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Evaluation of otoacoustic emissions and brainstem auditory evoked potential in infants with birth asphyxia

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ABSTRACT

Background: Recent technological evolutions allow for the identification of hearing level (HL) in infants soon after birth. The goal of early hearing detection and intervention is to maximize linguistic and communication skills and literacy development for children who are deaf or hard of hearing. Infants whose HL has been confirmed before 6 months of age must be provided early intervention. **Aims and Objectives:** The aim of the study was to observe the changes in the otoacoustic emissions (OAE) and brainstem auditory evoked potential (BAEP) in infants with birth asphyxia (BA). **Materials and Methods:** The present study was a case–control study. A total of 50 cases of infants with BA and 50 normal-term infants were part of the study after obtaining informed consent as per the ICMR guidelines. A through clinical examination and otoscopy examination were done to rule out any conductive hearing loss. Then, OAE and BAEP were recorded to estimate the hearing loss and hearing threshold of infants. **Results:** BAEP waveform I, III, and V absolute latencies were significantly prolonged among BA infants than normal infants. The interpeak latency (IPL) of the right ear III-V was significantly increased in BA infants. However, III-V and I-V latencies though prolonged in BA infants, they are not statistically significant. No significant interaural difference was noted in absolute and IPLs of both BA and normal infants. No significant relationship existed between the mode of delivery and the degree of hearing loss in both ears. Significant association was observed between the degree of hearing loss and severity of BA (hypoxic-ischemic encephalopathy) in both ears. **Conclusion:** BAEP recording in BA infants is useful to identify the hearing impairment at the earliest. The implication of this research work will help in early detection of hearing impairment, so that speech and language developmental delay in the child can be prevented.

Key words: Asphyxia; Infants; Hearing loss; Brainstem auditory evoked potentials

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INTRODUCTION

Assessment of hearing in children is one of the dark areas in our discipline in spite of the fact that 2 out of every 100 children under 6 years of age have permanent bilateral deafness above 60 dB hearing level (HL).[1,2] Hearing is one of the important five senses.[3] Much of our understanding of the physical, social, and biological universe is gained through hearing. Hearing depends on sound waves, which constantly inform the environmental activity,[4] and is also important for normal speech, language, and cognitive development which is crucial for verbal communication and personality development.[2,3] Globally, hearing loss is one of the most common sensory deficits in human beings.[4] It is the second most common form of disability after locomotor disability in India.[5]

Birth asphyxia (BA) is one of the main causes of stillbirth and early neonatal mortality apart from low birth weight and preterm delivery. According to the WHO, global

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disease burden estimates that BA was responsible for 42 million disability-adjusted life years in 2004, making it 8th leading cause of disease in all age groups.[6,7] Neonate is exposed to spectrum of disorders as a result of asphyxia, which includes hypoxic-ischemic encephalopathy (HIE), neuropathy, acute renal failure, systemic hypotension, cardiogenic shock, congestive cardiac failure, disseminated intravascular coagulation, necrotizing enterocolitis, meconium aspiration, and variety of metabolic problems like hyponatremia.[8] Electrophysiological procedures are most commonly used to identify the hearing loss in newborns and infants. These are otoacoustic emission (OAE) and brainstem auditory evoked potential (BAEP) that effectively assess the type and degree of hearing loss.[9] OAE is simple, cheap, quick, non-invasive, and reliable with a sensitivity of 100% and specificity of 99%.[4] It is also cost-effective, convenient, easy to use, and time saving. BAEP is the representation of electrical activity produced by the eighth cranial nerve and brainstem (integrity of auditory pathway) in response to auditory stimulus during the first 10 min.[10] Recent technological evolutions allow for the identification of HL in infants soon after birth. The goal of early hearing detection and intervention is to maximize linguistic and communication skills and literacy development for children who are deaf or hard of hearing. Infants whose HL has been confirmed before 6 months of age must be provided early intervention. Hence, the present study was undertaken to observe the changes in the OAEs and BAEP in infants with BA.

Aims and objectives

The current study aimed to observe the changes in the OAEs and BAEP in infants with BA.

MATERIALS AND METHODS

The present study was conducted at the Department of Otorhinolaryngology, Coimbatore Medical College Hospital, Coimbatore. It was a case–control study conducted from July 2015 to June 2016. A total of 50 cases of infants with BA and 50 normal-term infants were part of the study after obtaining informed consent as per the ICMR guidelines. BA infants were selected from babies admitted with pediatric inpatient and outpatient department, and normal infants were selected from the immunization and well-baby clinic, in the department of pediatrics, CMCH, Coimbatore. Term infants more than 37 weeks, birth weight more than 2500 g, Apgar score at 5 min ≤6, having HIE were recruited as cases. Term infants more than 37 weeks, birth weight more than 2500 g, and Apgar score at 5 min more than or equal to 7 were recruited as controls. Infants with *in utero* infections, hyperbilirubinemia and need phototherapy, meningitis, exposed to ototoxic drugs, ear malformations, Down's syndrome, family history of hearing loss, and consanguineous marriage were excluded from the study. A through clinical examination and otoscopy examination were done to rule out any conductive hearing loss. Then, OAE and BAEP were recorded to estimate the hearing loss and hearing threshold of infants. Biologic AUDX PRO equipment was used for recording OAE for both normal and BA infants. Intelligent Hearing System (Florida) (Smart EP, Universal Smart box Jr TM, Opti-Amp 8002) was used for recording BAEP in BA and normal infants.

Statistical analysis

Data were analyzed by SPSS 27.0 version. Data were checked for quality control in a spreadsheet and then expressed in mean and standard deviation. Student's t-test was applied to observe the significance of the difference between the groups. A probability value of <0.05 was considered statistically significant. The Chi-square test has been used for the association between degree of hearing loss and severity of BA.

RESULTS

Table 1 presents the demographic data of the participants. Age distribution between the control and BA groups was presented in Table 2. OAE recording of study groups was presented in Table 3. Absolute latencies in control and BA infants were presented in Table 4. Interpeak latencies (IPLs) in normal and BA infants were presented in Table 5. The interaural difference of absolute latency was presented

Table 1: Demographic data of the participants

Variables	Group I-control	Group II-Birth asphyxia
Participants	n=50	n=50
Mean birth weight	2.85±0.30	2.86±0.32
Gender-boys/girls	27/23	29/21

Table 2: Age distribution between the normal and birth asphyxia group

Age in days	Control group		Birth asphyxia group	
	Number	%	Number	%
0–120	31	62	37	74
121–240	09	18	07	14
241–360	10	20	06	12
Total	50	100	50	100

Table 3: OAE recording of study groups

Study group	Pass		Refer	
	Number	%	Number	%
Control	50	100	0	0
Birth asphyxia	0	0	50	100

OAE: Otoacoustic emission

in Table 6. The relationship between mode of delivery and degree of hearing loss in the right and left ear was presented in Figures 1 and 2. The relationship between the BA infants and degree of hearing loss in the right and left ear was presented in Tables 7 and 8. OAEs and BAEP were recorded both in 50 normal healthy infants and 50 BA infants. BAEP parameters, namely absolute latencies and inter peak latencies, were compared between the two groups. BAEP waveform I, III, and V absolute latencies were significantly prolonged among BA infants than normal infants. The IPL of the right ear III-V was significantly increased in BA infants. However, III-V and I-V latencies though prolonged in BA infants, they are not statistically significant. No significant interaural difference was noted in absolute and IPL of both BA and normal infants. No significant relationship existed between the mode of delivery and the degree of hearing loss in both ears. Significant association was observed between the degree of hearing loss and severity of BA (HIE) in both ears.

DISCUSSION

In this case–control study, the mean birth weight of 50 BA infants was 2.86±0.32, and the mean birth weight of 50 normal healthy infants was 2.85±0.30. Age and sex-matched study participants were selected, of which the majority belonged to 0–120 days of birth. All the babies were screened using OAE, of which all normal infants had "Pass" results and all BA infants had "Refer" results. All the babies were subjected to BAEP, of which absolute latencies of BA infants were prolonged significantly when compared to the normal infants. IPL was also prolonged in BA infants but it was not statistically significant when compared to the normal infants. Interaural difference of absolute and IPL in BA and normal group was not statistically significant. According to ASHA classification, the degree of HL was assessed in BA infants. In this study, there was no profound HL. The relationship between mode of delivery and HL was assessed in BA infants. Normal, minimal, mild, moderate, moderately severe, and severe HL in normal vaginal delivery (NVD) was 6%, 30%, 16%, 6%, 8%, and 0%, respectively; in forceps vaginal delivery (FVD) was 0%, 4%, 2%, 2%, 2%, and 2%, respectively; in elective lower segment cesarean section (LSCS) was 2%, 8%, 4%, 0%, 0%, and 2%, respectively; and in emergency, LSCS was 0%, 4%, 2%, 0%, 0%, and 0%, respectively, for the right ear. Normal, minimal, mild, moderate, moderately severe, and severe HL in NVD was 10%, 32%, 10%, 8%, 4%, and 2%, respectively; in FVD was 0%, 2%, 4%, 2%, 0%, and 2%, respectively; in elective LSCS was 2%, 10%, 0%, 0%, 2%, and 2%, respectively; and in emergency LSCS was 0%, 2%, 2%, 2%, 2%, and 0%, respectively, for the left ear. Furthermore, there is a significant association between BA with HIE and the degree of HL in both ears. These results are in accordance with earlier studies.[11-14]

It was showed that all the waves of absolute latencies are higher in BA than control group and were statistically significant. IPL of I-III, III-V, and I-V in BA group was prolonged but statistically not significant when compared to the control group except III-V IPL. Prolonged latency of wave V with normal IPL suggests the involvement of cochlear branch of 8th nerve or the cochlea. It may be

Table 4: Absolute latencies in control and birth asphyxia infants

Absolute latency (ms)	Control right ear	Birth asphyxia right ear	P-value	Control left ear	Birth asphyxia left ear	P-value
I	1.47±0.17	2.06±0.33	0.000*	1.54±0.31	2.05±0.44	0.000*
III	4.01±0.26	4.51±0.40	0.000*	4.07±0.35	4.53±0.45	0.000*
V	5.99±0.66	6.80±0.83	0.000*	6.25±0.64	6.96±0.88	0.000*

*P value less than 0.05 is significant

Table 5: Interpeak latencies in control and birth asphyxia infants

Interpeak latency ms	Control right ear	Birth asphyxia right ear	P-value	Control left ear	Birth asphyxia left ear	P-value
I-III	2.56±0.33	2.44±0.41	0.137	2.55±0.34	2.54±0.42	0.930
III-V	2.09±0.28	2.32±0.69	0.031*	2.14±0.37	2.28±0.49	0.104
I-V	4.66±0.50	4.82±0.92	0.288	4.67±0.55	4.87±0.68	0.115

Table 6: Interaural difference of absolute latency

Study group	RE I	LE I	P-value	RE III	LE III	P-value	RE V	LE V	P-value
Normal	1.47±0.1	1.54±0.3	0.102	4.01±0.2	4.07±0.3	0.138	5.99±0.6	6.25±0.6	0.071
Birth asphyxia	2.06±0.3	2.05±0.4	0.829	4.51±0.4	4.53±0.4	0.628	6.80±0.8	6.96±0.8	0.206

RE: Right ear, LE: Left ear

Table 7: The relationship between the birth asphyxia infants and degree of hearing loss in the right ear

Birth asphyxia infants	Degree of hearing loss in the right ear						
	Minimal	Mild	moderate	moderately severe	Severe	Normal	Total
Birth asphyxia without HIE	16	5	2	1	1	1	26
Birth asphyxia with HIE	7	7	2	4	1	3	24
χ^2=96.13, *P*=0.000*							50

HIE: Hypoxic-ischemic encephalopathy

Table 8: The relationship between the birth asphyxia infants and degree of hearing loss in the left ear

Birth asphyxia infants	Degree of hearing loss in left ear						
	Minimal	Mild	Moderate	Moderately severe	Severe	Normal	Total
Birth asphyxia without HIE	13	4	1	1	1	4	24
Birth asphyxia with HIE	10	4	5	3	2	2	26
χ^2=82.27, *P*=0.000*							50

HIE: Hypoxic-ischemic encephalopathy

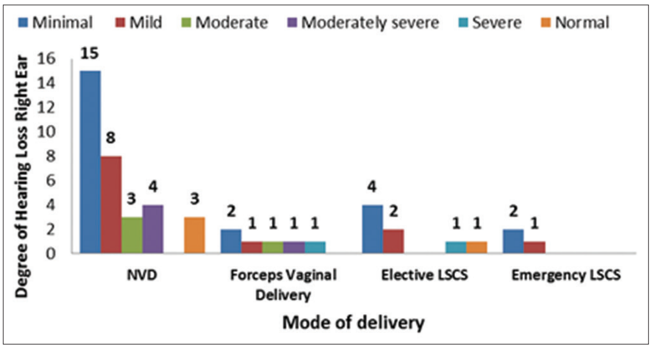

Figure 1: The relationship between mode of delivery and degree of hearing loss in right ear

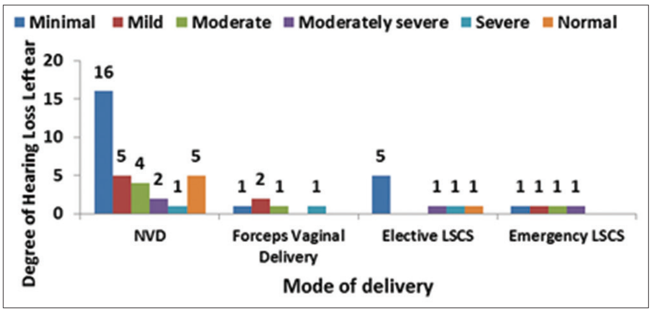

Figure 2: The relationship between mode of delivery and degree of hearing loss in left ear

depression of endocochlear potential due to hypoxia or acidosis. Study showed that neonates with BA had higher mean absolute latencies in BAEP whereas IPL did not show significant prolongation compared to controls. The BAEP waveform defects were suggestive of peripheral involvement (cochlear nerve or the cochlea) rather than brainstem abnormality. This observation is in dissimilarity to experimental as well as clinical data, which suggest that various brainstem nuclei and inferior colliculi are most vulnerable to BA. Early or primary neuronal injury occurs as a result of cytotoxic alterations due to failure of microcirculation, impairment of energy-producing molecular processes, increasing extracellular acidosis, and impairment of Na^+-K^+ ATPase membrane pumps, which results in excessive leakage of Na^+ and Cl^- into the cell which leads to intracellular accumulation of water. Free radical production also begins, which further compromises neuronal integrity. If not reversed, these processes lead to neuronal cell death within a short period of the acute insult, but recovery and reperfusion which occurs with resuscitation fuel the pathways to late (secondary) neuronal damage through a relatively large number of known pathophysiologic mechanisms.[12-17] In the current study, there is a significant relationship between the severity of BA and degree of hearing loss. In these babies, OAE was absent which is due to suppression of outer hair cells. This finding is consistent with the results of earlier studies. BAEP is used to identify the hearing loss.

Limitations of the study

The study results cannot be generalized as the sample size of study is less.

CONCLUSION

BAEP recording in BA infants is useful to identify the hearing impairment at the earliest. The implication of this research work will help in early detection of hearing impairment, so that speech and language developmental delay in the child can be prevented.

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KP, SMSK – Design of the study, review of literature, analysis, and preparing the manuscript, **CS –** Data collection, preparing the manuscript, **SSKG–** design of the study, Analysis and preparing the manuscript, Proofreading.

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