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The relationship between presbycusis and vestibular activity

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Abstract

Introduction

Presbycusis or age-related sensorineural hearing loss (SNHL) is a complex disorder that results in a slow deterioration in auditory function. A considerably high number of these patients with presbycusis or age-related SNHL also experience dizziness and related vestibular symptoms. Although auditory and vestibular systems are distinct, they work just alike. So, there is a great relation among their functions. Once one is stimulated, the other experiences changes as well.

Participants and methods

This study comprised 40 adult patients (50–75 years) without any vestibular symptoms or diagnosed vestibular diseases. Audiological status was measured with auditory brainstem response (ABR). The vestibular system was assessed using videonystagmography test battery, sensory organization test, and vestibular evoked myogenic potential (VEMP). 'Get up and go' test was used as a quick screening tool for detecting balance problems. Patients were divided into two groups: a study group (patients with SNHL) and a control group (patients without SNHL). ABR and VEMP results of the groups were calculated and compared.

Results

Absolute peak latencies of ABR waves I, III, and V were prolonged in the study group than the control group ($P < 0.0001$). VEMP results showed that P13 and N23 latencies were prolonged in the study group when compared with the control group ($P < 0.0001$).

Conclusion

Thorough full examination of the vestibular system, in conjunction with auditory functions in elderly persons, is recommended. This may help to discover their subclinical vestibular problem and guide physicians to design a suitable treatment plan that helps in decreasing risk of falls for aged persons.

Keywords: Presbycusis, vestibular, videonystagmography, vestibular evoked

Introduction

Presbycusis or age-related sensorineural hearing loss (ARSNHL) is a complex phenomenon consisting of elevation of the hearing levels as well as changes in the auditory processing. Although many adults keep good hearing as they age, hearing loss associated with ageing is common among elderly persons. Presbycusis or ARSNHL is especially caused by cochlear degeneration, most pronounced in the basal cochlear coil [1]. Presbycusis is a complex disorder that results in a slow deterioration in auditory function [2]. A considerable high number of these patients with ARSNHL also have dizziness and related vestibular symptoms. Although auditory and vestibular systems are distinct, they work just alike. So, there is a great relation among their functions. Once one is stimulated, the other experiences changes as well [3]. Many patients present to otolaryngology clinics with dizziness and hearing loss problems with no obvious pathology and are diagnosed with presbycusis or age-related vestibulopathy. A relationship is therefore highly possible between ARSNHL and vestibular dysfunction, in the absence of evidences of any inner ear or systemic diseases that could cause vestibular dysfunction [4]. The auditory brainstem response (ABR) is an objective electrophysiological method for assessing the auditory pathways from the auditory nerve to the brainstem [5]. ABR is a valuable tool in the

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standard clinical test battery in audiology in understanding the auditory brainstem. It is used for estimating the auditory sensitivity in patients with presbycusis [6]. Traditional videonystagmography (VNG) can evaluate occulomotor test battery and function of semicircular canals but not the utricle and saccule. Vestibular evoked myogenic potential (VEMP) presents a viable means to evaluate integrity of saccule and inferior vestibular nerve [7]. The saccule and cochlea develop from the same embryological origin in the membranous labyrinth, which is innervated by the inferior portion of the vestibular nerve. Pathologies affecting cochlea of the inner ear may therefore cause a dysfunction in the saccule as they have the same embryological origin. Computerized dynamic posturography (CDP) is a measure for the effective use of sensory cues (somatosensory, visual, and vestibular) to maintain balance and postural control. Although less specific than electronystagmography, CDP provides more global insight into a patient's ability to maintain equilibrium under more challenging environmental circumstances. This study aims to evaluate the relationship between the substructures of the vestibular system and the hearing system with the same embryological origin in persons with ARSNHL or presbycusis after excluding vestibular affection by VNG and sensory organization test (SOT). This was done by examining the saccule as a part of the vestibular system using VEMP and cochlea and auditory pathway using ABR.

Participants and methods

Participants

An informed consent was obtained from all subjects. Every participant in the study was examined bilaterally and each group consisted of 40 ears. Participants in this study were divided into two groups. The study group consisted of 20 patients with age range from 50–75 years diagnosed with bilateral mild to moderate sensorineural hearing loss (SNHL). A control group consisted of 20 healthy individuals with normal hearing of same age group. Patients with mixed types of hearing loss, perforated tympanic membrane, any vascular or neurological diseases, and confirmed peripheral or central vestibular diseases were excluded.

Equipment:

a) A two Channel Audiometer (Interacoustics, model AC40) with air & bone conduction facilities; Denmark.
b) Sound treated room (I.A.C model 1602); USA-North Aurora.
c) Middle ear analyzer (Impedance Audiometer Interacoustic AZ26); Denmark.
d) ABR was evaluated using Audera GSI, USA, Eden Prairie.
e) A videonystagmography (VNG) test using Interface controller 2000; USA, Torrance, CA.
f) VEMP was evaluated using Computerized Four-Channel Evoked Potential System Biologic model Navigator; Denmark.

Methods

All participants in this study were subjected to the following:

(1) Full history taking regarding any vestibular symptoms and hearing complaints
(2) Otological examination
(3) Basic audiological evaluation in the form of the following
    (a) Pure tone audiometry
        (i) Air conduction thresholds were tested at the following frequencies of 0.25, 0.5, 1, 2, 4, and 8 kHz
        (ii) Bone conduction thresholds at the following frequencies: 0.5, 1, 2, and 4 kHz.

A pure tone threshold in the range of 26–40 was considered mild SNHL, whereas threshold in the range of 41–60 dB HL was considered as moderate SNHL.

    (b) Acoustic immittancemetry testing: it included tympanometry and acoustic reflex threshold measurements
(4) ABR responses to rarefaction acoustic clicks were used as the acoustic stimulus; at rate of 21.4 clicks/s were delivered through monaural insertion earphones at an intensity of 90 dBnHL, total number of stimuli are 1000. Absolute latencies for waves I, III, and V and interpeak latencies (IPLs) I–III, III–V, and I–V were recorded for each participant and compared for both the groups
(5) VNG test battery using videogoggle was conducted for all participants in the study, searching for spontaneous, gaze evoked, positional, and positioning nystagmus. Oculomotor test battery included saccade. Eye tracking and optokinetic tests were done. Moreover, bithermal caloric test was performed
(6) Saccular function was tested by VEMP which was recorded from the sternocleidomastoid muscle (SCM). Active electrode was placed on the upper third of each SCM with a reference on the lateral end of the upper sternum, whereas the common electrode was placed on the forehead. During the test, the patient is instructed to turn his/her head toward the contralateral side of the tested ear to activate SCM. Stimuli were presented mono-aurally using monaural insertion earphones; rarefaction acoustic clicks were presented at a rate of 5 pulses per second and an intensity of 90 dBnHL with a window of 100 ms. The response to 200 stimuli was averaged twice, and the latencies of VEMP of waves P13 and N23 were measured for each participant and compared for both groups
(8) 'Get up and go' test: This is a quick screening tool for detecting balance problems. It requires the patient to stand up from a chair, walk 3 m, and turn around, return, and sits down again. Patients without neurological impairment who are independent with normal balance and mobility skills are able to perform the test in less than 10 s. Patients who take longer than 30 s to complete the test have been found to be dependent for most activities of daily living

and mobility skills [8]. An informed consent was obtained from all participants.

Every participant in the study was examined bilaterally, and results from both sides are added together. So, each group consisted of 40 ears.

Statistical methods

IBM SPSS statistics (version 23.0; IBM Corp., Armonk, New York, USA) was used for data analysis. Data were expressed as mean ± SD for quantitative measures. Comparison between two participant groups was done using Student's *t*-test. The probability of error (*P*) was considered as follows: *P* value more than 0.05 is nonsignificant, *P* value less than 0.05, significant, and *P* value less than 0.01 is highly significant.

Results

The mean age in the study group was 66.2 years, while it was 65.2 in the control group ($P > 0.05$). Mean PTA value was 20.71dB (min---max 10---25) in the control group and was 35.53 dB (min---max 31---60) in the study group ($P < 0.05$). All participants in control group had bilateral speech discrimination scores in the range of (88-100%) with Mean 97.7 and SD 3.9 and type (A) tympanogramindicating normal middle ear pressure and acoustic reflex threshold were within normal. Patients in study group had bilateral speech discrimination scores in the range of (72-84%) with the mean 75.3 and SD 3.2 and type (A) tympanogram indicating normal middle ear pressure and acoustic reflex threshold are preserved at 250Hz,500HZ, 1000Hz but lost at 4000Hz in some cases. ABR results showed that absolute peak latencies of wave I, III & V were prolonged in study group than control group and this prolongation was highly statistically significant. Also IPLs were prolonged in study group than control group but this prolongation is not statistically significant as shown in Table 1 and Fig. 1. VNG results, all participants showed normal occulomotor test battery, no positional or positioning nystagmus and normal caloric results. VEMP results showed that P13and N 23 latencies were prolonged in the study group when compared to the control group and this prolongation was highly statistically significant, also amplitude P13-N23was reduced in study group in comparison to the control group and this reduction was highly statistically significant as shown in Table 2 and Fig. 2. Normal Get up & go test; all participants were able to perform the test in the range between10-28 seconds.

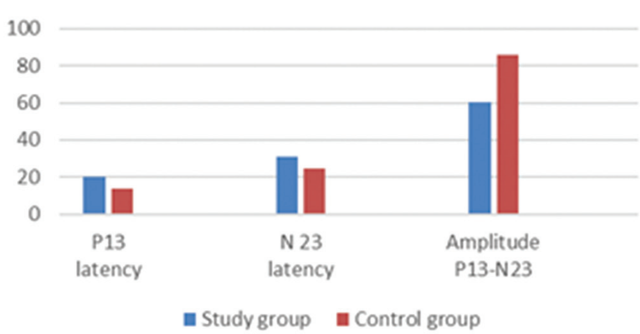

Figure 1: Comparison between absolute and interpeak auditory brainstem response latencies in the study and control groups. IPL, interpeak latency; PL, peak latency.

Discussion

The mechanism of interaction between auditory and vestibular system is not clear. There is a great relation among their functions. Once one is stimulated, the other experiences changes as well. There is a complex relationship between ARSNHL or presbycusis and vestibular system function. On an embryological basis, the saccule and cochlea develop from the same origin in the membranous labyrinth; this is innervated by the inferior portion of the vestibular nerve [3]. Although many patients with ARSNHL or presbycusis have vestibular dysfunction, the cause is not known whether it is owing to age-related changes in central nervous system or because of an association with presbycusis [4]. In this study, patients with presbycusis or ARSNHL were selected carefully to eliminate

Table 1: Comparison between absolute and interpeak auditory brainstem response latencies in study and control groups

	Study group	Control group	*F*	*P*
Wave I PL				
Mean	1.67	1.29	226.9	<0.001***
SD	0.04	0.02		
Wave III PL				
Mean	3.90	3.74	252.3	<0.001***
SD	0.05	0.04		
Wave V PL				
Mean	5.99	5.71	247.6	<0.001***
SD	0.10	0.05		
IPL I-III				
Mean	2.37	2.35	0.27	0.604
SD	0.03	0.03		
IPL III-V				
Mean	1.98	1.95	2.1	0.156
SD	0.04	0.02		
IPL I-V				
Mean	4.35	4.31	0.2	0.647
SD	0.02	0.03		

IPL, interpeak latency; PL, peak latency. ****P* < 0.01=HS, **P < 0.05=S, P > 0.05=NS.*

Table 2: Comparison between P13 and N23 latencies in study and control groups

	Study group	Control group	*F*	*P*
P13 latency	20.27	13.68	685.9	<0.001***
Mean	1.47	0.61		
SD				
N23 latency	31.2	24.47	174.9	<0.001***
Mean				
SD	3.06	1.11		

P<0.05 *Significant (S) and *P* < 0.01, ***Highly significant (HS).

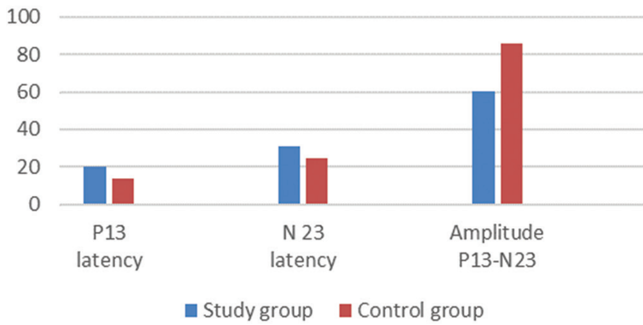

Figure 2: Comparison between P 13 and N 23 latencies in study & control groups.

any possible factors that cause vestibular dysfunction. This was done by taking full history about any vestibular symptoms and confirmed by normal VNG results, and normal Get up & go test. Results of ABR from both groups (Table 1) showed that absolute peak latencies of wave I, III & V were prolonged in study group than control group and this prolongation was highly statistically significant. This latency shift may be due to a peripheral mechanism producing a partial delay and desynchronization of the normal discharge. Khullar & Babbar, [6] reported same results and they attributed this shift in absolute latencies to high frequency hearing loss, as the peak of basilar membrane motion occurs at a point of hair cell loss. Thus hair cells located apically to the peak of membrane motion respond to the signal, resulting in an increase in response latency. Otto *et al* [9] concluded that when advanced age and high frequency hearing loss interact, high-frequency hearing loss is the greater factor in morphologic and latency changes. They indicated that the hearing impairment in the aged is probably due not only to changes in the end organ but also to brainstem changes but changes in the end organ have the upper hand in morphologic and latency changes. IPLs were prolonged in study group but this prolongation is not statistically significant. Similar results were obtained by Boettcher [10] as he did not find any interpeak latency abnormalities in older adults with normal hearing. Many authors examined patients with presbycusis or ARSNHL to identify possible changes in the auditory periphery. They stated that absolute latencies of ABR waves tend to increase with increasing age with no changes for IPLs [11]. On the other hand, Mazelova *et al* [12]compared the hearing abilities of a group of 30 elderly (67-93 years of age) subjects were compared with those of a group of 30 young (19-27 years of age) normal hearing volunteers to characterize the changes in the peripheral and central parts of the auditory system. They concluded that prsbycusis or ARSNHL represents a combination of deteriorated function of the auditory periphery with deteriorated function of the central auditory system. This variability is most probably related to age difference in each study. Regarding VEMP results table (2) showed that P13 and N 23 latencies were significantly prolonged in the study group when compared to the control group, also amplitude P13-N23 was reduced in study group in comparison to the control group and this reduction was highly statistically significant($P < 0.001$). This may be due to association of a subclinical peripheral vestibular deficit in the patients with ARSNHL or presbycusis, although there are no any possible obvious factors for vestibular pathologies. As posture control is mostly dominated by vestibulo-spinal tract that is executed mainly through otolith (utricle and saccule), this may put these patients in risk for fall although they record normal Get up & go test. This may be due to the alteration in the transduction of linear acceleration forces including gravity. The otolith then provides erroneous information for the control of posture, for the eye-head coordination as well as the sensation of upright posture [13]. Similar results obtained by Kurtarana *et al* [4] as they stated that pathologies affecting one part of the inner ear may cause a dysfunction in the parts with the same embryological origin. They concluded that ARSNHL or presbycusis may be accompanied by vestibular weakness without any possible predisposing factors for vestibulopathy. Santos *et al* [3] found that congenitally severe hearing loss can cause a great vestibular disturbance in children. They stated that disturb in auditory system can cause a big damage in the vestibular system as both systems have a close relationship. The weak point of this study is the complex and variable effect of aging on inner ear organs and its blood supply. Thus further studies with larger number of patients and different age groups will expand awareness for this issue.

Conclusion

Although auditory and vestibular systems are distinct, there is a great relation among their functions. So thorough full examination of the vestibular system, in conjunction with auditory functions in elderly persons is recommended especially those with ARSNHL or presbycusis. This may help to discover their subclinical vestibular problem and guide physicians to design a suitable treatment plan that helps in decreasing risk of falls in aged persons.

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Conflicts of interest

There are no conflicts of interest.

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