The Effect of Mode of Delivery and Hospital Type on Newborn Hearing Screening Results Using Otoacoustic Emissions: Based on Screening Age

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Abstract It is well known that false positive on newborn hearing screening increases cost and maternal anxiety and worry. We aimed to evaluate the influence of mode of delivery (cesarean, vaginal) and hospital type (private, public) on false positives first screening test based on screening age. Identification and control of these factors can reduce the rate of false positives. Overall, 2784 infants were evaluated by otoacoustic emissions test. Hearing screening test was performed before hospital discharge. Finally, rate of the false-positive between both delivery group and hospital types were compared on the basis of screening age. False-positive results are obtained when a condition is not present, but the test results indicate that it is present. False positive rate in the first screening test in vaginal delivery was significantly higher than cesarean delivery and rate of significantly decreased with screening age. This reduction was observed only in cesarean delivery. Also the rate of false positives in public hospital is 2.2 fold higher than private hospital ($P = 0.000$) and with increase in screening age, the rate of False positive is significantly reduced in private hospitals while this decrease is not observed in public hospital. Screening test be retarded as much as possible in cesarean group and private hospital and be conducted just prior to hospital discharge also in public hospital, screening test are done in a separate room.

In this way, false positive can be reduced by about six times and the cost and concerns imposed by the rate of false positives minimized.

Keywords Neonatal screening · Hearing · Otoacoustic emissions · False positive

Introduction

Hearing loss is among the most common birth abnormalities in infants. Since it is a hidden defect, its early diagnosis is difficult. According to the reports, in US nearly out of one thousand children, one child is born with severe or profound bilateral sensorineural hearing loss, which by including mild or moderate hearing loss this figure varies from 6 to 16 per thousand births [1]. In Iran, the prevalence of permanent hearing loss at birth has been reported about 3 per thousand births [2]. Hearing loss can have a deep and irreparable impact on speech and language development as well as social and emotional development of a child. Early detection provides the necessary ground for early intervention, rehabilitation, and compensation for language and communication impairment caused by hearing loss [3, 4].

Newborn hearing screening is a nationwide program to detect hearing loss in newborns. The goal of this program is to avoid delays in the detection of hearing loss and timely rehabilitation. In the programs, Otoacoustic Emissions test (OAE) is generally used since this test is reliable, fast, and inexpensive [5, 6]. One of the most important issues in hearing screening program is the rate of false positive (FP). FP refers to cases in which babies with normal hearing are submitted for further and additional evaluation in the coming weeks. To follow the issues concerned with these infants, additional time and costs are spent. In addition,

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mothers and families' concern about their newborn babies with hearing problems should be addressed at this time. On the other hand, false results and concerns of parents, particularly mothers, can have a negative impact on the relation between parents and the child. To reduce the negative effects, it is necessary to reduce FP results as much as possible [7, 8]. Mode of delivery, hospital type, and age of the newborn are of factors that influence the rate of FP of newborn hearing screening test. The research findings on the impact of delivery type on hearing screening results have been inconsistent. In most studies, in cesarean delivery (CD) higher FP rate has been reported due to higher volume of ear debris [9–11]. Some studies have reported more FP rate in vaginal delivery (VD) [12]. The main reason for this inconsistency may be related to the lack of review of the rate of FP at different times after birth in both delivery groups. Therefore, it is vital to isolate and categorize factors that may influence the success or failure of new-born audiological screening programs, such as mode of delivery and type of hospital (private or public).

The aim of this study is to evaluate the rate of FP results in OAE hearing screening test in CD compared to VD, and public hospital compared to private hospital at different times after birth. Therefore, the appropriate time to do the screening test is planned for both groups.

Materials and Methods

This study is a cross-sectional prospective cohort research. The sampling was done using census method. The population included all newborns of two hospitals Fatemiyeh and Bou-Ali in Hamadan from June 22nd, 2013 to September 22nd, 2013. The newborns were studied separately in two groups in the two hospitals. Babies were divided into two groups based on vaginal and cesarean delivery. A gynecologist determined the mode of delivery.

All boy and girl newborn who were hospitalized in women ward and had no problems at VD and CD at the initial examination determined by a pediatrician entered the study. Newborns admitted to the NICU for high bilirubin, congenital infections, low birth weight (<1500 g), bacterial meningitis, syndromes associated with hearing loss, low Apgar number and the ones with malformations in the ear canal were not included in the study. In total, 54 neonates were excluded from study.

Hearing tests in both hospitals were carried out using accuscreen system from Madsen Company. Every day before the test, the device was calibrated by 2 cc coupler. A two-step screening procedure recommended by State Welfare Organization of Iran has been implemented in our study as a cost-effective and accurate approach. The first step was performed in the hospital before discharge on day

1 or day 2. All infants were first tested for transient evoked otoacoustic emissions (TEOAEs). This includes the faster and less expensive OAE as the first test in newborns with no risk factors. Infants who failed first OAE (OAE1), were repeated OAE within 1–2 weeks later (OAE2). If failure persisted, AABR was performed. The rate of FP calculated by number of FP test results (OAE1 refer—OAE2 pass) was divided by the total number of tested. FP results are obtained when a condition is not present, but the test results indicate that it is present.

The OAE test in Bou-Ali and Fatemiyeh Hospitals was done every day except Fridays by an audiologist. Click stimulus was offered at the intensity of 80 dB SPL with rate of 50 per second.

The time required for the test is about 1–3 min. The newborn should be quiet (preferably in sleep or while breastfeeding) and the ambient noise should be in the least amount possible. Passing or referring in TEOAE test is done automatically based on the stability of 80 %. Responses with stability of more than 80 % were considered “passed” and with stability of less than 80 % were as “referred” [13].

In this study, the frequency and Chi square tests (χ^2) were used for statistical analysis. A *P* value of 0.05 was considered statistically significant. Ethical approval was obtained from Research and Ethics Committee, Hamadan University of medical sciences.

Results

During this study, 2838 newborns were born at the two mentioned hospitals, of which 2784 had OAE1 test performed after applying the exclusion criteria. Of the 340 (12.2 %) infants who failed OAE1, 332 were passed and 8 referred to OAE2 screen. The 8 infants were tested by AABR, and two were subsequently confirmed to have hearing loss.

Analyses of factors affecting FP OAE Neonatal Hearing Screening is shown in Table 1.

The rate of FP in VD (15.5 %) is 1.5 fold higher than CD (9.5 %); and in public hospital (14 %) it is 2.2 fold higher than private hospital (6.3 %).

In addition, the newborns were divided based on age into four groups at OAE1. When the four groups were simultaneously compared in terms of means of the Chi square test, we concluded that there is evidence of differences between them (*P* value <0.001).

As seen in Table 2, significant differences between age groups were found in CD when the groups were compared, but this difference was not observed in VD (*P* = 0.194). Difference between the age groups was significant in private hospital whereas, in the public hospital, there was no significant difference between the groups (*P* = 0.156).

Table 1 Analyses of factors potentially affecting false positive neonatal hearing screening

	False positive/ total (n)	Rate of false positive (%)	<i>P</i> (X ²)
Total	338/2782	12.1	
Mode of delivery			
VD	181/1149	15.7	0.000
CD	157/1633	9.6	
Hospital type			
Private	44/695	6.3	0.000
Public	294/2087	14	
Sex			
Male	175/1403	12.5	0.598
Female	163/1379	11.8	
Screening age			
3–9 (group 1)	110/694	15.9	0.000
10–16 (group 2)	88/698	12.6	
17–22 (group 3)	121/1077	11.2	
23–32 (group 4)	19/313	6.1	

Table 2 The rate of false positive based on screening age in OAE1

	3–9 (%)	10–16 (%)	17–22 (%)	23–32 (%)	<i>P</i> (X ²)
Mode of delivery					
CD	15.2	12.8	8.4	2.5	0.000
VD	16.2	12.4	18.3	17.6	0.194
Hospital type					
Public	15.7	13.1	14.6	9.5	0.156
Private	17.3	10.4	5.3	0.8	0.000

Fig. 1 Percentage of false positive (FP) OAE test by postnatal age at first OAE (hours): comparison of birth by VD versus CD

Figure 1 compares FP rates on first OAE test by postnatal age of VD versus CD-delivered infants. Infants born by VD had significantly higher rates of OAE failure on the

first test at age groups 3 and 4 ($P < 0.001$); however, there was no difference between the modes of delivery for an FP rate in the age groups 1 and 2.

Also infants born in public hospital had significantly higher rates of FP at age groups 3 and 4 ($P < 0.001$); however, there was no difference between both hospitals for an FP rates in the age groups 1 and 2 (Fig. 2).

As mentioned earlier, the OAE2 was performed 2 weeks after birth. At this stage, mode of delivery and the hospital type do not have a significant effect on the rate of FP (Table 3).

Discussion

A hearing screening program is a safe and effective method to detect early hearing loss in newborns. On the other hand, some of the newborns fail in the first screening test and the majority of them are FPs. These FP results can increase anxiety and family expenses. Identifying affective factors on the results of FP and trying to control these factors can play an important role in reducing the costs and aberrant stress of families [7].

In comparing the two delivery groups in this study, the rate of FPs in the first screening test in the VD group was significantly higher than cesarean delivery, which is in accordance with the studies of Farhadi et al. [14] and Olusanya [12], but the results were different from that of Smolkin et al. [9] that reported the failure of the first OAE of infants born by CD as 3.2 times more than the VD.

The low movement of tympanic and delay in absorption of fluid from the middle ear membrane in babies with VD in the first few days can cause a high rate of FP in this group [15]. So, in general, delivery type is an effective factor in the FP first hearing screening test. As shown in Table 1, by increasing the age of screening, the rate of FPs is significantly reduced which is consistent with studies of Torrico et al. [16], and Lupoli et al. [17], but this reduction was not found in Melo et al. [18]. In Melo's study, screening test was done on infants at least 24 h after birth; while in the present study, the major part of the infants were tested in the first 24 h after birth. Since, as the time of screening is delayed, the rate of FPs is reduced therefore no difference in Melo's study can be explained.

But the most important results of this study are related to Table 2 that in CD, by increasing the age of screening the rate of FP decreases; but in VD this decline cannot be seen. According to Fig. 1, the difference in FP rate in VD and CD can be seen at age groups of 3 and 4. This means that the screening test in the early hours after birth causes high rates of FP cases in both CD and VD; but as the screening before hospital discharge is delayed, the rate of FP in CD is reduced. However, this reduction was not observed with

Fig. 2 Percentage of false positive (FP) OAE1 test by postnatal age at first OAE (hours): comparison of public versus private hospital

Table 3 Analyses of factors affecting FP in OAE2 neonatal hearing screening

	False positive/ total (n)	Rate of false positive (%)	P
Mode of delivery			
CD	2/158	1.3	0.85
VD	4/182	2.2	
Hospital type			
Public	6/296	2.0	0.251
Private	0/44	0	

increasing age screening in VD. Studies show that the most important cause of FP cases in the early hours after birth is debris and fluid in the middle ear and external canal. On this basis, it appears that absorption of debris in newborns of CD occurs before VD. On the other hand, in Table 3 it can be seen that the rate of FP 2 weeks after birth has sharply fallen and there is no significant difference between VD and CD. This means that the debris absorption of the ear in both groups has happened after 2 weeks.

In private hospitals, the FP rate is less than public hospitals. This May be due to the location of the test. In private hospital tests are done in a separate and silent room, while in the public hospital tests are performed in women ward. With increase in screening age, the rate of FP is significantly reduced in private hospitals while this decrease is not observed in public hospital. Thus, delays in testing in private hospitals can reduce the amount of FP.

In Iran's Welfare Organization Protocol it is emphasized that the time for screening should be before discharge from the hospital, but there are no regulations about test timing. By carrying out such studies, some protocols about screening time can be offered to this organization. The results of this study shows that to reduce the cost of re-screening test as well as the stress caused by the referred test, at least in cesarean delivery, the newborn screening is delayed until discharge from hospital, so that FP is reduced

about six times. Also, as the existence of verneix in ear canal and middle ear is the most important factor in FP screening test, cleaning the ear canal and carrying out facilitating maneuvers in ear canal to a minimize the effect of this verneix, can minimize the rate of FPs [15, 19].

Alternately, it is suggested that in public hospital TEOAEs test are done in a separate room and be delayed until discharge from hospital.

The realization of the above suggestions can reduce the FP rate in the first screening test, thus reduces the costs and stress for families.

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Compliance with Ethical Standards

Conflict of interest Farhad Farahani, Morteza Hamidi Nahrani, Mohammad Ali Seifrabiei, Maryam Emadi declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual parents participants included in the study.

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