International Journal of Pediatric Otorhinolaryngology 111 (2018) 111–114

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

# Improving universal newborn hearing screening outcomes by conducting it with thyroid screening

Vida Rahimi[a,*], Ghassem Mohammadkhani[a], Farzaneh Javadi[b]

[a] Department of Audiology, School of Rehabilitation, Tehran University of Medical Science, Tehran, Iran
[b] Department of Prevention of Disease, Welfare Organization of Tehran, Tehran, Iran

ARTICLE INFO

*Keywords:*
Newborn hearing screening
Thyroid screening
Otoacoustic emission
Referral rate

ABSTRACT

*Objectives:* One of the most important factors that can improve hearing screening indicators is testing infants after 48 h of birth. The neonatal thyroid screening program is done during the third to fifth day after birth in many countries. So this screening is done at the appropriate time for hearing screening. The aim of the present study was to evaluate hearing screening outcomes (the referral rate, false positive rate, and positive predictive value) conducted with the thyroid screening at the healthcare centers and compare the results with hospital before discharge the infant.

*Methods:* This was a prospective exploratory cohort study. The study population included all the newborns at a hospital (group 1) and newborns who were referred to healthcare centers for thyroid screening (group 2), except for infants with risk factors, from March 2012 to December 2017. Transient evoked otoacoustic emissions (TEOAE) and automatic auditory brainstem response (AABR) were used for the evaluation. The results were compared between the two groups.

*Results:* Of the 4729 newborns, who participated in the study, 3001 were referred from a hospital (group 1) and 1728 from two healthcare centers (group 2). The referral rate in group 1 and 2 was 16.1% and 7.6%, respectively. Also, the false positive rate in group 1 and 2 was 15.9% and 7.6%, respectively. Our study showed that the referral rate and false positive rate of hearing screening in group 2 were significantly lower than that in group 1 ($p < 0.001$). The positive predictive value in group 1 was significantly higher than that in group 2 ($p < 0.05$). There was no significant sex difference in any of the variables.

*Conclusions:* Our results showed that performing the hearing screening during the thyroid program, instead of the hospital could be significantly improved screening outcomes and suggest that hearing and thyroid screening together after discharge from the hospital could be a good opportunity to introduce new framework for hearing screening in many countries.

## 1. Introduction

Permanent hearing loss is one of the most common congenital abnormalities. The incidence of neonatal hearing loss in the United States is nearly 1 infant from every 1000 births [1]. Since permanent and even temporary hearing loss can lead to delays in expressive and receptive language, cognitive, emotional, and social development in the early years, an early hearing impairment detection and intervention can be effective in avoiding the serious consequences [2]. The best way for early detection of hearing impairment is universal newborn hearing screening (UNHS). Recently, more than 90 percent of newborns were screened for hearing in America [3]. In developing countries, the hearing screening rate is growing in the hospitals but much less in the healthcare centers [4]. Currently, otoacoustic emission (OAE) tests and/or automated auditory brainstem response (AABR) tests are employed as screening tools in the newborn hearing screening programs. The most common method used in this program during the first screening is transient evoked otoacoustic emissions screening (TEOAE) [3,4].

One of the most important outcomes in hearing screening program is referral rate, especially false positive rate [4,5]. Studies have shown that false positives occur due to external ear canal involvement, such as due to collapse and debris, and middle ear involvement, such as due to the presence of amniotic fluid and mesenchyme [5,6]. Also, high ambient noise levels can be a factor responsible [7].

Generally, false referrals lead to a repeat test in the subsequent weeks [8]. This leads to wasted time and extra cost to the parents which, in some cases, results in the newborn not being brought back for

* Corresponding author. Department of Audiology, School of Rehabilitation, Tehran University of Medical Sciences, Piche-Shemiran, Enghelab Ave., Tehran, 1148965141, Iran.
*E-mail address:* v-rahimi@razi.tums.ac.ir (V. Rahimi).

https://doi.org/10.1016/j.ijporl.2018.06.002
Received 4 May 2018; Received in revised form 1 June 2018; Accepted 2 June 2018
Available online 05 June 2018
0165-5876/ 

the repeat test. This also leads to parental anxiety [9]. One of the challenges that UNHS faces is reducing the referral rate by using a quick and inexpensive method of newborn hearing screening. Some of these problems are due to the UNHS program recommendations that the first test should be done before discharge from the hospital. It means that the TEOAE or AABR test should be done within 48 h after birth [5].

According to some studies, newborn hearing screening within 24 h after birth has much higher referral rate and false positive rate [10]. In fact, the ideal time for hearing screening is 24 h after birth, and according to some studies, after 48 h [4,5,and8]]. However, most of the babies are discharged within 24–48 h after birth. The factors mentioned above increase false referrals and can cause inconvenience. It also creates incertitude regarding the screening process because of the referral of most neonates [5]. In this regard, researchers believe that one of the best strategies to reduce the occurrence of false positives is performing the newborn hearing screening at an older age, but the problem is often of follow-up that causes it to be impractical [5,11]. Akinpelu et al. (2014) [5] suggest that combining UNHS screening with other routine newborn health-facility visits after discharge from the hospital might alleviate this problem [5]. In this regard Welch and et al. (2015) did hearing screening with vaccination in 4–8 week on 60 infants in health care centers and showed positive hearing screening results with vaccination [12]. However, hearing screening for 4–8 weeks may delay the timely diagnosis of hearing loss in children. Another infant health services is thyroid screening. Since 1972 neonatal thyroid screening program solved the problem of congenital hypothyroidism in developed countries. Almost all industrialized countries in the world are doing systemic neonatal hypothyroid screening. Also, today this program is running in many developing countries [13,14]. In many countries neonatal thyroid screening is an epidemiological plan, and infants should be screened in the healthcare centers or hospital. In Iran, since 2005, thyroid screening has been carried out extensively as a national plot with screening rate 92–100% in some studies (15). Best time for thyroid screening is 3–5 days after birth. This is the closest screening after birth and provides a good opportunity for evaluation of the newborns that are referred to the healthcare centers after 72 h. According to studies this time (3–5 days) is appropriate time for hearing screening [5]. Thus, the aim of this study was to estimate the referral rate, false positive rate, and positive predictive value as outcomes of hearing screening combined with thyroid screening in healthcare centers and compare with the outcomes of the hearing screening plan in the hospital before the discharge of the infant.

## 2. Material and methods

This was a prospective exploratory cohort study. The study population included all the newborns at Besat hospital, and babies who came to Safa and Kolahdooz healthcare centers for thyroid screening in Tehran from March 2012 to December 2017. All the newborns in this hospital and the healthcare centers were studied in two separate groups. In the hospital, all the newborns were enrolled into the study before discharge (within 48 h after birth), and in the healthcare centers, all the children admitted for thyroid screening in the age range of 72 h to 5 days were included. Newborns with high-risk factors consisting of a history of admission to NICU for more than 48 h, congenital infections, high bilirubin level, low Apgar score, low birth weight ($< 1500$ g), bacterial meningitis, syndromes associated with hearing loss, and malformations in the ear canal were not included in the study. These risk group was not included since, the hearing screening should have been performed only on the day of hospital discharge and in these cases, and it is very variable. The screening tests in the hospital and healthcare centers were conducted by experienced audiologists in the pediatric field. The hearing tests in both places were performed using ECHOLAB system (Labat Company, Italy). This system allowed us to see the signal-to-noise ratio separately at frequencies from 1 to 5 kHz. In order to prevent the effect of external noise on the results, the tests were performed in silent rooms which were devoted to hearing screening in Besat hospital and the two healthcare centers. In our study, a two-step screening procedure was used. In the hospital, the first step was performed before discharge (after 24 h but before 48 h of birth). This step was carried out within 72 h to 5 days at the same time as the thyroid screening test was done in the healthcare centers. First, all the infants were tested for TEOAEs. If the infants failed in the first OAE (OAE1), it was repeated within 2 weeks (OAE2). In case the infant failed in OAE2, the AABR test was carried out, and finally, a diagnostic ABR was performed. The referral rate, false positive rate, and positive predictive value were calculated by the following formulas [5]:

Referral rate (RR) = NF-OAE/NTotal

False positive rate (FP rate) = NF-OAE - NF-ABR/NTotal

Positive predictive value (PPV) = NF-ABR/NF-OAE

NF-OAE is the number of infants who failed the OAE screening tests for the first time. False positive results occur when the test indicates a hearing loss whereas the person's hearing is actually normal. NF-ABR is the number of infants who failed the diagnostic ABR test. TEOAE test with click stimulation was carried out at an intensity of 80 dB SPL. For each test, the system probe was calibrated. The neonates were either in a state of sleep or calm in the mother's arms at the time of the test. The pass criteria in this research was a signal-to-noise ratio $\geq 6$ dB during at least three frequencies (2–5 kHz) with reproducibility $\geq 70\%$ (5).

In this study, the categorical variables have been expressed as number (percentage). Chi-square test and Fisher's exact test were used to compare the data from the hospital and healthcare centers. Data analysis was done using IBM SPSS Statistics for Windows, Version 22.0 (IBM Crop., Armonk, NY, USA). All the statistical tests were two-tailed, and a P-value less than 0.05 was considered statistically significant. Ethical approval was obtained from the ethics committee of Tehran University of Medical Sciences (number 9321).

## 3. Results

During this study period, 5207 newborns were born in the hospital and referred to the healthcare centers. Of these, 4729 newborns were enrolled into the study, and the remaining infants who had a risk factor or did not attend the next stage of testing were excluded. Of the 478 newborns who were excluded, only 57 infants (45 infants belonged to the hospital and 11 infants to the healthcare centers) did not attend at a later stage according to the prescribed protocol. Because we tried to reduce this amount by performing a free evaluation and follow up at a later stage. Among the 4729 newborns, 3001 belonged to hospital and 1728 to the two healthcare centers. Of the total, 618 infants failed in OAE1 (RR = 13%); 605 infants passed in OAE 2, and 13 were tested by AABR and diagnostic ABR to confirm the hearing loss (FP rate = 12%, PPV = 0.02). The result of the variables studied in the two groups with an emphasis on the age of screening is shown in Table 1.

As seen in Table 1, the referral rate in the hospital was 16.1%. This means that 16.1% of the newborns in the hospital failed at the first screening stage (OAE1) whereas this rate was only 7.6% in neonates referred to the healthcare centers. The results showed that the hearing screening in healthcare centers in combination with the thyroid screening program had a significantly lower rate of referral than for that in the hospital ($p < 0.001$). Also, 15.9% of the infants in the hospital, who had normal hearing, failed in the OAE test (false positive rate), and this rate was 7.4% in the healthcare centers. The results indicate a significant decrease in the false positive rate of neonates in the healthcare centers ($p < 0.001$). The positive predictive value in this research was the probability that the subjects with a positive screening test (failed in OAE) truly have hearing loss. This value in infants who came to the healthcare centers was significantly higher than those who came to the hospital ($p < 0.05$). There was no significant difference