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Original Article

Paediatrics Section

Risk Factors for Hearing Loss in High-risk Neonates at a Tertiary Care Centre in Central India: A Prospective Observational Study

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ABSTRACT

Introduction: Hearing impairment and deafness are global issues that affect 5% of the world's population, with nearly 34 million children requiring rehabilitation to address their Hearing Loss (HL). An approximately 10-20 fold higher incidence of audiological risk factors has been noted in Neonatal Intensive Care Units (NICUs), which translates that 2-5% of all newborns in NICUs may be affected. Early diagnosis of HL and intervention can be advantageous from the timely fitting of hearing aids or cochlear implants.

Aim: The aim of this study was to evaluate the risk factors for HL in NICUs and Special Neonatal Care Units (SNCUs) at a tertiary care hospital in Central India.

Materials and Methods: This prospective, observational, single-centre study was conducted from October 2019 to September 2021 in the Department of Paediatrics at Indira Gandhi Government Medical College and Hospital, Nagpur, Maharashtra, India. A total of 319 neonates at high-risk for HL, discharged from NICUs and SNCUs, were included in the study. The association between risk factors like prematurity, Low Birth Weight (LBW), Toxoplasmosis, Rubella, Cytomegalovirus, Herpes Simplex (TORCH) infections, neonatal asphyxia, neonatal sepsis, meningitis, exchange transfusion, assisted ventilation, and HL were studied. The chi-square test was used to assess the association between SNHL and risk factors.

Results: The incidence of Sensorineural Hearing Loss (SNHL) was 3.76%. Neonatal asphyxia (p-value <0.01), exchange transfusion (p-value <0.001), TORCH infections (p-value <0.001), meningitis (p-value <0.001), and assisted ventilation (p-value <0.001) were found to be significant risk factors associated with SNHL.

Conclusion: Based on the assessment of risk factors, it was concluded that neonates should undergo hearing screening tests within the first month of life, and a diagnosis should be made by three months of age. This allows specialists to initiate treatment and intervention by six months of age, helping children with impaired hearing avoid the harmful consequences of semantic deprivation.

Keywords: Deafness, Hearing aids, Neonatal sepsis, Screening test, Sensorineural hearing loss

INTRODUCTION

Of all the five special senses, hearing is one of the most significant and important senses for one's learning and development [1]. Any sort of impairment in the ability to hear proves to be a hindrance in one's language and speech development, thereby affecting education, social, and emotional status of a person [1]. The definition of Hearing Loss (HL) and hearing deficit varies in different classification systems, but the usual categories of HL are mild (21-40 dB HL), moderate (41-70 dB HL), severe (71-95 dB HL), and profound (>95 dB HL). Profound HL is termed as deafness [2].

Hearing impairment and deafness are global issues that affect 5% of the world's population. Nearly 432 million adults and 34 million children require rehabilitation to address their disabling HL. It has been estimated that by 2050, around 2.5 billion people will suffer from some form of HL, and approximately 700 million people will require hearing rehabilitation [3]. A recent study has shown that the prevalence rate of hearing impairment among neonates worldwide is around 1 to 6 per 1000, with an overall prevalence of about 2.21 per 1000 [4]. Approximately, a 10 to 20-fold higher incidence of audiological risk factors has been noted in NICUs, implying that 2-5% of all newborns in NICUs may be affected [5].

Language plays a vital role in a child's life to communicate and interact socially. Therefore, it is crucial to identify and address any hearing problems affecting speech as early as possible [6]. With the advent of sophisticated electro-acoustical tests like Otoacoustic Emissions (OAEs) and automated Auditory Brainstem Responses (a-ABRs), screening and diagnosing hearing disabilities have become very easy. These two tests are considered keystones of Universal Newborn Hearing Screening (UNHS) programs [6]. The Joint Committee on Infant Hearing (JCIH) has two separate sets of protocols for well-infant nurseries and NICUs. A two-step screening procedure is recommended for all healthy low-risk newborns, starting with OAEs followed by a-ABRs if no response is recorded at the original screening test [6].

For infants in the NICU who are highly susceptible to developing retrocochlear HL, JCIH recommends conducting both tests at the same time to reduce false-negative results associated with Auditory Neuropathy Spectrum Disorders (ANSDs) [6]. Auditory neuropathy is characterised by desynchronisation of the cochlear/auditory nerve, while the outer hair cell function is spared. This was confirmed and recognised for the first time in 1996 by the presence of normal OAEs compared to absent or exceptionally abnormal ABRs [7].

According to the World Health Organisation (WHO) report on hearing screening in 2021, early identification of deafness and early intervention will result in better outcomes in language development, which led to the inception of the newborn hearing screening program. The WHO has recommended that UNHS should be adopted by every country, and available rehabilitation services should also be offered [8]. While this has been implemented in several developed countries, implementing it in developing countries

remains a challenging task due to the inaccessibility of expensive screening devices [9].

It is estimated that the prevalence of congenital bilateral hearing loss is about 1.33 per 1000 live births, with 30-50% of cases attributed to perinatal environmental factors such as prematurity (<32 weeks), infections (TORCH), low birth weight (birth weight <1500 gm), APGAR score 0 <6 at five minutes, exposure to ototoxic drugs, the need for mechanical ventilation for >5 days, hyperbilirubinemia (>17 mg/dL), and craniofacial anomalies like pinna agenesis and canal agenesis [10]. Rest 50-70% of cases are considered to be genetic, resulting in either syndromic hearing loss (Usher-Jervell syndrome, Pendred syndrome, Alport syndrome, Lange-Nielsen syndromic HL) [10].

There is increasing evidence suggesting that early identification of deafness and early intervention result in better outcomes in language development [11,12]. The Government of India recommends that any child born from a high-risk pregnancy should be screened by otorhinolaryngologists/audiologists using OAEs (Otoacoustic Emissions) and then subjected to diagnostic tests [13]. This approach allows physicians to avoid the harmful consequences of semantic deprivation, and children with hearing impairment can have the opportunity to grow up normally, maintaining emotional and psychological integrity, and making academic and socio-economic progress [14].

Therefore, this study was designed to evaluate the risk factors for hearing loss among neonates admitted to the NICU and SNCU of a tertiary care hospital, with those affected by hearing loss being referred to audiologists.

MATERIALS AND METHODS

This was a prospective observational study conducted at the Department of Pediatrics, Indira Gandhi Government Medical College and Hospital, Nagpur, Maharashtra, India, from October 2019 to September 2021. The present study protocol was approved by the Institutional Ethics Committee with IEC no. 287-88/2020.

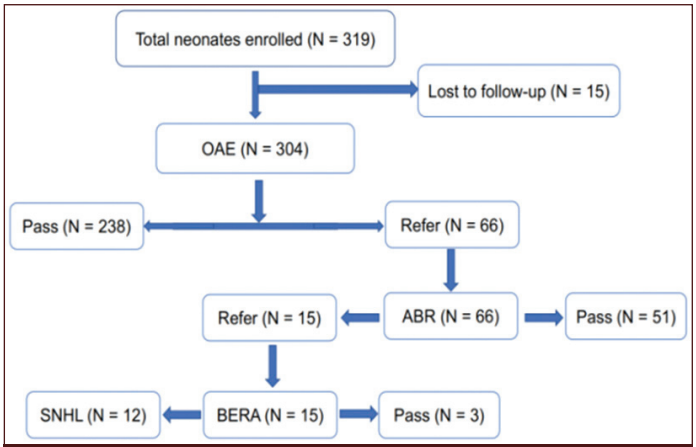
Inclusion criteria: All neonates who were at high-risk for Hearing Loss (HL) and were discharged from the Neonatal Intensive Care Unit (NICU) and Special Newborn Care Unit (SNCU), with parental informed consent, were included in the study.

Exclusion criteria: Neonates with active ear infections and severe multiple anomalies such as dextrocardia, critical congenital heart diseases, congenital diaphragmatic hernia, mermaid syndrome, harlequin ichthyosis, etc., were excluded from the study.

Sensorineural Hearing Loss (SNHL) is described as mild if hearing loss is in the range of 21-40 dB, moderate (41-70 dB), severe (71-95 dB), and profound (>95 dB) [15]. High-risk is defined as the presence of any one of the risk factors like TORCH infection, family history of SNHL, Low Birth Weight (LBW), prematurity, congenital anomalies, birth asphyxia, meningitis, neonatal sepsis, exposure to ototoxic drugs, requirement of exchange transfusion, and requirement of assisted ventilation for >three days [16]. An infant is considered small for gestational age if their weight is <10th percentile and large for gestational age if their weight is above the 90th percentile [17].

Sample size calculation: Based on the study by Joshi G et al., the incidence of HL in high-risk neonates was considered to be 26.5% [18]. The following assumptions were made: Confidence interval: 95%. Error (l)=20% of prevalence=20% of 26.5. Sample size (N)=3.84×p(1-p)=266. Considering a dropout rate of 20%, the sample size was (20% of 266)+266. Thus, the final sample size was 53+266=319.

Enrolled neonates were screened for HL before the age of three months using a three-stage screening protocol [6], which consisted of a preliminary screening with OAE. Neonates who were referred during the first OAE screening underwent further screening with Auditory Brainstem Response (ABR). Similarly, neonates who were referred during the second ABR screening were subjected to further screening with Brainstem Evoked Response Audiometry (BERA) to confirm the presence of SNHL [Table/Fig-1] [6].



[Table/Fig-1]: Procedure for screening of high-risk neonates for Hearing Loss (HL).
SNHL: Sensorineural hearing loss; OAE: Otoacoustic emissions; ABR: Auditory brainstem response; BERA: Brain-stem evoked response audiometry

STATISTICAL ANALYSIS

Data were collected and graphics were designed using Microsoft Office Excel 2019. The data were analysed using the Statistical Package for Social Sciences (SPSS) version 23.0 by IBM in Armonk, NY, USA. The categorical data were represented as frequency (percentage), and the continuous data were presented as mean (standard deviation, SD). The Chi-square test was used to assess the association between SNHL and risk factors. A two-tailed probability value of <0.05 was considered statistically significant.

RESULTS

A total of 319 neonates were included in the study, of which 15 neonates were lost to follow-up during the initial 6-month recruitment period. Since the study duration was two years and the parents did not report any complaints, the authors presumed that these 15 neonates did not have any HL and included them in the study. The age of the neonates ranged from 6 to 28 days, with a mean of 18.04±5.64 days. There were predominantly male neonates, with 173 (54.23%) males and 146 (45.77%) females, resulting in a male-to-female ratio of 1.18. Among the neonates, 178 (55.79%) were appropriate for gestational age, while 141 (44.21%) were small for gestational age. None of the neonates had a family history of HL. All neonates received aminoglycosides (amikacin/Gentamycin) with amikacin given at a dose of 15 mg/kg/dose and Gentamycin at a dose of 4 mg/kg/dose for 7-14 days, and none of them developed HL. Most of the neonates had no congenital anomalies (316, 99.05%), while the remaining 3 (0.94%) had congenital anomalies.

Among the 12 neonates with SNHL, the majority had mild SNHL (6, 50%), followed by profound SNHL (3, 25%) and severe SNHL (2, 16.67%). One neonate had moderate SNHL (8.33%) [Table/Fig-2]. Three babies with profound HL and 2 babies with severe HL were referred to the cochlear implant team in our hospital for further management and rehabilitation.

Risk factors	SNHL		p-value
	Yes (n=12) n (%)	No (n=307) n (%)	
Prematurity			
Yes (n=273)	09 (75%)	269 (87.6%)	0.27
No (n=46)	03 (25%)	38 (12.3%)	
LBW			
Yes (n=284)	09 (75%)	275 (89.5%)	0.11
No (n=35)	03 (25%)	32 (10.4%)	
Torch infections			
Yes (n=03)	02 (16.6%)	01 (0.3%)	**<0.001***
No (n=316)	10 (83.3%)	306 (99.6%)	
Neonatal sepsis			
Yes (n=246)	08 (66.6%)	238 (77.5%)	0.38
No (n=73)	04 (33.3%)	69 (22.4%)	
Neonatal asphyxia			
Yes (n=109)	08 (66.6%)	101 (32.8%)	**0.01***
No (n=210)	04 (33.3%)	206 (67.1%)	
Exchange transfusion			
Yes (n=07)	06 (50%)	01 (0.3%)	**<0.001***
No (n=312)	06 (50%)	306 (99.6%)	
Meningitis			
Yes (n=52)	07 (58.3%)	45 (14.6%)	**<0.001***
No (n=267)	05 (41.6%)	262 (85.3%)	
Assisted ventilation			
Yes (n=16)	07 (58.3%)	09 (2.93%)	**<0.001***
No (n=303)	05 (41.6%)	298 (97.07%)	

[Table/Fig-2]: Association between risk factors and SNHL.
Chi-square test; bold p-values are significant

DISCUSSION

The present study was performed to study the incidence of SNHL in high-risk neonates and evaluate the association of risk factors with the severity of SNHL, and evaluate the utility of OAEs for HL screening. Among the 319 neonates included in the study, 12 were found to have SNHL, resulting in an incidence rate of 3.76%. Similar to our findings, Meyer C et al., reported a 5.3% incidence of hearing impairment in neonates [19]. However, the relatively low incidence of HL observed in our study could be attributed to the larger sample size or the lower severity of illness in our study population.

The pathophysiology of hearing loss in preterm infants is multifactorial and includes factors such as the use of ototoxic drugs such as aminoglycosides and loop diuretics, noise exposure, hyperbilirubinemia, and hypoxia [20]. Among the 12 neonates with SNHL in our study, nine were premature (75%). Regina M et al., also demonstrated that 31.57% of neonates with HL were premature [21]. Another study by Sun JH et al., reported a 34.09% incidence of diagnosed HL in premature infants [22].

It is important to note that the development of hearing in the fetus depends on foetal growth and development during pregnancy, rather than the total duration of pregnancy. If the fetus grows slower than normal in the uterus, the ears may not fully develop [23]. In our study, the majority of neonates had a birth weight of 1-1.5 kg (62.38%), followed by 1.51-2.5 kg (26.96%) and >2.5 kg (6.27%). Therefore, 285 out of 319 babies had LBW. Among the 12 neonates with SNHL, nine had LBW (75.00%). Similarly, Zamani A et al., reported that among neonates with HL, 17% had a birth weight under 1500 grams, 8% had weights between 1500 and 2500 grams, and 6.2% had more than 2500 grams birth weight, with no significant association between birth weight and HL (p-value=0.25) [24].

Adequate oxygenation and perfusion are essential for inner ear function, and previous literature has shown that neonatal asphyxia can lead to inner ear degeneration, disappearance of the outer and inner hair cells, and degeneration of the positive maternal history of TORCH infections, particularly cytomegalovirus. In our study, SNHL was significantly greater among neonates with TORCH infection (2 out of 3 neonates) (p-value <0.0001). Similarly, Ospina-Garcia JC et al., reported a maternal history of TORCH infection in 1.45% of neonates [25].

The majority of NICU admissions receive potentially ototoxic drugs such as Gentamycin and Amikacin for the treatment of neonatal sepsis. In our study, the majority of neonates had a history of neonatal sepsis (77.12%). Among the 12 neonates with SNHL, eight did not have neonatal sepsis (66.67%), and there was no significant association between SNHL and neonatal sepsis (p-value=0.380). Similarly, Kim SY et al., reported that 60% of neonates with SNHL had early-onset neonatal sepsis, although the association was not statistically significant (p-value=0.057) [26].

CMV may cause damage to the inner ear through virus-mediated damage to neural cells or as a result of inflammatory responses to the virus, resulting in injury in the auditory apparatus and subsequent hearing loss [15]. In the present study, the majority of neonates had no maternal history of TORCH infection (99.06%), while the remaining 3 (0.94%) had cells [27]. Among the total of 109 (34.17%) neonates, in the study, who experienced neonatal asphyxia, eight of the 12 neonates with SNHL had neonatal asphyxia (66.67%), indicating a statistically significant association between SNHL and neonatal asphyxia (p-value=0.016). Similarly, Sun JH et al., found that 40% of newborns diagnosed with HL had asphyxia [22]. However, Hrncic N observed that only 2.55% (31/1217) of neonates had asphyxia [28].

Previous literature has shown that the auditory nuclei in the brainstem, including the inferior colliculus and the superior olivary complex, are particularly vulnerable to bilirubin toxicity. Lesions in these structures can lead to SNHL [29,30]. A study by Wickremasinghe AC et al., concluded that bilirubin levels well above the threshold for exchange transfusion were associated with SNHL [31]. The majority of neonates in the present study did not require exchange transfusion (97.81%), while the remaining (2.19%) did. Among neonates with SNHL, half of them required exchange transfusion (p<0.0001). These findings contribute to the existing literature.

Meningitis can cause sensorineural deafness by spreading the infection to the cochlea and damaging the hair cells [15]. It may also be due to inflammation of the auditory nerve [15]. In the present study, the majority of neonates did not have meningitis (83.70%), while the remaining (16.30%) did. Among neonates with SNHL, the majority had meningitis (58.33%), and there was a statistically significant association between SNHL and meningitis (p-value <0.0001). Maqbool M et al., reported a significant association between HL and meningitis (p-value=0.008) [32]. Similarly, Coenraad S et al., observed that meningitis was significantly associated with SNHL (p-value=0.04) [33].

HL is associated with environmental noise exposure, especially from life support equipment such as ventilation [15]. In the present study, the majority of neonates did not require assisted ventilation for >three days (94.98%). However, 16 neonates (5.02%) required assisted ventilation for >three days. Among the 12 neonates with SNHL, seven required assisted ventilation for >three days (58.33%),

and there was a statistically significant association between SNHL and the requirement of assisted ventilation for >three days (p-value <0.0001). Similarly, Joshi G and Goyani R reported a significant association between assisted ventilation for >five days and HL (p-value <0.050) [18]. Sererat C and Sererat W, and Pawar R et al., also reported similar findings [34,35].

Limitation(s)

Since this was a single-center study, large multicenter trials are needed to generalise study findings to the broader population.

CONCLUSION(S)

In the present study, neonatal asphyxia, meningitis, TORCH infections, exchange transfusion, and assisted ventilation were found to be significant risk factors for hearing loss among neonates.

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