Journal of Medicine in Scientific Research

Volume 3 | Issue 1 Article 6

Subject Area:

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Recommended Citation

Youssef El Gazzar, Hamouda Eid Ali; Taman, Khaled H.; Al, Magdy K.; Dwabah, Mahmoud H.; Alsoda, Mohamed F.; and EL Shourbagy, Omar E. (2020) "Some risk factors for neonatal sensorineural hearing loss in a neonatal intensive care unit," *Journal of Medicine in Scientific Research*: Vol. 3: Iss. 1, Article 6.
DOI: https://doi.org/10.4103/JMISR.JMISR_20_19

Some risk factors for neonatal sensorineural hearing loss in a neonatal intensive care unit

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Original Article

Some risk factors for neonatal sensorineural hearing loss in a neonatal intensive care unit

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Abstract

Background

The sensorineural hearing loss incidence (SNHL) ranges from 1 to 3 per 1000 live births in term healthy neonates, and 2–4 per 100 in high-risk infants, a 10-fold increase.

Objective

The aim was to estimate the incidence of SNHL among newborns in NICU at Ahmed Maher Teaching Hospital, Cairo, Egypt, and to describe the distribution of risk factors associated with SNHL and the effects of their interaction.

Patients and methods

The study was carried out on 710 neonates in a hospital in Cairo, Egypt. A total of 710 (401 males and 309 females) neonates were included in the study and had a birth weight ranging from 680 to 5500 g, and the mean gestational age was 35.8 ± 3 weeks. All the cases were screened for hearing loss using the transient evoked otoacoustic emission device, followed by a second-stage screening for those who failed, and cases were given a Refer then underwent an automated auditory brainstem response test.

Results

In the studied cases, 76.7% had hyperbilirubinemia, 8.73% were of low birth weight (<1500 g), and 15.5% were on mechanical ventilation. In the first screening phase, 80% were given a Pass response, and 20% were given a Refer response for the right ear. In the second screening phase, 91% were given a Pass, and 9% were given a Refer.

Conclusion

A comprehensive intervention and management program must be an integral part of screening programs in the postnatal period. Awareness about the value of hearing screening is important. Further assessment of the high prevalence of hyperbilirubinemia is needed.

Keywords: Hearing loss, high-risk, hyperbilirubinemia, low birth weight, mechanical ventilation, neonatal hearing screening

Introduction

Hearing impairment is 20 times more prevalent in neonates than are other disorders that are routinely screened for, including hypothyroidism, sickle cell anemia, and phenylketonuria [1].

A number of risk factors for sensorineural hearing loss incidence (SNHL) were described, involving low gestational age and birth weight, intrauterine and postnatal infections, neonatal asphyxia, requirement for prolonged oxygen therapy and respiratory support, hyperbilirubinemia needing exchange transfusion, hyponatremia, surgery during the neonatal period, congenital malformations, family history of hearing impairment, genetic abnormalities, and exposure to ototoxic medications such as diuretics and antibiotics [2].

Access this article online

Quick Response Code:

Website: www.jmsr.eg.net

DOI: 10.4103/JMISR.JMISR_20_19

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Submitted: 11-Mar-2019 **Revised:** 29-Mar-2019 **Accepted:** 17-Feb-2020 **Published:** 11-Jun-2020

How to cite this article: Dwabah MH, EL Shourbagy OE, Taman KH, Al MK, Alsoda MF, El Gazzar HE. Some risk factors for neonatal sensorineural hearing loss in a neonatal intensive care unit. J Med Sci Res 2020;3:35-9.

Current recommendations are to conduct universal hearing screening in all infants. Techniques used primarily involved automated auditory brainstem responses and otoacoustic emissions that provide noninvasive recordings of physiologic auditory activity and are easily performed in neonates and infants [3].

In contrast to the recommendations of the Joint Committee on Infant Hearing, neonatal hearing screening programs are still not universally available, and many countries still implement elective screening in high-risk neonates [4].

It was noted that early detection of hearing loss would improve the success of programs. Other studies supported by the National Institute of Health have concluded that children whose hearing loss is identified and who receive appropriate intervention before 6 months of age develop significantly better language ability than those who are identified later [5].

The primary goal of this study was to estimate the incidence of SNHL among newborns in NICU at Al-Munira Hospital, Cairo, Egypt, and to describe the distribution of risk factors associated with SNHL and the effects of their interaction.

Patients and methods

Ethical committee approval was taken. The study was conducted on 710 neonates (1420 ears right and left), comprising 401 males and 309 females, selected from a hospital between July 2016 and June 2017. The mean gestational age was 35.8 ± 3 weeks. Birth weight ranged from 680 to 5500 g. Transient evoked otoacoustic emissions (TEOAEs) between the first and fourth day of life were examined in all the newborns.

The screening was carried out over 2–3 days a week. These cases fulfilled the selection criteria of the HRR of the Joint Committee on Infant Hearing (1994).

A portable TEOAE screener (Echo-Screen, Madsen Electronics Ltd. 5600 Rowland Rd. Ste. 275, Minnetonka, Minnesota, 55343, United States) was used for the first-stage screening, which gave a Pass or Refer response. A second-stage screening after 3–4 weeks was carried out for cases given a Refer response, using the same equipment. Cases given a Refer response underwent an automated auditory brainstem response (AABR) test using the same portable Echo-Screen device at the age of 4 months. The newborns were tested with AABR after they failed the second-stage TEOAE tests, using three surface electrodes. The newborn was tested first at 35 and 55 dBnHL.

Both the TEOAE and AABR screening tests were conducted during natural sleep with no sedation.

Statistical analysis

All statistical calculations and analyses were carried out using the computer program SPSS version 12 (Statistical Package for the Social Sciences; SPSS Inc., Chicago, Illinois, USA). The basic statistical analysis included arithmetic mean, SD, range, frequencies (number of cases), and relative frequencies (percentages) of age and sex. All *P* values are two-sided; *P* value less than 0.05 was considered significant.

Results

In the initial (first) screening of the 710 neonates in the NICU using TEOAE devices, 80% were given a Pass response and

Table 1: Mode of delivery among the studied cases

	n (%)
Vaginal	270 (38)
CS	440 (62)
Total	710 (100)

CS, cesarean section.

Table 2: Ventilation method among studied cases

	n (%)
No	87 (12.3)
Nasal	14 (2)
CPAP	499 (70.2)
Mechanical ventilation	110 (15.5)
Total	710 (100)

CPAP, Continuous positive airway pressure

Table 3: Hyperbilirubinemia among studied cases

	n (%)
Negative	165 (23.3)
Positive	545 (76.7)
Total	710 (100.0)

Table 4: TEOAES stage 1 right ear

	n (%)
Pass	475 (80)
Refer	120 (20)
Total	595 (100)
Died	115
Total	710

Table 5: TEOAES stage 1 left ear

	n (%)
Pass	511 (85.9)
Refer	84 (14.1)
Total	595 (100.0)
Died	115
Total	710

A follow-up investigation was planned for all neonates who did not pass the initial screening by TEOAE. A second screening or rescreening was carried out in the follow-up clinic in Al-Monira Hospital, where 131 (18.5%) cases were given a Pass response and 13 (1.8%) cases were given a Refer response for the right ear, as shown in Table 6. Moreover, 135 (93.7%) cases were given a Pass response and nine (6.3%) cases were given a Refer response for the right ear, as shown in Table 6.

20% were given a Refer for right ear as in Table 4 and 85.9% were given a Pass response and 14.9% were given a Refer for left ear as in Table 5. The mode of delivery was 38% by vaginal delivery and 62% by CS as shown in Table 1.

From Table 2, the number of neonates who were on mechanical ventilation was 110 (15.5%), 499 (70.2%) on NCPAP, 14 (2%) on nasal oxygen, and 87 (12.3%) did not need to oxygen.

From Table 3, the most frequent risk factor in the NICU is observed to be hyperbilirubinemia; the number of neonates with neonatal hyperbilirubinemia was 545 (76.7%).

A follow-up investigation was planned for all neonates who did not pass the initial screening by TEOAE. A second screening or rescreening was carried out in the follow-up clinic in Al-Monira Hospital, but of them, 131 (18.5%) cases that were given a Pass response and 13 (1.8%) cases were given a Refer response for the right ear as shown in Table 6, and 135 (93.7%) cases that were given a Pass response and nine (6.3%) cases were given a Refer response for the right ear as shown in Table 7.

Table 8 shows that mean gestational age was 35.8 weeks, mean of birth weight was 2630.87 grams, mean of Appearance, Pulse, Grimace, Activity, and Respiration (APGAR) SCORE 1 min was 5.6 min, mean of APGAR SCORE 5 min was 8.4 min, mean of hemoglobin was 14.8 g/dl, mean of total leukocytic count was 13 718.78/cmm, mean of platelets count was 237 240.8/cmm, mean of blood pH was 7.3, mean of $PaCo_2$ was 34.16, and mean of HCO_3 was 17.12 (Tables 9 and 10).

Table 6: TEOAEs stage 2

	n (%)
Right ear	
Pass	131 (18.5)
refer	13 (1.8)
Total	144 (20.3)
Left ear	
Pass	135 (93.7)
refer	9 (6.3)
Total	144 (100.0)

Table 7: Outcomes

	n (%)
Died	115 (16.2)
Live	595 (83.7)
Total	710 (99.9)

Table 8: Descriptive statistics among studied cases

	Mean±SD
Gestational age (weeks)	35.8±3.0
Birth weight (g)	2630.87±770.91
APGAR score 1 min	5.6±1.2
APGAR score 5 min	8.4±1.39
Hemoglobin (g/dl)	14.8±2.3
Total leukocytic count	13718.78±6276.17
Platelet count	237240.8±80267.9
Blood pH	7.3±0.08
$PaCo_2$	34.16±14.86
HCO_3	17.12±5.7

This table showed mean of gestational age was 35.8 weeks, mean of birth weight was 2630.87 g, and mean of APGAR score 1 min was 5.6 min, mean of APGAR score 5 min was 8.4 min, mean of hemoglobin was 14.8 g/dl, mean of total leukocytic count was 13 718.78/cmm, mean of platelets count was 237 240.8/cmm, mean of blood pH was 7.3, mean of $PaCo_2$ was 34.16, and mean of HCO_3 was 17.12. Regarding the parametric correlations in 62 low-birth-weight neonates, there were significant correlations at the 0.01 level between birth weight and APGAR score 1 min; birth weight and APGAR score 5 min; between APGAR score 1 min and APGAR score 5 min, APGAR score 1 min and ventilation; between APGAR score 5 min and ventilation; abd between $PaCo_2$ and HCO_3. There was significant correlation at the 0.05 level between birth weight and ventilation, between APGAR score 1 min and TEOAEs S1 RT; and between ventilation and bilirubin. TEOAE, Transient evoked otoacoustic emission.

Discussion

The current study was carried out on 710 neonates in a Hospital, Cairo, Egypt. The number of neonates in the study was 710 (401 males and 309 females) and had a birth weight ranging from 680 to 5500 g. Their mean gestational age was 35.8 ± 3 weeks. All the cases were screened for hearing loss using the TEOAE device (Echo-Screen), followed by a second stage screening for those who failed the test with the TEOAE device. Those cases given a Refer were then made to undergo an AABR test.

Results of the current study showed that 76.7% of cases had hyperbilirubinemia, 8.73% were of low birth weight (<1500 g), and 15.5% were on mechanical ventilation. In the first screening phase, 80% were given a Pass response, and 20% were given a Refer response for the right ear. In the second screening phase, 91% were given a Pass and 9% were given a Refer. The highest referral rates were in neonates with multiple risk factors.

Farid *et al.* [6] studied 130 newborns, where 30 had no risk factors for hearing loss (60 ears). In screening, 26 (86.7%) neonates passed the test and four (13.3%) had a Refer result. The failure was higher than cited by many authors [7,8]; they found prevalence rates of hearing loss ranging from 0 to 5%. However, all the previous authors had screened their cases after the second day of life, whereas in our study, the cases were screened in the first 48 h of life, as reported by Levi *et al.* [9], who screened in the first 10–48 h of life and reported a 22% referral rate. When the test was repeated after 108 h of life, the failure rate decreased to ~1%. This could be explained by the presence of vernix caseosa in the external canal or effusion in the middle ear, which could have been residual amniotic fluid.

The most frequent risk factor encountered in the NICU was ototoxicity (100%), followed by hyperbilirubinemia (55%), low birth weight (14.5%), mechanical ventilation for more

Table 9: Parametric correlations in 62 low-birth-weight neonates

	Birth weight	Sex	APGAR 1M	APGAR 5M	Venntlation	HB	$PaCo_2$	HCO_3	Bilirubin	TEOAES S1R
Birth weight										
r		0.091	0.427**	0.368**	−0.320*	−0.128	0.080	0.181	0.024	−0.003
P		0.483	0.001	0.003	0.011	0.323	0.535	0.159	0.851	0.990
Sex										
r	0.091		−0.222	−0.079	0.103	−0.060	−0.026	−0.084	0.016	0.060
P	0.483		0.083	0.544	0.424	0.643	0.839	0.517	0.900	0.767
APGAR score										
r	0.427**	−0.222		0.826**	−0.699**	0.042	−0.013	−0.048	0.215	−0.466*
P	0.001	0.083		0.000	0.000	0.743	0.923	0.711	0.093	0.014
APGAR score 5M										
r	0.368**	−0.079	0.826**		−0.794**	0.123	−0.038	−0.051	0.225	−0.377
P	0.003	0.544	0.000		0.000	0.342	0.770	0.693	0.079	0.053
Ventilation										
r	−0.320*	0.103	−0.699**	−0.794**		−0.115	0.075	0.121	−0.303*	0.367
P	0.011	0.424	0.000	0.000		0.374	0.562	0.348	0.017	0.060
Hb										
r	−0.128	−0.060	0.042	0.123	−0.115		−0.045	−0.136	−0.161	−0.308
P	0.323	0.643	0.743	0.342	0.374		0.727	0.292	0.213	0.118
$PaCO_2$										
r	0.080	−0.026	−0.013	−0.038	0.075	−0.045		0.881**	−0.084	0.166
P	0.535	0.839	0.923	0.770	0.562	0.727		0.000	0.516	0.409
HCO_3										
r	0.181	−0.084	−0.048	−0.051	0.121	−0.136	0.881**		0.003	0.210
P	0.159	0.517	0.711	0.693	0.348	0.292	0.000		0.984	0.294
Bilirubin										
r	0.024	0.016	0.215	0.225	−0.303*	−0.161	−0.084	0.003		−0.094
P	0.851	0.900	0.093	0.079	0.017	0.213	0.516	0.984		0.639
TEOAES S1 RT										
r	−0.003	0.060	−0.466*	−0.377	0.367	−0.308	0.166	0.210	−0.094	
P	0.990	0.767	0.014	0.053	0.060	0.118	0.409	0.294	0.639	

Regarding the nonparametric correlations in 62 low-birth-weight neonates, there were significant correlations at the 0.01 level between APGAR score 5 min and APGAR score 1 min, between APGAR score 5 min and ventilation, and between ventilation and APGAR score 1 min. There was a significant correlation at the 0.05 level between APGAR score 5 min and birth weight, between ventilation and bilirubin, and between TEOAES.S1. RT and APGAR score 1 min. Hb, hemoglobin; TEOAES, transient evoked otoacoustic emission. *Correlation is significant at the 0.05 level (two-tailed). **Correlation is significant at the 0.01 level (two-tailed).

than 5 days (11.5%), and finally craniofacial anomalies (1%). Vohr *et al.* [10] found that the four most frequent risk factors in the NICU were ototoxic drugs, low birth weight, mechanical ventilation for more than 5 days, and a low Apgar score.

Korres *et al.* [4] found that toxic levels of ototoxic drugs, mechanical ventilation for more than 24 h, prematurity, and low birth weight were the four frequent risk factors. Although there is a slight difference between the two studies, ototoxic drugs, mechanical ventilation, and low birth weight were still the three most frequent risk factors in both studies. In contrast, hyperbilirubinemia was the most frequent factor encountered in our study and other studies carried out in Egypt [11,12].

This is a point that needs further research in coordination with pediatricians to assess its magnitude and effect, as neonatal jaundice is more likely to cause central rather than a peripheral hearing loss. This necessitates the combination of TEOAE and ABR in cases with neonatal jaundice [13,14].

Most of the studied neonates were delivered using a caesarian section (55%) with a mean weight of 3.19 ± 0.46 kg. All (100%) neonates attended the first-stage hearing screening, and only 27.8% of neonates attended the second stage. The most frequent risk factor was prematurity (54.6%). The percentage of high-risk babies was 19.1% of the total neonates for the 3 years recorded for high risk. Overall, 10.3% attended the second stage, and only one-fourth underwent diagnostic ABR. A percentage of 0.001–0.003 hearing disorder was recorded [15].

Elsanadiky and Afifi [15] showed that the highest risk factor was prematurity (54.6%), followed by sepsis (12.6%), hyperbilirubinemia (12.5%), hypoxia (2.8%), family history of hearing loss (2.4%), and congenital hearing loss (1.3%). The other 12.8% were admitted to the NICU for different causes (e.g. intrauterine growth retardation, respiratory distress syndrome, uncontrolled diabetes mellitus, and tachypnea).

TEOAE test revealed a failed response in some neonates, including high risk. Korres *et al.* [4], who examined hearing in

Table 10: Nonparametric correlations in 62 low-birth-weight neonates

	Birth weight	APGAR 1M	APGAR 5M	Ventilation	Bilirubin
Sex					
r	0.078	−0.210	−0.084	0.103	0.016
P	0.548	0.102	0.516	0.424	0.900
APGAR 5M					
r	0.286*	0.831**		−0.817**	0.214
P	0.024	0		0	0.095
Ventilation					
r	−0.236	−0.715**	−0.817**		−0.303*
P	0.065	0	0		0.017
Hb					
r	−0.080	0.026	0.118	−0.112	−0.167
P	0.537	0.841	0.361	0.388	0.195
$PaCO_2$					
r	0.046	−0.057	−0.048	0.092	−0.055
P	0.724	0.660	0.711	0.476	0.674
HCO_3					
r	0.147	−0.063	−0.057	0.112	0.010
P	0.255	0.624	0.660	0.385	0.938
Bilirubin					
r	−0.020	0.189	0.214	−0.303(*)	
P	0.876	0.141	0.095	0.017	
TEOAES 1 RT					
r	−0.080	−0.393(*)	−0.327	0.367	−0.094
P	0.690	0.043	0.096	0.060	0.639

Hb, hemoglobin; TEOAE, transient evoked otoacoustic emission.*Correlation is significant at the 0.05 level (two-tailed).**Correlation is significant at the 0.01 level (two-tailed).

well-nursery babies with TEOAEs in Greece, found a failure rate of 2.3%.

El-Gamal *et al.* [12], in Egypt, reported a failure rate of 54% in multiple risk factor neonates and 20% in the single risk factor neonates. However, Abdullah *et al.* [16] found that 11.8% of the screened high-risk neonates n Malaysia failed TEOAE test. Imam *et al.* [17] recorded a failed response by 28%.

Conclusion

TEOAE is a sensitive, rapid, and simple test in newborn hearing screening. Universal two-stage NHS protocol should include AABR for all babies, not only the high-risk group. It is the key components of what constitutes 'early intervention,' and in particular, what marks that intervention as being of high quality and leading to improved outcomes.

Recommendations

A comprehensive intervention and management program must be an integral part of the screening program in the postnatal period. Public awareness about the value of hearing screening is important for the follow-up to be more effective. Monitoring of ototoxic drug administration and further assessment of the high prevalence of hyperbilirubinemia are needed. A team of obstetricians, pediatricians, and audiologists is needed to identify and assess risk factors.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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