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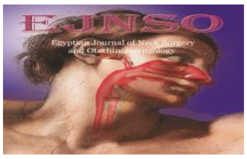

Evaluation of vestibular function in patients with chronic suppurative otitis media: safe type

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Abstract:

Background: Chronic suppurative otitis media is one of the most prevalent chronic infectious diseases in the globe, affects a wide range of racial and ethnic groups and has a high morbidity rate and may lead to intracranial and extracranial problems.

Aim and objectives: To evaluate the function of vestibular system in patients with safe type chronic suppurative otitis media.

Subjects and methods: The current study conducted on 50 patients with chronic suppurative otitis media presented at the Audiovestibular medicine units of Assuit University Hospital and Al-Azhar University Hospital, Assuit. They were divided into: study group consisted of 30 patients, having chronic dry suppurative otitis media and control group that comprised twenty healthy subjects, with apparently normal hearing sensitivity. All participants were subjected to evaluation the vestibular system functions using VNG, vHIT and B.C cVEMP.

Result: There was no statistical significance difference between studied and control groups in the result of vHIT (anterior, posterior and lateral canal). Regarding VNG: All patients showed absent spontaneous nystagmus. Only two patients (6.7%) with abnormal HSN. One patient showed positional nystagmus. Other patient showed positioning nystagmus. Caloric test was pathologic in (6.7%) two patients. There was no statistical significance difference between study and control group in p1 latency, N1latency, N1-P1 AMP (peak amplitude), asymmetry ratio according to result of cVEMP.

Conclusion; There was no statistical significance difference between the studied and control groups in the result of vHIT (anterior, posterior and lateral canal) and result of B.c cVEMP There is a significant finding in the results of VNG at post HS test, positional, and positioning test.

Keywords: Vestibular function, chronic suppurative otitis media, safe type.

Introduction

Chronic suppurative otitis media (CSOM), which affects people of all racial and cultural origins in both developing and developed countries, is one of the most common chronic infectious illnesses in the world. It has a high risk of morbidity and can cause extra- or intracranial complications. [1]

Acute, serous, and chronic forms of CSOM (CSOM) are characterized by varying degrees of inner ear lesions. They are more likely to cause hearing loss, tinnitus, balance problems, and vestibular affection. [2] Over the years, several| studies have looked into the possible clinical impact of CSOM on vestibular function. [1]

CSOM-related inflammatory lesions may have an impact on the vestibular system. Clinical investigations found that 40–60% of CSOM patients reported having

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vestibular problems, and a variety of vestibular function tests revealed anomalies, including posturography, vestibular evoked myogenic potentials, rotating chair, caloric testing, and vHIT. [1,3]

For patients with middle ear disorders intrinsic to CSOM (tympanic perforation, ossicular erosion, fibrosis or secretion in the middle ear, and conductive hearing loss), few vestibular functions test (such as vestibular evoked myogenic potentials) has validated results. This presents several challenges with regard to alterations secondary vestibular function to CSOM. [1,4]

It is also more challenging to accurately connect changes in vestibular function to CSOM since older adults with CSOM are more likely to have a range of other possible reasons of vestibular complaints. [1,5]

One vestibular function test that is not greatly impacted by CSOM is the video head impulse test, which may independently and unbiasedly assess each semicircular canal's functionality and provide essential details on vestibuloocular reflex (VOR) changes. The video head impulse test has been used with relatively little research in patients with CSOM, despite these benefits. Given the significance of the head impulse test in the diagnosis of VOR problems, changes in this test can help with the topographic characterization of vestibular modifications associated with CSOM. [6,7]

Numerous options to avoid the consequences are provided by the evaluation of vestibular function in patients with safe type chronic suppurative otitis media and help on selecting the most effective course of therapy and rehabilitation. [1,8] Inflammation of the labyrinth with acute and chronic otitis media can cause vertigo and hearing loss; this inflammation can manifest as either serous or suppurative labyrinthitis. However, rather than the bacterial infection entering the labyrinth, serous labyrinthitis is thought to be brought on by the transfer of bacterial toxins or inflammatory mediators to the inner ear. [9]

Patients and methods:

This prospective, case control study was conducted at Audiovestibular Medicine units- ENT Departments in Assuit University hospitals and Al-Azhar University hospital (Assuit) from June 2021 to November 2022 on 50 subjects who were divided into 2 groups: study group consisted of 30 patients, had dry chronic suppurative otitis media, safe type either unilateral or bilateral affection and control group that comprised twenty healthy subjects, with normal hearing sensitivity, i.e. their hearing threshold level was < 25 dB HL with no history of any general or ear diseases. They were well-matched to the cases regarding age and gender.

Inclusion criteria: all patients with safe type CSOM dry perforation, age from 10 years to 50 years old, both sexes and unilateral or bilateral affection.

Exclusion criteria: unsafe type CSOM, noise exposure, adhesive process, hereditary hearing loss, active discharging and ear surgery history.

A thorough history was taken for every patient with regard the onset, course, duration, and side effects of their hearing loss, as well as the length, frequency, and duration of their discharge, as well as any predisposing factors such as tinnitus, URTI, ear surgery, medical treatment history, and family history. The patients were also asked about their history of vertiginous attacks, including their duration, episodes linked to them, and their offensive or odorless discharge. To rule out active discharge and other diseases in the external auditory canal, otoscopic examination for cholesteatoma, drainage, and perforation.

Basic audiological evaluation:

- Pure tone audiometric air conduction test, bone conduction, and speech testing (speech reception threshold (SRT) and speech discrimination score).
- Middle ear immittance was measured, which includes tympanometry (to assess middle ear function).

Vestibular evaluation :

I**. VNG Testing:**

48 hours before the test, the patients were instructed to stop taking any vestibular suppressants. The patient was advised to keep his head still and focus on a series of dots that appeared between Rt, Lt, up, and down. Eye movements were recorded for thirty seconds during visual fixation and an additional thirty seconds during non-visual fixation. For the gazing test, the patient was instructed to look straight ahead and concentrate on the object in the middle before turning their head thirty degrees to the right, left, up, and down. Ten seconds are spent in the eccentric stare and about thirty seconds are spent keeping fixation in the center look. Normally, nystagmus shouldn't be induced.

Examining the ocular-motor pathways in the cerebellum and brainstem that are necessary for the vestibuloocular reflex (VOR) to work was done using oculomotor testing. These assessments include:

- **Smooth Pursuit Test:** The assigned job required the subject to monitor the movement of a sinusoidal item that was moving horizontally at two different frequencies (0.2 and 0.4 Hz). Both the asymmetry and the gain of eye movement were evaluated on both sides.
- **Saccade Test:** The participant was instructed to track and concentrate on an object that was moving randomly between 5 and 30 degrees to the right and left. An evaluation was conducted on the precision, speed, and delay of the response.
- **Optokinetic Test:** The OKN test involved having the participant follow a sequence of targets moving at a speed of 30 frames per second to the right and then left.

Positioning tests: Dix—Hallpike maneuver is utilized to determine whether nystagmus related to benign paroxysmal positional vertigo (BPPV) is present or absent. The response is triggered by motion rather than location.

Positional tests: This experiment aims to explore the effects of various head angles in a gravitational environment. After putting the patient in each position, the examiner gives them a minimum of 20 to 30 seconds to be assessed.

Headshake Test: In order to minimize visual suppression, the person was positioned in an upright position. The subject's head underwent lateral movement for 20 seconds at a frequency of 2 hertz per second. Following the cessation of head movement, the subject's eyes exhibited motion.

Caloric Test: A bithermal air caloric test was conducted, and eye movements were recorded using a video-based system. The participant was positioned in a supine posture with the head elevated at an angle of 30 degrees to align the horizontal canal vertically. Bithermal air caloric stimulation were conducted, using temperatures of 50± 0.4°C and 24± 0.4°C. [10] For air stimulation, the patients were irrigated using an airflow of 8 L/min for 60 seconds at 50°C and 24°C [11]**,** creating an endolymphatic current comparable to that produced by water at 44°C and 30°C. [12] The proper mental exercises were administered, and nystagmus was noted. The formula of **Jongkees et al. (1973)** [13] was utilized to calculate the abnormalities of low frequency horizontal canal function, asymmetry of reaction, and unilateral weakness. During the caloric test, fixation suppression was also noted. By identifying nystagmus an involuntary fast eye movement in response to different stimuli, VNG can differentiate between peripheral and central vertigo. After every irrigation, the maximum SPV of nystagmus was examined, and the canal paresis (CP) was estimated using Jongkees' formula. Only when canal paresis (CP) was equivalent to 25% or higher was it deemed serious.

- CP%= [(RC + RW) – (LC + LW) / (RC + RW + LC + LW)] X 100.
- (CP= canal paresis, RC= right cool, RW= right warm, LC= left cool, LW= left warm).

II. v HIT:

The video head impulse test apparatus consists of goggles with a transparent mirror that projects the patient's view onto the camera and a high-definition video camera that operates at a frequency of 250 Hz. The speed of head movements is quantified using a minuscule sensor, which is subsequently captured by a camera and scrutinized by a computer software. In order to prevent any distortions and ensure the stability of the goggles, the system was securely attached to the patient's head. The test was carried out following the conventional methods recommended by **MacDougall et al.** [7]**.** Using video analysis, the EyeSeeCam System software automatically calculates the average individual gains of head impulses. The area under the curve for eye movement divided by the corresponding head movement is used to calculate this.[14] The vHIT was captured using the vHIT EyeSeeCam device. An assessment was conducted on all the horizontal and vertical canals. The participant was directed to fixate on an object located at a distance of 1.2 meters. Initially, the process of calibrating is executed. During each trial, the examiner positioned themselves behind the patients and executed head impulses at a little angle (10–20◦) and at a suitable velocity (150–200◦/s). An abnormal test was determined when the VOR gain values were below 0.8 for horizontal canals or 0.7 for vertical canals, in addition to the presence of pathological corrective saccades. [6] Analyzed were the frequency and magnitude of the corrective saccades. Abnormal corrective saccades were defined as those that happened in over 50% of head impulses. Given that modest corrective saccades are prevalent among individuals with good health, it is necessary for the lowest amplitude of saccades to be greater than half of the velocity of head movement. The saccades should manifest in a direction opposite to that of the rotation of the head.[15]

III. Bone Cervical Vestibular Evoked Myogenic potential:

Before applying the electrodes, the patient’s skin was cleaned while they were sitting upright to get low impedance below 5K ohms. [16] The placement of the electrodes was as follows: the active electrode was positioned at the ground electrode was positioned on the opposing sternocleidomastoid (SCM) muscle, the reference electrode was firmly secured in the suprasternal notch, and the middle of the SCM on the side being tested **(figure 1)**. The participant was directed to contract the muscle by rotating his chin towards the opposite shoulder during periods of tonic stimulation. Additionally, he was taught to rest between these periods to prevent exhaustion. [16] The stimuli consisted of short tone bursts, specifically bone conducted stimuli at a frequency of 500 Hz. These tone bursts had a duration of 8 ms and a rise/fall time of 2 ms. They were provided using a bone vibrator radio ear B81, which had specific housing dimensions of 16mm in height, 31.7mm in length, 18.2mm in width, and weighed 20 g. [17] B81 is interoperable with the identical audiometers as B71 and exhibits superior electro-acoustic performance. B81 enables the assessment of sensorineural hearing loss at higher hearing levels compared to B71 below 1500 Hz. [17-18] It is positioned on the mastoid process of the same side as the stimulated ear. The stimuli were provided to one ear at an intensity of 50 decibels over normal hearing level for bone conduction vestibular evoked myogenic potential (VEMP) testing, at a frequency of 500 Hertz. A minimum of 100 measurements that met the specified requirements were combined and two sets of averaged signals were acquired at each intensity level to verify consistency. The analysis was conducted within a time range of 50 milliseconds, with a rate of 5.1 occurrences per second, as reported by Tseng et al., 2013 . [16]

N.B: B71 was used to elicit a response but unfortunately the response had distorted morphology and diminished amplitude. B81 that showed best response and morphology (**Figure 2).**

The presence or absence of waves was assessed. The initial positive polarity (P1) that occurs at a latency of roughly 13 ms after stimulation initiation and the subsequent negative polarity (N1) that occurs at a latency of almost 23 ms after stimulation onset were identified as the biphasic P1-N1 wave. Peak to peak P1-N1 amplitude and P1 and N1 latencies were measured when the biphasic P1-N1 was present. Asymmetry amplitude Ratio or the inter-aural latency difference (IAD) of amplitude is the difference in amplitude between the two ear peaks of P1-N1 divided by the total amplitude of both ears: IAAD = Rt + Lt / Rt + Lt. An IAAD > 0.36 was considered abnormal. [19]

Statistical analysis:

The process of inputting and analyzing data was carried out utilizing SPSS version 22, which is a software program created especially for social science statistical analysis. The chi-square test, Pearson correlation, Mann-Whitney test, and Spearman correlation were employed.

Results

The present study comprised two groups of adults: The control group included 20 patients (40 ears) apparent healthy individual. The study group included 30 patients (48 ears): 18 of them had bilateral perforation, 12 had unilateral perforation and a normal tympanic membrane in the opposite side. The mean duration of hearing loss is 6.5 ± 6.74 years (ranging from 1-13 years).

The study group included 30 patients (48 ears): 18 of them had bilateral perforation was 60.0%., 12 had unilateral perforation was 40.0%, and a normal tympanic membrane in the opposite side. The mean duration of hearing loss is 6.5 ± 6.74 years (ranging from 1-13 years), the mean duration of vertigo 0.72 ± 1.03 (ranging from 0.5-1.75 years).

The length of the dryness varies. Sometimes ears get wet, but they treated and healed. Compared to the time of dryness, the wetness is brief.

There was statistically significant difference regarding PTA (AC) at (0.5KHZ, 1 KHZ ,2 KHZand4 KHZ) and regarding PTA (Bone conduction) at (0.5HZ,1 KHZ,2 KHZ and 4 KHZ).

ABG average Mean ± SD was 22.55 ± 5.82. All subjects in the control group have type (A) tympanogram. All affected ear type (B) tympanogram with high volume. Volume of EAC Mean ±

SD was (2.68 ± 1.21), dry ear was 100%.

All subjects showed absent of spontaneous nystagmus. Only two patients (6.7%) showed abnormal HSN slow-phase eye movements towards the COM-side (7°) and other patient (6°). One patient showed right beating nystagmus was observed in positional head right, center and left toward CSOM side (8°). Other patient showed left beating nystagmus was observed in DHR (5°) and left supine toward CSOM side (6°). Caloric test was pathologic in (6.7%) two patients. There were 2 subjects with canal weakness. One patient showed unilateral weakness, and other patient showed unilateral weakness to CSOM side (Table 1) .

NB: All patient had normal ocular motility test in the form of normal saccadic eye test, normal Pursuit test and normal optokinetic test .

Bone conduction VEMP was preserved in all CSOM cases which was 30 patients have unilateral and bilateral perforation that equal 48 ears and in controls which was20 apparently healthy individual equal 40 ears (Figure 3).

Table 1. Demographic and Preoperative Airway Assessment Characteristics of Study Participants

Figure (1): Electrode montage for BC cVEMP testing**.**

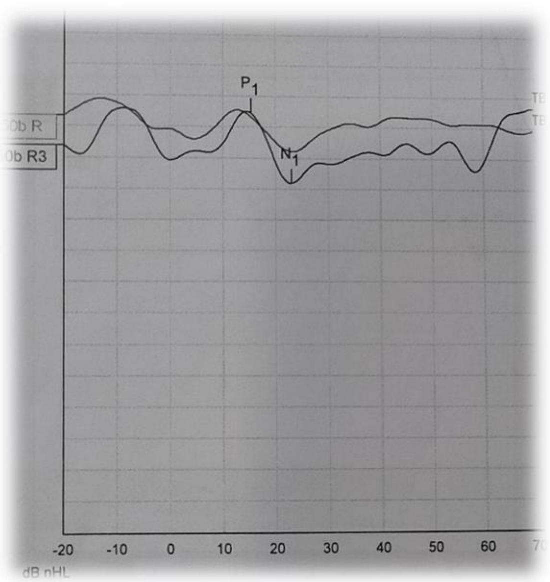
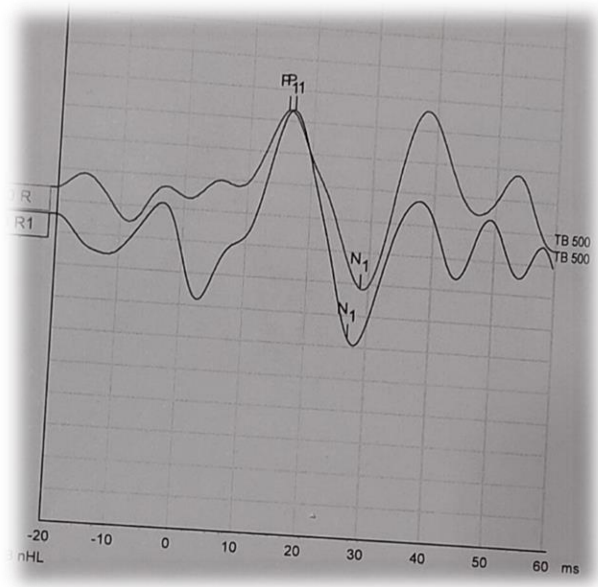
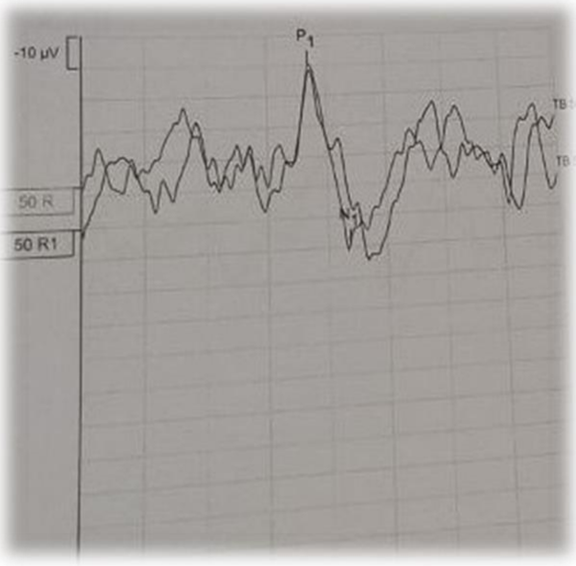
B71 cVEMP	**B81 cVEMP**
	

Figure (2): BC cVEMP trace with B71 Vs B81

Results of videonystagmography test battery in study group Table (1):

Spontaneous nystagmus results (Absent)	30	100%
Head shake (Abnormal)	2	6.7%
Positional (Dix-Hallpike) (present)	1	3.3%
Positioning (Dix-Hallpike) (present)	1	3.3%
Caloric results (Abnormal)	2	6.7%
Side of weakness: Unilateral Right Left	 2 1 1	 6.7% 3.3% 3.3%

Bone conducted VEMP trace in one in the controls	**Bone conducted VEMP trace in one in the cases.**



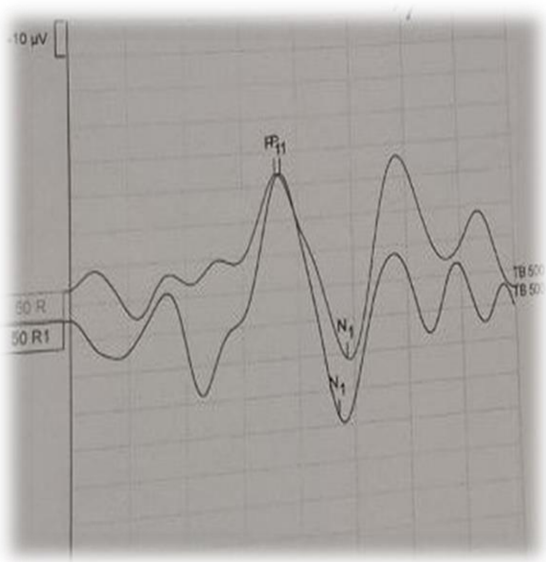


Figure (3): shows bone conducted VEMP trace in one in the controls and in one in the cases.

Table (2): Results of B.C cVEMP, vHIT (Posterior, anterior and lateral canal) in the two groups Mean ± SD (30patient = 48 ears of study group and 20 person = 40 ears of control group):

	Group I	Group II	P-value
B C cVEMP			
P1 Latency: Mean ± SD Range	 16.06 ± 1.14 13.8-18.2	 15.77±1.14 13.3-17.6	 0.319
N1 Latency: Mean ± SD Range	 24.32 ± 2.07 21.4-28.6	 24.92 ± 1.83 22.5-31.3	 0.158
P1-N1 AMP: Mean ± SD Range	 62.21 ± 9.96 49.1-87.7	 63.15 ± 10.52 50.0-85.6	 0.669
IAAD: Mean ± SD Median (Range)	 0.09 ± 0.06 0.07 (0.01-0.27)	 0.16 ± 0.19 0.12 (0.01-0.70)	 0.236

There was no statistical significance difference between study and control group in p1 latency, N1latency, N1-P1 AMP (peak amplitude), asymmetry ratio according to result of cVEMP.

Table (3): Results of vHIT (Posterior, anterior and lateral canal) in the two groups Mean ± SD (30patient = 48 years of study group and 20 person = 40 ears of control group):

vHIT (Posterior canal)					
Right Gain: Mean ± SD Range	 1.10 ± 0.14 0.80-1.30		 1.04 ± 0.12 0.85-1.20		 0.139
Left Gain: Mean ± SD Range	 1.12 ± 0.18 0.80-1.60		 1.06 ± 0.12 0.87-1.20		 0.258
Asymmetry: Absent	30	100.0%	20	100.0%	
Catch up saccade: Absent	30	100.0%	20	100.0%	
vHIT (Anterior canal)					
Right Gain: Mean ± SD Range	 1.07 ± 0.14 0.80-1.40		 1.02 ± 0.12 0.80-1.20		 0.219
Left Gain: Mean ±SD Range	 1.16 ± 0.14 0.90-1.50		 1.11 ± 0.07 1.00-1.20		 0.192
Asymmetry: Absent	30	100.0%	20	100.0%	
Catch up saccade: Absent	30	100%	20	100%	

Lateral canal					
Right Gain: Mean ± SD Range	0.99 ± 0.10 0.80-1.30		0.97 ± 0.07 0.80-1.11		0.397
Left Gain: Mean ± SD Range	0.98 ± 0.09 0.80-1.20		1.01 ± 0.09 0.85-1.20		0.372
Asymmetry: Absent	30	100.0%	20	100.0%	
Catch up saccade: Absent	30	100%	20	100.0%	

There was no statistical significance difference between study and control group in the result of vHIT (Posterior and anterior and lateral canal) **(Figure 4-6).**

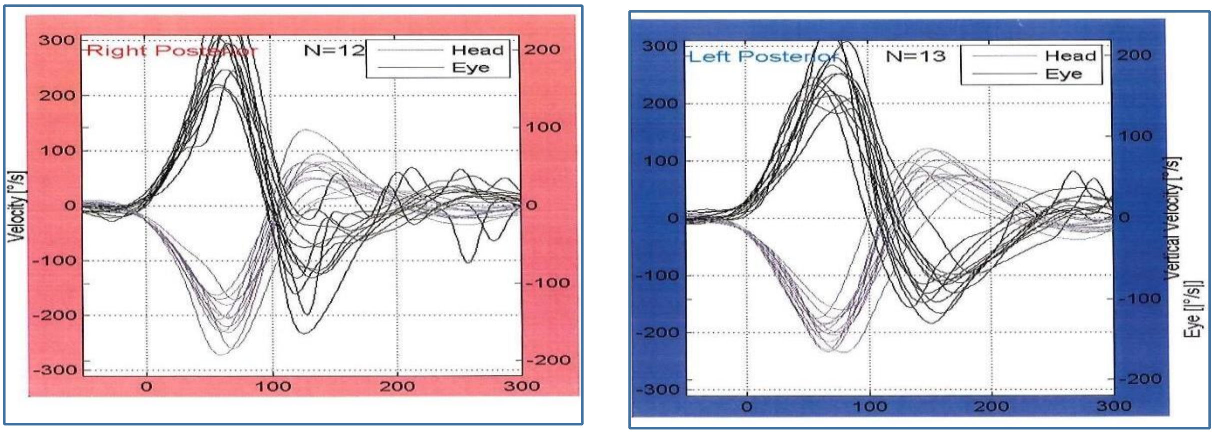


Figure (4): Results of vHIT of Posterior Canal Right and Left.

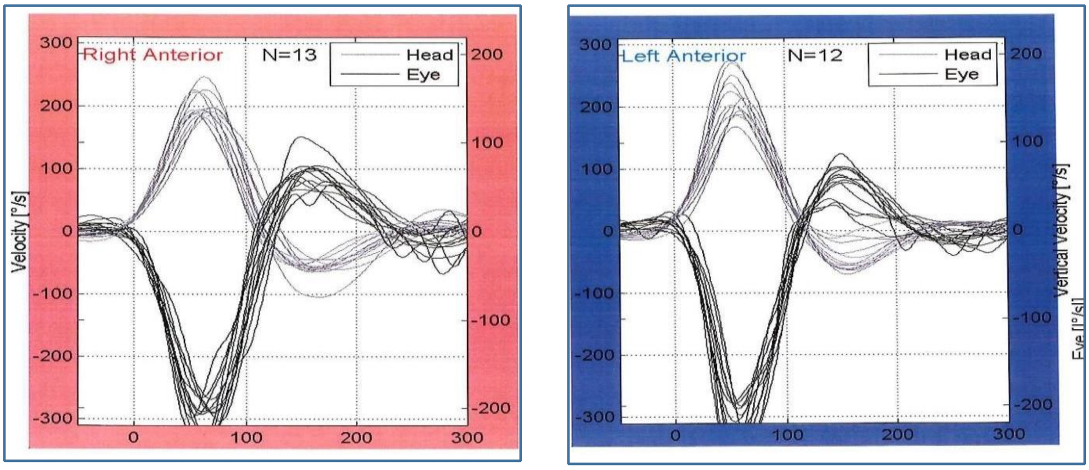


Figure (5): Results of vHIT of Anterior Canal Right and Left.

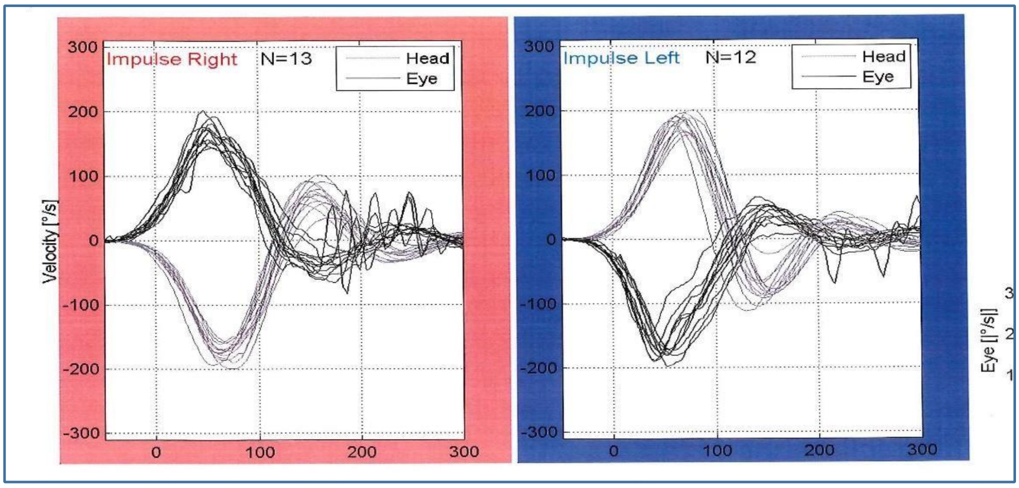


Figure (6): Results of vHIT of Lateral Canal Right and Left.

Table (4): **Cases with abnormal vestibular function tests.**

	PHS	Positional test	CW	cVEMP	vHIT
Case 1	**+Ve**	**-Ve**	**+Ve**	**-Ve**	**-Ve**
Case 2	**+Ve**	**+Ve**	**-Ve**	**-Ve**	**-Ve**
Case 3	**-Ve**	**+Ve**	**-Ve**	**-Ve**	**-Ve**
Case 4	**-Ve**	**-Ve**	**+Ve**	**-Ve**	**-Ve**

The aberrant findings for the entire test battery were summarized in **table 4**, case number one showed post head shaking nystagmus and unilateral caloric weakness, case number two showed post head shaking and positional nystagmus, case number three showed only positional nystagmus and case number four just unilateral caloric weakness toward CSOM side.

Discussion:

Chronic suppurative otitis media may cause functional impairment to the inner ear, leading to hearing loss and dizziness.[20] The identical pathogenic factor spreading via the round window can result in modified protein expression, leading to damage in the cochlea and vestibular system.[21]

The vestibular functions were evaluated in patients with chronic suppurative otitis media using different vestibular tests, such as the Video-Nystagmography (VNG) test battery, which includes bithermal air caloric, video Head Impulse Test (vHIT), and Bone-Conducted Vestibular Evoked Myogenic Potential (BC VEMP).

The current study included 30 patients with chronic suppurative otitis media (CSOM) of the safe type and control group of 20 healthy individuals was also included.

The average age in the present study was 24.5 ± 10.19, with a median value of 22.0. The gender distribution consisted of 53.3% males and 46.7% females. There were no statistically significant variations in age or gender between the two groups.

The current study investigated the distribution of audiovestibular symptoms in the study group. It was found that there was a history of hearing loss, tinnitus, and dizziness, which were exclusively present in the study group. The condition was observed in all 30 patients (100%) in the study group, in

18 patients (60%), and in 14 patients (46.7%), respectively.

The present study found that individuals with perforated ears experienced an average of mild to moderate conductive hearing loss. The audiograms exhibited a range of descriptive variations, ranging from mild to severe mainly conductive hearing loss.

The vestibular evaluation tests conducted in our study involved the use of videonystagmography (VNG) to measure various types of nystagmus, including spontaneous nystagmus, gaze provoked nystagmus, and head shaking nystagmus. Additionally, we performed tests to evaluate saccades, smooth pursuit, optokinetic responses, as well as the Dix Hallpike maneuver, positional head and body tests, and bithermal air caloric irrigation. No instances of spontaneous or gaze-evoked nystagmus were detected in our patients during the experiment (Table 1).

According to our data, which are consistent with those of **Kim et al.** [22], Out of the 34 patients, 32 (94%) did not show any signs of spontaneous or positional nystagmus. One patient had spontaneous and positional nystagmus that beat weakly towards the right, while the second patient presented spontaneous and positional nystagmus that beat weakly towards the left.

In the present study, we observed head shaking nystagmus in 2 patients, which accounted for 6.7% of the total. This nystagmus was consistently horizontal and directed towards the side affected by chronic suppurative otitis media (CSOM) as irritative lesion**. Lee et al.** [23] discovered that 48% of the individuals had abnormal HSN. Seven out of twelve individuals with pathologic HSN exhibited slow-phase eye movements towards the COM-side. However, a total of five respondents, accounting for 42% of the participants, displayed slow phase eye movements towards the side that was not affected. This suggests that they are prone to vestibular compensation, which may explain the difference. This phenomenon might be attributed to either an increase in the gain of the vestibuloocular reflex (VOR) at the central level or a recovery of the peripheral response to stimulation of the damaged vestibular system. [24]

In contrast, Mostafa and his colleagues found that every patient successfully completed the head thrust and head shaking tests. [25] The chronic process of otitis media was suspected to be the cause of the central compensation mechanism.

The results of our investigation indicated that 96.7% of the participants in the study group had normal positional findings, as assessed by the Dix Hallpike maneuver. One patient exhibited left, center, and right positional nystagmus towards the side affected by chronic suppurative otitis media (CSOM). During the Dix-Hallpike test, the patient had leftward beating nystagmus when laying on both the left and right sides, indicating an irritative nystagmus. **Kim et al.,** [22] Patients with Otitis Media with Effusion (OME) or Acute Otitis Media (AOM) who did not have dizziness had both positional nystagmus that changed direction and fixed-direction nystagmus of an irritative or paretic nature. These various types of nystagmus have also been associated with certain inner ear disorders, such as sudden sensorineural hearing loss, Meniere's disease, and Ramsay Hunt syndrome.[26]

Unlike our results **Chang et al.** [27] Upon examination, no evidence of positional or spontaneous nystagmus was seen. Mostafa et al. also reported normal positional tests in all patients with chronic suppurative otitis media (CSOM) in their study. [21] In our investigation, all patients exhibited normal results in the saccades test, smooth pursuit test, and optokinetic test. Similarly, Mostafa et al. found all patients had a normal smooth pursuit, normal saccades and normal optokinetic tests. [25]

Caloric testing is the prevailing method used in the present investigation to determine the presence and lateralization of peripheral vestibular hypofunction. The caloric test primarily examines the function of the lateral canal by stimulating the flow of endolymph fluid. **Paparella et al.** [28] conducted a study on the results of air caloric testing in patients with unilateral otitis media, both pre- and post-surgery. They reached the following conclusions: Individuals with tubes or a tiny ear perforation may demonstrate a caloric response that is equal to the unaffected side. Conversely, individuals with extensive perforations on one side may exhibit an excessively active caloric response on the perforated side. A moist ear with a significant hole or cavity may display an unusual form of horizontal nystagmus when exposed to warm air caloric stimulation. This inverted nystagmus is likely caused by the cooling of the inner ear fluid due to the evaporation of mucus or the stimulation of moisture in the middle ear chamber by dry, heated air. An experiment demonstrating the disappearance of inverted nystagmus when a warm air stimulus was saturated with water vapor offered supporting evidence for this notion. The presence of dry open mastoid or fenestration cavities has been found to result in hyperactive caloric reactions, as described by **Lee et al**.[23] and Gianoli & Soileau [29].

Our investigation found that air caloric tests exhibited a preference for causing weakness on the contralateral (COM) side. The rate of abnormality in our caloric testing is 6.7%.

Siampara et al. a study that looked at the results of hot and cold caloric tests in people with chronic suppurative otitis media (CSOM) discovered that canal paresis was rare (5.3%). This is due to the fact that, as was already noted, the caloric test provides information mainly regarding the low-frequency responses of horizontal SCC. [30]

It is lower than that of a previous publication that showed a high rate of pathogenic caloric response (76%).[29] Their elevated rate may have arisen due to the intricate challenges that their research population had to confront. Two patients have a stapes subluxation, three fistulas in the semicircular canals, and bilateral COM in thirteen cases. Moreover, a significant proportion of their patients had undergone previous ear interventions, and 44% of them disclosed a medical background of vertigo or dizziness. The study observed that the labyrinth on the side of the cochlear nerve can be impacted or gradually deteriorated by inflammatory processes, despite anatomical changes that may decrease the sensitivity of the ear canal to caloric stimulation on that side. [20, 31]

Bone conduction VEMP:

It is possible that the cVEMP response will not be detected if there is a hearing loss due to defect in conduction pathway and the difference in sound transmission between the air and bone routes is more than 20 dB.[25]

Individuals with chronic otitis media may utilize BC stimulation as an alternative to the stimulating sound in order to enhance the VEMP test response rate. In contrast, the outcomes of the VEMP test can offer insights into the operation of the inferior vestibular nerve, saccule, and posterior semicircular canal. [32]

All cases of chronic suppurative otitis media (CSOM) and the control group have shown preserved bone conduction vestibular evoked myogenic potentials (VEMP) in the present study (Table 2).

Patients diagnosed with CSOM exhibited normal bilateral interaural attenuation difference (IAAD), normal amplitude, and normal latency.

The present investigation found no statistically significant disparity in the latencies of P1 and N1, as well as the amplitude of P1-N1, between the cases with chronic suppurative otitis media (CSOM) and the intact ear of the control group. This suggests that middle ear problems did not have an impact on bone-conducted VEMP, making it a potentially useful tool for patients of chronic suppurative otitis media (CSOM).

The current experiment determined the average values for the bone conduction vestibular evoked myogenic potential (VEMP) parameters in both groups:

In CSOM patients, the bone conduction cVEMP response was measured at P1 latency = 16.06 ± 1.14 msec, N1 latency = 24.32 ± 2.07 msec, P1-N1 amplitude = 62.21 ± 9.96 uV, and IAAD = 0.09 ± 0.06, and in control group was measured at P1 latency = 15.77±1.14 msec, N1 latency = 24.92 ± 1.83 msec, P1-N1 amplitude = 63.15 ± 10.52 uV, and IAAD = 0.16 ± 0.19. This agreed with Shabana et al., 100% of bone cVEMP responses were detected in CSOM. By using vibrator B71, they used BC stimuli 1000 Hz tone bursts at level 60 dB nHL. They did not find any statistically significant differences between the ears of the CSOM and the controls with regard to P13, N1 latencies, or P1-N1 amplitude. [33]

This was in line with Seo et al.,[34], The study showed that both the CSOM group and their control group were able to measure the bone conduction cVEMP response. The average delay for the P1 wave was 15.6 ms (standard deviation of 2.0), and the average latency for the N1 wave was 23.6 ms (standard deviation of 2.1). The upper limit of the normal range for IAR was established as 40.7%, with a mean IAR of 16.59% (standard deviation 12.1).

Seo et al., [34] It was found that there was no difference in the peak-to-peak amplitude of the bone conduction VEMP and the average latency of the P1 and N1 waves between the ears affected by COM and the unaffected ears.

The integrity of the cochlear and vestibular afferents is probably required to elicit these reactions from the sternocleidomastoid (SCM) muscle. The presence of either blockage in the external ear canal or changes in the middle ear did not eliminate or weaken the evoked responses in cases of conductive hearing loss. [35] Vestibular Evoked Myogenic Potentials (VEMPs) have been observed when bone conduction stimuli are used in cases of conductive hearing loss. This can occur when there is either blockage of the external ear canal or changes in the middle ear. However, these conditions do not eliminate or weaken the elicited responses. [35]

The video head impulse test has numerous benefits for assessing the vestibular function of persons with chronic suppurative otitis media (CSOM). [36] Due to its easily verifiable nature, this test is neither affected by the existence of conductive or mixed hearing loss, nor by the age of the patient. [37] In comparison to the air caloric test, the vHIT has several advantages. It enables the individual study of the vestibuloocular reflex (VOR) for each semicircular canal (SCC), whereas the caloric test only evaluates the horizontal SCC. Additionally, the caloric test only captures low-frequency responses.

The ongoing analysis has found that there is no statistically significant disparity in the anterior, posterior, and average VOR gain and lateral SCCs between the groups of patients and controls (Table 3).

The average VOR gain of the SCCs showed no significant differences ($p > 0.05$) between the groups or among the different canals in the present investigation.

The obtained average was within the normal range in all examined canals, including the group with chronic suppurative otitis media (CSOM).

The CSOM subgroup and the control group did not significantly differ in VOR gain, according to the research done by Monsanto et al. However, 23% of the individuals exhibited abnormal vHIT results due to the presence of cholesteatoma. Specifically, four cases showed incorrect results in the posterior canal, while five cases showed abnormal results in the lateral canal. Two participants exhibited overt saccades, which were also noticed in the clinical HIT test. In four cases, the saccades recorded in the lateral canals were classified as covert, while in two cases they were classified as overt. None of the volunteers in the control group showed any abnormal video-HIT results. [8]

Tomaz et al., [14] However, it was found that all subgroups of COM had a higher occurrence of corrective eye movements (ranging from 4.6% to 18.1%) compared to the control group. When analyzing the COM subgroups individually, Eye movements were shown to occur much more frequently in the CSOM and cholesteatomatous groups than in the CNSOM group ($p = 0.004$). In every examined canal, including the COM groups, the average VOR gain of the SCCs was discovered to be within the normal range. While no significant changes were identified in other comparisons between groups or various canals ($p > 0.05$), there was a statistical difference in the mean values obtained in the anterior SCC between the cholesteatomatous and control groups. Even though there were no changes in the absolute values of the VOR mean in the COM groups, certain findings imply that COM can induce noticeable alterations in the video head impulse test in some COM patients. The most notable changes among them are as follows: (1) Patients with COM displayed elevated levels of variability and asymmetry in their VOR gain outcomes compared to the control group; (2) In comparison to normative data, the COM group showed a larger frequency of gain variations; and (3) the COM group showed a higher incidence of corrective saccades, which are linked to a lower VOR gain, in comparison to the control group. The disparity may be ascribed to the patients with CSOM who did not satisfy our exclusion criteria and exhibited middle ear tissue abnormalities that were clinically refractory (such as tympanosclerosis, granulation tissue, cholesterol granuloma, fibrosis, erosion of the bone or ossicles, cholesteatoma).

Thus, even when compensatory saccades are absent, the results can still indicate potential alterations in the function of the semicircular canals (SCCs) related to chronic suppurative otitis media (CSOM). However, there is currently no experimental study in the existing literature that provides evidence to support the theory that chronic otitis media (COM) directly harms the peripheral vestibular system, specifically the SCCs. Nevertheless, the findings do support the notion that changes in SCC function can occur as a result of COM, even in cases where corrective saccades are not observed. Nevertheless, when examining temporal bones affected by COM, histological investigations indicated a noteworthy decrease in the concentration of type I hairy cells in the saccule and utricle macules, as well as type II hairy cells compared to the control group in the lateral and posterior semicircular canals' ampullary crests. [2-3,27]

The results of the video head impulse test in patients with COM have not been thoroughly studied in the literature. [1]

D'Albora et al., [38] found that three patients with horizontal SCC fistulas owing to chronic suppurative otitis media (CSOM) underwent a bedside head impulse test in a case study. The presence of the fistulas was confirmed using radiological and surgical means, and the test revealed symptoms of refixation saccades. Two of these patients underwent a video head impulse test, which revealed a reduction in the vestibulo-ocular reflex (VOR) gain along with the presence of both overt and covert saccades.

Covelli et al., [39] reported that the authors of their study used the video head impulse test to assess the function of the lateral semicircular canal (SCC) in eight patients with cholesteatoma and chronic otitis media (COM) with labyrinthine fistula. They found that in 62.5% of the cases, the preoperative exam showed normal vestibuloocular reflex (VOR) gain. The authors hypothesized that if there is no toxic impact or other comorbid condition, the basic exposure of the labyrinth due to bone erosion does not cause functional impairment. Additionally, they stated that although there was no statistical validation, the small sample size allowed for useful information about vestibular function in cases of lateral SCC fistula and assisted in gathering preoperative data on SCC function in cases with minimal symptoms and negative non-instrumental signs.

The current study utilized vHIT to conduct a comparative analysis between the CSOM group and the control group. The results showed that the mean VOR gain of the SCCs fell within the typical range for both groups. Additionally, VNG testing revealed that most patients with CSOM safe type experienced positional nystagmus, while 6.7% of patients showed calorie abnormalities. However, all patients maintained preserved BC VEMP.

The current study is subject to constraints due to the implementation of highly tight exclusion criteria, resulting in a reduced number of participants in the study. Nevertheless, it was imperative to minimize any biases to maintain the integrity of the objective, thus necessitating the application of these criteria.

The VNG test battery exhibited anomalous results when compared to the vHIT and BC cVEMP tests in the present investigation. The reason for this is that the cervical vestibular evoked myogenic potential (cVEMP) evaluates the otolith organs, while the video head impulse test (vHIT) evaluates the entire semicircular canals (SCCs) at a high frequency. On the other hand, the caloric test only provides information on the low frequency response of the lateral SCC. VNG appears to have a higher sensitivity in diagnosing chronic peripheral vestibular lesions.

In addition, the high frequency VOR evaluation conducted by vHIT only assesses type I hair cells. It is likely that type II hair cells experience more damage, which is not detected by vHIT. [40]

Another constraint of the video head impulse test is its limited ability to detect compensated or chronic vestibular disorders, despite being unaffected by middle ear issues and conductive or mixed hearing loss. [36-37]

Conclusion

The current study observed a significant number of individuals with chronic suppurative otitis media (CSOM) who reported vestibular symptoms. Within the VNG test battery, two patients exhibited notable post head shaking nystagmus, two patients had positional nystagmus, and two patients indicated caloric weakening on the same side as their chronic suppurative otitis media (CSOM) condition within the study group. Bone conduction cervical vestibular evoked myogenic potentials (cVEMPs) were detected in all patients with chronic suppurative otitis media (CSOM) utilizing B81.VNG is a reliable test, it appears to be an effective tool for diagnosing chronic vestibular lesions.

Patients with chronic suppurative otitis media (CSOM) are advised to undergo vestibular examination, particularly when being prepared for surgery in advance. It is advisable to conduct a comprehensive examination of vestibular function in a significant number of patients, while broadening the inclusion criteria to encompass the dangerous kind. Additional evaluation is required to compare the sensitivity of VNG, vHIT, and ocular VEMP in detecting chronic vestibular lesions.

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Conflicts of interest: None.

Ethical approval and consent to participate: The study was conducted in accordance with Helisinki standards for human studies and ARRIVE standards for studies. Un informed written consent was obtained from patients or their relatives. The study was approved by Ethical committee of the Faculty of Medicine, Assuit University, Egypt with IRP local approval number 17101495.

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