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Audiological Evaluation and Cochlear Reserve in Posterior Canal Benign Paroxysmal Positional Vertigo

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ABSTRACT

Background: Benign paroxysmal positional vertigo (BPPV) is a peripheral vestibular disorder affecting the semicircular canal (SCC). It is important to determine the potential contribution of posterior canal BPPV (PC-BPPV) to function of cochlear outer hair cells, by application of Otoacoustic emission (DPOAE and TEOAE) and to investigate changes of pure tone audiometry (PTA) thresholds in patients suffering from PC-BPPV.

Objective: This study aimed to assess the audiological and cochlear reserve in PC-BPPV.

Patients and Methods: This prospective study involved twenty patients with PC-BPPV. All patients in this study were evaluated by the Dix Hallpike test. Basic audiological evaluations included pure tone audiometry (PTA), immittancemetry and otoacoustic emissions audiometry (OEA), which included transient-evoked otoacoustic emissions (TEOAE) and distortion product otoacoustic emissions (DPOAE).

Results: There was a significant positive correlation between age and pure tone audiometry (PTA), which increased by increase of the age in the studied PC-BPPV patients. Also, there was a significant negative relationship only between DPOAE (1 KHz) and PTA (1 KHz) but DPOA at 2, 4, and 8 KHz revealed statistically non-significant difference at all other OAE PTA.

Conclusion: We concluded that as the age increased, a statistically significant threshold increased at high frequencies (4000 to 8000 Hz) suggestive of presbycusis. Considering the correlation between PTA and DPOAE, we concluded that otoacoustic emissions could be a complementary modality for the detection and control of hearing abilities.

Keywords: BPPV, Posterior semicircular canal, Vertebrobasilar insufficiency, Immitancemetry, Otoacoustic emissions.

INTRODUCTION

Benign paroxysmal positional vertigo (BPPV) is a peripheral vestibular disorder affecting the semicircular canal (SCC) commonly but not solely the posterior canal SCC (PC-SCC). Affection of the lateral SCC (LSCC) and superior SCC (SSCC) frequently occurs too. BPPV, with its distinctive, short-duration vertigo and associated nystagmus is elicited by provocative head motion in relation to gravity, occasionally lying down. In fact, when the patient gives a previous history of the word “bed”, the examiner has to take into consideration BPPV. It is of great significance to note that up to 1/3 of cases could be presented with an unusual history; as a result entire vague cases must undergo provocative positioning. Despite the site of lesion being in the end-organ, BPPV isn’t accompanied by impaired hearing or tinnitus; nor are there disturbing neurologic manifestations [1].

The mechanism of detached otoconia isn’t totally identified. It appears that inner ear diseases which detaches otoconia and yet doesn’t affect SCC functions could be accompanied by secondary BPPV. It has been demonstrated that the most common diseases accompanied by secondary BPPV are head traumas, vestibular neuritis, Meniere's disease, and postoperative. The remaining disorders which affect the inner ear and are included in the pathogenesis of secondary BPPV are sensorineural hearing loss and migraine. Preferably, for an etiological correlation to be evident, BPPV has to be on the same side to the accompanying condition and manifestations have to develop simultaneously or following the development of the original disease. In certain cases, it isn’t obvious whether there exists a true contributing effect or there is an accidental relationship. In the majority of cases with BPPV, a direct correlation with an ipsilateral disease process affecting the labyrinth cannot be recognized and idiopathic BPPV is still the commonest diagnosis [2].

With regard to the cause of BPPV, it could be classified into primary BPPV that happens in a spontaneous manner. Of note, there are certain predisposing factors which could increase its incidence including old age, osteoporosis, vitamin D insufficiency, and vertebrobasilar insufficiency. Secondary BPPV occurs in addition to ear diseases, which include Meniere’s disease, vestibular neuritis, vascular and otosclerosis, chronic suppurative otitis media, or after ear surgeries. Post-traumatic BPPV occurs when the symptoms develop within three days after traumatic head injury. Of note, trivial head traumas, which include domestic traumas and could stimulate otoconial detachment, which ultimately ends in BPPV development [3].

Till now, fewer research emphasized on secondary BPPV, that might be considered as an underdiagnosed entity. In spite of the clear similarities, changes between the clinical features and the outcomes of repositioning approaches between the numerous forms of secondary and idiopathic BPPV appear to dictate various diagnostic, counseling, management, and follow-up planes. **Ibekwe and Rogers** [1] highlighted the co-existence of BPPV with several pathological conditions, which also are known to be accompanied by dizziness. In such patients, BPPV is frequently underdiagnosed, as

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dizziness is related to the original pathological condition.

Conventional pure tone audiometry is a test used to diagnose hearing loss. Distortion product OAE are objective tests utilized to evaluate the activity of the outer hair cells, it can detect compromised cochlear function in the lack of audiometric hearing loss [4]. It is important to detect the potential contribution of posterior canal BPPV to function of cochlear outer hair cells, by application of Otoacoustic emission (DPOAE and TEOAE) and to investigate changes of PTA thresholds (PTT) in patients suffering from posterior canal BPPV [5].

This work aimed to assess the audiological and cochlear reserve in posterior canal BPPV.

PATIENTS AND METHODS

This prospective study involved twenty patients with PC-BPPV. They were collected from the Audio-vestibular Unit, ENT Department, Faculty of Medicine, Mansoura University through the period from April 2022 to April 2023.

Inclusion criteria: Adult patients aged more than 18 years old diagnosed with posterior canal BPPV by Dix–Hallpike test, and didn't have ENT surgical intervention.

Exclusion criteria: Patients with age below 18 years, with spontaneous nystagmus, with positive manifestations concerning lateral or anterior canal BPPV, with ototoxic drug use, with neurologic diseases, with poor neck range of motion, with autoimmune diseases or immunodeficiency syndrome and blind patients.

Methods: Every patient was subjected to personal history (age, sex, residence and occupation), full audiological history, present history (analysis of complaint, onset, duration of the disease, and progression of the disease) and past history (previous medical illness, previous ocular or audiological disorders, and previous medication). All patients in this study were evaluated by the Dix Hallpike test. Every patient had bilateral otoscopy to confirm the patency of external acoustic meatus to confirm valid PTA and OAE measurements. Basic audiological evaluations included PTA, immitancemetry and OAE. OAE included TEOAE and DPOAE.

Ethical approval: Mansoura Faculty of Medicine Medical Ethics Committee gave its approval to this study. All participants gave written consents after receiving all information. The Helsinki Declaration was followed throughout the study's conduct.

Statistical Analysis

Data analysis was conducted by SPSS software, version 25 (PASW statistics for windows, Chicago, SPSS Inc.). Qualitative data were expressed utilizing number and percent. Quantitative data were expressed utilizing median for non-normal distribution of data and mean ± SD for normal distribution of data following testing normality by utilizing Kolmogorov-Smirnov test. The significance of the acquired results was judged at $P \leq 0.05$ level.

RESULTS

This was a non-randomized, prospective case series study that was conducted on 20 consecutive adult patients with posterior canal BPPV. They were 8 males (40%) and 12 females (60%). Diagnosis by Dix-Hallpike test found 12 right sided (60%) and 8 left sided lesion (40%). The age of patients ranged from 40 to 72 years with a mean of 55.45 ± 10.08 years, the mean ages of males and females were matched (58.88 ± 11.79 years and 53.17 ± 8.53 years respectively) (Table 1).

Table (1): Distribution of age, sex and laterality of the studied patients

Variables	Males		Females		Total	
	No.	%	No.	%	No.	%
Sex	8	40	12	60	20	100
Dix-Hallpike test	Right		Left		Total	
Laterality	12	60	8	40	20	100
Age	Min	Max	Min	Max	Min	Max
Range (years)	40	70	42	72	40	72
Mean ±SD (years)	58.88 ± 11.79		53.17 ± 8.53		55.45 ± 10.0	

Pure tone audiometry was done to all patients at 250, 500, 1000, 2000, 4000, and 8000 Hz, the means of dB ± SD were 22 ± 2.99, 22 ± 3.77, 22.5 ± 6.18, 22.25 ± 12.72, 26 ± 11.77 and 33.75 ± 19.53 dB, respectively (Table 2).

Table (2): Pure tone audiometry (PTA) of the studied patients

PTA (Hertz)	Range	Mean ±SD
250	15 – 25	22.00 ± 2.99
500	15 – 30	22.00 ± 3.77
1000	15 – 40	22.5 ± 6.177
2000	15 – 65	22.25 ± 12.72
4000	15 – 70	26.00 ± 11.77
8000	15 – 90	33.75 ± 19.53

Otoacoustic emission (OAE) distribution of the studied patients by DPOAE was absent in 4 cases (20%), passed in 3 patients (15%) and partially passed in 13 cases (65%) (Table 3).

Table (3): Distribution of otoacoustic emission of the studied patients

OAE	DPOAE	
	No.	%
Absent	4	20
Passed	3	15
Partially passed	13	65
Total	20	100

Otoacoustic emission of the studied patients by DPOAE were 3.790 ± 7.08, 6.065 ± 5.27, 4.872 ± 8.42, and 1.840 ± 5.96 at 1, 2, 4, and 8 KHz, respectively (Table 4).

Table (4): Otoacoustic emissions (OAE) of the studied patients

OAE	Range	Mean ±SD
1 KHz	-10 – 15.3	3.790 ± 7.08
2 KHz	0.3 – 16.3	6.065 ± 5.27
4 KHz	-3.5 – 20.4	4.872 ± 8.42
8 KHz	-6.0 – 10.0	1.840 ± 5.96

Table (5) showed a significant positive correlation between age and pure tone audiometry, as PTA increased by increase of the age in the studied PC-BPPV patients. Correlation coefficient (r) and regression analysis between age of patients and pure tone audiometry at 250 Hz, demonstrated a significant weak positive correlation (r=0.2218, p = 0.042), at 500 Hz revealed a significant positive correlation (r=0.4184, p=0.009), at 1000 Hz revealed a significant positive correlation (r = 0.4164, p=0.009), at 2000 Hz revealed a significant positive correlation (r = 0.5255, p = 0.007), at 4000 Hz revealed a significant positive correlation (r=0.5288, p=0.007) and at 8000 Hz revealed a significant positive correlation (r = 0.6678, p = 0.004).

Table (5): Correlation coefficient (r) between age of the patients and pure tone audiometry

PTA (Hz)	Correlation (r)	P value
250	0.2218	0.042*
500	0.4184	0.009*
1000	0.4164	0.009*
2000	0.5255	0.007*
4000	0.5288	0.007
8000	0.6678	0.005*

Table (6) summarizes the correlation between DPOAE and PTA and revealed there was a significant negative correlation only between DPOAE (1 KHz) and PTA (1 KHz). On the other hand, DPOA at 2, 4, and 8 KHz revealed statistically non-significant difference at all other OAE PTA.

Table (6): Correlation coefficient (r) between DPOAE and OAE in different pure tone audiometry

Distortion-product OAE (DPOAE)								
PTA	1 KHz		2 KHz		4 KHz		8 KHz	
OAE	r	p	r	p	r	p	r	p
1 KHz	-0.277	0.045*						
2 KHz			-0.221	0.056				
4 KHz					-0.001	0.959		
8 KHz							0.068	0.082

PTA: Pure tone audiometry, OAE: otoacoustic emission, r: correlation coefficient, P: probability of error (significance), *p <0.05: significant.

DISCUSSION

BPPV is featured by vertigo paroxysms stimulated by head movement in the direction of gravity [6].

It could be explained by migration of degenerated otoconia to the SCC, making them of great sensitivity to head movement. Additionally, it has been considered as the commonest etiology of dizziness and vertigo globally [7, 8].

In this study, we compared hearing level detected by two methods (conventional audiometry and OAE) in cases with unilateral PC-BPPV. There were no studies that mentioned cochlear affection in cases with BPPV. This study was conducted on 20 successive adult cases with PC-BPPV. They were 8 males (40%) and 12 females (60%). Diagnosis by Dix-Hallpike test found 12 right sided (60%) and 8 left sided lesions (40%).

The age of patients ranged from 40 to 72 years with a mean of 55.45 ± 10.08 years and the mean ages of males and females were matched (58.88 ± 11.79 years and 53.17 ± 8.53 years respectively). PTA was done to all patients at 250, 500, 1000, 2000, 4000, and 8000 Hz, the means of dB ± SD were 22 ± 2.99, 22 ± 3.77, 22.5 ± 6.18, 22.25 ± 12.72, 26 ± 11.77 and 33.75 ± 19.53 dB respectively. Our study is the first study to use OAE as an investigating tool for BPPV. OAE of the studied patients by DPOAE revealed absence in 4 cases (20%), passed in 3 patients (15%) and partially passed in 13 cases (65%), while by TEOAE it was absent in 5 cases (25%), passed in 4 patients (20%) and partially passed in 11 cases (55%). Statistically there was no significant difference between the two tests (p >0.05).

Then distortion product OAE amplitudes were compared with PTA thresholds at matched frequencies with no evidence of a strong correlation was apparent. This agrees with **Wooles *et al***. [9] who studied sixteen separate PTA thresholds that were compared with distortion product OAE amplitudes and an association of such measurements was conducted where increased PTA threshold was recognized in thirteen out of sixteen individual. When distortion product OAE amplitudes were compared with PTT at matched frequencies, no evidence of a robust relationship was apparent.

In addition, 7 out of 16 individuals had considerable distortion product OAE with increased PTT.

Our study demonstrated that there was a significant positive association between age and PTA, as PTA increases by increase of the age in the studied PC-BPPV cases.

This agrees with **Lee *et al.*** [10] who studied 188 older individual's (91 females, 97 males) in which the mean rate of change in thresholds was 0.7 dB per year at 0.25kHz, increasing in a gradual manner to 1.2 dB annually at 8 kHz and 1.23 dB annually at 12 kHz. The degree of change for thresholds increased significantly with age, at 0.25 to three, ten, and eleven kHz for females and at six kHz for males. Women were commonly affected in our study. This agrees with **von Brevern *et al.*** [11] and **Imai *et al.*** [12] who studied 20 cases with PC-BPPV (seven men and 13 women, 48–88 years old with median age of 69 years, right ear was affected in 11 and left ear was affected in nine).

CONCLUSION

We concluded that as the age increased, a statistically significant threshold increased at high frequencies (4000 to 8000 Hz) suggestive of presbycusis. There was no statistically significant difference observed between hearing thresholds and the presence of PC-BPPV. Considering the correlation between PTA and DPOAE, we concluded that OAE could be a complementary tool for the detection and control of hearing abilities.

Conflict of Interest: None.
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