Research Article

Effect of Different Blood Groups on Auditory Brainstem Response Findings

Karupaiah Kamalakannan[1*], Aronprabu Chrislin Sona[1], Sivagnanam Sivaranjani[1], Surendran Thiriveni[1], Kumaar Bhuvaneswari[1], Prashanth Prabhu[2]

[1.] *Department of Audiology and Speech-Language Pathology, Holy Cross College (Autonomous), Tiruchirappalli, India*
[2.] *Department of Audiology, All India Institute of Speech and Hearing, Mysuru, India*

Use your device to scan and read the article online

Citation: Kamalakannan K, Sona AC, Sivaranjani S, Thiriveni S, Bhuvaneswari K, Prabhu P. Effect of Different Blood Groups on Auditory Brainstem Response Findings. Aud Vestib Res. 2023;32(4):344-50.

https://doi.org/10.18502/avr.v32i4.13598

Highlights

- Auditory Brainstem Response findings were compared between different blood groups
- Overall, there is a reduction of amplitude for persons with blood group O
- It is recommended to monitor auditory nerve function among people with blood group O

Article info:
Received: 26 Mar 2023
Revised: 17 May 2023
Accepted: 21 Jun 2023

[*] **Corresponding Author:**
Department of Audiology and Speech-Language Pathology, Holy Cross College (Autonomous), Tiruchirappalli, India.
kamal.audiology@gmail.com

ABSTRACT

Background and Aim: The human blood group system can have an effect on the health and auditory system. The present study aimed to determine the differences in the Auditory Brainstem Response (ABR) recordings among persons with different blood groups (AB, A, B, O).

Methods: Sixty adults aged between 18 and 25 years with normal hearing sensitivity took part in the study. Further, they were grouped into four groups based on their blood groups (A, B, AB, O). Each group consisted of 15 participants. Auditory brainstem responses were recorded for all the participants at different rates (11.1/s and 90.1/s).

Results: The results of the study showed that the amplitude of ABR waves was significantly reduced for individuals with blood group O at lower repetition rate. The amplitude and latency of wave V was reduced at higher repetition rate among individuals with blood group O. There was no significant difference for all the other parameters across the groups.

Conclusion: The result of the study suggests the possibility of lesser auditory nerve functioning and increased risk of cochlear synaptopathy in persons with the O blood group.

Keywords: Auditory brainstem response; outer hair cell; auditory nerve; cochlear synaptopathy

Introduction

The human blood group system influences the health and auditory system. The eight major types of blood groups (A+, A–, B+, B–, O+, O–, AB+, AB–) are established by the presence of two antigens (A and B) on the surface of red blood cells and the presence of a protein (Rhesus factor). The variations in the antigen structure of the blood groups modify the blood function. This may be associated with vulnerability to certain diseases such as pancreatic cancer, hemorrhagic disorders, infections, and peptic ulcers [1]. Susceptibility to high noise levels varies among individuals because of factors such as race, cholesterol level, blood pressure, melanin content, etc. [2, 3]. Genetic differences among persons with various blood groups can influence susceptibility to some disorders [4]. Previous studies have reported increased susceptibility to Noise-Induced Hearing Loss (NIHL) in individuals with the O blood group [5, 6]. Several biological differences in the blood group system could be a risk factor for the susceptibility of developing certain diseases, such as gastric cancer in A blood group individuals and peptic ulcer in O blood group individuals [7]. Research also indicates that noise-exposed industrial workers and military personnel with blood group O may have heightened risk of acquiring NIHL. These findings suggest that NIHL susceptibility might be linked to the ABO blood group status [8, 9].

The internal auditory artery supplies blood to the stria vascularis in the cochlea, which is associated with the production of endocochlear potentials. Adequate functioning of hair cells depends on the regulation of endocochlear potentials [10]. ABO blood group system influences the hematological function of the stria vascularis. Two important glycoproteins –von Willebrand Factor (vWF) and thrombospondin (TSP), are responsible for monitoring hearing status among ABO blood group individuals. vWF contains a protein essential for clotting blood, and reduction in these levels results in a higher possibility of hemorrhagic disorders. The difference in the levels of vWF can alter the hearing status. Prolonged bleeding and clotting time are reported in persons with an O blood group due to lower vWF levels [11, 12]. It is reported that persons with blood group O had reduced amplitude in otoacoustic emissions (OAE) at ultra-high frequencies and altered middle ear functioning [13-15]. Hence, persons with the O blood group are more prone to cochlear dysfunction than others.

A large-scale study reported that there were no significant differences for transient evoked otoacoustic emissions (TEOAEs), distortion product otoacoustic emissions (DPOAE), and DPOAE input-output measures in adults with O blood groups compared to those with non-O blood groups. In addition, there were no significant differences across different age groups [16].

Considering the previous studies, it is understood that ABO blood group status could be associated with cochlear function. However, it is unclear, whether Auditory Brainstem Response (ABR) outcomes are also affected by blood group status. In general, ABR recordings are affected by stimulus rate. Studies have shown that when the rate of stimulation is beyond 30/s, there is prolongation in latency of all components and decrease in amplitude of earlier components were observed [17-20]. A recent literature also indicates that auditory brainstem response findings in people with O blood group have decrement in wave I and cochlear microphonic amplitude and with the trend of prolongation of wave I latency [21]. These findings suggest that ABR outcomes could be influenced by the ABO blood group status. In addition, people with O blood group might have a higher risk of neural dysfunctioning compared to others [21].

The aim of the current study was to estimate the differences in the auditory brainstem response recordings of younger adults with normal hearing across varying groups of blood (AB positive, A positive, B positive, O positive) at two stimulus rates (11.1/s and 90.1/s).

Methods

A total of sixty college-going young female adults, aged between 18 to 25 years (mean age: 19.6 years) with known blood group status, were recruited using a non-random sampling method. They were divided into four groups depending on their blood group status (A, B, AB, and O), and each group consisted of 15 participants. The participants blood group details were

retrieved from the individuals' hematological test report which was conducted during their academic period. All the participants had positive rhesus factors. Only female participants were included in the study because latency and amplitude of the ABR components are reported to vary across gender [22, 23]. Other factors such as skin or eye colour were not considered in the study.

Procedure

Prior to audiological evaluation, a detailed case history was obtained from all the individuals to rule out otological problems, hearing loss, history of noise exposure. Any participants with above mentioned conditions were excluded from the study. Air conduction thresholds were estimated using a calibrated, two-channeled clinical audiometer 'Inventis Piano' (Inventis Padova, Italy) with Telephonics Dynamic Headphones 39 earphones enclosed in MX-41/AR supra-aural ear cushions and the bone conduction thresholds were measured using the Radio Ear B-71 bone vibrator. A Criterion for normal hearing sensitivity (≤15 dB HL) at octave frequencies from 250 Hz to 8000 Hz in air conduction and from 250 Hz to 4000 Hz in bone conduction was considered in pure tone audiometry using "modified Hughson-Westlake procedure" in both the ears to rule out any peripheral hearing loss [24]. Immittance audiometry was carried out using a calibrated 'Inventis Clarinet' (Inventis Padova, Italy) middle ear analyzer to assess the middle ear functioning. Tympanogram was measured using a probe tone of 226 Hz and acoustic reflexes at 500, 1000, 2000, and 4000 Hz. The modality used was quick mode (screening). All the participants had 'A' type tympanogram with acoustic reflexes present at 500, 1000, 2000 and 4000 Hz [25-27]. OAE measurements were carried out using the calibrated "Intelligent Hearing Systems Duet" (IHS, Miami, FL). TEOAEs were measured using screening mode for the frequencies 1000, 1500, 2000, 3000 and 4000 Hz with the click stimulus at the presentation level of 80 dB pe SPL. Presence of TEOAEs were based on the lax criteria of 50% reproducibility and +3 dB signal to noise ratio at three consecutive frequencies [28, 29]. All the Participants were met the inclusion criteria and underwent for further evaluation. All the tests were conducted in an acoustically treated room. The permissible noise level of the room was as per ANSI/ASA S3.1-1999 standards [30].

Auditory brainstem response

Auditory brainstem response was recorded using a dual-channel calibrated auditory evoked potentials system, Intelligent Hearing Systems Duet (IHS, Miami, FL). According to the 10–20 International system [31], one positive electrode was placed on the scalp at Fz (high forehead). Two negative electrodes were placed at the mastoid region of the right (M2), and left side (M1), and one ground electrode was placed at FPz (lower forehead), with the absolute and interelectrode impedances below 5 KΩ and 2 KΩ, respectively [32]. Stimulus and acquisition parameters of ABR are as follows. Clicks stimulus with the duration of 100-micro seconds was presented at 90 dB nHL at a rate of 11.1/s and 90.1/s through Etymotic Research 3A insert receivers. Single presentation level was used in the study because recording ABR at higher intensity level along with higher stimulation rate is useful in detecting the retrocochlear lesions i.e. beyond the cochlea which including abnormalities in the auditory nerve and structures of the auditory brainstem [33]. Recorded responses were amplified with a gain of 100,000 times, band pass filter settings used was between 100 Hz and 3000 Hz, and rarefaction polarity was used. To obtain better replications, three repetitions of 1500 sweeps were obtained at each rate. For waveform analysis, 12-ms analysis time was used for both the ears [33]. The ABR was measured for both ears independently in every participant. The absolute latency, inter peak latencies, and amplitudes of waves I, III, and V at 11.1/sec and absolute latency and amplitude of wave V at 90.1/sec were measured and compared. Other parameters were not considered as earlier peaks were not present in all the participants of the study.

Statistical analysis

IBM SPSS (Statistical Package for the Social Sciences) statistics version 21.0 was used for data analysis. The normal distribution of the data was analysed using the Shapiro-Wilk test of normality, which showed non-normal distribution of the data across the participants ($p<0.05$). Hence, non-parametric tests were carried out for further statistical analysis.

Results

A descriptive statistical analysis of the data was done to determine the mean and standard deviation.

The study demonstrated the reduction in the amplitude of waves of ABR at 11.1/s and 90.1/s and prolongation of absolute latency of wave V at 90.1/s in adults with blood group O compared to the adults with other blood groups. The other parameters were similar between the blood groups. The mean absolute latency and inter-peak latencies of auditory brainstem response waves for different blood groups is shown in Table 1.

The mean values for amplitude of ABR waves for different blood groups is shown in Table 2.

Kruskal-Wallis H tests were carried out for the statistical analysis across all the blood groups for absolute latency, absolute amplitude, and inter peak latencies separately, demonstrating a significant difference between absolute amplitude and absolute latency ($p<0.05$). Mann-Whitney U tests were carried out to estimate the differences between the blood groups. The results showed that significant decrement ($p<0.05$) in the amplitude of wave I, III, and V for individuals with blood group O at 11.1/s. The mean and standard deviation of amplitude of ABR waves across blood groups is shown in Figure 1.

The results also showed that there was a no significant difference ($p>0.05$) for absolute latencies and inter peak latencies for at 11.1/s. Thus, the amplitudes of ABR waves were reduced in individuals with blood group O compared to other blood groups. In addition, there was a significant prolongation of wave V and reduction in amplitude ($p<0.05$) at a 90.1/s rate for blood group O compared to persons with other blood groups. The results also showed that there was no

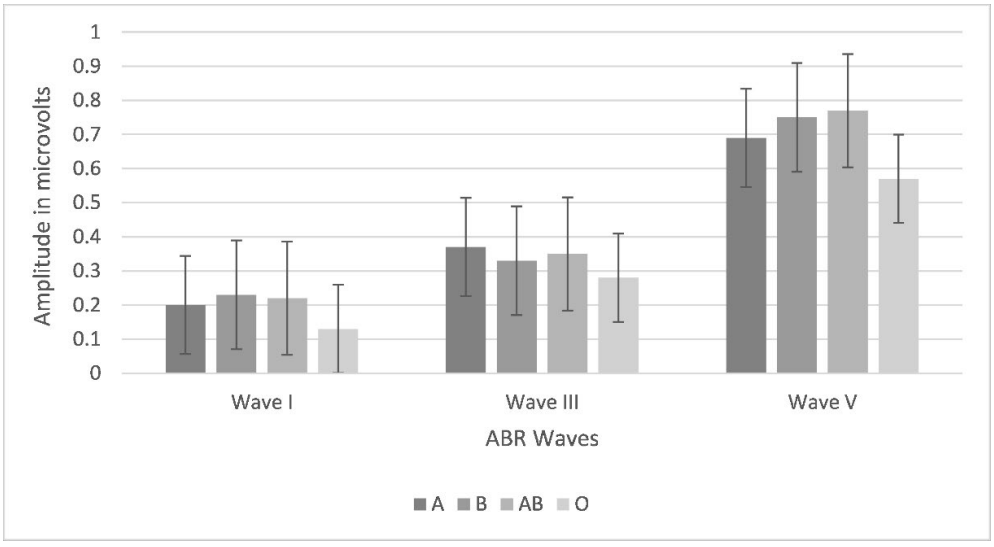

Figure 1. Mean and standard deviation of amplitudes of auditory brainstem response waves for individuals with different blood groups A, B, AB, O. ABR; auditory brainstem response

Table 1. Mean absolute latency and inter-peak latencies of auditory brainstem response waves for different blood groups

Repetition rate	Parameter	A	B	AB	O
11.1/sec	Wave I latency	1.70 ms	1.67 ms	1.63 ms	1.71 ms
	Wave III latency	3.57 ms	3.72 ms	3.43 ms	3.56 ms
	Wave V latency	5.43 ms	5.49 ms	5.53 ms	5.59 ms
	Inter peak I-III	1.91 ms	1.85 ms	1.97 ms	2.07 ms
	Inter peak III-V	1.93 ms	1.89 ms	1.95 ms	2.09 ms
	Inter peak I-V	3.81 ms	3.94 ms	3.89 ms	4.15 ms
90.1/sec	Wave V latency	5.93 ms	5.97 ms	5.91 ms	6.15 ms

Table 2. Mean absolute amplitude of auditory brainstem response waves for different blood groups

Repetition rate	Parameter	A	B	AB	O
11.1/sec	Wave I amplitude	0.20 µV	0.23 µV	0.22 µV	0.13 µV
	Wave III amplitude	0.37 µV	0.33 µV	0.35 µV	0.28 µV
	Wave V amplitude	0.69 µV	0.75 µV	0.77 µV	0.57 µV
90.1/sec	Wave V amplitude	0.53 µV	0.57 µV	0.55 µV	0.43 µV

significant difference in amplitude, latencies and inter-peak latencies at 11.1/sec and 90.1/sec between blood groups A, B and AB.

Discussion

The current study investigated the effect of different blood groups on ABR results across blood groups. The results showed a reduction in amplitude of wave I, III and V at 11.1/s and a trend of reduced amplitude of wave V at 90.1/s was observed for persons with blood group O compared to other blood groups. In general, amplitude denotes the number of neurons firing [32]. The amplitude of wave I reflects the neural activity of synaptic connections between the inner hair cells and spiral ganglion neurons from the cochlear nerve. The amplitude of ABR wave I at suprathreshold levels can be a good indicator for predictive of degree of cochlear synaptopathy. Therefore, the decrement in the amplitude of wave I was attributed to the lesser neural activation and reduced cochlear synaptic transmission for persons with blood group O [34, 35, 21].

The current study findings are agreeable to the results of previous study which reported that decreased amplitude of wave I in individuals with blood group O indicates reduced cochlear and neural dysfunction [21]. Glycoproteins such as TSP and vWF plays an essential role in the formation of cochlear blood vessels and synaptic growth. Deletion of TSP genes might result in the dysfunction of cochlear synapses, which is associated with a heightened risk of reduced cochlear function in individuals with the O blood group [36].

These findings suggest that O blood group individuals might have a higher chance of diffuse cochlear dysfunction than others. It is also well-stated that cochlear synaptopathy leads to auditory abnormalities [34]. Furthermore, reduction in amplitude of waves III and V at lower stimulus rate and reduction of amplitude of wave V at higher stimulus rate could be linked to reduced number of neurons firing at the level of cochlear nucleus and lateral lemniscus [21, 33].

In the present study, no significant difference was observed in absolute latency of ABR waves I, III and V at lower stimulation rate across different blood groups. These findings are in contrast to previous study results showed that there is a trend of prolonged latency of wave I at lower stimulation rate was observed in O blood group persons compared to other groups [35].

However, in the current study there were no significant difference in the other ABR parameters such as inter peak latencies of wave I-III, III-V and I-V across the individuals with the different blood groups. In addition, the prolongation of latency of wave V at 90.1/s was observed in persons with blood group O. This finding could be attributed to the effect of stimulation rate.

In ABR, the latency of wave V are contribution of both axonal and neuronal transmissions. Therefore, increasing stimulation rate i.e. at 90.1/s could result in prolongation of wave V of ABR [33]. At higher stimulation rates, cochlear neuron firing might be stressed for individuals with O blood group [21]. From the above finding it is suggested that adults with blood group O might have relatively reduced functioning of the cochlear nerve compared to non-O blood group individuals. The cochlear/neural function of persons with different blood groups could be also influenced by biological differences [4, 14].

Conclusion

The current study conducted the auditory brainstem responses measurements among persons with varying blood groups. The findings of the present study indicate

that persons with blood group O might have a higher risk of cochlear synaptopathy and/or neural dysfunction at the level of the brainstem compared to persons with other blood groups. Hence, it is recommended to monitor cochlear/neural function status among the persons with blood group O. Future studies can be carried out on other electrophysiological measures with varying stimulus/acquisition parameters in a large sample size might provide insights and extend the current findings.

Ethical Considerations

Compliance with ethical guidelines

All of the testing procedures were accomplished using a non-invasive technique in the current study and adhered to the conditions of the institutional ethical approval committee (HCS/ERB/PB-2022/02). The test procedures were clearly explained to the participants before testing. Informed consent: Prior informed consent was taken from the participants for their willingness to participate in the study.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Authors' contributions

KK, ACS, SS, ST: Study design, acquisition of data, drafting the manuscript, interpretation of the results; KB: Supervision, interpretation of the results, drafting the manuscript, critical revision of the manuscript; PP: Study design, supervision, critical revision of the manuscript and statistical analysis.

Conflict of interest

The authors report no conflicts of interest.

Acknowledgments

The authors acknowledge with gratitude the Principal, Secretary, Academic Coordinator, Head of the Department, Holy Cross College (Autonomous), Tiruchirappalli, for their constant guidance. The authors also like to thank the participants for their support and co-operation.

References

[1] Anstee DJ. The relationship between blood groups and disease. Blood. 2010;115(23):4635-43. [DOI:10.1182/blood-2010-01-261859]

[2] Plontke S, Zenner HP. Current aspects of hearing loss from occupational and leisure noise. GMS Curr Top Otorhinolaryngol Head Neck Surg. 2004;3:Doc06. Epub 2004 Dec 28.

[3] Henderson D, Subramaniam M, Boettcher FA. Individual susceptibility to noise-induced hearing loss: an old topic revisited. Ear Hear. 1993;14(3):152-68. [DOI:10.1097/00003446-199306000-00002]

[4] Sircar S. Principles of medical physiology. 1st ed. Stuttgart: Thieme; 2008.

[5] Chow KT, McPherson B, Fuente A. Otoacoustic emissions in young adults: Effects of blood group. Hear Res. 2016;333:194-200. [DOI:10.1016/j.heares.2015.09.006]

[6] Lashley FR. Clinical Genetics in Nursing Practice. 3rd ed. New York: Springer Publishing Company; 2005.

[7] Edgren G, Hjalgrim H, Rostgaard K, Norda R, Wikman A, Melbye M, et al. Risk of gastric cancer and peptic ulcers in relation to ABO blood type: a cohort study. Am J Epidemiol. 2010;172(11):1280-5. [DOI:10.1093/aje/kwq299]

[8] Doğru H, Tüz M, Uygur K. Correlation between blood group and noise-induced hearing loss. Acta Otolaryngol. 2003;123(8):941-2. [DOI:10.1080/00016480310000746]

[9] Nair S, Kashyap RC. Prevalence of Noise Induced Hearing Loss in Indian Air Force Personnel. Med J Armed Forces India. 2009;65(3):247-51. [DOI:10.1016/S0377-1237(09)80015-4]

[10] Salt AN, Melichar I, Thalmann R. Mechanisms of endocochlear potential generation by stria vascularis. Laryngoscope. 1987;97(8 Pt 1):984-91. [DOI:10.1288/00005537-198708000-00020]

[11] Takayama W, Endo A, Koguchi H, Sugimoto M, Murata K, Otomo Y. The impact of blood type O on mortality of severe trauma patients: a retrospective observational study. Crit Care. 2018;22(1):100. [DOI:10.1186/s13054-018-2022-0]

[12] Koster T, Blann AD, Briët E, Vandenbroucke JP, Rosendaal FR. Role of clotting factor VIII in effect of von Willebrand factor on occurrence of deep-vein thrombosis. Lancet. 1995;345(8943):152-5. [DOI:10.1016/s0140-6736(95)90166-3]

[13] Prabhu P, Shaji SR, Vipinan KM, Ramanunny NV, Nagaraju B. Effect of different blood groups on tympanometric findings and acoustic reflex thresholds. Eur Arch Otorhinolaryngol. 2020;277(12):3513-8. [DOI:10.1007/s00405-020-06244-9]

[14] Chen WW, Chow KT, McPherson B. ABO Blood Group and Cochlear Status: Otoacoustic Emission Markers. Ear Hear. 2018;39(3):555-62. [DOI:10.1097/AUD.0000000000000509]

[15] Prabhu P, Chandrashekhar A, Cariappa J, Ghosh N.

Effect of Blood Group on Ultrahigh Frequency Auditory Sensitivity. Int Arch Otorhinolaryngol. 2018;22(4):364-7. [DOI:10.1055/s-0037-1613711]

[16] Mo C, Ma TF, McPherson B. ABO blood group and cochlear function: evidence from a large sample size study. Int J Audiol. 2022:1-11. [DOI:10.1080/14992027.2022.2158379]

[17] Burkard RF, Sims D. The human auditory brainstem response to high click rates: aging effects. Am J Audiol. 2001;10(2):53-61. [DOI:10.1044/1059-0889(2001/008)]

[18] Fowler CG, Noffsinger D. Effects of stimulus repetition rate and frequency on the auditory brainstem response in normal cochlear-impaired, and VIII nerve/brainstem-impaired subjects. J Speech Hear Res. 1983;26(4):560-7. [DOI:10.1044/jshr.2604.560]

[19] Stockard JJ, Stockard JE, Sharbrough FW. Detection and localization of occult lesions with brainstem auditory responses. Mayo Clin Proc. 1977;52(12):761-9.

[20] Don M, Allen AR, Starr A. Effect of click rate on the latency of auditory brain stem responses in humans. Ann Otol Rhinol Laryngol. 1977;86(2 pt. 1):186-95. [DOI:10.1177/000348947708600209]

[21] Yang Y, Hood LJ, McPherson B. Association between ABO blood group status and cochlear/neural function: auditory brainstem response findings. Acta Otolaryngol. 2021;141(3):273-8. [DOI:10.1080/00016489.2020.1858236]

[22] Esteves MC, Dell' Aringa AH, Arruda GV, Dell' Aringa AR, Nardi JC. Brainstem evoked response audiometry in normal hearing subjects. Braz J Otorhinolaryngol. 2009;75(3):420-5. [DOI:10.1016/S1808-8694(15)30661-3]

[23] Allison T, Wood CC, Goff WR. Brain stem auditory, pattern-reversal visual, and short-latency somatosensory evoked potentials: latencies in relation to age, sex, and brain and body size. Electroencephalogr Clin Neurophysiol. 1983;55(6):619-36. [DOI:10.1016/0013-4694(83)90272-9]

[24] Carhart R, Jerger JF. Preferred Method For Clinical Determination Of Pure-Tone Thresholds. J Speech Lang Hear Res. 1959;24(4):330-45. [DOI:10.1044/jshd.2404.330]

[25] Margolis RH, Heller JW. Screening tympanometry: criteria for medical referral. Audiology. 1987;26(4):197-208. [DOI:10.3109/00206098709081549]

[26] Jerger J. Clinical experience with impedance audiometry. Arch Otolaryngol. 1970;92(4):311-24. [DOI:10.1001/archotol.1970.04310040005002]

[27] Jerger S, Jerger J. Diagnostic value of crossed vs uncrossed acoustic reflexes: eighth nerve and brain stem disorders. Arch Otolaryngol. 1977;103(8):445-53. [DOI:10.1001/archotol.1977.00780250039002]

[28] Harrison WA, Norton SJ. Characteristics of transient evoked otoacoustic emissions in normal-hearing and hearing-impaired children. Ear Hear. 1999;20(1):75-86. [DOI:10.1097/00003446-199902000-00007]

[29] Kemp DT, Ryan S, Bray P. A guide to the effective use of otoacoustic emissions. Ear Hear. 1990;11(2):93-105. [DOI:10.1097/00003446-199004000-00004]

[30] American National Standards Institute. Maximum permissible ambient noise for audiometric test rooms (ANSI S3.1-1999). New York: American National Standards Institute; 1999.

[31] Jasper H. The 10-20 electrode system of the International Federation. Electroencephalogr Clin Neuropysiol. 1958;10:370-5.

[32] Hood LJ. Clinical applications of the auditory brainstem response. San Diego: Singular Pub. Group; 1998.

[33] Hall JW. Handbook of auditory evoked responses. Boston: Allyn & Bacon; 1992.

[34] Chen D, Jia G, Ni Y, Chen Y. Hidden hearing loss: current perspectives and potential therapies. J Bio-X Res. 2019;2(02):62-7.

[35] Liberman MC, Kujawa SG. Cochlear synaptopathy in acquired sensorineural hearing loss: Manifestations and mechanisms. Hear Res. 2017;349:138-47. [DOI:10.1016/j.heares.2017.01.003]

[36] Mendus D, Sundaresan S, Grillet N, Wangsawihardja F, Leu R, Müller U, et al. Thrombospondins 1 and 2 are important for afferent synapse formation and function in the inner ear. Eur J Neurosci. 2014;39(8):1256-67. [DOI:10.1111/ejn.12486]