ORIGINAL ARTICLE

Brain evoked response audiometry recording from the mastoid and earlobe electrodes in normal-hearing children

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ABSTRACT

Background: Electrode placement plays an important role in Brain Evoked Response Audiometry (BERA) recording. It is important to measure wave latency and amplitude accurately in determining hearing level. Young children usually have limited mastoid area, and in certain condition, it is often difficult to place the vibrator and electrodes coinciding on the mastoid. Therefore, earlobe electrode is considered as an alternative placement. Purpose: The aim was to correlate the wave V latency and amplitude on the mastoid and earlobe electrodes in BERA recording.

Materials and methods: Our study was a cross-sectional study conducted at Cipto Mangunkusumo Hospital, Jakarta, Indonesia, between November 2020 and November 2021. Our subjects were infants and young children with normal hearing who underwent BERA examination. Electrodes were used to record BERA, and the electrodes were placed over the earlobes and mastoid area. Clicks at 20, 40, and 60 dB and tone burst at 500 Hz were used as stimuli for both ears.

Result: Fifty subjects (100 ears) were included in the study. Our statistical analysis showed that there was a strong correlation between wave V latencies from mastoid and earlobe electrode. Moderate correlation was also found in wave V amplitude between both electrodes.

Conclusion: Our study has demonstrated that placing electrodes on the earlobe area is reliable, particularly in certain condition when placing the electrodes on the mastoid area is not possible.

KEYWORDS:
Brain Evoked Response Audiometry, Wave latency, Electrode placement, Mastoid, Earlobe

INTRODUCTION

Hearing is one of the sensory functions that is essential to daily life. Hearing loss will cause limited communication skills and hinder the process of growth and development, especially in infants. An examination to evaluate peripheral hearing thresholds using Brain Evoked Response Audiometry (BERA) was introduced in 1970 by Jewett. BERA examination is a technique for measuring the activity response of the auditory nerves starting from the cochlea to the brain stem. It causes changes in electrical potential after a sound stimulation is given, through either air or bone.[1,2] Auditory Evoked Potential (AEP) is classified based on latency, anatomical generator, and its relationship with the origin of the stimulus, which is endogenous or exogenous.[3]

BERA examination is used for both screening and diagnostics among infants. AEP is an electrical potential evoked in the brain due to sound stimulation, which can be recorded by placing electrodes on the surface of the scalp. In general, the electrodes are placed both on the mastoid and vertex. Waves I, III, and V are usually detected in BERA examinations for infants. Wave I amplitude is usually found greater in infants than in adults. In addition to amplitude, an assessment of wave latency is also carried out, which includes absolute, inter-wave, and inter-ear latencies. Absolute latency and inter-peak interval are the most widely, clinically used assessment. Within the normal hearing threshold, wave V can be easily identified to the lowest intensity; therefore, it can be used to estimate peripheral hearing threshold.[1] Compared to other parameters, wave V latencies are the most important to be analysed, especially their correlation with age, sex, and amount of hearing loss.[4]

The length of the latency is influenced by several factors including the placement of the surface electrodes. The placement of electrodes must consider several factors, namely: (1) how to prepare the skin for electrode placement, (2) types of electrodes available for recording auditory evoked responses, (3) electrode sites or locations, (4) customary labels used to describe electrode sites, (5) electrode terminology such as non-inverting versus inverting, and (6) electrode combinations or arrays.[2]

The absolute latency is influenced by several factors including the placement of the surface electrodes. It is recommended that surface electrodes should be placed on the scalp, and generally, the electrodes are placed on the mastoid area. The area is recommended for electrode placement since it is easy to clean and hairless.[5] The scalp hair should be oil-free. The patient's hair, therefore, should be washed using shampoo on the day of examination.6 The non-inverting electrode is placed over the vertex of the head, and the inverting electrode is placed over the earlobe or mastoid prominence. Electrodes that are placed over the mastoid process or earlobe should be symmetrical.[7]

Young children usually have limited mastoid area; therefore, it is often difficult to perform examination when we need to evaluate the bone conduction threshold due to the position of

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the bone vibrator and electrodes coinciding on the mastoid. Electrode placement on the earlobe was considered as an alternative to electrode placement on the mastoid. Therefore, we aim to study the correlation between mean latency and amplitude on earlobe electrodes and mastoid electrodes in normal-hearing children.

MATERIALS AND METHODS

Our study was a cross-sectional study, which was conducted between November 2020 and January 2021. Our subjects were infants and children with normal hearing who had been confirmed with BERA at Cipto Mangunkusumo Hospital. Our inclusion criteria were term infants (0 to 1 years old with normal gestational age of 37–42 weeks) and young children aged 1 to 5 years with normal peripheral hearing threshold (20 dB). Patients who did not complete BERA examination under any circumstances such as restlessness and uncooperativeness during the procedure were excluded from this study. The subjects were examined using headlamp, otoscope, nasal speculum, and tongue spatula. Furthermore, inter-acoustic tympanometry, Biologic Navigator Pro OAE, and BERA were also used in this study.

Subjects with normal results of tympanogram and OAE (Oto Acoustic Emission) were further evaluated using BERA examination. Infants underwent BERA examination without sedation, while young children were given sedation (chloralhydrate 50 mg/kg BW). Electrodes were placed on both the mastoid and vertex after the skin was cleaned using abrasive electrode prep gel. The same preparation was also made on the earlobe by cleaning and removing the accessories such as earrings.

Furthermore, electrode discs were filled with conduction paste and were attached to the vertex and mastoid area of both ears. The parameters used were rarefaction polarity in click stimuli and alternating polarity in tone burst stimuli. The stimulus rate was 27.7/second. The recording was done at an intensity of 60, 40, and 20 dB for both ears. The 80-dB intensity was not performed considering the normal hearing threshold of the subjects. When the wave V was detected at 20 dB (normal peripheral hearing threshold), an additional recording was performed by moving the electrodes from the mastoid to the earlobes, and we used the same parameters. The absolute latency and amplitude of wave V were then recorded, which served as inputs to our data. The results of the examination were then analysed using SPSS version 26.0.

RESULTS

Fifty subjects (32 males and 18 females) participated in the study (Table I). Their age was between 2 and 60 months (median age = 24.82 months). In total, 100 ears were included and analysed to evaluate data distribution. Statistical analysis demonstrated that wave latency and amplitude in all subjects had a normal distribution. In Tables II-IV, we present data of wave V latency and amplitude of both electrode placements, i.e., on the mastoid and earlobe area. An example of BERA wave from the earlobe electrode and mastoid electrode is presented in Figure 1. The statistical analysis showed that wave V latency of electrode placement on the mastoid and earlobe with click stimuli at 60, 40, and 20 dB had a strong to very strong correlation with R values ranging between 0.800 and 0.944 (p=0.00). Meanwhile, with an alternating stimulus of tone burst at 500 Hz, the wave latency of 60, 40, and 20 dB had also shown a moderate to strong correlation between both recordings with an R-value

Table I: Subject characteristics

	0–24 months	24–60 months	Total (subjects)
Gender			
Male	15	17	32
Female	12	6	18
Total (subjects)	27	23	50

Table II: Correlation between wave V obtained from electrodes placed over mastoid and earlobe area at 60-dB intensity

	Latency Mean (±SD)	R	p	Amplitude Mean (SD)	R	p
Right Ear ME (Click)	5.85 (0.4)	0.944**	0.000	0.09 (0.05)	0.517**	0.000
Right Ear LE (Click)	5.93 (0.37)			0.10 (0.04)		
Left Ear ME (Click)	5.85 (0.38)	0.800**	0.000	0.11 (0.07)	0.508**	0.000
Left Ear LE (Click)	5.96 (0.41)			0.11 (0.07)		
Right Ear ME (Tone Burst 500 Hz)	8.09 (0.76)	0.913**	0.000	0.16 (0.08)	0.598**	0.000
Right Ear LE (Tone Burst 500 Hz)	8.23 (0.68)			0.20 (0.09)		
Left Ear ME (Tone Burst 500 Hz)	8.05 (0.72)	0.896**	0.000	0.22 (0.11)	0.716**	0.000
Left Ear LE (Tone Burst 500 Hz)	8.24 (0.69)			0.23 (0.08)		

**Pearson Correlation Test
ME: Mastoid Electrode
LE: Earlobe Electrode

Table III: Correlation between wave V obtained from electrodes on the earlobe and the mastoid area at 40-dB intensity

	Latency Mean (±SD)	R	p	Amplitude Mean (SD)	R	p
Right Ear ME (Click)	6.43 (0.38)	0.842**	0.000	0.09 (0.05)	0.700**	0.000
Right Ear LE (Click)	6.52 (0.38)			0.07 (0.04)		
Left Ear ME (Click)	6.44 (0.37)	0.903**	0.000	0.08 (0.04)	0.467**	0.000
Left Ear LE (Click)	6.54 (0.39)			0.08 (0.04)		
Right Ear ME (Tone Burst 500 Hz)	9.64 (0.91)	0.588**	0.000	0.13 (0.06)	0.585**	0.000
Right Ear LE (Tone Burst 500 Hz)	9.81 (0.97)			0.13 (0.05)		
Left Ear ME (Tone Burst 500 Hz)	9.60 (0.9)	0.688**	0.000	0.16 (0.07)	0.618**	0.000
Left Ear LE (Tone Burst 500 Hz)	9.76 (0.81)			0.17 (0.07)		

**Pearson Correlation Test
ME: Mastoid Electrode

Table IV: Correlation between wave V obtained from electrodes on the mastoid and earlobe area at 20-dB intensity

	Latency Mean (SD)	R	p	Amplitude Mean (SD)	R	p
Right Ear ME (Click)	7.27 (0.41)	0.845**	0.000	0.06 (0.04)	0.644**	0.000
Right Ear LE (Click)	7.42 (0.45)			0.07 (0.05)		
Left Ear ME (Click)	7.30 (0.35)	0.881**	0.000	0.06 (0.04)	0.551**	0.000
Left Ear LE (Click)	7.43 (0.42)			0.08 (0.13)		
Right Ear ME (Tone Burst 500 Hz)	11.84 (0.79)	0.632**	0.000	0.10 (0.06)	0.789**	0.000
Right Ear LE (Tone Burst 500 Hz)	12.17 (0.78)			0.10 (0.06)		
Left Ear ME (Tone Burst 500 Hz)	11.91 (0.82)	0.649**	0.000	0.11 (0.6)	0.679**	0.000
Left Ear LE (Tone Burst 500 Hz)	12.1 (0.81)			0.11 (0.08)		

**Pearson Correlation Test
ME: Mastoid Electrode
LE: Earlobe Electrode

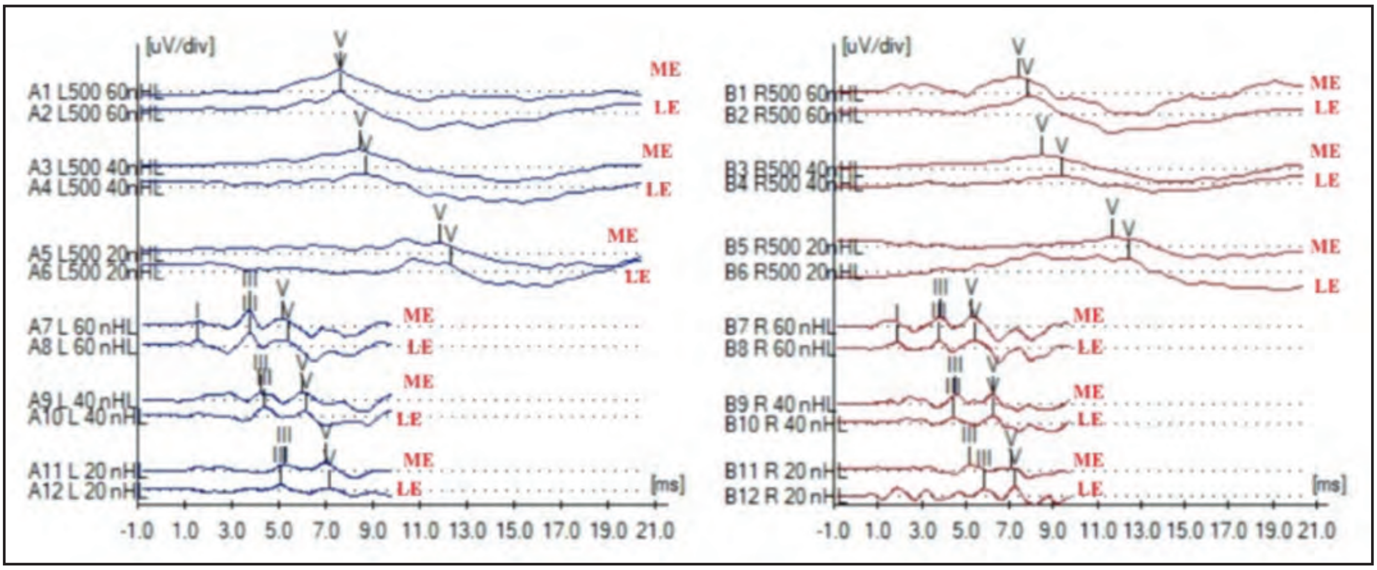

Fig. 1: Left and right ear BERA wave from the mastoid electrode (ME) and earlobe electrode (LE).

between 0.588 and 0.913 (p=0.00). The amplitude of wave V in both mastoid and earlobe electrode placement showed moderate correlation with R-values between 0.467 and 0.789 (p=0.00).

DISCUSSION

In our study, the BERA examinations were carried out twice for each subject by placing the electrode disc on the mastoid and the earlobe area in children. Our study collected the data that could be used as a reference for normal hearing children's wave latency when using electrodes placed on the earlobe. Assessment of wave latency and amplitude was performed for both recordings, and a strong to very strong correlation was found especially in click stimuli in intensities of 20, 40, and 60 dB. Such correlation showed that BERA wave recording with electrode placement on the earlobe is reliable even in children. Other study in adult patient found that the earlobe and mastoid are close enough to the potential generator or the cochlea for resulting latencies within normal limit.[8] Our study result was consistent with previous literature; however, the wave latency obtained from the lobe electrode is slightly longer than the mastoid electrode. This should be noted by the examiner, but this is negligible because the range is still within the normal limit.

Previous experimental recordings have shown that the amplitudes of cochlear and auditory nerve potentials become smaller as the distance between the physiological generators and recording site increases.[9] Wave V amplitude may slightly reduce with earlobe placement.[2] Our finding is also consistent with this literature and shows moderate wave V amplitude correlation between mastoid and earlobe electrode.

There are several advantages with electrode placement on the earlobe area such as the absence of muscle contraction, making distance between the electrode and the bone vibrator; thus, reducing electrical artifacts in bone conduction BERA recording. The placement of electrodes on the earlobe could also be beneficial in some cases, particularly when it is not possible to place the electrode on the mastoid area. However, one of the disadvantages is the possibility of electrode migration due to soft and flexible anatomy of the earlobe. This condition can be avoided by securing the earlobe electrode with tape. In the case of microtia/anotia, in which the earlobe is too small/missing, the electrode can be placed on the skin tag.[2]

Some research reports have suggested another option for electrode placement such as ear canal electrode. However, despite their advantages and disadvantages, the ear canal electrode size can still be too large for infants' ears, and there is a possibility that the electrode could dislodge or move. Atcherson et al.[3] found that there was no statistical advantage of ear canal electrodes for wave I enhancement compared to the earlobe or mastoid electrode placement.

There are some limitations in our study as we did not separate the subjects based on gender when conducting the analysis. Most of our subjects are males who tend to have longer latencies than females because of the comparable head size, while gender is one of the influencing factors that should be considered when evaluating BERA absolute latency.[10-12]

CONCLUSION

Our study has demonstrated that there is a strong correlation between wave V latency obtained from mastoid and earlobe electrode. Therefore, placing electrodes on the earlobes area is reliable, particularly in certain condition when placing the electrodes on the mastoid area is not possible.

ETHICAL AND CONSENT

Our study has received approval from the Ethics Committee (Faculty of Medicine Universitas Indonesia Protocol number 20-07-0840) and research permission from Cipto Mangunkusumo General Hospital. Informed consent has also been obtained from the patients' parents before the initiation of the study.

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