

RESEARCH ARTICLE

The prevalence of hearing loss in infants hospitalized in the neonatal intensive care units

Nasrin Gohari^{1,2*}, Farhad Farahani³, Soraya Gharebaghy⁴, Sanaz Alaei⁵, Shahla Ahmadi¹, Zahra Mozafari¹

¹- Department of Audiology, School of Rehabilitation, Hamadan University of Medical Sciences, Hamadan, Iran

²- Department of Audiology, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

³- Department of Ear, Nose and Throat, Faculty of Medicine, Hamadan University of Medical Sciences, Hamadan, Iran

⁴- Department of Occupational Therapy, School of Rehabilitation, Hamadan University of Medical Sciences, Hamadan, Iran

⁵- Neonatal Intensive Care Units, Fatemeh Hospital, Hamadan University of Medical Sciences, Hamadan, Iran

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Abstract

Background and Aim: Studies have shown that several factors affect the hearing loss of infants hospitalized in the neonatal intensive care unit (NICU). These factors include hyperbilirubinaemia, low birth weight, asphyxia, and prematurity. This study aimed to investigate the prevalence of hearing loss and its risk factors in NICU infants.

Methods: This is a cross-sectional study. Samples were 159 infants admitted to the NICU in Fatemeh and Shahid Beheshti hospitals in Hamadan, Iran, who were selected using a convenience sampling method. Their hearing was screened using transient evoked otoacoustic emission (TEOAE) and automated auditory brainstem response (AABR) tests; in case of failure in these tests, auditory brainstem response (ABR) was performed.

Results: Of 159 infants, 9 (5.66%) were identified with different types of hearing loss where 4 (2.51%) had sensory-neural hearing loss, one (0.62%) had auditory neuropathy and 4 (2.51%) had conductive hearing loss. There was a statistically significant relationship between hearing

loss and birth weight < 1500 g, hyperbilirubinaemia, antibiotic therapy, family history of hearing loss, asphyxia and Apgar score < 5.

Conclusion: Prevalence of hearing loss in NICU infants is noticeable so hearing assessment after discharge is necessary. Due to the presence of auditory neuropathy, simultaneous use of TEOAE and AABR tests in these infants is recommended.

Keywords: Infant hearing screening; neonatal intensive care unit; auditory brainstem response

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Introduction

Early detection of neonatal hearing loss by using newborn hearing screening is essential for treatment. It can enhance the child's health and cognitive growth and development. Failure to diagnose hearing loss can have adverse effects on the child's language and perception [1], and is associated with an increased risk of learning disabilities, increased rehabilitation and specialized training costs, and medical expenses [2]. Chronic

* **Corresponding author:** Department of Audiology, School of Rehabilitation, Hamadan University of Medical Sciences, Shahid Fahmideh Blvd., Hamadan, 6517838736, Iran. Tel: 009881-38381571, E-mail: n.gohari@umsha.ac.ir

hearing loss has been reported as one of the most common congenital disorders with a prevalence of 1–3 per 1000 live births [3]. The prevalence of hearing loss in newborns with risk factors is 10 times higher than in well babies [4]. In one study, the prevalence of congenital hearing loss was 2.27 per 1000 live births in well babies and 49.18 per 1000 in infants admitted to the neonatal intensive care unit (NICU) [5]. It has been reported that the prevalence of hearing loss in NICU infants is 2–4% [6], and the risk of sensory-neural hearing loss (SNHL) is 0.33% higher in these infants [7]. Among studies in Iran, the prevalence of severe bilateral hearing loss was reported 1.4 per 1000 live births in well babies by Farhadi et al. using a two-step transient evoked otoacoustic emission (TEOAE) screening protocol [8], 0.8 per 1000 live births by Torkaman et al. [9], 4.8 per 1000 live births by Arjmandi et al. [10], 1.6 per 1000 live births by Gohari et al. using the TEOAE protocol and 2 per 1000 live births using both TEOAE and automated auditory brainstem response (AABR) protocols [11]. In another study, the prevalence of hearing loss was 8% in at-risk infants and 16% in NICU infants [12]. There are prenatal, perinatal and postnatal factors that can lead to hearing loss. These risk factors are called auditory risk factors which include family history of permanent hearing loss, hospitalization in the NICU for more than five days, use of ototoxic medications, congenital infections, rubella, cytomegalovirus, syphilis, herpes, toxoplasmosis, craniofacial anomaly, genetic postnatal bacterial/viral infection, genetic syndrome, neurodegenerative disease, head trauma, and chemotherapy [13]. Children admitted to the NICU have risk factors including low birth weight, prematurity, perinatal asphyxia, severe hyperbilirubinemia, prolonged mechanical ventilation, hypoglycemia, and long-term treatment with aminoglycoside [14]. Table 1 presents the risk factors for hearing loss in the neonatal period according to the Joint Committee on Infant Hearing [15]. Early diagnosis and treatment of hearing loss in the first months of life is considered necessary in the infant intervention programs and is one of the national goals [16]. Due to the importance

of hearing loss prevalence for treatment decisions, it is necessary to study it in each city. To our knowledge, few studies have been conducted on the prevalence of hearing loss in infants hospitalized in NICUs in Iran, and no study has investigated it in Hamadan City. In this regard, the purpose of this study was to determine the prevalence of hearing loss in infants hospitalized in the NICU in Hamadan, Iran. The results of this study can be used to develop preventive and rehabilitation programs for NICU infants.

Methods

This is a cross-sectional study. Samples were selected using a convenience sampling method from among infants admitted to the NICU in Fatemieh and Shahid Beheshti hospitals in Hamadan after discharge within 24 months. Infant information such as age, gender, weight, and type of risk factor when enrolling in the NICU were first recorded and then were screened based on TEOAE-AABR protocol using the Madsen AccuScreen device (Taastrup, Denmark). For the TEOAE test, the intensity of click stimulation in the device was set to 75 dB SPL, while for the AABR test it was set to 35 dB nHL. The stimulation rate was 11 with rare polarity [11]. If the infant was failed in both TEOAE and AABR tests or in one of them, s/he would go under clinical assessment. The clinical assessment was performed using a diagnostic ABR device (Neurosoft, Ivanovo, Russia) and an acoustic immittance device (GSI Inc., USA). Diagnostic ABR device was initiated to track the wave V with a click stimulation intensity of 70 dB nHL and a stimulation rate of 11 with rare polarity. In case of a wave V absence, higher levels of wave thresholds were detected. A tympanometer with a 1000-Hz probe tone was also used to examine the middle ear. Before screening infants, their mothers signed a written consent form to answer the questions. Then, the collected data were analyzed in SPSS 16 at the significance level of 0.05 using frequency for description and Chi-square test to evaluate the association between hearing loss and risk factors such as birth weight < 1500 g, family history of hearing loss, having parents

Table 1. Risk factors for hearing loss in the neonatal period according to the Joint Committee on Infant Hearing, 1994

1	Familial history of permanent childhood sensory-neural hearing loss in utero infections, such as cytomegalovirus, herpes, toxoplasmosis or rubella
2	Craniofacial anomalies inducing morphological abnormalities of the pinna, ear canal, nose and throat
3	Birth weight less than 1500 g
4	Hyperbilirubinemia at serum levels requiring exchange transfusion
5	Ototoxic medications, inducing but not limited to aminoglycosides alone or in combination with loop diuretics
6	Cerebral complications (bacterial meningitis)
7	Severe birth asphyxia (Apgar scores < 5 at 1 min or < 7 at five minutes)
8	Assisted ventilation lasting five days or longer
9	Syndromes: stigmata or other findings associated with a syndrome known to include a sensory-neural and/or conductive hearing loss

with cousin marriage, hyperbilirubinemia at serum levels requiring exchange transfusion, prematurity, asphyxia, any syndrome, antibiotic therapy, oxygen therapy, phototherapy, and Apgar score < 5 at one minute after birth.

Results

There were 203 NICU infants of whom 44 needed no hearing assessment. The remained 159 infants underwent AABR and TEOAE tests. Of these, 9 (5.67%) failed in these tests and 150 (94.33%) were passed. Prevalence and types of

hearing loss are shown in Fig. 1. There were four infants with SNHL, four with conductive hearing loss, and one with auditory neuropathy. There was a statistically significant relationship between hearing loss and birth weight < 1500 g, hyperbilirubinemia requiring exchange transfusion, antibiotic therapy, family history of hearing loss, and Apgar score < 5 in NICU infants ($p < 0.05$); and asphyxia was extremely significant ($p = 0.05$) that is shown in Table 2. Risk factors for five children (3.13%) with permanent hearing loss are presented in Table 3.

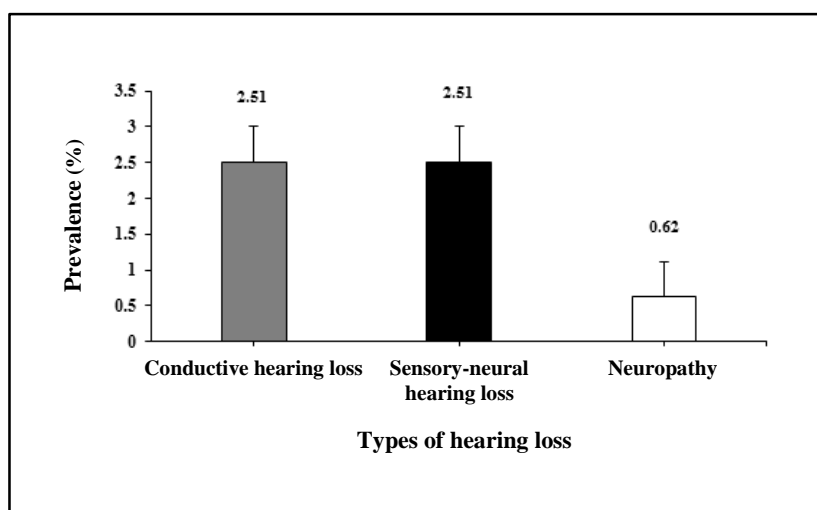


Fig. 1. Percentage of infants with various types of hearing disorders (n = 159).

Table 2. The relationship between the prevalence of hearing loss and the risk factors for hearing loss

Factor	Test's result		Percentage of referred infants	p
	Number of infants rejected (number of ears)	Number of infants accepted (number of ears)		
Sex				
Boy	8	77	5.03	0.064
Girl	1	73	0.62	
Birth weight less than 1500 g				
Yes	1	26	0.62	< 0.001*
No	8	124	5.03	
Family history of hearing loss				
Yes	2	4	1.25	0.037*
No	7	146	4.40	
Kinship marriage of parents				
Yes	3	26	1.88	0.445
No	6	124	3.77	
Hyperbilirubinemia				
Abnormal	7	147	4.40	0.017*
Normal	2	3	1.25	
Prematurity				
Yes	4	65	2.51	0.779
No	5	85	3.14	
Asphyxia				
Yes	4	118	2.51	0.050*
No	5	32	3.14	
Syndrome				
Yes	0	1	0	0.053
No	9	150	5.66	
Antibiotic therapy				
Yes	4	14	2.51	0.007*
No	5	136	3.14	

*Chi- square test

Table 2. The relationship between the prevalence of hearing loss and the risk factors for hearing loss-continue

Factor	Test's result		Percentage of referred infants	p
	Number of infants rejected (number of ears)	Number of infants accepted (number of ears)		
Oxygen therapy				
Yes	3	68	1.88	0.720
No	6	82	3.77	
Phototherapy				
Yes	7	110	5.03	0.430
No	2	10	0.62	
Ventilation				
Yes	1	4	0.62	0.669
No	8	146	5.03	
Apgar score				
≥ 5	8	138	-	< 0.001*
< 5	1	2	-	

*Chi- square test

Discussion

In this study, the prevalence of neonatal hearing loss was 3.13% (2.51% SNHL and 0.6% neuro-pathy). Molini et al. reported a prevalence of 2% among well babies and 4.3 % for infants who were at risk of hearing loss [17]. Since all at-risk infants including NICU infants were screened in this study, there was higher prevalence. Hille et al. reported a prevalence of 3.2% in NICU infants [15] which is close to the prevalence rate reported in the present study. Pourarian et al. found out that, among 124 infants in Shiraz, 17 infants had hearing loss and the prevalence rate was about 13.7% [18]. In the study by Rai and Thakur, the prevalence of hearing loss in infants admitted to the intensive care unit (ICU) was 4.91% (49.18 per 1000 live births) [5]. Yoshikawa et al. reported a prevalence of 0.8% in healthy infants and 7.8% in NICU infants by performing the AABR test (in the first stage) and diagnostic ABR [19]. The lower prevalence rate in our study may be due to the high volume of missing data

and lack of a national law that all newborns must receive hearing screening.

In this study, the hearing loss risk factors included low birth weight (< 1500 g), hyperbilirubinemia requiring exchange transfusion, antibiotic therapy, family history of hearing loss, asphyxia and Apgar score < 5. According to Rechia et al., the use of ototoxic medications is the most common cause of hearing loss in infants hospitalized in the NICU [20]. In the study of Pourarian et al. the risk factors of hearing loss in infants were gestational age of less than 36 weeks, antibiotic therapy and oxygen therapy. On the other hand, there was no significant relationship between hearing loss and the use of ventilator, hyperbilirubinemia, sepsis, congenital heart disease, congenital pneumonia, transient tachypnea of newborn, and respiratory distress syndrome [18]. In our study, the association between hearing loss and antibiotic therapy was also significant which is consistent with their study. According to Rai and Thakur, the common

Table 3. Risk factors in infants with permanent hearing loss (n = 5)

Case	1	2	3	4	5
Low birth weight	+	-	-	-	-
hyperbilirubinemia	-	+	+	-	+
Asphyxia	+	-	+	-	-
Marital status of parents	+	-	-	-	-
Prematurity	-	-	+	-	+
Family history	-	-	+	+	-
Oxygen therapy	+	-	+	-	-
Phototherapy	-	+	+	-	+
Antibiotic therapy	+	-	+	+	-
Ventilation	-	-	-	+	-
Apgar < 5	-	-	+	-	-

risk factors of hearing loss in newborns were culture positive postnatal infections, asphyxia, low birth weight, and prematurity [5]. In our study, hearing loss also had a significant relationship with asphyxia and low birth weight (< 1500 g). Yoshikawa in a study at the University of Tokyo found that the increase in the prevalence of hearing loss in infants was related to factors such as congenital infection, high C-reactive protein, chromosomal aberration, and central nervous system disorder [19]. The prevalence of hearing loss due to positive y history in infants with congenital hearing loss is 7.29% [21]. In our study, two in four infants with SNHL had a family history of hearing loss. Chromosomal evaluation was not performed in our study, so it cannot be said with certainty that the main cause of hearing loss in two study infants was genetic.

In the study conducted by Poonual et al., it was found that low birth weight, Apgar score < 6 at five minutes after birth, craniofacial anomalies, sepsis, and ototoxic exposure were the risk factors for bilateral hearing loss in infants aged 3 months [22]. According to Coenraad et al., dysmorphic features, low Apgar scores at one

minute, sepsis, meningitis, cerebral bleeding, and cerebral infarction are associated with SNHL in ICU infants independent of NICU infants admittance [23]. In our study, the use of ototoxic medications and low Apgar were also reported as risk factors. It is possible that with the increase of cases, a higher number of risk factors be identified. According to Xu et al., from 2530 infants at the NICU, 22 neuropathic infants were identified that its causes were reported asphyxia and hyperbilirubinemia [24]. In our study, one infant with high hyperlipidemia was also given an exchange transfusion. This infant was diagnosed with hearing neuropathy which is consistent with the findings of Xu et al. The infant passed the TEOAE test but failed in AABR test which highlights the importance of performing both TEOAE and AABR tests simultaneously for hearing screening.

Numerous factors have been reported for hospitalization in NICU by different studies; each of the hospitalized infants may have one or more risk factors or may have different risk factors. The study samples may also be different; therefore, each study reports different risk factors for hearing loss in infants. It seems that with the increase of study samples, more risk factors can be identified. One of the limitations of this study was the lack of infants referred to hearing evaluation which needed obtaining information from the hospitals and mass media for early diagnosis and intervention of hearing loss.

Conclusion

The prevalence of hearing loss in NICU infants is noticeable. Because of the possibility of auditory neuropathy, the use of TEOAE and AABR tests simultaneously is essential for these infants. The significant risk factors were hyperbilirubinemia requiring exchange transfusion, antibiotic therapy, asphyxia, Apgar score < 5, and a family history of hearing loss. It is necessary to inform families and hospital staff about the prevalence of hearing loss and its consequences in infants.

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Conflict of interest

The authors state that there was no conflict of interest.

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