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Research Article

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Presbycusis: Comparison between the Auditory Brainstem Response (ABR) and the Pure Tone Audiometry (PTA) in Presbycusis Patient

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Abstract

Background: Presbycusis is a complex phenomenon resulting from an elevation hearing levels as well as changes in auditory processing. Chronic diseases such as diabetes (D), arterial hypertension (H) may act as an accelerating factor in age-related degeneration of the auditory system. The most used diagnostic test is PTA, ABR is recorded when the pure tone audiometry cannot be access.

Objective: to compare the relation between ABR and PTA threshold in presbycusis patients and evaluate the influence of diabetes and/or hypertension on the relationship between ABR and PTA threshold.

Material and methods: This is a prospective hospital-based study on the comparison between ABR and PTA of presbycusis patients (≥ 50 years old) composed of 35 females and 21 males. The participants were divided into groups, set as follows group 1 composed of 21 patients, group 2 comprising 12 patients, group 3 made of 14 patients and group 4 composed of 9 patients.

Results: The comparison between the mean threshold difference of ABR and PTA in group I and II was significant at each frequency with the mean difference in decibel was<20 dB at high frequency and>20 dB at 0.5 and 1 kHz in group 2,while in group 2 a mean difference<20 dB at all frequency range. Group III exhibited a significant difference at high frequency only, we found a mean difference<20 dB at 4, 8 and 2-4 kHz and>20 dB at 0.5, 1, and 2 kHz. However, group IV showed no significant difference between ABR and PTA thresholds, the mean threshold difference was>20 dB at each frequency.

Conclusion: it was found that there is a positive relationship between ABR and PTA, threshold, which appear to be insignificant in presbycusis patients with both hypertension and diabetes; this may be probably related to synergic effects of the two chronic illnesses on the cochlea.

Keywords: Presbycusis; Auditory brainstem response; Pure tone audiometry

Introduction

Being one of the high prevalence of chronic conditions in the old population [1]. Presbycusis also called age-related hearing loss is the most common bilateral, progressive sensorineural age-related hearing impairment, which is attributed to the internal ear disorders particularly the degeneration changes in the hair cell of the cochlea and the auditory nerves fibers connections [2]. After 60 years, one in four people suffer from presbycusis embracing two-thirds of cases, after age 65, presbycusis affects one in three people and one in two people after age 70. It is usually seen after the age of 50 but sometimes earlier and more intensely in some families that have predispositions to presbycusis. Many implications are included such as communications difficulties, psychological disorders, social isolation and may induce negative impact in the quality of life of the individual, Risk factors such as diabetes mellitus and high blood pressure are also involved [3,4]. Some studies have demonstrated that chronic diseases affecting old people such as diabetes mellitus may be related to the hearing changes [5,6].

In general, pure tone audiometry (PTA) and the auditory brainstem response (ABR) are mainly used in the assessment of the auditory sensation in the patients with suspected presbycusis. Basically, these two ways of thresholds evaluation are different. Pure tone audiometry is a subjective test to assess the degree of the hearing loss, this method involves peripheral and central auditory hearing loss [7]. In this subjective test, a continuous tone stimulus (duration.0.3 s) of variable frequency is used. PTA explores the patient's ability to hear beeps (white noises) in low to high frequencies in the air and bone conduction, the former reflecting the transmission of sound vibration from the ear pinna to the inner ear, the second, and the electrical perception of sound from the inner ear to the brain. Presbycusis initially affects high frequencies, PTA results of the patient with presbycusis shown symmetrical sensorineural hearing loss at high frequency [8]. Thus, the auditory brain response is one of the useful tests which represents the objective examination of choice when the goal is to recognize the level of hearing, especially when the subjective test is unpredictable or unreliable [9]. The recorded electrical response is generated up to the midbrain. This objective test uses click as types of stimulus sound, ABR stimuli are typically 1–2 ms in duration and stimuli used to elicit behavioral responses are approximately 200-2,000 ms in duration and its spectrum contains all the audible frequencies [10]. However, the electrophysiological hearing threshold for clicks is not strictly accurate in terms of frequency or intensity related to hearing. Some studies have investigated the relationship between electrophysiological threshold and PTA hearing level. In general, the results suggest that the objective thresholds obtained on ABR represent an estimate of the subjective threshold. Some studies demonstrated that the differences between ABR and behavioral thresholds vary depending on stimulus frequency, typically ranging from several decibels at high frequencies to as much as 15-20 dB at lower frequencies [11,12]. Age-related differences in ABR and behavioral

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thresholds are probably based on a reduction in the number of spiral ganglion fibers in older participants [13].

Although several studies have tried to assess the correlation of diabetes, hypertension with the hearing disorder, these correlations remain unclear. However, some studies demonstrated that diabetes or hypertension can aggravate hearing loss and may cause the abnormality of the auditory brainstem response. So, how far can Diabetes and hypertension affect the relation between the Pure Tone Audiometry and the Auditory Brainstem Response results in presbycusis. Therefore, the aim of this study is to evaluate the relationship between the pure tone audiometry (PTA) threshold and auditory brainstem response result in presbycusis patients.

Materials and Methods

Subject

This is a prospective hospital-based study of sixty patients with presbycusis. Patients ≥ 50 years old with clinical diagnosis of presbycusis confirmed with bilateral sensorineural hearing loss on diagnostic pure tone audiometry were selected for the study. Questionnaires were administered to the patients and information obtained included the demographic data, symptoms, history of noise exposure, use of alcohol and smoking, use of ototoxic drugs and presences of other chronic diseases like diabetes and hypertension. An otological inspection was made and audiological assessment was conducted to exclude middle ear disorders. Among the 60 patients selected for the study, only 56 patients that had complete data records were used for analysis. We divided the participants into groups, set as follows group 1 (presbycusis alone) composed of 21 patients, group 2 (presbycusis+diabetes) comprising 12 patients, group 3 (presbycusis +hypertension) made of 14 patients and group 4 (presbycusis+diabetes +hypertension) composed of 9 patients.

Pure tone audiometry measurement

The PTA machine used was an interacoustic diagnostic audiometer AD229E with maximum output levels of 120 dB HL in the concerned frequency region. For purposes of the comparison to ABR threshold data, only behavioral thresholds for octave frequencies from 500 to 8000 Hz were included in the analysis

ABR measurement

We use intelligent hearing (smart EP/universal smart box) machine to evaluate the hearing. Two recording channel was made using vertex and ipsilateral mastoid electrodes, and a ground electrode on the forehead. The parameter setting was as follows: Stimulus sound type: click, Transuder: earphone, Stimulus sound duration: 100s, Repetition rate (RR): 19.3/s, Number of sweeps: 1024 times/s, filter settings: 100-3000 Hz. some ABR measurements were initiated with an 80 dBnHL click, other was initiated with a 60 dBnHL depending on the PTA dB response on high frequency. If a well-formed ABR was measured, the intensity was decreased in 20 dB steps until the response was no longer evident.

Data analysis

Statistical data analysis was performed using SPSS software version20.0 (SPSS, Inc, Chicago, Illinois, USA). Numerical variables were conforming to the normal distribution. Since there was no significant difference between ears, the ears were grouped and we used the average threshold of ABR and PTA for analysis. The relationship between the click-evoked ABR thresholds (2-4 kHz) and behavioral PTA thresholds at frequencies of 0.5, 1, 2, 4, 8 and 2-4 KHz was analyzed. Mean difference threshold, the standard deviation, the standard error was obtained. Pearson bivariate correlation analysis was used to assess the correlation coefficient between ABR and PTA. we have performed the analysis as follow: multiple linear regression models with ABR as independent variable and PTA as dependent variable, with age, gender, alcohol, smoking as possible confounding factors. The level of significance was set at $P<0.05$.

Results

In this study, we did the comparison between ABR and PTA in people with presbycusis. There were 35 females and 21 males aged from 50 to 83. Among them, some patients presented other symptoms like tinnitus, dizziness, ear fullness and other aggravating factors (Table 1).

Indices	**N**	**Percentage%**
Age		
50-59	21	37.5
60-69	19	33.9
70	16	28.57
Gender		
Female	35	62.5
Male	21	37.5
Associated symptoms		
Tinnitus	38	67.9
Ear fullness	19	33.9
Vertigo	22	39.3
Possible risk factors		
smoke	9	16.1
Alcohol	9	16.1
Diabetes (D)	12	21.4
Hypertension(H)	14	25
(D+H)	9	16.1
No(D+H)	21	37.5

Table 1: The general demographic data of 56 patients.

We first assessed the mean threshold difference between ABR and PTA in group 1 (presbycusis alone). We found a mean threshold within 20 decibels at high frequencies and mean threshold>20 decibels at lower frequencies with a standard deviation>15. P value was significant at all range ($P<0.05$) with a strong correlation at all range frequency with the best correlation point at 2 kHz (Table 2). In addition we performed a multivariate regression analysis between ABR and PTA to evaluate the role of confounding factors like age, gender, alcohol and

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smoking, we also obtained a significant p value at all frequency, showing that these factors did not influence the correlation between ABR and PTA in patient with presbycusis only Table 2.1.

		PTA	Frequency			
	0.5	1	2	4	8	2-4
Mean difference, dB	20.47	21.19	17.38	15.83	15.71	15.65
SD	13.88	13.61	10.79	13.21	13.53	10.58
SE	3.03	2.97	2.37	2.88	2.95	2.31
r	0.679	0.706	0.741	0.576	0.525	0.678
P	0.001	<0.0001	<0.0001	0.006	0.015	0.001

Table 2: Results of the relationship between ABR (2-4 kHz) and PTA (at 0.5 to 8 kHz and 2-4 kHz) in group 1. SD: Standard Deviation of Mean Difference dB; SE: Standard Error of Mean Difference dB; r: Correlation Coefficient of Mean Difference dB; P: p-value of the Correlation Coefficient.

	0.5	1	2	4	8	2.-4
β	0.924	1.036	1.165	0.999	0.801	1.082
P	0.001	<0.001	<0.001	0.018	0.036	0.003

Table 2.1: The relationship between ABR and PTA analyzed by multivariate regression model in group 1. Adjust: age, gender, alcohol and smoking.

Then we evaluated the mean threshold difference in group 2 where we obtained a difference within 20 decibels at all frequencies with a P<0.05 showing a correlation between ABR and PTA, and their correlation coefficient was strong at all range with the best agreement at 8 kHz as shown in Table 3.

In this group, a multivariate regression analysis between ABR and PTA was also performed and shows a significant p value Table 3.1.

		Pure tone	Audiometry	Frequency		
	0.5	1	2	4	8	2-4
Mean difference, dB	17.5	13.95	12.08	12.91	13.12	10.83
SD	14.84	12.12	9.81	11.06	8.33	10.66
SE	4.28	3.5	2.83	3.19	2.4	3.07
r	0.61	0.693	0.759	0.702	0.798	0.742
P	0.035	0.012	0.004	0.011	0.002	0.006

Table 3: Results of the relationship between ABR (2-4 kHz) and PTA (at 0.5 to 8 kHz and 2-4 kHz) in group 2. SD: Standard Deviation of Mean Difference dB; SE: Standard Error of Mean Difference dB; r: Correlation Coefficient of Mean Difference dB; P: p-value of the Correlation Coefficient.

	0.5	1	2	4	8	2-4
β	0.966	0.913	0.88	1.032	1.032	0.956
P	0.035	0.015	0.035	0.09	0.025	0.057

Table 3.1: The relationship between ABR and PTA analyzed by multivariate regression model in group 2. Adjust: age, gender, alcohol and smoking.

The comparison made between the two tests in group 3 shown also a difference of mean threshold within 20 decibels at high frequencies and>20 decibels at low frequencies, but in this group, the mean difference at low frequencies is very high compared to the two previous groups. The standard deviation was also calculated for each frequency. The correlation between ABR and PTA in group 3 was observed only at 4 kHz, 8 kHz and 2-4 kHz with P<0.05 (Table 4).

We did not perform the multiple linear regression for group 3 and 4 because their correlations value are no statistically significant.

	Pure tone	Audiometry	Frequency	

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	0.5	1	2	4	8	2-4
Mean difference, dB	28.92	27.5	20.71	9.28	11.6	12.85
SD	19.5	18.1	14.59	6.68	8.52	10.52
SE	5.21	4.83	3.89	1.78	2.27	2.81
r	0.131	0.159	0.21	0.771	0.719	0.595
P	0.655	0.587	0.472	0.001	0.004	0.025

Table 4: Results of the relationship between ABR (2-4 kHz) and PTA (at 0.5 to 8 kHz and 2-4 kHz) in group 3. SD: Standard Deviation of Mean Difference dB; SE: Standard Error of Mean Difference dB; r: Correlation Coefficient of Mean Difference dB; P: p-value of the Correlation Coefficient.

Furthermore, we investigated 9 patients diagnosed with presbycusis associated with hypertension and diabetes grouped in group 4, the mean threshold difference in this group was totally different from the expected decibels, at all frequencies the difference was above 20 decibels with a standard deviation>16. There was no significant correlation at all in each frequency; the P-value was statistically insignificant for each frequency as detailed in Table 5.

		Pure tone	**Audiometry**	**Frequency**		
	0.5	1	2	4	8	2.-4
Mean difference, dB	31.66	30.27	26.38	23.05	24.16	22.5
SD	17.85	17.29	18.03	19.51	19.96	20.39
SE	5.95	5.76	6.01	6.5	6.65	6.79
r	0.251	0.161	0.183	0.186	-0.012	0.185
p	0.514	0.679	0.638	0.632	0.976	0.634

Table 5: Results of the relationship between ABR (2-4 kHz) and PTA (at 0.5 to 8 kHz and 2-4 kHz) in group 4. SD: Standard Deviation of Mean Difference dB; SE: Standard Error of Mean Difference dB; r: Correlation Coefficient of Mean Difference dB; P: p-value of the Correlation Coefficient.

We did not perform the multiple linear regression for group 3 and 4 because their correlations value are no statistically significant.

Discussion

Through this prospective study, we made a comparison between the auditory brainstem response threshold and pure tone audiometry threshold. We did this study because there were cases where the ABR threshold was high compared to PTA threshold and others where the PTA threshold was high compared to ABR threshold. Many studies have been done on hearing threshold estimation using the auditory brainstem response, ABR and PTA threshold varies depending on stimulus frequency, typically ranging from several decibels at high frequencies to as much as 15-20 decibels at lower frequencies [12]. Boettcher et al reported that the difference between PTA and ABR thresholds was much larger in older individuals than in young participants [10]. The differences between ABR and behavioral thresholds were approximately 12 dB, 7.5 dB and 8 dB for 1 kHz, 2 kHz, and 4 kHz, respectively in young (17-37 years old) human participants. In contrast, older participants (65-74 years old) had ABR-behavioral threshold differences of 17.5, 18 and 21 dB at the three frequencies, 1 kHz, 2 kHz, and 4 kHz respectively. The difference threshold was larger from 5,5 to 13 decibels(10).As it has been shown in group 1 where the patient did not have the associated chronic diseases as well as group 2 and group 3, we have the larger mean difference at lower frequencies. Boettcher et al finding is different to what we observed except in group 4 where all frequency has the larger mean difference, above 20 decibels in each frequency. We think that age can have an effect on the results. In the above-mentioned study, they used people aged 65 to 74, but in our analysis, we used patients aged 50 to 83 years. This may also due to associated chronic disease(diabetes), Another study was done in 2005, they tested PTA, vocal audiometry and the auditory brainstem response in patients with type 2 diabetes with healthy subjects and identified hearing loss with abnormal the auditory brainstem response in patients with diabetes which worsened with age [14].

In addition, P-value of the correlation coefficient obtained in group 1 and group 2 shown patients that, there is a correlation between ABR and PTA threshold in presbycusis at each frequency only can be affected if there is an associated chronic disease like diabetes and hypertension. In participants with presbycusis that presented hypertension as the associated risk factor, the correlation was only significant at high frequencies but those with both associated chronic diseases did not have a significant correlation. The difference observed between groups can be explained by the effect of aging on the cochlea and also the effect of hypertension as well as diabetes by inducing angiopathy and neuropathy.

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Diabetic neuropathy may cause a second degeneration of the eighth cranial nerve causing neural hearing loss and diabetic angiopathy resulting in diffuse thickening of the basement membrane and vascular endothelium, may interfere directly in the supplementation of nutrients and oxygen in the cochlea due to reduced transport induced by thickening of the capillary membrane. But it can also interfere indirectly by promoting a reduced circulation caused by vascular atrophy thus causing cell and biological tissue death [6]. Some studies reported that 2.8% of patients with idiopathic sudden sensorineural hearing loss have a vascular origin. While 71% of them are idiopathic, ear microcirculation's abnormality which can lead to chronic hearing disorder may be induced by an increase in blood viscosity [15]. Another study conducted by Balletshofer et al. state that patients with ISSHL had endothelial dysfunction confirming that the microcirculation abnormality plays a role in the pathogenesis of the illness [16]. Also, the formation of a pro-thrombotic state can be predisposed by the endothelium dysfunction [17]. A study conducted by Ciccone MM et al confirmed that ISSHL may be related to endothelium dysfunction [18]. This reports shows that endothelium dysfunction has a strong impact on the cochlea inducing hearing disorders. However, hypertension is an accelerating for the degeneration of auditory system, it affects the physiological mechanisms of the inner ear by the increases blood viscosity, leading to decreasing capillary blood flow and oxygen transportation [19].

Studies have been made on the comparison between auditory brainstem response threshold and pure tone audiometry threshold on cochlear hearing loss (all types), it has been reported that these two hearing threshold assessment methods have a better correlation point at frequencies 2 and 4 kHz. However, our study is focused on the patients with presbycusis, we fund that the best correlation point in group 1, group 2 and group 3 was 2 kHz, 8 kHz, and 4 kHz respectively, group 4 was insignificant at all frequencies. The best correlation point obtained corroborate with the study made by JFC van der drift et al and Bellman et al on the comparison between ABR and PTA in cochlear hearing loss in adults (all ages) where they found that ABR and PTA have a better correlation in point 2 and 4 kHz [20,21].

Through this study, we found that ABR and PTA threshold does not only correlate at high frequencies as demonstrated in studies where the comparison was based on cochlear hearing loss, in presbycusis ABR and PTA mean threshold difference has a significant correlation at high frequencies as well as at low frequencies, except when there is an associated chronic diseased cited above is either significant at high frequencies or insignificant at all frequencies.

Therefore, we think that it is important when a patient with presbycusis present to the clinic for a hearing threshold assessment, in addition to the subjective test which is no more than the pure tone audiometry known as the standard test for hearing evaluation, an auditory brainstem response should be performed to estimate whether the speech hearing ability of the patient differs from the hearing threshold of each frequency. It can also help to assess whether the patient is suitable for hearing aids, to provide a reference for finding a better solution in the future. Thus, we also think that hearing aids may have a poor effect on presbycusis patient with large differences in PTA and ABR threshold. Therefore, the search for better ways to improve the auditory speech recognition ability of the patient should be the focus of future research.

Conclusion

Generally, the excepted value for the auditory threshold difference between the auditory brainstem response and pure tone audiometry is within 20 decibels, in patients with only presbycusis this interval was respected. Presbycusis patients with both diabetes and hypertension did not respect the interval they had the greater mean difference at each frequency. The correlation between ABR and PTA was significant in presbycusis patient in all range, but significant at high frequencies for subjects with hypertension and insignificant in participants with both associated illness. The better correlation point in the three groups (group 1, group 2, and group 3) with significant correlation was at 2, 8 and 4 respectively. We conclude that hypertension and diabetes influence the relationship between ABR and PTA threshold, which gets worse with age.

Limitations of the Study

In this study, the limitation is that the sample size is not enough, maybe if this is the comparison was made with group the threshold difference between ABR and PTA would be clear. We suggest for further study the onset of disease (e.g between presbycusis and diabetes which one of them was first found), the intake and duration of medication (for diabetes) should be investigated since they may have an effect on the hearing disorder.

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Conflict of Interest

There is no conflict of interest.

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