

ORIGINAL ARTICLE

## Study of Prevalence and Causes of Hearing Loss in High Risk Neonates Admitted to Neonatal Ward and Neonatal Intensive Care Unit

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**Background and Objective:** Hearing loss in neonates is one of the most important problems. Any delay in early diagnosis and intervention will cause a great undesirable impact on speech, language and cognitive abilities. So, it is always recommended that if there is significant prevalence of neonatal hearing loss, screening programs should be performed at least on high risk population of neonates to detect cases actively.

**Materials and Methods:** This is an analytic, cross-sectional study on 1,823 low risk neonates and 876 high risk neonates admitted at "Kodakan", "Alzahra", and "Talegani" hospitals during years 2004-2006. Method of sampling was simple randomized sampling. In all neonates otoacoustic emission was performed and if it was abnormal second otoacoustic emission after two weeks of antibiotic therapy was done. Neonates with abnormal second otoacoustic emission underwent auditory brainstem response. Criteria for hearing loss was hearing threshold more than 30 dB in auditory brainstem response. Data was statistically analyzed.

**Results:** Prevalence of sensori-neural hearing loss was 0.2 percents in low risk neonates and 4.2 percent in high risk neonates. Auditory brainstem response was abnormal bilaterally in 62.2 percent and unilaterally in 37.8 percent. Factors which had significant relationship with hearing loss include: Birth weight less than 1,500 gram, Craniofacial abnormalities, meningitis, using of ototoxic drugs in neonates, mechanical ventilation more than five days, prematurity, familial history of hearing loss, hyperbilirubinemia requiring exchange transfusion.

Factors that didn't have statistically significant relation were intrauterine infections, using of ototoxic drugs in pregnancy, finding related to one of the syndromes accompanied with hearing loss, and APGAR score 0-4 at first minute and 0-6 at fifth minute.

**Conclusion:** Prevalence of sensorineural hearing loss in high risk neonates was 4.2 percent in our study. This is twenty-fold more than low risk neonates. Since early diagnosis and intervention will prevent significant complications and on the other hand the cost of screening tests is very low, it is important and logical from the point of health and economy that the screening tests should become necessary for all of neonates.

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### Introduction

Prevalence of hearing loss in low risk infants is 2-6 in a thousand alive birth<sup>[1]</sup>. Prevalence of hearing loss in high risk infants is 10-50 times more than low risk newborns<sup>[2]</sup>. According to this fact that high risk infants involve 12 to 16 % of total infants, so, more than 50% of infants with hearing difficulty are in this group<sup>[1]</sup>.

According to this fact that nature hearing plays an important role in language development and a resultant infant's learning ability, timely diagnosis and treatment intervention is necessary.

Yoshinaga-Itano et al. (1998) compared language abilities of infants suffering from hearing loss with

normal infants, and they found that: Although the effect of severe hearing loss has been well recognized, it is clear that infants with mild and moderate hearing loss suffer from defect in speaking and language development<sup>[5]</sup>. Diagnosis of hearing loss in infants is impractical by common clinical examination (observation of behavior). Although parents doubtly refer to hearing when they observe their infant does not respond to voices or respond properly.

Average age for diagnosis of hearing loss by parents is 2-3 years of age. For cases with mild or moderate hearing it will not be diagnosed until age 4.<sup>[1]</sup> For diagnosis of hearing loss in infants, observational physiological tests such as otoacoustic emission (OAE) and auditory brainstem responses (ABR) are

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used successfully<sup>[7, 8]</sup>. Both technologies are non-invasive and natural acoustic physiologic activities are recorded easily in infants. American Academy of Pediatrics has recommended hearing evaluation in infants until third month of age, treatment intervention begin before six months in order to shape natural language development<sup>[3]</sup>. Age of diagnosis in U.S in 1988 was 25 months<sup>[1]</sup>. With performance of general hearing screening the age of diagnosis has reduced, so, in 1999 it reduced to 14 months and currently it has decreased to 3-6 months<sup>[6]</sup>.

Recent findings indicate that not only hearing screening is practical but also it has benefit of early intervention in infants with hearing loss. Effectiveness and reliability of early diagnosis have been proven by screening tests<sup>[7]</sup>. These tests have been reported as cost-effective methods in separated hospitals in different programs in U.S<sup>[8]</sup>.

We have studied prevalence of hearing loss in high risk infants and compared these infants with those healthy. Obtaining some information about hearing loss prevalence in high risk infants offers information about present condition, so, we can persuade health officials for comprehensive screening, prevention-based measures, proper treatments and finally reduce hearing loss outbreak in high risk infants.

*Goals of study include:*

1. General goal: determination of prevalence and causes of hearing loss in high and low risk infants.
2. Specific goals:
  - 2-1. Determination of hearing loss prevalence in low risk infants.
  - 2-2. Determination of hearing loss prevalence in high risk infants.
  - 2-3. Comparison of hearing loss in high and low risk infants.
  - 2-4. Determination of various types of hearing loss and their severity in high and low risk infants.
  - 2-5. Comparison of various types of hearing loss and their severity in high risk and low risk infants.
  - 2-6. Determination of frequency and effects of risk factors related to hearing loss.

**Material and Methods**

Our study is cross-sectional, analytical and observational. Studied population consist of high risk infants hospitalized in ICU ward of Kodakan, Alzahra and Talegani hospitals as case group.

Low risk infants selected from women hospitals were control group. This study was performed between 2004 and 2006. Data of high risk and low risk infants were entered into a data sheet and analyzed using SPSS (version 14) software. T-test, mono-variable analysis, exact fisher and Chi square tests were performed. p-value < 0.05 was considered significant. A total of 1,823 low risk infants (control group) and 873 high risk infants (case group) were studied. Low risk infants were those infants who did not have any risk factor. High risk infants had at least one of these risk factors:

1. Birth weight less than 1,500 gram.
2. Craniofacial abnormality.
3. Suffering from bacterial meningitis.
4. Intrauterine infection like measles, syphilis, toxoplasmosis, CMV and herpes.
5. Put on ototoxic drugs during neonatal period.
6. Put on ototoxic drugs during pregnancy.
7. Mechanical ventilation more than 5 days.
8. Stigma or other signs of a syndrome in association with hearing loss.
9. APGAR score of 0-4 in first minute or of 0-6 in fifth minute.
10. Prematurity (gestational age lower than 37 weeks).
11. Familial history of sensorineural hearing loss .
12. Hyperbilirubinemia requiring blood exchange.

At first all infants were examined by a pediatrician and in cases of having at least one of the mentioned risk factors they were referred to otolaryngologist, and they were categorized at high risk infants. All high risk and low risk infants were tested by OAE. In case of normal response, the examination was discontinued. Infants with impaired OAE (due to acute otitis media and serous otitis media) were treated with antibiotics for two weeks. After two weeks, OAE was repeated. In case of impaired second OAE, ABR was performed. In infants with blood bilirubin more than 20 mg/dl or infants required blood exchange, ABR was conducted at the beginning as OAE was unreliable in this group. In this study the criteria for hearing loss was hearing threshold more than 30 dB in ABR in either ear.

**Results**

In this study 1,823 infants without risk factors were investigated, this group was called low risk. Among this group, 949 (52%) were male and 874 (48%) were

female. Average age of low risk infants was 1.36 day 2.49. Average age of pregnancy for low risk infants was 37.5 weeks 0.90.

Out of 1,823 low risk infants, 20 showed abnormal second OAE, and they were tested using ABR. Among these infants, 4 had impaired ABR (0.21%). Of these 4 one had unilaterally abnormal ABR and three had bilaterally abnormal ABR. So, prevalence of hearing loss in low risk infants was 0.21% (2.1 in a thousand).

Infants having at least one risk factor for hearing loss were considered high risk group. Total of 873 high risk infants were studied. Among them, 478 (55.6%) were male and 389 (44.4%) were female. Average age was 11.53 days 6.25. Average age for pregnancy was 38.24 weeks 2.25 for high risk infants.

Out of 873 high risk infants, 60 (6.78%) had abnormal OAE in second test, so they were tested using ABR. In 37 infants (4.2%) ABR was abnormal. Thus, prevalence of hearing loss in high risk infants was 4.2%. This frequency was 20 times more than low risk infants. Of these 37 infants with impaired ABR, it was abnormal bilaterally in 23 infants (62.2%) and unilaterally in 14 infants (38.7%). Of 14 infants, ABR was abnormal in the right ear of 9 cases and in the left ear of 5 cases.

According to data mentioned in Table-1, there was no significant correlation after analyzing with Chi-square test between low APGAR with abnormal ABR and any of intrauterine infection, consumption of ototoxic drugs during pregnancy, sign of syndromes in association with hearing loss. There was significant correlation after analyzing with Chi-square test between other risk factors and abnormal ABR.

### Discussion

In our study prevalence of hearing loss in high risk infants was 4.2% in alive birth. This figure is in line with average of prevalence of hearing loss in world in high risk infants (2%-5%) [2].

According to studies by Yoshinaga et al., Gupta et al. and Maisoun et al. hearing loss prevalence was reported to be 7.8%, 29.1% and 13.5% that are more than our study [5,15,17].

Prevalence of hearing loss in study of Oghalai et al., De capua et al. were 1% and 1.78% that are lower than our study [4,12]. The reason for these differences might include different screening protocols and real difference in hearing loss incidence in world. Hyperbilirubinemia was the most common risk factor in our study. We divided hyperbilirubinemia into

**Table 1.** Statistical analysis of risk factors with reference to the frequency of risk factors and abnormal ABR.

Risk factor	Frequency of neonates with a risk factor (%)	Frequency of abnormal ABR among neonates with a risk factor	p-value	Correlation
Birth weight less than 1,500g	27(3.1%)	4(14.8%)	0.000	Significant
Craniofacial abnormality	51( 5.8%)	3(5.9%)	0.002	Significant
Meningitis	11(1.2%)	1(9.1%)	0.015	Significant
Intrauterine infection	13(1.4%)	0 (0%)	0.692	not Significant
Treatment with ototoxic drugs in neonate	317(36.4%)	17(5.4%)	0.000	Significant
Treatment with ototoxic drugs during pregnancy	18(2.1%)	1(5.6%)	0.086	not significant
Mechanical ventilation more than five days	31(3.5%)	4(12.9%)	0.000	Significant
Signs of syndromes in association with hearing loss	28(3.2%)	1 (3.6%)	0.241	not significant
Low APGAR	47(5.3%)	2(4.3%)	0.055	not significant
Prematurity	106(12.2%)	10 (9.4%)	0.000	Significant
Familial history of hearing loss	17(1.9%)	3(17.6)	0.000	Significant
Hyperbilirubinemia requiring blood exchange	8 (0.9%)	5(62.5%)	0.000	Significant

\* Auditory Brainstem Response

Total number of high risk neonates were 873.

p-value <0.05 shows significant relation between risk factor and abnormal ABR

required phototherapy and required blood exchange. There were 628-hyperbilirubinemia case from total high risk infants who required phototherapy. Although monovariate analysis indicates significant correlation between this risk factor and hearing loss; since odd ratio is less than one therefore this factor did not increase probability of hearing loss. Hyperbilirubinemia required blood exchange had considerable risk ratio for hearing loss. Relationship between this risk factor and hearing loss especially auditory neuropathy has been recognized. Many studies confirm this issue [12,16,18,22]. An important point in screening is high percentage of false negative response in OAE of infants with hyperbilirubinemia who required blood exchange. Therefore, in their screening ABR should be conducted at first. In our study in eight high risk infants (0.9%) there was icter that required blood exchange in which in 62.5% of them prevalence of hearing loss was 15 times more than average hearing loss prevalence in high risk infants (rephrase this sentence). The relationship between consumption of ototoxic drugs in neonatal period was the other risk factor. Out of 873 high risk infants, 317 (36.4%) had history of treatment with ototoxic drugs. The relationship between this factor and hearing loss is significant ( $p=0.000$ )

Aminoglycosides especially Amikacin were the most common drugs. In many studies, there was a meaningful relationship between this factor and hearing loss in infants [19,20]. In the meantime, there are some other studies indicating no meaningful relationship between this factor and hearing loss in infants [4,10,11,14,21].

Some studies show less aminoglycoside ototoxicity in infants than adults [19,20] which might be the reason for no meaningful relationship in some studies. Ototoxic drug-consumption history in pregnant mothers was studied, this was considered in 18 high risk infants, but there was no meaningful relationship between this factor and hearing loss in neonates ( $p=0.86$ ).

Birth weight less than 1,500 gram was considered in 27 (3.8%) high risk infants and there was meaningful relationship between this risk factor and hearing loss ( $p=0.000$ ). Prevalence of hearing loss among these infants was 14.8%, which was 3.5 times higher than average prevalence of hearing loss in high risk neonates. According to this result this factor is one of the main risk factors .

In 31 (3.5%) high risk infants, mechanical ventilation more than 5 days had been investigated. Relationship

between mentioned factor and hearing loss is significant ( $p=0.000$ ). Prevalence of hearing loss in these infants was 12.9%, which is three times more than average prevalence of hearing loss in high risk neonates. Thus, the correlation between mechanical ventilation and neonatal hearing loss has been established [12, 16].

Craniofacial abnormality is the other risk factor. This factor has been reported in 51 (5.8%) infants. Prevalence of hearing loss among these infants was 5.9%, and the relationship between this risk factor and hearing loss was significant ( $p=0.002$ ). In most studies [5, 12, 13, 20] the importance of this risk factor has been established. The most common craniofacial abnormality was cleft lip and cleft palate. Since these infants were referred to pediatrics center, then, screening for hearing loss was conducted.

Syndromes with hearing loss were studied. It was reported in 28 cases (3.2%) of high risk infants, this relationship was not significant ( $p=0.241$ ). Infants with hearing loss and other signs (like as iris color, cavity around ears, goiter, shape of skull, excessive fingers) should be investigated in terms of association with syndromes. Other studies have shown significant relationship [9,11,12, 22]. Familial history of hearing loss was indicated in 17 (1.91) of high risk infants and among them 17.7% suffered from hearing loss which is four times more than average prevalence of hearing loss in high risk neonates. There is a meaningful relationship between this factor and hearing loss ( $p=0.000$ ). In many studies there is a meaningful relationship between this risk factor and hearing loss [11,14,15]. Therefore, if there is familial history of hearing loss, genetic consultation before marriage or pregnancy is necessary.

The other risk factor is low APGAR. This factor has been reported in 47 (5.3%) high risk infants, and 4.3% of infants with low APGAR suffered from hearing loss. There is no meaningful relationship between this factor and hearing loss in our study ( $p=0.055$ ).

In 13(1.4%) high risk infants, intrauterine infection was indicated, but there was no hearing loss in these cases. Therefore, a meaningful relationship was not established ( $p=0.692$ ) but in other studies this relationship was shown. The reason for lack of this relationship in our study was small number of cases of intrauterine infection. Prematurity was reported in 106 (12.2%) of high risk infants with 9.4% prevalence of hearing loss among them that is 2 times more than

average prevalence of hearing loss in high risk infants. There was a meaningful relationship between prematurity and hearing loss ( $p=0.000$ ).

The other risk factor that studied was meningitis; this factor was reported in 11 (1.2%) infants with 9.1% prevalence of hearing loss among them. The relationship between meningitis and hearing loss was meaningful ( $p=0.015$ ).

Age of diagnosis is an important criterion of hearing screening program. In our study mean age was 3.5 0.5 months. The results show that awareness of hearing loss by parents may delay the diagnosis of hearing loss until 12th month<sup>[2]</sup>. It has established that if diagnosis is made until 6th month, intervention will lead to normal cognition, speech and language development<sup>[6]</sup>.

Prevalence of hearing loss in high risk neonates in our study was 4.2% in alive birth, which is similar to ratios in medical textbooks and articles (2-5%). Following risk factors had meaningful relationship with hearing loss: (Factors are listed according to prevalence order).

- 1- History of medication of ototoxic drugs in neonates
- 2- Prematurity
- 3- Craniofacial abnormality
- 4- Mechanical ventilation more than 5 days
- 5- Birth weight less than 1500 gram
- 6- Familial history of hearing loss
- 7- Suffering from meningitis
- 8- Icter required blood exchange

There was no meaningful relationship between following factors and hearing loss:

- 1- Intrauterine infection
- 2- Consumption of ototoxic drugs during pregnancy
- 3- Low APGAR
- 4- Signs of syndromes with hearing loss.

Elimination of those factors which don't have meaningful relationship requires several studies. Lack of relationship relates to failure in diagnosis of intrauterine infection or small number of cases with these factors.

Among studied risk factors, the most common risk factors are treatment with ototoxic drugs in neonates, prematurity and birth weight less than 1,500 gram. Also, there was only one risk factor in 32.4% of neonates with hearing loss and two or more risk factors in 67.6%. Existence of hyperbilirubinemia which required phototherapy enhances effects of risk factors.

According to prevalence of hearing loss in high risk infants and this fact that timely diagnosis and treatment prevents future disabilities and reduces costs and on the other hand cost of screening programs is low and lead to reduce age of diagnosis to 3.5 months, therefore performance of screening programs is cost-effective and increases health level. Also, it is ideal that screening tests are conducted in low risk infants since cost of these tests is low and timely diagnosis prevents handicap in future.

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