ORIGINAL ARTICLE

Does an early discharge of a newborn influence the success of the newborn hearing screening in developing countries? A hospital based study

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ABSTRACT

Aim To investigate outcomes of newborn hearing screening (NHS) with transient evoked otoacoustic emissions (TEOAE) depending on the time from the birth to hearing screening.

Methods A prospective study was performed in the Cantonal Hospital Zenica, Bosnia and Herzegovina. The NHS with TEOAE was done before hospital discharge for all infants. The total of 1217 newborns were tested during a six-month period, from 1st February to 31st July 2016. The data of 1167 were available for analysis. Those data were divided in four groups depending on the time passed from the birth to hearing screening: Group A (n = 133 newborns, NHS performed in the first 24 hours after birth); group B (n = 294 newborns, NHS performed between 24-36h after birth); group C (n = 184 newborns, NHS performed between 36-48h after birth) and group D (n= 556 newborns, NHS performed later than 48h after birth).

Results Total referral rate was 19.1% (n = 223): for group A 30.1% (n=40), for group B 25.2% (n=74), for group C 19.0% (n=35) and for group D 13.3% (n=74). There was statistically significant difference between groups A and C (p=0.03), between groups A and D (p<0.001) and between groups B and D (p<0.001) in total and in well baby nursery (WBN).

Conclusion The total referral rates in NHS were high because of early post birth discharge of newborns. The NHS should be performed in infants older than 36 hours according to the results in this study.

Key words: developing countries, hearing loss, neonatal screening, otoacoustic emissions

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INTRODUCTION

The first European Consensus Development Conference on Neonatal Hearing Screening in 1998 and Joint Committee in Infant Hearing have recommended a hearing screening of all babies prior to the first month of age (1,2). Many countries perform their national newborn hearing screening (NHS) programs seriously (3-5). The incidence of bilateral congenital and early-onset hearing loss varies from 1 to 3 per 1000 live births based on studies from various countries (6-9). It is very important to verify if the child has hearing loss in early childhood. If the hearing loss is detected early, rehabilitation process will be started on time giving the child better chance for proper speech and language development, which is of great importance for academic achievement (10). It is recommended to perform NHS before hospital discharge whenever possible to reduce the subsequent need for outpatient follow-up (11). The problem of early discharge of newborns from birth centres is well known in developing countries (12) like in Bosnia and Herzegovina. It has been estimated that up to 90% of newborns with hearing loss live in developing countries (13). It has been suggested that the best time for NHS is later than 24 hours after birth in order to decrease the influence of transient outer and middle-ear conditions on outcomes of the NHS. The collapse of the ear canal, presence of amniotic fluid and mesenchyme in outer or middle ear, which is common in newborns, could affect outcomes of the NHS (14,15). Screening with an otoacoustic emission (OAE) technique results in 20% referral rates when done within the first 24h post birth, but when the screening is performed later than 24h after birth, referral rates drop to 3% (11,16,17).

The aim of this study was to analyse the influence of early hospital discharge of newborns on an outcome of the first hearing test in NHS in the Cantonal Hospital Zenica.

PATIENTS AND METHODS

Patients and study design

On average 3000 newborns are born in the Cantonal Hospital Zenica (CHZ) Bosnia and Herzegovina every year. Up to 10 newborns are born every day. All infants placed at well-baby nursery (WBN) in CHZ are usually discharged the next day after birth, except those delivered with Caesarean section. Infants placed on neonatal intensive care unit (NICU) are discharged when their health condition improves.

A prospective study was performed during the period of six months (1st February - 31st July, 2016) in the Department of Ear, Nose and Throat (ENT) at CHZ.

Hearing screening of neonates was performed before discharge from the hospital. All mothers were informed about the procedure by the examiner. Parental permission was obtained before performing NHS. Only one mother did not allow hearing screening of her baby. Newborns were screened in well-baby nursery (WBN) and in Newborn Intensive Care Unit (NICU) as well. Hearing screening was performed by experienced staff of physicians and medical technicians from ENT Department.

Institutional approval of the Ethics Committee was obtained before the beginning of the study.

Methods

Transient evoked otoacoustic emissions (TEOAE) was the diagnostic method for NHS used in this study. The probe of this handheld device with rubber tip, which is equipped with a small speaker and a microphone, was placed in the external ear canal of the newborn. A click sound was emitted from the speaker. That sound, characteristic for TEOAE test, causes movements of the basilar membrane in cochlea. Because of that, sound outer hearing cells generate new sound (OAE). This OAE was recorded in the external auditory channel with a microphone placed in the probe. A brand new Interacoustics device "Titan" (Interacoustics A/S, Denmark) was used for screening of all infants. The device used an in-ear calibration before the screening commenced. The nonlinear click stimulus was used with intensity set at 83 dB peak equivalent SPL for maximum time of 120 seconds and minimal 80 sweeps. Acceptable noise level was 55dB SPL. Screening protocol was set up on five frequency bands cantered on 1, 1.5, 2, 3 and 4 kHz. The screening techniques provided a pass or refer result without the need for a subjective data analysis. An automated pass criterion of three bands was utilized based on TEOAE signal to noise ratio of minimal 8 dB for frequency band cantered on 1 kHz and 6 dB for other four frequency bands. A reproducibility value of minimal 30% was required for the band response to be considered as pass. If OAEs are registered in

the ear the result "pass" appears on display of the device and the test result that appears on display is "refer" if OAEs are not registered in the ear.

Time passed from birth to screening was recorded, as well as the results of the screening for each ear. Depending on time passed from the birth to screening the results of the first hearing test were divided in four groups. In the group A the first hearing test of NHS was performed in the first 24h after birth, group B contained the results of the first hearing test of NHS performed between 24-36h after birth, in the group C were results of the first hearing test of NHS that was performed between 36- 48h after birth and in group D the first hearing test was performed later than 48h after birth. The results were compared and analysed in the total sample, but also separately for the newborns that were placed on WBN and on NICU.

Statistical analysis

All data was recorded at Interacoustics software Ottoacces and subsequently captured on an MS Excel database. Descriptive statistics provided the frequency distribution and measures of standard deviation. Chi-square test was used to investigate correlation between the four groups (A, B, C and D). The significance level for all statistical tests was set at the $p < 0.05$.

RESULTS

The total number of 1217 infants was screened. There were 642 (52.8%) male and 573 (47.1%) female newborns. Gender data were missed for two (0.2%) infants. Data of the screening time was missed to be verified for 50 (4.1%) infants.

In well-baby nursery (WBN) 930 of 1217 newborns (76.4%) were placed, of which 481 (51.7%) male and 448 (48.2%) female newborns. For one (0.1%) newborn gender data was missing. Data of the screening time were missing for 46 (4.9%) infants in this group.

A total of 287 (23.6%) newborns were placed in the NICU, 161 (56.1%) male and 125 (43.6%) female newborns. For one (0.3%) infant gender data were missing. Data of the screening time were missing for four (1.4%) infants. In total the data of 1167 infants were available for analysis, 884 of the infants were placed in WBN and 283 were placed in the NICU. More than half of the infants were screened in first 48h after birth, in the total sample (52.4%) and in WBN (63.1%). In the NICU 81.3% of the infants were screened after 48h after the birth. The results of the first hearing test were similar in the total sample and in WBN with the lowest refer rate in group D (total sample 13.3% and WBN 8.3%) and the highest refer rate in group A (total sample 30.1% and WBN 29%). In the NICU lowest refer rate was noted in group B (18.8%) and highest refer rate in group A (44.4%) (Table 1).

Table 1. Distribution of neonates according to groups and results of the first hearing test

Groups	Time for NHS	No (%) of infants	Pass (%)	Refer (%)
Overall				
Group A	< 24h	133 (11.4)	93 (69.9)	40 (30.1)
Group B	24-36h	294 (25.2)	220 (74.8)	74 (25.2)
Group C	36-48h	184 (15.8)	149 (81)	35 (19)
Group D	>48h	556 (47.6)	482 (86.7)	74 (13.3)
Total		**1167 (100)**	**944 (80.9)**	**223 (19.1)**
WBN				
Group A	< 24h	124 (14)	88 (71)	36 (29)
Group B	24-36h	278 (31.5)	207 (74.5)	71 (25.5)
Group C	36-48h	156 (17.6)	128 (82.1)	28 (17.9)
Group D	>48h	326 (36.9)	299 (91.7)	27 (8.3)
Total		**884 (100)**	**722 (81.7)**	**162 (18.3)**
NICU				
Group A	< 24h	9 (3.2)	5 (55.6)	4 (44.4)
Group B	24-36h	16 (5.6)	13 (81.2)	3 (18.8)
Group C	36-48h	28 (9.9)	21 (75)	7 (25)
Group D	>48h	230 (81.3)	183 (79.6)	47 (20.4)
Total		**283 (100)**	**222 (78.4)**	**61 (21.6)**

NICU, Neonatal Intensive Care Unit; WBN, Well Baby Nursery;

For all study groups, the total refer rate was 19.1% (223/1217 infants). The frequency of "refer" results of the first test showed statistically significant difference between group A (30.2%) and group D (13.3%) ($p<0.001$), group A (30.2%) and group C (19%) ($p=0.003$) and between the group B (25.2%) and group D (13.3%) ($p<0.001$). There was no statistically significant difference in the frequency of "refer" results of the first hearing test between group A (30.2%) and group B (25.2%) ($p=0.407$), between group B (25.2%) and group C (19%) ($p=0.094$) and between group C (19%) and group D (13.3%) ($p=0.083$) (Table 2).

In well-baby nursery (WBN) statistically significant difference in the frequency of "refer" results of the first test was noted between group A (29%) and group C (17.9%) ($p=0.049$), group A (29%) and group D (8.3%) ($p<0.001$), between group C (17.9%) and group D (8.3%) ($p=0.002$) and group B (25.5%) and group D (8.3%) (Table 2).

In the NICU it was found that the frequency of "refer" results in the first hearing test was lowest if the test was performed for a newborn older than 48 hours. However, the frequency of "refer" result of the first hearing test between groups A

(44.4%), B (18.8%), C (25%) and D (20.4%) did not show statistically significant difference in any combination of the groups (Table 2).

Table 2. Statistical significance of the difference in frequency of "refer" results of the first hearing test among the studied groups (A, B, C, D) in total and by departments

	p		
Group	**Total**	**NICU**	**WBN**
A : B	0.407	0.170	0.626
A : C	0.03*	0.197	0.049*
A : D	<0.001*	0.086	<0.001*
B : C	0.094	0.787	0.071
B : D	<0.001*	0.865	<0.001*
C : D	0.083	0.837	0.002*

*Statistical significance
Group A, newborn hearing screening (NHS) performed in first 24h after birth; Group B, NHS performed between 24-36 hours after birth; Group C, NHS performed between 36-48 hours after birth; Group D, NHS performed later than 48 hours after birth;
NICU, Neonatal Intensive Care Unit; WBN, Well Baby Nursery;

The overall TEOAE refer rate was significantly higher for infants screened before 24h (Group A) after birth (30.1%) than in infants screened between 36 - 48h (Group C) after birth (19.0%) or screened later than 48h (Group D) after birth (13.3%) ($p<0.05$). Infants screened between 24 - 36h (Group B) after birth (25.2%) had a lower refer rate than those screened before 24h (Group A) after birth and a higher refer rate than infants screened between 36 - 48h (Group C) after birth (19.0%) or screened later than 48h (Group D) after birth (13.3%). Referral rate decreased progressively with increasing age of newborns at the time of screening (Figure 1).

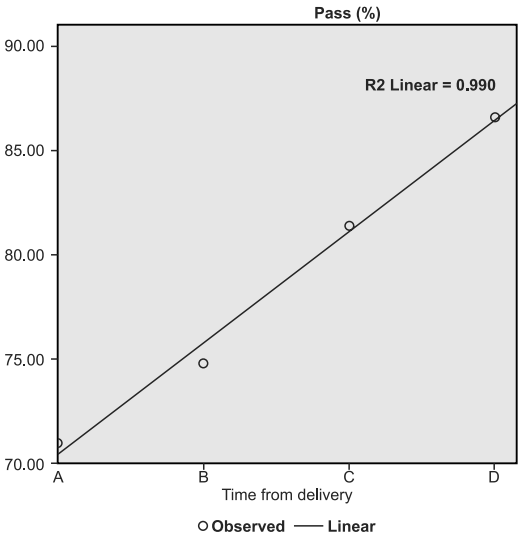

Figure 1. Referral rate decreased progressively with increasing age; A – screened in first 24 hours after birth; B – screened 24-36 hours after birth; C – screened 36- 48 hours after birth; D – screened 48 and more hours after birth

For all groups, the total referral rate only on the right ear was 7.8% (95 of 1217) and only on the left ear 9.3% (113 of 1217). There were 74 out of 1217 newborns (6.1%) with the refer result on booth ears. From these 74 newborns, 58 (6.2%) were in the WBN and 16 (5.6%) were in the NICU. Data of screening time was missed to be noted for 11 infants. So the data of 63 newborns with the refer result on both ears were analysed (47 in WBN and 16 in NICU) (Table 3).

According to the data, the earliest pass on both ears was 6 hours after birth.

Table 3. Distribution of newborns with refer result on both ears in groups and in units

		No (%) of infants		
Group	**Time for NHS**	**Total**	**NICU**	**WBN**
A	< 24h	15 (23.81)	2 (12.5)	13 (27.66)
B	24-36h	26 (41.27)	2 (12.5)	24 (51.06)
C	36-48h	7 (11.11)	1 (6.25)	6 (12.76)
D	>48h	15 (23.81)	11 (68.75)	4 (8.52)
Total		**63 (100)**	**16 (25.40)**	**47 (74.60)**

NHS, newborn hearing screening; NICU, Neonatal Intensive Care Unit; WBN, Well Baby Nursery

DISCUSSION

Before an initiation of this study the NHS has not been implemented in the Cantonal Hospital Zenica. The aim of this study was to test the screening protocol of NHS with TEOAE in order to identify possible difficulties for its implementation in our hospital. The TEOAE is a non-invasive diagnostic method that is safe and harmless for newborns. With time of performance from a few seconds to a maximum of a few minutes and with a high percentage of specificity and sensitivity TEOAE is the most commonly used test for NHS (11,18). The TEOAE test provides an insight into the status of external, middle and inner ear which is a peripheral part of the auditory system (11,18). TEOAE with automatic display of results, without the need to evaluate the results of the test by the clinician, is mostly used as an initial hearing test in NHS (18). This diagnostic method (TEOAE) does not examine retrocochlear part of the auditory system, and auditory neuropathy may be missed to diagnose. This is considered as a major disadvantage of this method (2). Because of that, a two-step screening protocol is proposed. In this protocol after a few refer results with TEOAE an automated auditory brainstem responses (AABR) examination must be performed. It is also proposed that an automated auditory brainstem responses (AABR) exami-

nation should be performed for all newborns with risk factors for developing hearing impairment (2). It has been already shown that if the screening test is performed in a very early stage (<48h) after the birth, it may not give correct results (12,14,15). In this study the refer rate of 30.1% was reported in group A when TEOAE is performed in the first 24h after birth. A study from South Africa showed the refer rate of 55% when TEOAE is performed in the first 24h after birth (12).

In group B infants in our study, when TEOAE was performed between 24-36h after birth, the refer rate of 25.2% was noted; in the study from Italy the refer rate was 12.6% when OAE was performed at the same time (19). In our study the refer rate of 19% was reported in group C when TEOAE was performed between 36-48h after birth. In the study from South Africa the refer rate of 36% was reported when TEOAE was performed before 48h after birth (12). Kemaloglu reported refer rates from a hospital in Turkey of 17.97% when the hearing screening test with TEOAE was performed between 24-48h after the birth, which is similar to the results of our study (20). On the other hand, some studies have demonstrated lower refer rates compared to the results of this study in group C (19%). The results in a study from Iran showed 11.68% refer rate when TEOAE was performed within 48h after birth (21). Canet et al. reported the refer results of screening with OAE in 48h after birth in Spain as 6.3% (22). In group D refer rate of 13.3% was noted in this study (TEOAE is performed later than 48h after birth). In the study from Michaelle van Dyk et al. when OAE was performed later than 48h after birth (group D) refer rate was 26% (12). Similar result as in our study were reported from China with 11.1% refer rate when screening with TEOAE was performed between 48-72h after birth (23). Some of these studies were conducted in developed and some in developing countries. The refer rate might be much more important for developing countries (12). All newborns with refer result on the first hearing test (hearing screening) should come for the next hearing examination. The next hearing examination with TEOAE or AABR is a standard procedure of NHS for children with refer results of the first hearing test (2). A large refer rate increases the cost of NHS programs because of doing this standard procedure to a large number of children with false positive (refer) results of the first hearing test (2). Developing countries have fewer resources for such programs and must pay more attention to costs than developed countries (12). Socioeconomic development of countries makes citizens more conscious about health as well as many other issues. Limited economic situation of citizens in developing countries can limit access to health care. In many countries in recent years, early discharge from the hospital is preferred after delivery. Economic reasons as well as the risk of hospital infection may be a possible cause for this early discharge of the infants from the hospital (12). This may require the hearing screening test very early. If the newborn hearing screening is done at very early stage after birth (<48h), it will not be possible to get credible results and it may cause high refer rates (14,15). In the current study the intention was to determine the optimal time for the NHS test in CHZ. All infants from well-baby nursery in the Cantonal Hospital Zenica are discharged on the following day after birth day except those delivered with Caesarean section. In this study 52.4% newborns were discharged in 48h after birth and 11.4% even before 24h. The refer rate for infants screened after 24h was significantly less than those screened before 24h.

With bilateral refer result there were 63 infants and almost 76% of them were screened before the age of 48h and almost 23% even before 24h of age.

In the WBN there were 6.2% and in the NICU 5.6% newborns with bilateral refer result of the hearing screening in our study. In the WBN almost 92% of infants with bilateral refer result were screened before 48 h of age and almost 28% in the first 24h after birth. In NICU the outcome was completely different. Almost 70% of infants with refer result on both ears were screened later than 48h after birth. This can be attributed to the reasons for referral to a NICU (low birth weight, prematurity, infection, hyperbilirubinemia, respiratory distress syndrome etc.). These reasons are potential risk factors for the development of hearing impairment (24). Therefore NHS in these infants with risk factors for hearing impairment is very important.

It is obvious that early hospital discharge of newborns affects the outcome of the NHS success in CHZ in the same way as shown in other studies from developing countries (12). For early discharged newborns, followed by early NHS, the probable reasons for high refer rates are pre-

sence of amniotic fluid and mesenchyme in outer and middle-ear or collapse of the ear canal and the presence of debris in outer ear (14,15). Consistent with the findings of some studies (25,26), in our study it has been shown that referral rate decreased progressively with increasing age.

In conclusion, the best recommended time for the NHS in the current conditions in CHZ is after 48 hours from birth. That would be on the third day of an infant's life or after. The results show that NHS could be done on the second day of the infant's life but with high risk for referral results. The NHS should not be done in the first 24h of the infant's life according to the results in this study, which is in accordance with other studies.

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TRANSPARENCY DECLARATION

Competing interests: None to declare.

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