INTRODUCTION

Infant hearing loss stands out as the most common congenital sensory disorder. Its late detection compromises speech, language and cognitive skills essential for optimal early childhood development. Auditory cortex and neural connections develop with acoustic stimuli [1]. Globally, over 665,000 babies are born annually with significant hearing loss and this estimate increases with age, almost doubling by age of nine years [2].

Universal newborn hearing screening is being promoted as an early detection strategy for hearing loss. Since optimal intervention for communication disorders is time-bound in early childhood, infants with hearing loss cannot afford to wait. The technology and expertise has developed to allow screening to detect hearing loss in newborn babies. Early intervention for permanent childhood hearing impairment has shown to reduce the deleterious effects of impaired audition on language and cognitive and social skills of affected children [3].

For effective treatment, congenital or perinatal hearing loss should be recognized within three months of birth, with formal diagnosis and initiation of early intervention beginning before the 6th month of age [4].

The first level of hearing screening takes place during the first 2-3 days of life, using the otoacoustic emission (OAE) test; all newborns are also analyzed for audiological risk factors. OAEs are believed to reflect the active biomechanical movement of
the basilar membrane of the cochlea [5]. Infants who don’t pass
the screening test and infants with high risk factors for hearing
loss are referred to the second level where infants meet the audi-
tory brainstem response (ABR) testing. The third level is advanced
audiological centers, which are responsible for ultimate treatment
and rehabilitation for children with hearing loss or deafness. This
program provides a chance for early diagnosis and proper treat-
ment of hearing impairment.

Joint Committee on Infant Hearing (JCIH) published the risk
factors of hearing loss in neonates and gave resolution and stan-
dards for universal detection of hearing loss. Under ideal condi-
tions, instruments designed specifically for newborns can test
and record findings on sleeping newborns in <5 minutes [6].

One purpose of this investigation was to document the fre-
cuency of risk factors and the other purpose was, to imply their
influence on the transient evoked OAE (TEOAE) of infants.

**MATERIAL AND METHODS**

The study was conducted at the Department of Otolaryngology-
Head and Neck Surgery in Haydarpaşa Numune Education and
Research Hospital.

The screening was carried out by audiologists with the neonate
lying on and sleeping. Distortion product OAEs (DPOAEs) were
detected with the following preset test protocols; our paradigms
were DP-gram, because we tested the ears at different frequen-
cies (frequencies tested, 4; frequency range, 2,000 to 5,000 Hz;
averaging time, 4 seconds per frequency; passing frequencies for
overall test pass, 3).

A probe was inserted into the external auditory canal. The
loud-speaker generates the acoustic stimuli, while the micro-
phone measures the resulting OAE that is produced within the
cochlea and then transmitted back through the middle ear into
the external auditory canal. The ears were screened separately.
Pass means, ear tested passed the test, refer means ear tested
failed the test. When a neonate has a test result as “refer,” the
test in this case was repeated a few minutes later and a neonate
with persistent “refer” was taken as an indication for further
testing. The test repeated within a week. Those failing the repeat-
screening with DPOAE (Natus Bio-logic AuDX Pro, Natus,
San Carlos, CA, USA) and data was subjected to descriptive statisti-
cal measures. Chi-square test, exact test of Fisher test were used,
following usual conditions of application. Kolmogorov Simirnov
test was used to analyze the distribution of data.

**RESULTS**

Between 2009 and 2012, 2,284 infants were admitted to our
clinic, of which all of them screened with distortion evoked OAE
(DEOAE). There were 1,220 males and 1,064 females. Total of
4,568 ears were examined during the period of the study. Of the
4,568 ears screened for the presence of OAEs, 519 (11.3%) did
not have emissions. A total of 157 neonates (6.8%) failed the
screening test in both ears while 205 (8.9%) failed the screening
test in only one ear. Of those failing the test, 207 of them were
males while 155 were females (Table 1).

There was no statistically significant difference in sex distur-
bance, birth weight, familial hearing loss, hyperbilirubinemia,
those hospitalised in the intensive care unit between OAEs passed
neonates and did not (P>0.05).

The risk factors that are statistically significant were vaginal
birth, maternal infections during pregnancy, intermarriage of par-
ents and low birth weight.

**Table 1. The distribution and prevalence of risk factors in the studied
population**

| Variable                        | OAE pass | OAE refer | P-value |
|--------------------------------|----------|-----------|---------|
| Sex                            |          |           |         |
| Female                         | 909 (85.4)| 155 (14.6)| 0.117   |
| Male                           | 1,013 (83.0)| 207 (17.0)|         |
| Birth type                     |          |           |         |
| Vaginal birth                  | 998 (82.5)| 211 (17.5)| 0.027   |
| Cesarean section               | 922 (85.9)| 153 (14.1)|         |
| Birth weight                   | 3,228±893| 3,121±668 | 0.103   |
| Maternal infection             |          |           |         |
| +                              | 9 (60.0) | 6 (40.0)  | 0.010   |
| −                              | 1,913 (84.3)| 356 (15.7)|         |
| Familial hearing loss          |          |           |         |
| +                              | 93 (83.8)| 18 (16.2) | 0.914   |
| −                              | 1,829 (84.2)| 344 (15.8)|         |
| Parents being relative         |          |           |         |
| +                              | 308 (80.2)| 76 (19.8) | 0.020   |
| −                              | 1,614 (84.9)| 286 (15.1)|         |
| Low birth weight               |          |           |         |
| +                              | 36 (73.5)| 13 (26.5) | 0.038   |
| −                              | 1,886 (84.4)| 349 (15.6)|         |
| Hyperbilirubinemia             |          |           |         |
| +                              | 258 (88.1)| 35 (11.9) | 0.050   |
| −                              | 1,664 (83.6)| 327 (16.4)|         |
| Intensive care                 |          |           | 0.861   |
| +                              | 390 (84.4)| 72 (15.6) |         |
| −                              | 1,532 (84.1)| 290 (15.9)|         |

OAE, otoacoustic emission.
As the delivery type compared, the occurrence of refer in infants with vaginal birth (17.5%) are more than caesarean section (14.1%, \( P=0.027<0.05 \)).

Also parents being relative infants (40.0%), infant having maternal infectious disease (40.0%, both \( P=0.010<0.05 \) and low birth weight infants (26.5%, \( P=0.038<0.05 \)) were risk factors which were significantly related to “refer” result of DEOE.

**DISCUSSION**

One newborn every 500–1,000 births presents hearing impairment, which are greater incidence than the other incidence of diseases seen at birth [1]. In some populations incidence could be greater depending on different factors.

Hearing screening on infants has been performed in many developed and developing countries for early detection of hearing loss. The primary goal of this screening programme is early detection and the JCIH screening recommends that all infants with risk indicators should undergo periodic monitoring for three years. The 2007 statement expands screening protocols for newborn intensive care unit infants and provides additional guidance for the diagnostic audiology evaluation, medical evaluation, early intervention, surveillance, communication and tracking [7].

As has been observed in the literature, first-stage screening is with OAE is and requires those who pass to be exited from the program, whereas those who fail possibly after few repeat tests are scheduled for automated auditory brainstem response (AABR) screening [8].

In a study, syndromes associated with hearing loss and mechanical ventilation for more than 5 days were statistically significant risk factors in the occurrence of hearing loss. They added that most common risk factors are ototoxic medications, premature birth, low birth weight, intensive care in excess of 7 days. They concluded that as the number of risk factors an infant is exposed, the probability of hearing impairment increases [4].

They found that mechanical ventilation and intensive care was associated with hearing loss but in our study there was no statistically significant difference between infants hospitalized in intensive care unit and infants who didn’t (\( P>0.05 \)). According to literature [9], the application of mechanical ventilation could significantly damage the peripheral segment of the hearing tract. Also reported that days under mechanical ventilation and length of hospital stay were significantly increased in the group of children with sensorineural hearing loss (SNHL) [10].

In a report a risk factor hyperbilirubinemia which was found on only two occasions and was not taken into account for statistical analyses [2]. We had 293 infants requiring phototherapy for hyperbilirubinemia. But we found no correlation between hyperbilirubinemia and hearing loss.

Coenraad et al. [11] concluded a report that low APGAR scores (at 1 minute), sepsis, meningitis, cerebral bleeding and cerebral infarction are risk factors for SNHL.

Risk factor registers are used to select which babies are target-ed for follow-up examinations, but such a system has fundamental problems with deciding on inclusion criteria, the under-reporting of risk factors, under-utilisation by babies enrolled, and the high cost of pediatric audiology. Risk factors are only as useful as their predictive power. Many children have ototoxic medications while in neonatal intensive care, or have a family history of hearing loss, but very few of these develop a problem [12].

Hearing losses may be caused by adverse environmental conditions surrounding the pregnancy or birth, or by certain hereditary conditions, both of which may have delayed audiological symptom expression. Not enough is known about which risk factors are relevant, which babies have the risk factors, or which babies will fail to attend follow-up, the effectiveness of targeted hearing loss testing is questionable at this point in time. A system needs to be developed to clarify which risk factors are discoverable, predictive and useful.

Maris et al. [13] performed a retrospective analysis on the prevalence of auditory neuropathy/dyssynchrony in a population of infants referred after failed a neonatal hearing screening. This is a neuropathy of the cochlear nerve in combination with a general peripheral neuropathy. Normal TEOAE in combination with an absent or severely abnormal ABR are crucial for diagnosis [13]. Because of this they concluded that ABR must be the method of choice for neonatal hearing screening.

The effect of intermarriage of parents on neonatal hearing screening didn’t study before. When this risk factor analyzed, there was a statistically significant difference between neonatas’ parents being relative (40.0%) and those weren’t (15.7%, \( P=0.010<0.05 \)).

The risk factors mentioned in this study are for the congenital hearing loss babies and in these babies the patients with auditory neuropathy could be included. While evaluating these babies this must be kept in the mind.

Postnatal hearing loss is a looming challenge faced by early intervention programmes. Universal neonatal hearing screening programmes use registers to enrol at-risk infants into follow-up tests. This wealth of knowledge would help evaluate the current practice and determine the need for improved or additional screening and diagnostic procedures.

Limitation of this study was the absence of the automated ABR, necessary for confirmation and identification of hearing loss after the OAE screening.

In conclusions, the risk factors that are statistically significant in our study were vaginal birth, maternal infections during pregnancy, intermarriage of parents and low birth weight. There was no statistically significant difference in sex disturbance, birth weight, familial hearing loss, hyperbilirubinemia, those hospitalised in the intensive care unit between OAEs passed neonates and did not.

Little is understood about the numbers and characteristics of
babies who go on to have significant hearing losses and couldn’t pass a newborn hearing screen. The data from universal neonatal hearing screening programmes would be useful for developing evidence-based practice and policy regarding children with significant post-natal hearing losses. The goal of early hearing detection and intervention is to maximize linguistic competence and literacy development for children who are hard of hearing.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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