

## Original Research Article

# Hearing impairment among high risk neonates born in a tertiary care hospital in north Kerala: a cross sectional study

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## ABSTRACT

**Background:** Hearing is necessary for the proper mental and social development of a new-borns child. Delay in diagnosis leads to improper development of social and mental skills. The prevalence of congenital hearing loss is greater than prevalence of screened metabolic syndromes. There are multiple maternal and intrapartum risk factors associated with hearing impairment. Most of the causes are treatable. Objectives was to find out the proportion of hearing impairment in neonates and its risk factors in a tertiary care hospital in north Kerala.

**Methods:** This cross-sectional research was performed in a tertiary care hospital in Northern Kerala between January 2018 and June 2019 after obtaining informed consent and institutional ethical committee clearance among those who fulfilled the inclusion and exclusion criteria. All the high-risk new-borns were subjected to Otoacoustic examination. Those who did not pass the first OAE were subjected to second OAE after one month. Those who did not pass in the examination were subjected to BERA. Those high risk children who did not pass the BERA were considered having hearing impairment and were subjected to further investigation and appropriate management.

**Results:** The prevalence of hearing impairment was 0.5%. 0.25% were unilateral and 0.25% were bilateral. Pregnancy induced hypertension, premature labour, lower segment Caesarian section, low birth weight, small for gestational age, respiratory distress, hyperbilirubinemia and presence of congenital malformations were significantly associated with hearing impairment.

**Conclusions:** Since most of the congenital hearing loss among high risk neonates can be treated, a nationwide standardized hearing assessment program is advocated for the early detection of high risk children with hearing loss.

**Keywords:** High risk neonates, Early hearing loss, Risk factors, Screening

## INTRODUCTION

Hearing is one of the key factors for proper development of speech, language and communication skills. Childhood hearing impairment (HI) can have profound effects on overall development, interpersonal communication, quality of life and daily function.

Hearing loss is a common congenital anomaly and various studies all over the world report congenital bilateral hearing loss in 1-5 per 1000 live births and unilateral hearing loss in 1-8 per 1000 live births. The

prevalence of congenital hearing loss is higher than prevalence of screened metabolic syndromes (Phenyl ketonuria, Congenital hypothyroidism, sickle cell anemia etc.).<sup>1-6</sup> In India, the prevalence of neonatal hearing loss varies between 1-8 per 1000 live births. Prevalence of neonatal hearing loss is high (0.3-14.1%) in NICU graduates and babies who have other high risk factors.<sup>7,8</sup>

There are a variety of maternal factors which include GDM, intake of drugs like loop diuretics, aminoglycosides, chemotherapeutic agents etc., along

with infections (Torch), genetic/syndromic causes and trauma in the baby.<sup>1,9-11</sup>

Many of the causes are preventable/ treatable if detected early. The critical period for language learning is within the first 36 months of life.<sup>12</sup> Hence early detection and appropriate treatment is crucial in improving the overall development of the child in cognitive, motor and social domains, and thereby reducing the morbidity related to treatable hearing loss. The earlier the detection, the better the reduction of the deleterious effects of impaired audition and better the development of the child.<sup>13-17</sup>

For the development of speech and language skills, Auditory stimulation during the first 6 months of life is critical.<sup>12</sup> The factors that are expected to affect the normal development of speech and language skills that will eventually also predict cognitive development in children include hearing capacity, mild to profound degree of Hearing Impairment (HI), age of identification of hearing loss, age of intervention, aided audibility, duration, consistency of hearing aid use, and characteristics of the child's language environment. To mitigate its adverse effects on the development of cognitive, psychological and verbal communication skills, early detection of HI accompanied by a timely and efficient intervention is necessary.<sup>9</sup> Multiple studies have shown that infants who obtain intervention before the age of 6 months have better school results, improved Vocabulary and communication skills by ages 2–5 years.<sup>18</sup>

However, the troubling truth is that the average age at which a child who has a profound, bilateral sensorineural hearing loss is diagnosed at around 24 months, while HI of lesser degrees is often identified at an average age of 48 months, especially in rural areas due to the poor Knowledge and awareness about HI and its relationship with speech and language development as well as of infrastructure.<sup>8</sup> In recent years, the technology and expertise has to detect hearing loss earlier in newborns. Early detection will also lead to faster placement of specialised hearing aids coupled with communication development services. Thus, unnoticed or late diagnosis in infants and young children results in permanent impairment. Early detection, recognition, and effective action at the earliest are therefore prime requirements.<sup>19</sup>

In several parts of the western world, Universal neonatal hearing screening (UNHS) has been introduced for the detection of hearing impairment in newborns. Most of the neonatal facilities in the United States and European Union have implemented mandatory screening of all newborns.<sup>13</sup> The main objectives of the early detection and intervention program under Universal New-born Hearing Screening (NHS) program are described as “1-3-6” objectives. This suggests that newborns be screened before 1 month of age, confirm the diagnosis of hearing loss, fit hearing aid before 3 months, and enroll the child before 6 months of age for early

intervention.<sup>20</sup> The Joint Committee on Infant Hearing 2007 recommends that all infants should be screened before the first month of age. This recommendation is accepted by hospitals nationally and has been institutionalized as a standard of treatment.<sup>13,14,21</sup>

In this prevailing context, the current study was undertaken to find out the proportion of hearing impairment in neonates and its risk factors in a tertiary care hospital in north Kerala.

## **METHODS**

This cross sectional study was conducted in a tertiary care hospital in North Kerala after getting clearance from the Institutional Ethical committee. All the high risk neonates born in the hospital between January 2018 and June 2019 and those who fulfilled the inclusion and exclusion criteria were included in the study. After extensive literature search, the following conditions were considered as being at high risk

### ***Demographic social factors of mother***

Demographic social factors of mother were maternal age <16 or >40 yr, illicit drug, alcohol, cigarette use by mother, poverty (below poverty line), unmarried or single mother and emotional or physical stress of mother.

### ***Past medical history of mother***

Past medical history of mother were genetic disorders, diabetic mellitus, hypertension, asymptomatic bacteriuria and immune mediated disease.

### ***Previous pregnancy***

Previous pregnancy were intrauterine fetal demise, neonatal death, prematurity, intra uterine growth retardation, congenital malformation, incompetent cervix, blood group sensitization, neonatal jaundice, neonatal thrombocytopenia, hydrops and inborn errors of metabolism

### ***Present pregnancy***

Present pregnancy were abruptio placenta, placenta previa, sexually transmitted diseases, multiple gestation, preeclampsia, premature rupture of membranes, poly/ oligohydramnios, hypercoagulable states, abnormal fetal USG finding and treatment of infertility.

### ***Labour and delivery***

Premature labour (<37 wks), postdate pregnancy (>42 wks), fetal distress, breech presentation, meconium stained fluid, nuchal cord, cesarean section, forceps delivery and APGAR score <4 at 1 min.

### Neonate

Birth weight <2.5 kg, birth weight >4.0 kg, small for gestational age, large for gestational age, respiratory distress, cyanosis, congenital malformation and pallor, plethora, petechie.

The parents of the high risk neonates were explained about the need for the test and detailed information about the procedure and the benefits of undergoing the procedure. Those who accepted to do the test were requested to fill the parental consent form.

A structured proforma was used for data collection. The proforma contained questions related to mother's antenatal history, previous pregnancy details and past medical history. All the high risk neonates were subjected to routine ENT examination involving inspection of the pre-aural, pinna and post aural regions. Otoscopic examination of the external auditory canal and tympanic membrane was done using heine 3000 series otoscope.

A qualified and well trained audiologist performed the screening otoacoustic emission test in a sound treated room along with the caretaker when the child was sleeping during the first week after delivery or after stabilizing the general condition of the child. Those neonates who failed in the first screening procedure were subjected to undergo a second screening. Those infants who failed in the second screening were further subjected to Brainstem Evoked response audiometry or auditory brain stem response for the confirmation of hearing loss.

The sensitivity of OAE is 80-90% and that of BERA is 84-90%. Both methods have a specificity of more than 90%.<sup>22</sup> A total of 1231 high risk neonates who fulfilled the inclusion and exclusion criteria were enrolled in the study after getting parental consent. 805 passed OAE in the first screening and 426 failed. All the 426 were requested to come back after one month of which only 402 turned and 24 did not. Hence the final sample came to 1207 excluding the 24 infants who did not turn up for second OAE.

### Data analysis

The data recorded was entered in Microsoft Excel, double checked and was analysed using SPSS software. Descriptive measures were expressed as frequencies with percentages and mean with Standard Deviation. Bivariate analysis to find out the association between hearing impairment with the risk factors was done using Fischer exact test.  $P < 0.05$  was considered statistically significant.

### RESULTS

Total 49.6% of the study population were female child and 50.4% were male child. 44% had hyperbilirubinemia, 26% were born by caesarean section, 24% were low birthweight babies, another 18% were Small for gestational age and 13% of the mothers had eclampsia (Table 1). The External auditory canal and Tympanic membrane of all the high risk babies were normal. 66.6% of the participants passed the OAE in the initial testing done within one week of birth.

**Table 1: Distribution of study population according to the presence of risk factors for hearing.**

Identified Risk Factor	Frequency	Percentage
Family history of sensorineural hearing loss	0	0
Gestational diabetes mellitus	11	9.7
Pregnancy induced hypertension	153	12.7
Hypothyroidism	105	8.7
Abruptio placenta	7	0.6
Placenta previa	18	1.5
Multiple gestation	51	4.2
Preeclampsia	39	3.2
Pre mature rupture of membranes	121	10
Polyhydramnios	45	3.7
Oligohydramnios	143	11.8
Premature labour	202	16.7
Fetal distress	5	0.4
Meconium stained amniotic fluid	62	5.1
LSCS	898	74.4
BW < 2.5 kg	291	24.1
BW > 4 Kg	1	0.1
Small for gestational age	222	18.4
Large for gestational age	34	2.8
Respiratory Distress	100	8.3
Hyperbilirubinemia	529	43.8
Congenital malformation	11	0.9

**Table 2: Association between hearing loss and Risk factors.**

Risk Factor	Hearing loss present		Hearing loss absent		Fischer exact value	P value
	Number	Percentage	Number	Percentage		
Male sex	5	83.3	603	50.2	2.621	0.218
Gestational diabetes mellitus	0	0	117	9.7	0.647	1
Pregnancy induced hypertension	3	50	150	12.5	7.589	0.030
Hypothyroidism	0	0	105	8.7	0.575	1
Abruptio placenta	0	0	7	0.6	0.035	1
Placenta previa	0	0	18	1.5	0.091	1
Multiple gestation	0	0	51	4.2	0.266	1
Preeclampsia	0	0	39	3.2	0.201	1
Pre mature rupture of membranes	1	16.7	120	10	0.295	0.470
Polyhydramnios	1	16.7	44	3.7	2.812	0.204
Oligohydramnios	0	0	143	11.9	0.810	1
Premature labour	4	66.7	198	16.5	10.788	0.009
Fetal distress	0	0	5	0.4	0.025	1
Meconium-stained amniotic fluid	0	0	62	5.2	0.327	1
LSCS	2	33.3	896	74.6	5.339	0.040
BW<2.5 kg	6	100	285	23.7	18.981	<0.001
BW>4 Kg	0	0	1	0.1	0.005	1
Small for gestational age	5	83.3	217	18.1	16.942	0.001
Large for gestational age	0	0	34	2.8	0.175	1
Respiratory distress	4	66.7	96	8	27.048	0.001
Hyperbilirubinemia	6	100	523	43.5	7.728	0.005
Congenital malformation	3	50	8	0.7	160.905	<0.001

The rest 33.4% were subjected to repeat OAE after one month. 97.8% of those who did not pass the first screening OAE, passed at second OAE screening. Nine neonates who did not pass even in second OAE examination were subjected to BERA. Six of the nine neonates (0.5%) were found to have sensorineural hearing loss. Three of them (0.25%) had unilateral and bilateral hearing loss, respectively.

Association between hearing impairment and known risk factors were measured using Fischer exact test. Pregnancy induced hypertension, premature labour, lower segment Caesarian section, low birth weight, small for gestational age, respiratory distress, hyperbilirubinemia and presence of congenital malformations were significantly associated with hearing impairment (Table 2).

## DISCUSSION

A hospital-based cross-sectional study was done on high risk neonates born in a tertiary care hospital in Kerala. A total of 1207 infants who satisfied the inclusion and exclusion criteria were included in the study. Each one of them underwent hearing screening with OAE and those who did not pass the OAE even after second time were subjected to confirmation of hearing loss with ABR.

The overall prevalence of hearing impairment is 0.5% in our study. Similar results were obtained by studies done

by other authors-0.5% by Nair et al, 0.63% by James et al, 0.7% by Paul et al in Kerala, 0.56% by Nagapoomnima et al in Karnataka, 0.58% by Yenamandra et al in North India. Straaten et al and Finitzo et al reported similar prevalence in western countries Else et al reported a prevalence of 3.2% in their study in Netherlands.<sup>2,23-29</sup>

Pregnancy induced hypertension, premature labour, lower segment Caesarian section, Low birth weight, small for gestational age, respiratory distress, Hyperbilirubinemia and congenital malformations were significantly associated with hearing impairment in our study.

Boskabadi et al in their study found that Serum total bilirubin, creatinine levels, microcephaly, hemolytic diseases of newborn and opisthotonos were associated with sensorineural hearing loss.<sup>30</sup> Unidentified causes, ABO and Rh incompatibility, G6PD deficiency, and sepsis are the most common causes of jaundice among infants with sensorineural hearing loss.

Total 66% of hearing impaired babies were born premature. Similar results were obtained by studies done by Pourarian et al, Dommelen et al.<sup>31,32</sup> The pathophysiology of hearing loss in preterm infants is very complex and while prematurity alone does not have a significant effect on hearing, it is also correlated with many other risk factors that can synergistic affect hearing. The risk of hearing loss is substantially higher than general newborn population.<sup>33</sup>

All those who had hearing impairment were underweight (less than 2.5kg) and 83.3% of them were small for gestational age. The mean birth weight of babies with hearing loss is 1331.67±486 gram. Kraft et al<sup>34</sup> in their study observed that there was a 6-fold greater risk for hearing loss in children with birth weight<1500 gms when compared with those with birth weight between 3500 grams and 3999 grams. Dommelen et al also stated that the prevalence of SNHL consistently increased with decreasing birth weight (1.4-4.8% from 1500 to<750 g and with decreasing gestational age.<sup>32</sup>

Babies born with low birth weight also have many other risk factors that may cause brain damage or hearing loss such as immaturity, ototoxic drug administration, noise from the incubator, perinatal complications like hypoxia, acidosis and so on. It is therefore reasonable to believe that cochlea and auditory pathway are at a risk of damage.<sup>7</sup>

In our study, 66.67% of infants with hearing loss had history of respiratory distress immediately following birth. Jiang et al<sup>35</sup> examined the long term impact of perinatal and postnatal asphyxia and concluded that hypoxic status in response to a stimulus will lead to a depression of the endocochlear potential and a decrease in transduction current of the hair cells and leads to threshold elevation. Christine et al<sup>37</sup> tested 12 babies with severe birth asphyxia and identified 4 babies (33%) with hearing impairment.

Due to their underdeveloped respiratory system, preterm neonates require prolonged oxygen. Additionally, they are also vulnerable to various infections on account of their weak immune mechanism, thus exposing them to medications, few of which are ototoxic.

Redistribution of the blood from the periphery and the non-vital organs to the brain and central nervous system is one of the effects of hypoxia. It is therefore evident that blood and oxygen shortages would affect the brain only at the last. Peripheral organ damage generally precedes brain or central nervous system damage that would result in an auditory dysfunction. The ear should be one of the last organs to suffer from neonatal hypoxia because of its proximity to the brain and central nervous system. Infants who have continued depressed cerebral activity are also at a significant risk for major neurological impairments and derangements in other organs.<sup>7</sup>

In our study, all the hearing impaired infants had history of neonatal hyperbilirubinemia for which each one underwent phototherapy treatment. A study by Hassan et al<sup>30</sup> found that the chance of hearing damage was 10-50 times higher for icteric infants with a bilirubin level greater than 20 mg/dl. It was also stated that bilirubin levels have a high predictive power (82%) in determining the prognosis of sensorineural hearing disorders in icteric neonates. The relationship of serum bilirubin levels and hearing impairment in neonates was also identified by De

Vries et al, which further supports the findings of our study. However, even without developing kernicterus, hyperbilirubinemia requiring an exchange transfusion can damage the hearing system.<sup>37</sup> The mechanisms causing bilirubin neurotoxicity have not yet been elucidated. It is not certain why only few babies with a certain level of bilirubin develop hearing loss or neurological damage.<sup>30</sup>

The correlation between high bilirubin levels and SNHL originates from the association between bilirubin encephalopathy and subsequent deafness. High bilirubin levels tend to cause delays in auditory brainstem response latencies, suggesting changes in upper auditory pathways that return to normal as the level of bilirubin decreases.<sup>38</sup> De Vries and colleagues documented correlations between birth weight, bilirubin concentration, and SNHL in a group of children<34 weeks' gestation. There was little evidence of a direct relation between bilirubin and SNHL. Unconjugated bilirubin is displaced from albumin in the presence of acidosis thereby increasing the free bilirubin concentration and hence the risk of neuronal damage.<sup>37</sup>

The pathophysiological mechanism of eclampsia in HI is poorly understood, but endothelial dysfunction is currently most popularly hypothesized to be a central pathophysiologic feature of preeclampsia which can lead to altered vascular reactivity, loss of vascular integrity, and activation of the coagulation cascade.<sup>7</sup> In addition, other pathophysiologies such as vasospasm, vasculopathy, inflammatory changes, and immunologic factors are being considered as the potential effects. Since the ear is an end-organ, it is highly susceptible to ischemic and immunologic damages. Since cochlea depends on a single terminal branch of the posterior cerebral circulation, vascular occlusion has been attributed for hearing losses.<sup>39</sup>

Hypotension has been attributed to either sudden or slowly progressive sensorineural hearing loss. A state of hemodynamic imbalance associated with hypotension plays a significant role in the genesis of cochlear damage. A blood pressure-dependent sympathetic effect on the labyrinthine circulation has been documented. Animal studies, demonstrated reduction in inner ear blood flow after a hemorrhagic hypotension, predicting a similar behavior in humans. On the other hand, it is well known that even through physiological changes in systemic blood pressure, the blood flow in the brain will be maintained. A similar blood flow regulatory mechanism is believed to be present for cochlea.<sup>7</sup>

## CONCLUSION

For a holistic mental and social development of the newborn, early identification, correct diagnosis, and appropriate treatment is necessary. The association between risk factors and occurrence of hearing loss has also been documented. A structured National hearing assessment program is advocated for all the newborn

children for the identification of at risk infants for hearing loss since most of the conditions are treatable.

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