

A study on prevalence of hearing impairment in newborns with birth asphyxia admitted to neonatal intensive care unit

Pawar R.¹, Illalu S.², Fattepur S.R.³

¹Dr. Rajeshwari Pawar, ²Dr. Illalu Shivananda, ³Dr. Fattepur Sudhindrashayana R, all authors are affiliated with Department of Paediatrics, Karnataka Institute of Medical Sciences, Hubli, Karnataka, India.

Corresponding Author: Dr. Fattepur Sudhindrashayana R., Department of Paediatrics, Karnataka Institute of Medical Sciences, Hubli, Karnataka, India. E-mail: sshayan26@gmail.com

Abstract

Background: Hearing is a vital part of a newborn's contact with his environment. Consequences of perinatal asphyxia range from death to various degrees of neuro-developmental sensory or motor deficits. One of its well-known sequelae is sensorineural hearing impairment. Hence this study was undertaken to find the prevalence of hearing impairment in inborn neonates with birth asphyxia. **Methods:** Prospective Observational study was conducted to assess the prevalence of hearing loss in neonates with birth asphyxia admitted to the NICU at KIMS, Hubballi, Karnataka, India, from January 2015 to December 2015. Auditory function was examined by Otoacoustic emission (OAE) followed by auditory brainstem response (ABR) test and distortion product OAE (DPOAE). Statistical analysis, Chi-square test was used and testing data was analysed using the SPSS software version 22. **Results:** Among the 150 neonates, prevalence of hearing impairment among term neonates with birth asphyxia was 9.9% (14/141). Babies with severe birth asphyxia ($P=0.00037$), hypoxic ischemic encephalopathy ($P=0.00914$), convulsions ($P=0.0093$) and those who were mechanically ventilated ($P=0.0003$) were more prone to develop hearing impairment. **Conclusions:** The prevalence of hearing impairment among term neonates with birth asphyxia was 9.9% (14/141). Two staged screening with OAE, which is a feasible screening test in resource poor set up, can be used as a screening modality for hearing impairment in babies with birth asphyxia.

Keywords: Birth asphyxia; Term neonates; Hearing impairment; Otoacoustic Emission; Auditory brainstem response.

Introduction

Hearing is a vital part of a newborn's contact with his environment. The ability to communicate, acquire skills and perform academically is all greatly dependent on the ability to hear [1]. Hearing impairment is a hidden disability which is usually detected after 2 years of age [2]. OAE and ABR have been recommended as useful screening protocol in Newborn Hearing Screening [3]. OAE screening test is fast and easy test and can be conducted with or without sedation to newborn [4]. Consequences of perinatal asphyxia range from death to various degrees of neuro-developmental sensory or motor deficits. One of its well-known sequelae is sensorineural hearing impairment. Adequate oxygenation and perfusion are essential for inner ear function and studies showed that neonatal asphyxia can cause inner ear degeneration, disappearance of the outer and inner hair cells, and degeneration of the spiral and vestibular ganglion cells [5].

Congenital or early childhood onset of deafness or severe-to-profound hearing impairment, as reported by the World Health Organization (WHO), is encountered in approximately 0.5–5 per 1,000 neonates and infants [6]. United States Preventive Services Task Force reported that the prevalence of neonatal hearing loss in the Neonatal Intensive Care Unit (NICU) is 10-20 times greater than the prevalence of hearing loss in a population of normal neonates [7]. Considering the infrastructure limitations in our country and as limited studies are available regarding hearing evaluation and birth asphyxia as a risk factor for hearing impairment including northern part of Karnataka, this study was undertaken to screen the possible burden of hearing impairment among the inborn neonates with birth asphyxia admitted to NICU KIMS, Hubballi by using OAE and ABR.

Aims and Objectives

To find the prevalence of hearing impairment in inborn neonates with birth asphyxia

Manuscript received: 10th January 2019

Reviewed: 20th January 2019

Author Corrected: 27th January 2019

Accepted for Publication: 31st January 2019

Materials and Methods

Place of study: Department of Paediatrics, Karnataka Institute of Medical Sciences, Hubli, Karnataka

Type of study: Prospective observational study conducted from January 2015 to December 2015.

Inclusion Criteria: Term neonates born in KIMS, Hubballi with birth asphyxia defined as Apgar score of < 7 at 1 minute were included in the study as defined by WHO South East Asia, Neonatal Perinatal Mortality Database working definition of Birth Asphyxia [8].

Exclusion criteria: Neonate with any congenital anomalies was excluded.

Sampling methods and Collection: All cases which were inborn in KIMS, Hubballi and having birth asphyxia with Apgar score of <7 were included. Five components were used to assess the Apgar score— Heart rate, Respiration, Muscle tone, Reflex irritability and Color. Apgar score was performed at 1 minute, 5 minute of birth and every 5 minutes for up to 20 minutes, if the 5 minute Apgar score was below 7.

Moderate birth asphyxia was defined as Apgar score between 4 to 6 at 1-minute of age severe birth asphyxia as Apgar score of 3 or less at 1-minute of age

A detailed history and clinical examination done and documented in preformed proforma. Newborns with birth asphyxia were screened by OAE -1 (First screening) by trained Audiologist in acoustically treated room before discharge. Results were interpreted as 'pass' for normal hearing and 'refer' for who needed further evaluation. Follow up OAE-2 (Second screening) was done in 'refer' cases after 10 to 14 days.

ABR was done immediately for confirmation of hearing impairment in those cases with OAE-2 results as 'refer'. Those newborns showing hearing impairment by ABR were referred for further management to otorhinolaryngologist.

OAE Test procedure: OAE screening was done in an acoustically treated sound chamber in Department of Audiology only after removal of debris from external auditory canal and examination by an otorhinolaryngologist. OAE screening was carried out in order to avoid high referrals due to middle ear pathology. The screening was carried out using Biologic Natus AUDX Pro instrument. DPOAE

screening was carried out at 5kHz, 4kHz, 3kHz and 2kHz for each ear separately. Clean and appropriate probe fit, minimum noise levels were ensured during the testing. 2 attempts of recording were done. Results were recorded as either 'pass' (normal functioning) or 'refer' (poor functioning).

Auditory Brainstem Response Testing procedure: Auditory brainstem responses were recorded in infants when a refer result is obtained in second stage of OAE screening. ABR was carried out using Biologic Natus Navigator PRO diagnostic instrument. Negative electrodes were placed in horizontal montage on the test ear mastoid, positive on non-test ear mastoid and ground electrode over forehead. Impedance is maintained at <5k ohms at all electrode sites. The following recording, stimulus and acquisition parameters were set before carrying out the test.

Stimulus parameters

Stimulus: Clicks, (100 micro sec duration)

Intensity: start at 90 dBnHL; reduced until peaks were present. Repetition rate – 11.1/second

Recording parameters

Epoch time- 16ms

Averages- 2000

Acquisition parameters

Gain- 100000

Filter setting- 30Hz to 3000Hz

Recording of waveforms was carried out at different intensities starting at 90dB nHL which was further reduced in 10dB steps until peaks were present. Two replications were obtained at each intensity and peaks I, III, V were marked wherever present. The lowest intensity until which Peak V was present was found and diagnosis would be made based on the same.

Classification of hearing loss: Clark's classification

-10 to 15 dB	- Normal hearing
16 to 25 dB	- Minimal hearing loss
26 to 40 dB	- Mild hearing loss
41 to 55 dB	- Moderate hearing loss
50 to 70 dB	- Moderately severe hearing loss
71 to 90 dB	- Severe hearing loss
>90 dB	- Profound hearing loss

Statistical analysis: Data was entered in and analyzed using the SPSS software version 22.0. Test result was considered significant if p value was less than 0.05.

Results

During the study period, 2454 newborns were admitted in inborn NICU KIMS Hubballi. Among them 713 babies were admitted for birth asphyxia out of which 604 were term babies who had birth asphyxia. One hundred and fifty term babies with birth asphyxia met the inclusion criteria.

These 150 neonates with birth asphyxia were screened initially with OAE for hearing impairment and among them 57.3% (86/150) babies had pass results and 42.7% (64/150) had refer results. Second screening with OAE was conducted on 55 babies (9 babies lost follow up) who failed the first screening and among them 58.1% (32/55) babies had pass results and 41.8% (23/55) babies had refer results(Figure 1).

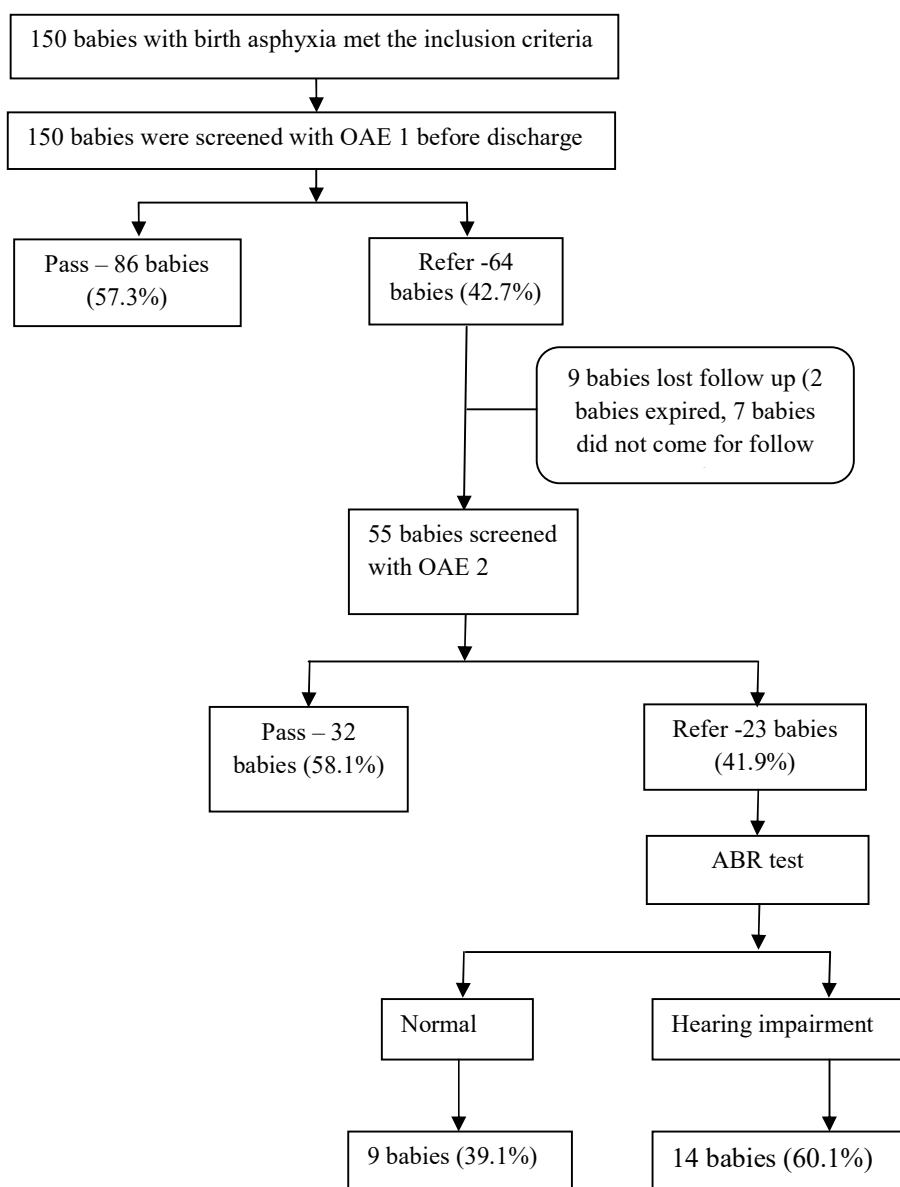


Figure-1: Hearing Screening Result

ABR testing for confirmation of hearing impairment was done on 23 babies who had refer results on second OAE. Among 23 babies, 60.9% (14/23) babies had hearing impairment and 39.1% (9/23) babies had normal hearing. The Prevalence of Hearing impairment among term neonates with birth asphyxia was 9.9% (14/141) (Figure 1).

Table 1 shows the baseline characteristics of 150 neonates with birth asphyxia.

Table-1: Baseline Characteristics of 150 Babies

Characteristic	Category	No.	Percentage N =150	Mean ± SD	
Gender	Male	86	57.3	-	
	Female	64	42.7	-	
Birth weight	<2.5 kg	39	26	2.62 ± 0.38	
	>2.5kg	111	74		
Consanguinity	Consanguineous	60	40	-	
	Non consanguineous	90	60	-	
Mode of delivery	NVD	104	69.3	-	
	LSCS	27	18	-	
	Instrumental delivery	19	12.7	-	
Meconium Aspiration Syndrome(MAS)	Yes	58	38.7	-	
	No	92	61.3	-	
Apgar at 1 minute	4 to 6 (moderate birth asphyxia)	131	87.3	-	
	≤ 3 (severe birth asphyxia)	19	12.7		
HIE	HIE of any stage	Stage 1	11	7.3	-
		Stage 2	48	32	-
		Stage 3	06	4	-
		Total	65	43.3	-
	No HIE	85	56.7	-	
Hyperbilirubinemia requiring	Phototherapy	13	8.7	-	
	Exchange transfusion	0	0	-	
Sepsis	Yes	13	8.7	-	
	No	137	91.3	-	
Meningitis	Yes	2	1.3	-	
	No	148	98.7	-	
Mechanical ventilation	Yes	14	9.3	-	
	No	136	90.7	-	
Duration of Mechanical ventilation	< 5 days	11	78.6 n=14	-	
	> 5 days	03	21.4 n=14	-	

Table-2: Grades of Hearing Loss (N=14)

Classification of hearing loss	Right EAR	Left EAR	Bilateral	Total
Mild	1	2	5	08
Moderate	1	1	1	03
Moderately Severe	0	0	1	01
Severe	1	0	1	02
Total	03	03	08	14

As shown in table 2, in our study most of the babies i.e., 57.1% had mild grade of hearing loss. Two babies (14.28%) had severe grade of hearing loss.

The comparison of various risk factors associated with hearing loss in babies with birth asphyxia is shown in Table 3. In our study only 6.5% (8/123) babies with moderate birth asphyxia had hearing impairment as compared to 33.3%(6/18) babies with severe birth asphyxia had hearing impairment and the difference was statistically significant (P=0.00037). The statistically significant risk factors for development of hearing impairment in babies with birth asphyxia were - Hypoxic ischemic encephalopathy (P=0.00914), convulsions (P=0.0093) and mechanical ventilation (P=0.0003).

Table-3: Table Comparing Various Risk Factors Associated with Hearing Loss in Birth Asphyxia Babies

Characteristics	Category	Hearing Impairment N=14	Normal Hearing	Total no. of babies with birth Asphyxia N=141	Chi-square value	P value
Gender	Male	9	71	80	0.3608	0.548
	Female	5	56	61		
Birth weight	<2.5 kg	4	32	36	0.61	0.805
	>2.5 kg	10	95	105		
MAS	Yes	4	50	54	0.685	0.43
	No	10	77	86		
Apgar at 1 minute	4 to 6 (moderate birth asphyxia)	8	115	123	12.058	0.00037
	≤ 3 (severe birth asphyxia)	6	12	18		
HIE of any Stage	Yes	12	50	62	10.993	0.00914
	No	2	77	79		
HIE	Stage 1	2	9	11	9.659	0.008
	Stage 2	6	39	45		
	Stage 3	4	2	6		
Hyperbilirubinemia requiring Phototherapy	Yes	1	10	11	0.00	0.994
	No	13	117	130		
Sepsis	Yes	3	9	12	3.33	0.0679
	No	11	118	129		
Meningitis	Yes	1	0	1	1.808	0.178
	No	13	127	140		
Mechanical ventilator	Yes	5	8	13	13.035	0.0003
	NO	9	119	128		

Table-4: Multiple logistic regression analysis of hearing impairments with other variables

Independent variables	Adjusted OR	Std. Err.	Z -value	P -value	95% CI for OR	
					Lower	Upper
Gender	0.71	0.51	- 0.4800	0.6320	0.18	2.87
HIE	11.97	10.71	2.7800	0.0050*	2.08	69.08
Convulsions	0.06	0.10	- 1.7400	0.0830	0.01	1.44
Sepsis	0.51	0.56	- 0.6100	0.5420	0.06	4.47
Mechanical ventilation	0.83	1.11	- 0.1400	0.8870	0.06	11.42
Likelihood chi-square = 24.7500, p = 0.0001*						

Table 4 shows multivariate analysis of various risk factors associated with development of hearing impairment in babies with birth asphyxia. HIE was found to be associated with development of hearing impairment in babies with birth asphyxia (P=0.0050, OR-11.97, CI-2.08-69.08).

Discussion

Perinatal asphyxia is a condition characterized by an impairment of the exchange of respiratory gases resulting in hypoxemia and hypercarbia, accompanied by metabolic acidosis. The consequences of perinatal asphyxia can range from death to various degrees of neurodevelopment sensory or motor deficits.

One of the well-known consequences of birth asphyxia is sensorineural hearing loss. Auditory nucleus (Dorsal cochlear nuclei) in the brainstem is very sensitive to hypoxia and hearing loss in babies with birth asphyxia is due to damage to this brainstem nucleus.

Severe hypoxia will cause irreversible damage to the cochlea including outer hair cells and edema of stria vascularis, which leads to change in the sound waves of mechanical form into electrochemical energy along with damage to the fibers of the auditory nerve, so auditory signals can't be passed on to the brainstem. Joint committee on infant hearing suggests that babies with Apgar score of 0-4 at 1 minute and 0-6 at 5 minutes are at risk of having hearing impairment [9].

In our study, we included babies with both moderate and severe birth asphyxia and found a prevalence of 9.9% (14/141). Prevalence of hearing impairment among babies with birth asphyxia varies in different studies from NO hearing impairment to as high as 60%.

Prevalence also varied depending on the definition of with asphyxia. Most of the studies have included babies with severe birth asphyxia. Laxmi. T et al, who conducted a study in 2014 on babies with birth asphyxia with Apgar score of <6 at 1 minute and 5 minutes found the prevalence to be 60% [10].

A seel et al conducted a study on babies with Apgar score of 0-4 at 1 minute and found the prevalence of hearing impairment to be 13.3% [11]. Gouri et al and Patel. R et al found the prevalence of hearing impairment to be 30% and 35.3% respectively [12, 13].

A Study conducted by Binay C et al who included the babies having Apgar score of 0-4 at 1 minute or 0-6 at 5 min, found no hearing impairment [14]. Nagpoornima et al conducted a study who included babies with severe birth asphyxia requiring ventilation found the prevalence of 1.9% [15].

Male: female ratio in our study was 1.8:1 which was similar to study conducted by Mishra et al [16]. Studies conducted by Aseel et al, Gouri et al among high risk

neonates for hearing impairment found no relationship between gender and hearing impairment [11, 12]. In our study, there was no statistically significant relationship between hearing impairment and meconium aspiration syndrome. Our findings were similar to studies conducted by Binay C et al and Aseel et al but study by Gouri et al found statistical significance between these two [11, 12, 14].

Majority of the babies in our study i.e., 72.5% (45/62) had stage 2 HIE. When hearing, impairment was compared with different stages of HIE, it was found that babies with stage 3 HIE were more prone to develop hearing impairment as compared to babies with other stages of HIE. This finding suggests that as the severity of hypoxia increases the chances of baby developing the hearing impairment increases.

These findings are similar to study conducted by Mishra et al [16]. Neonatal convulsions have been reported to be a risk factor for abnormal hearing [17]. In our study, there was a statistically significant relationship between convulsions and hearing impairment (P=0.0093).

Screening for hearing loss in newborns is based on two concepts. First, a critical period exists for optimal language skills to develop, and earlier intervention produces better outcomes. Second, treatment of hearing defects has been shown to improve communication [18, 19, 20]. Baradaranfar et al had 2.9% of babies with birth asphyxia and APGAR Scores of <5 at 5 min [21].

Joint Committee on Infant Hearing (JCIH) suggests that babies who are mechanically ventilated for more than 5 days are at higher risk of developing hearing impairment. Binay C et al and Patel R et al found that babies mechanically ventilated for more than 5 days were at more risk to develop hearing impairment [13, 14]. In our study, we found that babies with birth asphyxia who were mechanically ventilated were more prone for development of hearing impairment as compared to babies who were not mechanically ventilated.

Conclusion

The prevalence of hearing impairment among term neonates with birth asphyxia was 9.9% (14/141). Babies with severe birth asphyxia had greater incidence of hearing impairment as compared to babies with moderate birth asphyxia and the difference was statistically significant.

Original Research Article

The statistically significant risk factors for development of hearing impairment in babies with birth asphyxia are- Hypoxic ischemic encephalopathy, convulsions and mechanical ventilation. Gender and me conium aspiration syndrome were not significantly associated with development of hearing impairment in babies with birth asphyxia

What is already known?

Hearing impairment is a known risk factor among NICU graduates especially with birth asphyxia babies.

What this study add to existing knowledge?

Two staged screening with OAE, which is a feasible screening test in resource poor set up, can be used as a screening modality for hearing impairment in babies with birth asphyxia.

Limitation- Follow up of the babies who passed the screening test for hearing impairment was not done.

Contributions by authors: All the three authors contributed equally for conception, acquisition and interpretation of data and drafting of the article.

Acknowledgements**Declarations**

Ethical approval: Not required

Funding: Nil, **Conflict of interest:** None initiated,

Perission from IRB: Yes

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How to cite this article?

Pawar R., Illalu S., Fattepur S.R. A study on prevalence of hearing impairment in newborns with birth asphyxia admitted to neonatal intensive care unit. *Int J Pediatr Res.* 2019;6 (01):42-49. doi:10.17511/ijpr.2019.i01.07

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