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Original Research Article

AN AUDITORY ASSESSMENT OF LOW BIRTH WEIGHT INFANTS USING BRAINSTEM EVOKED RESPONSE AUDIOMETRY

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ABSTRACT

Low birth weight is a major risk factor for hearing loss. Low birth weight is defined by WHO as weight at birth less than 2500g irrespective of gestational age. The aim of this study was to assess the incidence of hearing impairment in low birth weight infants using brainstem evoked response audiometry and to compare and analyze the BERA responses in low birth weight infants & infants with normal birth weight and hearing. The study was conducted in 50 low birth weight infants & 50 healthy infants with normal birth weight, between the age of 3-12 months, in the Audiology Lab of ENT Department, B.J.Medical College and Civil Hospital, Ahmedabad, Gujarat after seeking Ethical committee permission. Double channel BERA was done on infants using RMS MEDULLA AD 1.33 machine. Threshold of wave V, absolute latencies of waves I,III,V and interpeak latencies I-III, I-V, III-V of low birth weight and healthy infants were compared and analyzed. There was statistically significant increase in wave V threshold in low birth weight infants compared to control group of infants with normal birth weight and hearing. The absolute latencies of waves I, III, V and interpeak latencies III-V and I-V were significantly prolonged in low birth weight infants compared to infants with normal birth weight and hearing. All these changes in BERA were suggestive of sensorineural hearing loss in low birth weight infants. There was no statistically significant changes in the interpeak latency I-III. In our study, 50% of low birth weight infants had hearing impairment wherein 26% of low birth weight infants had profound, 4% had severe and 20% had moderate levels of hearing loss. Hence, all the low birth weight infants should be subjected to newborn hearing screening.

Keywords: BERA (brainstem evoked response audiometry), Hearing impairment, LBW.

INTRODUCTION

Deafness and hearing impairment is increasing rapidly globally. As per the WHO report, over 5% of the world's population have disabling hearing loss. About 34 million children are affected by hearing impairment. Upto 3 out of every 1000 babies are born with hearing loss or acquire it soon after birth.[1]The estimated prevalence of childhood-onset deafness in India is 2%.[2]

Hearing impairment has a detrimental impact on the development of newborn infants.[3] A deaf or hearing impaired child cannot learn language as language can only be learnt through hearing. As the deaf child does not learn language, the child cannot speak and becomes mute. Inadequate development of language/ communicative skills will lead to lack of access to education. This will result in social isolation of the child. It adversely affects the cognitive, social, emotional, psychological development of the child. Also, it reduces the employment opportunities of the child in adulthood.[6]

The critical language learning period of a child is from birth to about three and half years of age. After this critical language learning age the remedial measures to teach the child proper speech and language are practically ineffective.[6] The plasticity of brain reduces drastically as the child grows older. It is hence essential that the child has access to sound be it through hearing aids or cochlear implants at the youngest possible age while the plasticity of the brain is still at its maximum level. This can lead to normal speech development.[6,3]

The Joint Committee on Infant Hearing endorses **early hearing detection and intervention** for infants with hearing loss to maximize their linguistic competence and literacy development. JCIH proposes that hearing of all infants should be screened at no later than 1 month of age and infants with confirmed hearing loss should receive appropriate intervention at no later than 6 months of age.[9]

LOW BIRTH WEIGHT AND HEARING LOSS

Low birth weight is an important risk factor for hearing loss.[1] Low birth weight is defined by the WHO as weight at birth less than 2500g (up to and including 2499 g) irrespective of gestational age. A baby's low weight at birth is either the result of preterm birth (before 37 weeks of gestation) or of restricted foetal (intrauterine) growth or it can be an occurrence of both.[11] So, Low birth weight babies include preterm & term small for date babies. There are nearly 8 million infants born with low birth weight in India.[11]

Birth weight is an indicator of health of the newborn baby and its an important determinant of child survival. Low birth weight infants are anatomically and functionally immature. Birth weight less than 1500g was first identified as a high risk criteria for hearing loss by JCIH in 1972.[14] Indian Academy of Paediatrics has recognized low birth weight as a high risk criteria for hearing loss and recommends the screening of all low birth weight infants.[8] The hearing loss in LBW infants can be due to immature auditory system, sepsis, TORCH infection, exposure to hyperbilirubinemia, aminoglycosides, hypoxic and noisy environments.

IMMATURE AUDITORY SYSTEM

Preterm infants have immature auditory system due to which they are susceptible for hearing loss.[15] In premature new born there is increased absolute latency and interpeak interval values compared to term new born. This may be related to delayed myelinization of developing auditory pathway.[16]

HYPOXIA

Low birth weight babies are more likely to have suffered episodes of hypoxia.[15] Adequate oxygenation and perfusion are essential for normal cochlear function. In newborn infants with hypoxia, the spiral ganglion cells were affected first. Severe hypoxia may cause irreversible damage to cochlea, particularly outer hair cells and stria vascularis.[17]

HYPERBILIRUBINEMIA

These babies have immature metabolic functions and immature blood brain barrier and are therefore prone for bilirubin-associated brain damage at lower levels of bilirubin compared to normal birth weight babies,[15,19] Kernicterus characterized by necrosis of cochlear nucleus and spiral ganglion cells may result in hearing loss. Majority of children with kernicterus have unrecordable BAEP.[18]

NOISE INDUCED HEARING LOSS

Low birth weight neonates spend a variable amount of time in the intensive care units as they suffer from various morbidities.[20] Exposure to constant background noise generated by life-support machines in the NICU can produce hearing loss. Noise trauma can produce damage to outer and inner hair cells, stria vascularis, spiral ganglion cells and supporting cells. As hair cells from the human cochlea lack the ability to regenerate, severe acoustic trauma/ prolonged noise exposure may lead to complete sensorineural hearing loss.[17]

SEPSIS

Because of their immature defenses low birth weight infants are prone for sepsis. The damage to the ear caused by sepsis is called Sepsis otopathy. Sepsis induces apoptosis of supporting cells of the organ of Corti and also damages the inner hair cells.[21]

TORCH infection

Low birth weight due to intrauterine growth retardation can occur as a result of intrauterine TORCH infection. It can cause damage to cochlear hair cells and spiral ganglion cells.[17]

AMINOGLYCOSIDES like amikacin used in the treatment of certain infections can produce irreversible hearing loss by causing hair cell death.[17]

With the advent of brainstem evoked response audiometry (BERA), detection and quantification of hearing impairment has been easier in pediatric patients who are unable to cooperate with routine testing.[13] BERA is an objective electrophysiological test of the auditory system. It basically ascertains the structural and functional integrity of the auditory pathway from the spiral ganglia to the level of inferior colliculus in midbrain. It can also predict the approximate hearing threshold and asses the severity of hearing loss.[7]

BAEP comprises of five waveforms(wave I–V) and three interpeak latencies(I–V,I–III, III–V) Wave I is generated from distal portion of cochlear nerve, wave II from proximal portion of cochlear nerve, wave III from cochlear nucleus, wave IV from superior olivary complex and wave V from lateral leminiscus and inferior colliculus.[6,12] The exact site of origin of each wave is not very precise. In infants only waves I, III and V are clearly identifiable.[6] The parameters measured for the analysis of BAEP are 1) Wave V threshold 2)Absolute latency of waves I, III , V 3)Inter peak latencies I–V, I–III, and III–V

AIM

The aim of this study is to assess the incidence of hearing impairment in low birth weight infants using BERA and to compare and analyze the BERA responses in low birth weight & normal birth weight infants.

MATERIALS AND METHODS

The study was conducted in 50 low birth weight infants & 50 term normal birth weight infants of 3-12 months age, in the Audiology lab of ENT department, Civil hospital, B. J. Medical College, Ahmedabad, Gujarat. Ethical committee permission was obtained for this study

The low birth weight infants were selected from High Risk Clinic of Paediatric department, a special clinic for the follow up and care of sick infants. The control group of healthy infants were selected randomly from Well baby clinic and Paediatric OPD.

SUBJECT SELECTION

1. **Inclusion Criteria**

- Infants 3 months-1 year of age with birth weight less than 2.5Kg and normal age matched term healthy babies with birth weight 2.5 kg or more.
- Gender: both

2. **Exclusion Criteria**

- Infants whose parents do not consent to BERA.
- Apparently healthy infants who fail in BERA test.
- Infants with craniofacial anomalies, syndromes associated with hearing loss, neurodegenerative disorders & head trauma

Written informed consent was taken from the parents after explaining them the procedure & its significance. A detailed medical history & thorough ENT examination was carried out before the procedure. Infants were sedated with syrup pedichloryl. Then they were subjected to BERA test. The entire BERA procedure was carried out in a soundproof, airconditioned, semidarkened room on sleeping subject. Double channel BERA was done using RMS MEDULLA AD 1.33 machine which is a fully computerized machine.

After cleaning the forehead, vertex and both mastoid regions with spirit, surface electrodes were fixed at the vertex (CZ), both mastoids (A1 and A2) and forehead (Fpz-ground); using RMS recording paste and it was secured with tape. Once, the electrodes and TDH-49 earphone were placed, the impedance of electrodes were checked. The impedance between electrodes was kept below 5KΩ.

BERA was done using sweep speed of 1 ms/div with a sensitivity of 250nV. Highpass and Lowpass filters were kept at 100 Hz and 2500Hz respectively. Binaural auditory stimulus consisting of alternate condensation and rarefaction clicks of 100 microseconds were delivered through electrically shielded TDH-49 earphones at a rate of 25.1/sec for a time duration of 10 msec. The stimulus was first given at 70 dB SPL and if wave V appeared then intensity was progressively reduced by 10 dB until the threshold level was attained. Incase of no response at 70 dB SPL, then intensity was progressively increased by 10 dB until a response was obtained or 120 dB SPL was attained whichever earlier. A total of 2,500 stimulations were averaged and the process was repeated at least once to ensure reproducibility of the response.

The lowest click intensity at which the wave V persisted while decreasing the intensity of sound from 70 dB SPL or the lowest click intensity at which wave V appeared first while increasing the intensity of sound from 70 dB SPL was taken as the threshold of hearing of the subject. BERA threshold is defined as the minimum sound intensity at which a recognizable wave V is present. **A threshold of 40 dB SPL was considered as the pass criteria for test.** Apparently healthy babies with normal birth weight who passed the BERA test were enrolled in the study as the standard control group. All low birth weight infants irrespective of their BERA results were enrolled as the study group.

The absolute latency of waves I, III, V and interpeak latencies I-III, I-V, III-V of the low birth weight infants and healthy infants of control group with normal birth weight and hearing were compared at 70 dB SPL.

DATA ANALYSIS

Data were entered in Excel sheet and the mean and standard deviations for various parameters were calculated in excel. The comparison of means was done using z test in excel sheet and the p values were derived to test the significance of various findings

RESULTS

The control group of infants with normal birth weight and normal hearing consisted of 29 male and 21 female infants with a mean age of 5.66 (≈6) months. The study group of LBW infants consisted 30 male and 20 female infants. The study group had a mean age of 6.62(≈ 7) months. Out of 50 low birth weight infants there were 33 infants (66%) with birth weight of 1.5-2.49 Kg and there were 17 infants (34%) with very low birth weight ie, birth weight less than 1.5Kg.

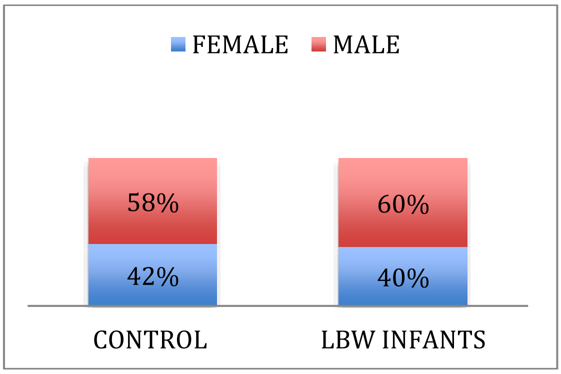

Figure 1: Gender Distribution Among Control and LBW Infants

Table 1: Gender Distribution Among Control Group of Normal Birth Weight And Normal Hearing Infants And LBW Infants		
	CONTROL (Number)	**LBW INFANTS (Number)**
FEMALE	42%(21)	40%(20)
MALE	58%(29)	60%(30)

Table 2: Age Distribution Among Control Group of Normal Birth Weight and Normal Hearing Infants and LBW Infants

	MEAN±SD (months)
CONTROL	5.66±2.124
LBW INFANTS	6.62±2.498

Table 3: Distribution Of Birth Weight Among LBW Infants

Birth Weight (Kg)	**Number Of Infants**
1.5-2.49	33(66%)
<1.5	17(34%)
	TOTAL=50

Out of 50 LBW infants who underwent BERA, 25 had hearing impairment in our study.ie, 50% of LBW infants had hearing impairment. 26% of LBW infants had profound, 4% had severe and 20% of them had moderate levels of hearing loss.

Among the 25 infants with hearing impairment 13 had profound, 2 had severe and 10 had moderate levels of hearing loss. Out of 13 infants with profound hearing loss no BERA response could be obtained from 10 infants (77%).

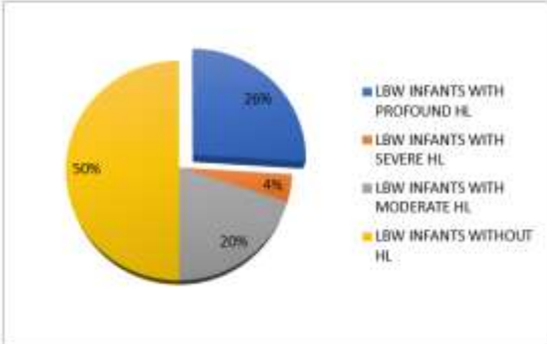

Figure 2: LBW Infants and Hearing Impairment

Out of 33 infants with birth weight of 1.5-2.49 Kg,15 infants had hearing loss ie;45.5% while out of 17 infants with very low birth weight 10 had hearing impairment, ie;58.8% of very low birth weight infants had hearing impairment. The distribution of infants with hearing loss in low birth weight (1.5-2.49Kg) and very low birth weight (<1.5 Kg)groups is shown in the following table(4):

Table 4: LBW Infants and Hearing Impairment

BIRTH WEIGHT (Kg)	**DEGREE OF HEARING LOSS**			
	MODERATE	**SEVERE**	**PROFOUND**	**TOTAL INFANTS WITH HL**
2-2.49	5	0	3	8
1.5-1.9	3	0	4	7
<1.5	2	2	6	10

Out of 13 infants with profound hearing loss, 6 (46%) had birth weight less than 1.5 Kg, 4(31%) had birth weight in the range 1.5 to 1.9 Kg while 3 (23%) had birth weight in the range 2 to 2.49Kg.

Of the low birth weight infants with hearing loss, 15 infants had history of NICU stay more than 5 days, 12 had birth asphyxia, 9 had hyperbilirubinemia, 9 were preterm, 3 had TORCH infection and 2 had septicemia

Table 5: LBW Infants with Hearing Loss and Other Associated Risk Factors for Hearing Loss

NO	**RISK FACTORS**	**NO. OF INFANTS**
1	NICU STAY MORE THAN 5 DAYS	15
2	BIRTH ASPHYXIA	12
3	HYPERBILIRUBINEMIA	9
4	PRETERM	9
5	TORCH	3
6	SEPTICEMIA	2

Wave V threshold of control group was 37.7 dB with standard deviation of 4dB while that of low birth weight infants was 52dB with a standard deviation of 22dB.That means the wave V threshold is higher in low birth weight infants compared to control group of infants with normal birth weight and hearing. This finding was found to be statistically significant.

Table 6: Comparison of Wave V Threshold of Control and LBW Infants

	Mean±SD (dB)	Z score	p value
CONTROL(N=50)	37.7±4.191	-4.121	**<0.01 S**
LBW INFANTS(N=40)	52±21.626		

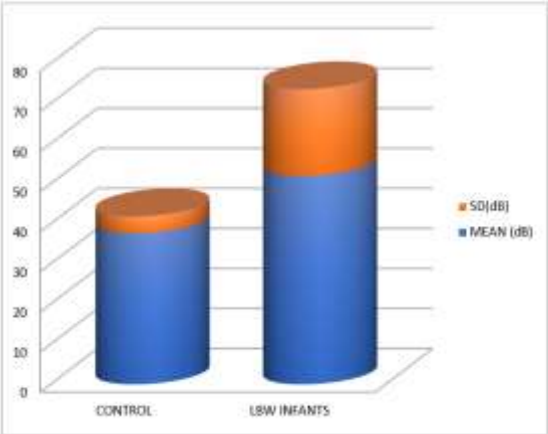

Figure 3: Comparison of Wave V Threshold of Control and LBW Infants

The mean absolute latency of wave I in control group of infants with normal birth weight and hearing was found to be 2.56 msec with a standard deviation of 0.288 while that of LBW infants was found to be 2.84 msec with a standard deviation of 0.501. This shows an increase in absolute latency of wave I in LBW infants compared to the control group and it was found to be statistically significant also. There was statistically significant increase in absolute latency of wave III in LBW infants compared to infants with normal birth weight and hearing; with a mean absolute wave III latency of 5.0 msec with standard deviation of 0.537 in LBW infants and 4.69 msec with a standard deviation of 0.328 msec in control group of infants. There was also statistically significant increase in absolute latency of wave V in LBW infants compared to control group of infants. The mean absolute latency of wave V in control group of infants with normal birth weight and hearing was 6.67 msec with standard deviation of 0.284 while that of LBW infants was 7.38 msec with a standard deviation of 0.579.

Table 7: Comparison of BERA Parameters of Control and LBW Infants

	Control(n=50)	LBW infant(n=35)	Z score	P value
Parameter	**Mean±SD(msec)**	**Mean±SD(msec)**		
Absolute latency				
I	2.562±0.288	2.843±0.5013	-2.987	**<0.05,S**
III	4.69±0.328	5.0±0.5368	-3.041	**<0.05,S**
V	6.666±0.284	7.377±0.5791	-6.72	**<0.01,S**
Interpeak latency				
I-III	2.128±0.3044	2.157±0.3616	-0.389	>0.05,NS
I-V	4.104±0.3487	4.534±0.719	-3.281	**<0.01,S**
III-V	1.976±0.2661	2.377±0.598	-3.718	**<0.01,S**

p<0.05-SIGNIFICANT
p>0.05-NOT SIGNIFICANT

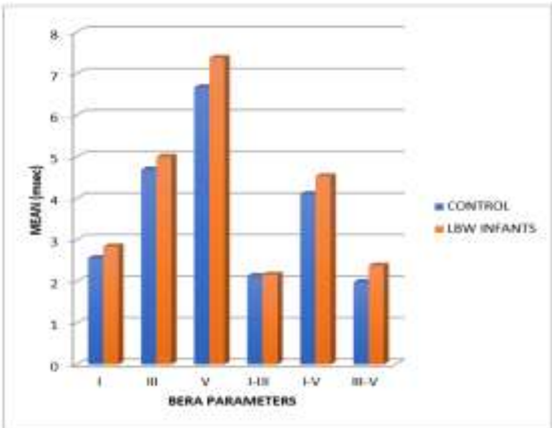

Figure 4: Comparison of BERA Parameters in Control and LBW Infants

The mean interpeak latency I-III of control group of infants was found to be 2.13 msec while that of LBW infants was 2.16 msec. There was no statistically significant changes in the interpeak latency I-III.

The mean interpeak latencies I-V and III-V of control group of infants was found to be 4.1 and 1.98 miliseconds respectively while that of LBW infants was 4.5 and 2.38 milliseconds respectively. There was found to be a statistically significant increase in the interpeak latencies I-V and III-V in LBW infants compared to control group of infants with normal birth weight and hearing.

DISCUSSION

In our study the incidence of hearing impairment in LBW infants was found to be 50%. While 26% of LBW infants had profound hearing loss, 4% had severe and 20% had moderate levels of hearing loss. 40% (10) of infants with hearing loss had no BERA response at all. The incidence of hearing impairment in LBW infants is highly variable from 6.3% to

63.33%. The prevalence of impaired hearing in the very low birth weight neonates cared at Neonatal intensive care unit was 6.3% in the study of Natacha et al.[23] In the study of Anupriya Deshpande et al.;out of 30 babies with LBW,19 had hearing impairment. That means the incidence of hearing impairment in LBW infants is about 63.33% in their study.[22] In the study of Ishika Vashistha et al prematurity and very low birth weight associated hearing loss was found to be 17.02% and 17.05% respectively.[10] While in the study of Bhagya et al out of 10 LBW infants they screened 8 had hearing loss ie, 80%.[24]

In our study, out of 33 infants with birth weight of 1.5-2.49 Kg,15 infants had hearing loss ie;45.5% while out of 17 infants with very low birth weight 10 had hearing impairment, ie;58.8% of very low birth weight infants had hearing impairment. This shows that infants with birth weight less than 1.5Kg have more chances of hearing loss than infants with birth weight of 1.5 to 2.49Kg. In other words, as the birth weight reduces the risk for hearing loss increases.

Also, our study shows that the severity of hearing impairment increases with the decrease in birth weight. Out of 13 infants with profound hearing loss, 6 (46%) had birth weight less than 1.5 Kg, 4(31%) had birth weight in the range 1.5 to 1.9 Kg while 3 (23%) had birth weight in the range 2 to 2.49Kg.

In our study 9 low birth weight babies with hearing loss were found to be preterm babies,15 had history of NICU stay more than 5 days,9 had hyperbilirubinemia,12 had birth asphyxia, 3 had TORCH infection and 2 had septicemia.

In the study of Ishika Vashistha *et al* NICU stay more than 5 days and hyperbilirubinemia requiring exchange transfusion had a prevalence of hearing impairment of 20.68 and 36.36% respectively.[10] In the study of Bhagya *et al* out of 18 patients with severe hearing impairment 3 had hyperbilirubinemia and 7 had birth asphyxia. While out of 50 cases of profound hearing loss, 10 infants were preterm, 18 had hyperbilirubinemia, 12 had birth asphyxia and 4 had low birth weight.[24]

During, the analysis of BERA parameters there was statistically significant increase in wave V threshold in LBW infants compared to control group of infants with normal birth weight and hearing. Wave V threshold of control group was 37.7 dB SPL with standard deviation of 4dB while that of the LBW infants was 52dB SPL with standard deviation of 22dB. This proves that there is hearing impairment in LBW infants. In the study of Anupriya Deshpande *et al* there was statistically significant increase in wave V threshold in LBW infants compared to control group of infants.[22]

The absolute latencies of waves I, III, V and interpeak latencies III-V and I-V were significantly prolonged in LBW infants compared to control group of infants , which is suggestive of sensorineural hearing loss in low birth weight infants. In the study of Anupriya Deshpande *et al* there was prolonged absolute wave V latency and prolonged interpeak latency III-V which is suggestive of sensorineural hearing loss.[22]

CONCLUSION

Our study shows that there is a high incidence of hearing impairment in low birth weight infants. As the birth weight reduces the risk for hearing loss increases. Infants with birth weight less than 1.5 Kg have more chances of hearing loss. Also, the severity of hearing impairment increases with the decrease in birth weight. Low birth weight infants because of prematurity and intrauterine growth retardation are prone for hyperbilirubinemia, bacterial sepsis and birth asphyxia which necessitates neonatal intensive care in noisy incubators. All these factors act synergistically to produce hearing impairment in low birth weight infants. Therefore, hearing loss in low birth weight infants is multifactorial. The high incidence of hearing impairment in LBW infants along with the greater proportion of profound hearing loss, seen in our study calls for an early neonatal hearing screening of low birth weight infants and an early intervention for hearing impairment preferably before 6 months as the critical language learning period is from birth to three and half years and this will ensure normal speech and language development so that we can gift a normal life to the child.

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