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Early Diagnosis and Intervention for Hearing Loss in Newborns Discharged from Intensive Care Units: a Four-year Follow-up Study in North of Iran

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Abstract

Background

Background: Hearing loss is the most common congenital disorder the incidence of which is further increased in the presence of risk factors for hearing loss among newborns admitted to the neonatal intensive care unit (NICU). The aim of this study was early diagnosis and intervention for hearing loss in newborns discharged from NICU.

Materials and Methods

This prospective cohort study was conducted on 3,362 newborns discharged from the NICU in several hospitals in Babol, Iran. Each newborn was evaluated through the transient evoked otoacoustic emission (T) EOAE test. In the absence of any result, retests including TEOAE and diagnostic auditory brainstem response (ABR) were conducted. In case of hearing loss, intervention programs including hearing aids fitting and cochlear implant were considered for infants. Each newborn infant was follow-up for four years. The infant's age was also calculated during the hearing loss diagnosis and the intervention program.

Results

Sensorineural hearing loss (SNHL) was diagnosed in 35 (1.04%) of the infants at an average age of 105.65 ± 96.72 days. Most of hearing loss diagnosis (51.43%) was before the age of 3 months. Hearing aids were fitted for 25 infants (80.64%) with a mean age of 9.61 + 7.64 months. Cochlear implants were done for two (8%) children. At the end of the follow up, all of the children except one case (3.22%) were able to use verbal communication.

Conclusion

Hearing screening of the high risk NICU graduate babies has reduced the age of hearing loss diagnosis to 3 months. The presence of severe to profound hearing loss in this population highlights the importance of early diagnosis and intervention.

Key Words: Brainstem evoked response, Hearing loss, Newborn, Risk factor, Screening.

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1- INTRODUCTION

Congenital hearing loss is one of the most common congenital disorders with a prevalence of 1 to 3 per 1000 births (1). The number of newborns with hearing loss is greater than those with diseases such as phenylketonuria or hypothyroidism that are screened at birth (2, 3).

Hearing loss is increased by 10 to 50 times in the presence of risk factors for sensorineural hearing loss (SNHL), especially among newborns admitted to the NICU (3). Late diagnosis of hearing loss hinders language development and cognitive-psychosocial development which in turn weakens the affected individual's educational and professional progress (4). Identification of hearing loss during the first months of life can alleviate the serious consequences of hearing loss. This goal could be achieved by implementing hearing screening programs for all newborns or at least high-risk newborns (3, 5). The universal newborn hearing screening (UNHS) program is implemented in many countries for early diagnosis and intervention of congenital hearing loss (6). It is recommended that all neonates must be screened for hearing loss by 1 month of age, have a diagnostic audiologic evaluation by 3 months of age, and are enrolled in appropriate early intervention services by 6 months of age. This time frame is fundamental and represents the important periods of growth and hearing development are commonly referred to as the 1-3-6 Plan (7-9).

The universal newborn hearing screening program has significantly improved hearing loss diagnosis in terms of the infant's age. Meanwhile; usefulness of suitable reinforcement resulting from this screening program has been financially and developmentally confirmed in several papers (10). Hearing screening services and their available resources (financial resources, equipment, trained personnel and facilities) are an important priority for early diagnosis of hearing loss newborns with hearing loss can be diagnosed as soon as possible for optimal intervention through objective techniques like Otoacoustic emission (OAE) and auditory brainstem response (ABR) (4). Hearing loss diagnosis age plays an important role in determining communication skills of newborns with hearing loss. Thus, the diagnostic follow up test is necessary for newborns, who have not passed screening so that their hearing loss can be proved in case it exists. This assessment is essential for early diagnosis of hearing loss. Unfortunately, not all newborns receive the recommended follow up test (8). This leads to an increase in the hearing loss diagnosis age. If newborn hearing screening is not implemented, more than 30% of perceptual hearing loss remain unknown before 3 years of age and treatment would not start before the child has reached the age of 40 months (11, 12).

No review of diagnosis associated with early intervention of hearing loss has been yet reported in the hospitals in Babol, Iran. This study examined the hearing screening procedure conducted on newborns at risk of hearing loss in Amirkola Children's Hospital in Babol, a hospital which receives patients from all over the Mazandaran province, Iran. This study was designed in the Audiology Unit of this center. The aim of this study was early diagnosis and intervention for hearing loss in newborns discharged from NICU to reduce the severe consequences of hearing loss.

2- MATERIALS AND METHODS

2-1. Study Design and Population

A prospective cohort study hearing evaluations were conducted in the Audiology Unit of Amirkola Children's Hospital in Babol city, North of Iran. All newborns discharged from NICU of this Hospital and Ayatollah Rouhani Hospital

from January 2011 to January 2015 was enrolled.

2-2. Methods

The program started with hearing screening at the first stage. Each newborn admitted to the NICU underwent hearing assessment in the first week after being discharged via the transient evoked otoacoustic emission test (TEOAE). After presenting click stimulus, each infant's hearing was measured in the recommended level of 83 dB SPL. In the presence a "passed" result, the infant's hearing condition was considered to be normal. When hearing loss is present, transient evoked otoacoustic emissions (TEOAE) are typically absent (Failed result). In these cases, retest including transient evoked otoacoustic emission (TEOAE) and diagnostic auditory brainstem response (ABR) tests were conducted to determine the exact threshold.

Auditory brainstem response (ABR) was conducted in a quiet room, while the child is slept in quiet conditions. The result was recorded using disposable electrodes placed on both mastoid and forehead. Band-pass filter was presented in the 100-3000 Hz, repetition frequency range 21.1 stimulation per second, alternating polarity clicks, within a time window of 10 ms. Click stimulus was presented to start at intensity level of 70 dBHL (hearing level) and was decreased in 10-20 dB steps. In case of normal hearing, it was recorded up to 20 dBHL, but in case of hearing loss it was recorded as long as no result was obtained. On the other hand the minimum level at which the wave V was detected, regarded as the threshold (**Figure.1**).

After assessments and in case of hearing loss, an early intervention program was planned for all newborns. This program included follow-up audiometric examination which was either behavioral audiometry or auditory steady state response (ASSR) test depending on the infant's age and condition. Auditory brainstem response (ABR) could not differentiate the degree of hearing loss between the severe and profound level, in these cases the auditory steady state response (ASSR) test is indicated. All the subjects with moderate and higher mean hearing loss were considered for hearing aid fitting. A cochlear implant was also proposed for newborns with profound hearing loss. During the hearing loss diagnosis and intervention program, the age was calculated based on the babies' chronological age (**Figure.2**).

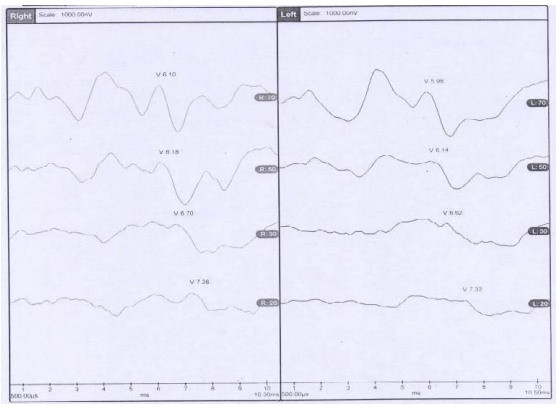

Fig.1: Auditory brainstem responses (ABR) waves in a normal infant at the age of one year.The presence of wave V in 20 dBHL indicate a normal hearing threshold.

2-3. Measuring tools

Data collection tool in this study was a checklist list composed of risk factors for hearing loss based on the joint committee on infant hearing recommendation. Transient evoked otoacoustic emission (TEOAE) and brainstem response (ABR) tests were conducted with the Ero Scan pro device manufactured by Maico Company (Germany) and Epicplus device made by Labat Company in Italy respectively.

Hearing loss is classified according to its severity: normal (<20 dB), mild loss (20 to 40 dB), moderate loss (41 to 55 dB), moderately severe loss (56 to 70 dB), severe loss (71 to 90 dB), and profound loss (>90 dB) (13).

2-4. Inclusion criteria

- All the newborn babies discharged from NICU with risk factors for hearing impairment based on the Joint committee on infant hearing (JCIH),
- Parental consent.

2-5. Exclusion criteria

- Conductive hearing loss (CHL) diagnosed during the study,
- Lack of willingness of parents.

2-6. Ethical considerations

This study is noninvasive and the subject is not exposed to any harm. In order to comply with ethical considerations informed consent was obtained from parents.

2-7. Data analyses

All data were gathered and analyzed by SPSS-19 Software (SPSS, Chicago, IL, USA) Significance was indicated by a P-value less than 0.05.

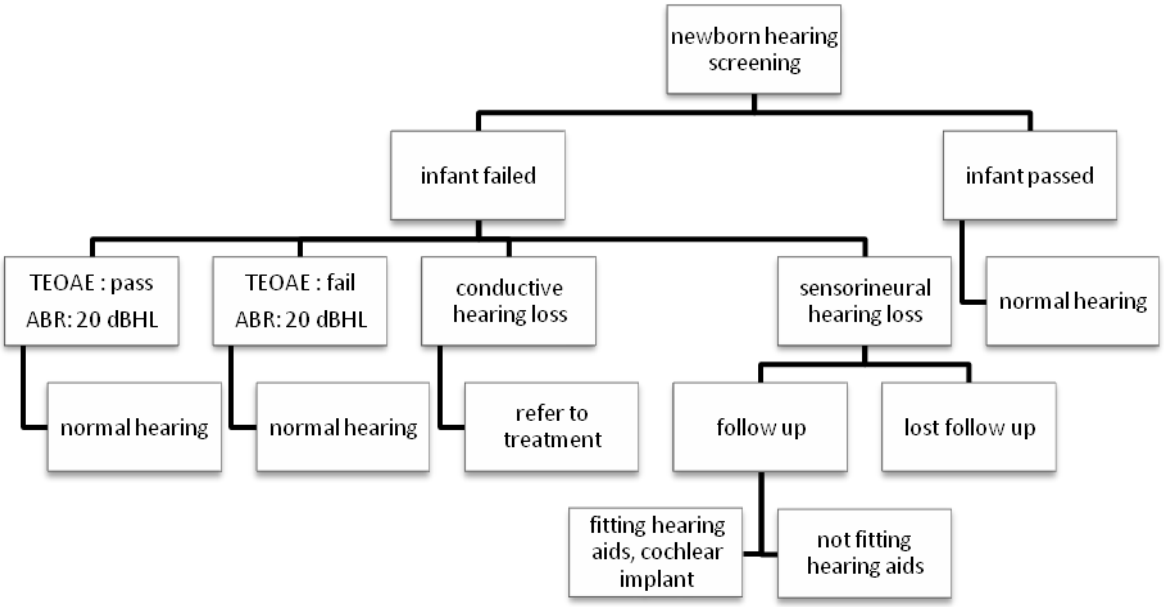

Fig2: The schematic representation of the study protocol

3- RESULTS

The study was conducted on 3,362 newborns discharged from the NICU of hospitals in Babol- Iran, during January 2011 to January 2015. Three hundred twenty-one newborns (9.54%) failed TEOAE screening test in one or both ears and were referred for retest through TEOAE and diagnostic ABR tests.

In the re-test, two weeks after the TEOAE test, 272 subjects passed the test and their ABR was recorded up to the level of 20 dBHL. In this step, six other subjects also, failed TEOAE test, but their ABR showed a normal threshold. A total of 278 newborns (86.60%) had normal hearing. Eight newborns (2.49%) had slight to moderate conductive hearing loss, out of which one subject (0.31%) had earlobe and right auditory canal atresia, 3 subjects (0.93%) had cleft palate and 4 subjects (1.24%) had otitis media. Thirty five newborns (10.90% of neonates with failed results) had some degree of slight to profound sensorineural hearing loss. Here, we will discuss the profile of these subjects, in the below:

3-1. Profile of subjects

Subjects with hearing loss included 20 males (57.14%) and 15 females (42.86%) in the age range of 10 days to one year.

3-2. Identification of hearing loss

3-2-1. Diagnosis age

The lowest and the highest age of hearing loss diagnosis were 10 days and one year, respectively. The mean age of hearing loss diagnosis was 105.65 $\pm$ 96.72 days. Age distribution is shown in **Table.1**.

The most frequent age of hearing loss diagnosis was before three months of age. Four cases (11.43%) of hearing loss diagnosis were after 6 months of age, which was for some reasons such as long-term hospitalization of newborns, the presence of other diseases and not referring to audiological evaluation.

3-2-2. Hearing loss degree

In 34 (97.14%) cases hearing loss was bilateral and only in one (2.86%) case hearing loss was unilateral. The degree of hearing loss after the initial diagnosis is presented in **Table.2**. The highest degree of hearing loss was in severe range.

3-3. Follow-up

Follow-up program was conducted on 31 newborns (88.57%). Four (11.43%) newborns lost this screening for reasons such as; lack of follow-up by family, distance from residence and other problems of newborns. Follow-up program was composed of further diagnostic evaluations included behavioral audiometry, ASSR test and ABR retest. The results of 31 (88.57%) newborns that were followed up are presented in **Table.3**. In the diagnostic evaluation of hearing loss, one severe to profound subject changed to severe.

3-4. Intervention type

Hearing aids were fitted for 25 newborns (80.64%). One subject with unilateral hearing loss, two subjects with hearing loss less than moderate and age-appropriate speech development, two subjects with moderate hearing loss and one with profound hearing loss did not receive hearing aids because of the unwillingness of their families. The latter had mental retardation in addition to hearing problems, and his hearing loss was diagnosed at the age of one year and did not receive hearing aids up to age 3 years (the time of this study).

At the time of review of this study, cochlear implant was performed on two (8%) children with profound hearing loss at the age of 14 months and one child at the age of 18 months. The other children with profound hearing loss are undergoing the required evaluations for cochlear implant.

3-5. Children's age at the time of intervention

Twenty-five children who benefited from hearing aids fitting had a mean age of 9.61 $\pm$7.64 months ranging from 4 to 31 months of age. **Table.4** shows the age distribution of fitting the hearing aids. In 15 (52%) newborns a hearing aid fitting was performed before 6 months of age and in 12 (48%) newborns it was performed after 6 months of age. All newborns with profound hearing loss received hearing aids before 6 months of age. Lower degree of hearing loss delayed the age of fitting the hearing aids.

3-6. Communication method

At the end of the study, all infants and children except one case used verbal communication method to communicate. Only one child with profound hearing loss that did not use a hearing aid because of the unwillingness of his family used gesture communication method.

Table-1: The age distribution of the infants at the time of diagnosis of hearing loss

Age (month)	Number	%
0-3	18	51.43
3-6	13	37.14
6-9	1	2.86
9-12	3	8.57
Total	35	100

Table 2: The degree of hearing loss after initial diagnosis

Degree	Number (Per Ear)	%
Normal*	1	1.43
Mild	2	2.86
Moderate	10	14.28
Moderate to severe	7	10
Severe	27	38.57
Severe to profound	23	32.86
Total	70	100

*One patient had unilateral hearing loss.

Table -3: The degree of hearing loss before and after follow up

Initial diagnosis (Per Ear)	Follow up (Per Ear)
1 Normal*	1 Normal
2 Mild	2 Not Follow
10 Moderate	8 Moderate 2 Not Follow
7 Moderate to Severe	7 Moderate to Severe
27 Severe	25 Severe 4 Not Follow
23 Severe to Profound	21 Profound
70 Total	62 Total

*One patient had unilateral hearing loss.

Table-4: The age distribution of the children at the time of fitting hearing aid

Age (month)	Number	%
0-6	13	52
6-12	3	12
12-18	5	20
18-24	1	4
24-31	3	12
Total	25	100

4- DISCUSSION

The results of this study showed that 1.04% of the NICU graduates had hearing loss, in which most of them the degree of hearing impairment was severe to profound while for some infants who lost the follow up most of them received rehabilitation, and eventually almost all of them were able to use verbal communication. Screening program provides the effective treatment as soon as possible before demonstration of symptoms. When hearing problem is diagnosed early, available effective treatments could ensure growth and development of the newborn (14).

According to the international standards in the universal newborn hearing screening programs, the audiological reference rate should be less than 5%, but in our study this rate was 9.54%. In other studies, the lack of response was reported less, but only ranging from 2.8 to 14.3 (9, 10, 12, 14-16). This higher difference may be for reasons such as sample size, screening technologies, test environment or procedural issues (15). However, in the evaluation of high risk newborns, the referral rate with otoacoustic emission (OAE) could be increased by 12% (16). In this study, the prevalence of hearing loss was 10 per 1,000 births, which might have remained unidentified if the diagnosis program had not been implemented. This emphasizes the screening and follow-up of hearing in this group of newborns. In similar international studies, the degree of hearing loss in newborns at high risk of hearing loss was reported in the range of 1.7% to 4.9% (3, 5, 12, 15-19). The lower number in this study might be related to given the methodological differences, the test used may be automated auditory brainstem response (a) ABR against diagnostic auditory brainstem response (ABR). Auditory brainstem response (ABR) test is the gold standard test to assess hearing function in newborns younger than 6 months and it seems to be a more valid test because of its highest sensitivity and specificity for high risk newborn hearing screening (17).

In this study, the highest mean of hearing loss in both ears (71.43%) was from severe to profound range. Coenraad and Robertson in separate studies emphasized this finding (hearing loss greater than 70 dB) (5). The effects of higher hearing loss are obvious on speech and language development and function in life. The average age of diagnosis of hearing loss was 3 months and 15 days. Diagnosis before the three months of age accounted for 51.43 of the population. Gaffney et al. (2010) diagnosed hearing loss in 52.7% of newborns before three months of age (8). Langagne et al. (2010) also, reported the mean age of hearing loss diagnosis through universal screening to be 3.2 months (2). Many teams around the world reported the reduction of diagnosis age, amplification and intervention of hearing after the implementation of universal newborn hearing screening (UNHS) compared to before. However, in some cases, it has not yet reached joint committee on infant hearing (JCIH) standards (8, 12, 20-23). Implementation of neonate hearing screening has brought the mean age of hearing loss diagnosis in Babol closer to that designated in international standards.

Due to the reduction of the age of diagnosis, the age of intervention has also been reduced. Hearing aid fitting was considered for all infants with moderate and higher mean hearing loss. Among them, 25 (80.64%) children with a mean age of 9.61 months received hearing aids. In 52% of the subjects, including all infants with profound hearing loss, hearing aids were fitted before the age of 6 months. In the study conducted in France by Ohl et al. (2009), 73.91% of hearing-impaired newborns were managed before 6 months of age (16). In other universal newborn hearing screening (UNHS) studies, the intervention age varies between 4 and 10 months (2, 6, 20, 24-26). Holster et al. (2009) reported that the mean age of hearing aids fitting for hearing loss greater than 40 dB was 8 months. In the subjects with severe to profound hearing loss the age of hearing aid fitting arrives to 6 months (24).

Uus and Bamford (2006) obtained the mean age of hearing aid intervention as 16 weeks. Children with moderate hearing loss, were fitted with hearing aids later than those with severe to profound hearing loss (25). Moderate hearing loss increases the mean age of hearing aids fitting. Children with moderate hearing loss

receive hearing aids almost five months later than those with profound hearing loss (6, 20). It seems that given the otitis media (OM) which causes moderate transient conductive hearing loss, it is difficult to determine the exact hearing status of these individuals. Moreover, due to the hidden nature of hearing loss, many families of these children do not tend to use hearing aids. Thus, rehabilitation in these children takes place later. Timely and appropriate intervention is required to reduce future problems with speech and language. In addition, several studies had shown the increased age for hearing aids fitting in high risk newborns compared to the well-baby (12, 20).

4-1. Limitations of the study

Four out of 35 infants who were diagnosed to have hearing loss at the time of initial screening lost their follow-up hearing tests, so if their follow-up test results were measured they might alter the final results, although it does not seem that these effects were significant.

5. CONCLUSION

According to the obtained results, implementation of the universal hearing screening program has reduced the hearing loss diagnosis age to 3 months. Thus, this screening provides some evidence for diagnosis and early intervention. The high incidence of severe to profound hearing loss highlights the importance of early diagnosis before the age of 6 months so that the more serious consequences of hearing loss can be avoided. This program is more difficult to conduct on newborns with moderate hearing loss. Though satisfactory joint committee on infant hearing (JCIH) indices and criteria for screening and intervention of hearing loss have not been fully achieved, they could be achieved through closer cooperation between the baby's parents, pediatricians, ear, nose and throat specialists (ENT), audiologists, and health centers.

6- CONFLICT OF INTEREST: None.

7- ACKNOWLEDGMENT

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