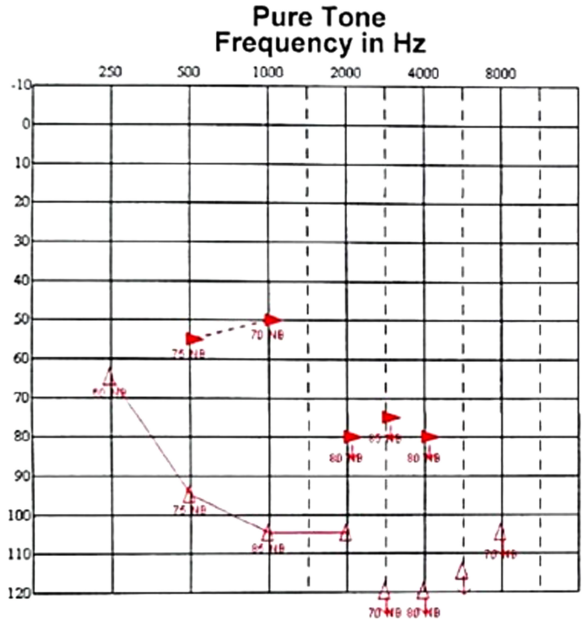


Figure 2. Video head impulse testing (vHIT) results on presentation: low gain of 0.61 with overt corrective saccades and a low PR score of 16 in the right semicircular horizontal canal. Low gain of 0.57 in the right anterior semicircular canal without corrective saccades.



	SRT	SRT MASK	MASK Level	%Disc	MASK Level	dB
RIGHT	65	90	60			
LEFT						

Figure 4. Pure tone and speech audiometry were performed at the conclusion of conservative treatment.

prescribed including complete bed rest with head elevation, stool softeners, and oral corticosteroids. The following day, the vertigo subsided. Also, there was some improvement in the low-frequencies bone conduction PTT with SRT of 90 dB HL (Figure 4). Right inner ear barotrauma with probable PLF was diagnosed and an exploratory tympanotomy was performed. A perilymph leak was visualized at the round window niche and temporal fascia patches enforced by absorbable gelatin sponges were applied to both round and oval windows.

On follow-up 2 months after surgery, the patient had no vestibular symptoms and reported a slight improvement in her right ear hearing. Examination revealed normal tympanic membranes, no spontaneous nystagmus, negative head impulse, and fistula tests. Video head impulse test demonstrated normal RH SCC gain of 0.87 with overt CS of 67% frequency, 200°/s peak velocity, and a PR score of 50, still considered a gathered pattern.[2] The right posterior canal gain was 0.57 accompanied by overt and covert CS with a frequency of 100% and PR score of 32 (Figure 5). Audiometry revealed improved PTT in the low-frequency range. The SRT was 70 dB HL and WRS was 52% (Figure 6). On a subsequent follow-up 5 months after surgery, the patient had no vestibular complaints and her examination was normal. Video head impulse test demonstrated normal gains of all SCCs with right posterior canal overt CS of 100% frequency, 170°/s peak velocity, and a PR score of 30(Figure 7). The audiogram was largely unchanged. This case report received an exemption from the institutional review board. This study was approved by the Ethics Committee of HaEmek Medical Centre (Date: January, 2022). Verbal informed consent was obtained from the patient who agreed to take part in the study.

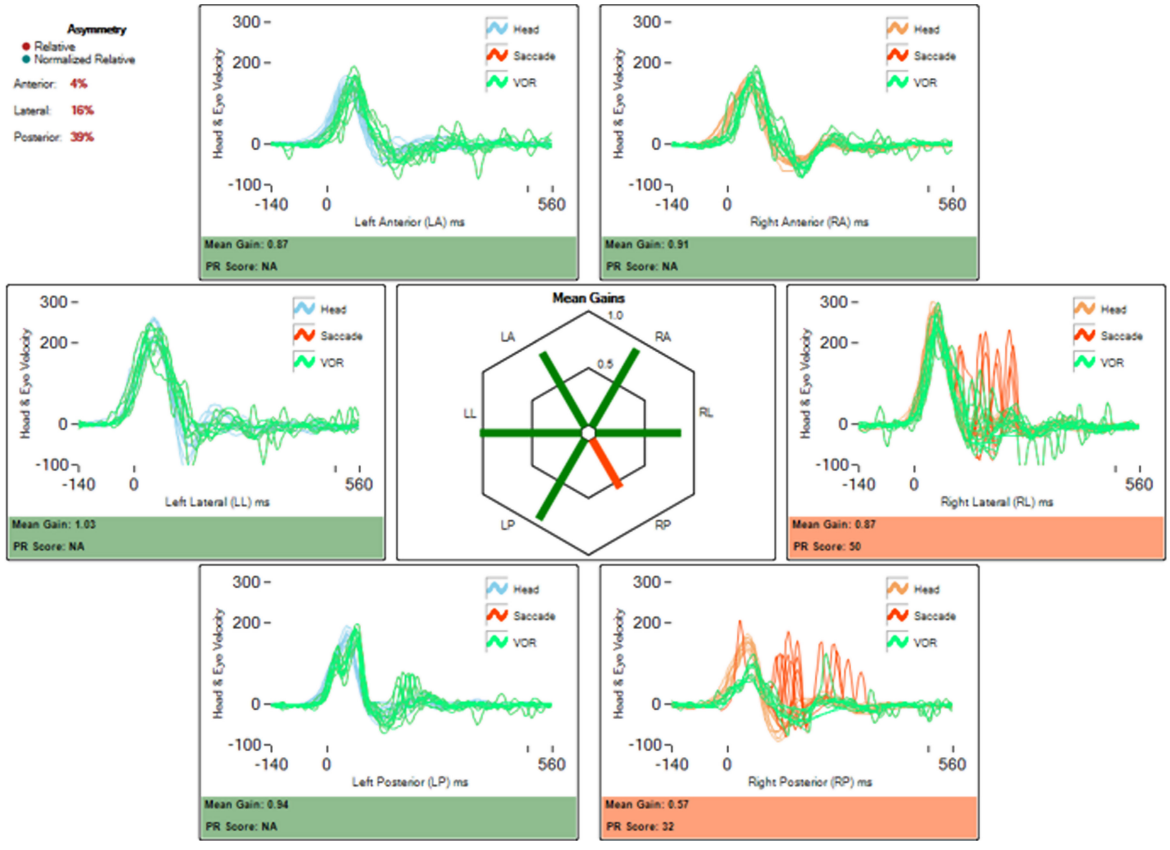
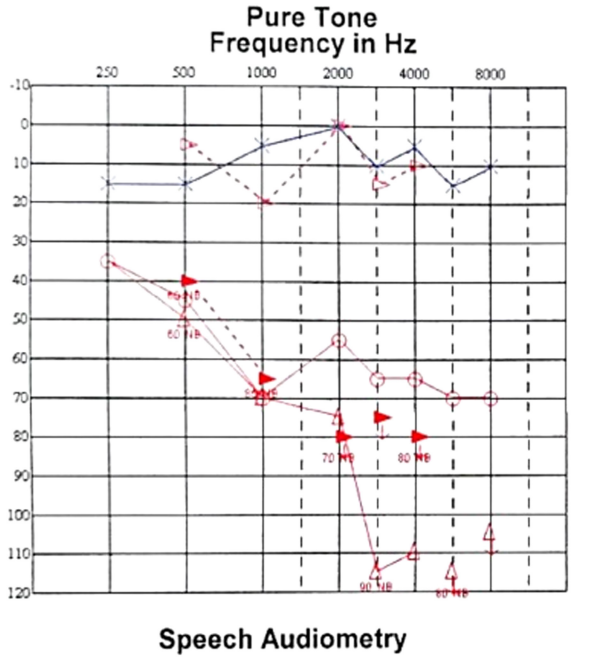


Figure 5. Video head impulse testing (vHIT) results on follow-up 2 months after surgery: normal gain (0.87) with overt corrective saccades with a PR score of 50 in the right semicircular horizontal canal. Low gain (0.57) in the right posterior semicircular canal with corrective saccades and a PR score of 32.



	SRT	SRT MASK	MASK Level	%Disc	MASK Level	dB
RIGHT	60	70	50	52%	65	95
LEFT	5			100%		40

Figure 6. Pure tone and speech audiometry were performed 60 days post-surgery.

DISCUSSION

Goodhill[4] categorized PLF as either implosive or explosive. Implosive forces involve external pressure acting on the oval and round windows, whereas explosive force is an inside-out pressure vector afflicting the oval and round windows that arise from increasing cerebrospinal fluid pressure transmitted to the inner ear. One of the possible pressure conduits from the intracranial cavity to the inner ear is the VA.[5] It has been previously shown that PLF formation is associated with its enlargement,[6,7] probably by easier transmission of pressure to the perilymphatic space.[8] In the present case, HRCT demonstrated VA mid-width diameter of 1.2 mm on the affected right side, compared to 0.8 mm on the left, being within the 1-1.5 mm widening reported by Madden et al[3] to be associated with SNHL. This widened VA could have been a significant predisposing factor for the development of PLF during skydiving when ear pressure equalization by Valsalva maneuver is practiced.

Although the entity of PLF was suggested more than 100 years ago, its definite diagnosis remained controversial.[1] While intraoperative visualization of perilymph leakage might confirm a certain diagnosis of PLF, the authenticity of such an observation is highly controversial while taking into account the total small volume of the perilymphatic fluid and the possibility that transudates or local anesthetics accumulate at the windows niches.[1]

Once PLF is suspected, an initial trial of conservative treatment including bed rest, corticosteroids, and stool softeners is recommended. If the initial management fails to improve the patient's vestibular symptoms, or the diagnosis of PLF is preceded by a clear

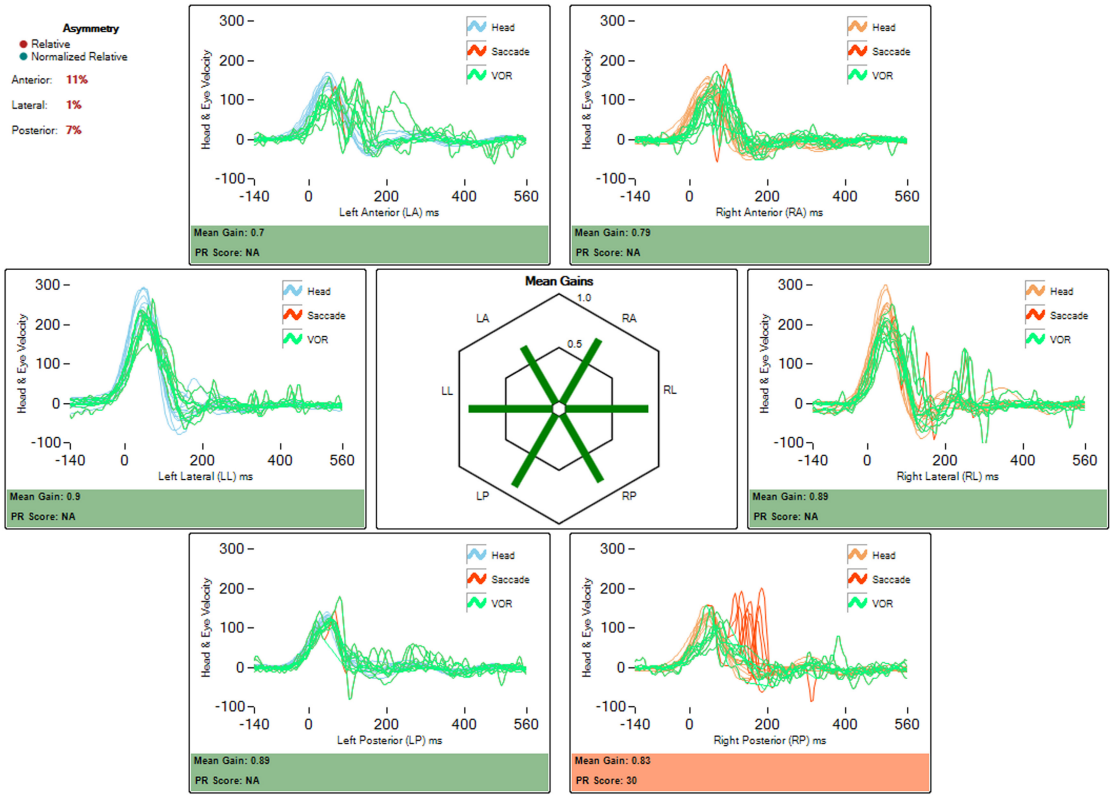


Figure 7. Video head impulse testing (vHIT) results on follow-up 5 months after surgery: normal gains of all semicircular canals. Overt corrective saccades in the right posterior canal with a PR score of 30.

etiologic event such as barotrauma, as in the present case, surgery is warranted.[1,8] Although a complete resolution of the hearing loss following surgery is not anticipated,[1] a recent study of 41 PLF cases reported significant hearing improvement following window patching in 26 (65%) subjects.[9]

An explorative tympanotomy was undertaken and both round and oval window niches were sealed following previous recommendation of both windows patching regardless of whether perilymph leak is identified.[1]

We present for the first time the utility of vHIT in the diagnosis, management, and follow-up of PLF. The finding on the presentation of decreased RH and right anterior SCCs gains combined with RH SCC frequent CS of high frequency, high velocity, and gathered pattern has confirmed significant right-sided vestibulopathy. This was taken into consideration while favoring surgical intervention. The first follow-up vHIT findings of normal horizontal SCC gain with gathered saccades of lower frequency and velocity indicated vestibular compensation dynamics and are in line with the symptomatic relief reported by the patient.[2] On the second follow-up, vHIT showed normal gains of all SCCs with overt-gathered SC of the right posterior canal alone, further demonstrating the dynamics of vestibular recovery post-PLF.

We report a case of surgically confirmed PLF resulting from skydiving-induced inner ear barotrauma, presenting with profound unilateral SNHL and significant vestibulopathy. Video head impulse test was employed as a diagnostic tool, guiding appropriate management and delineating vestibular compensation and residual dysfunction during follow-up. The HRCT demonstration of widened VA as a predisposing factor for the occurrence of PLF emphasizes the role of this imaging modality in assessing the risk for PLF recurrence.

Ethics Committee Approval: This study was approved by the Ethics Committee of HaEmek Medical Centre (Date: January 2022).

Informed Consent: Verbal informed consent was obtained from the patient who agreed to take part in the study.

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