e-ISSN: 0975-1556, p-ISSN:2820-2643
Available online on www.ijpcr.com
International Journal of Pharmaceutical and Clinical Research 2024; 16(8); 863-869

Original Research Article

To Study the Effect of Birth Weight on Neonatal Hearing by Otoacoustic Emissions Screening

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Received: 25-05-2024 / Revised: 23-06-2024 / Accepted: 25-07-2024
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Conflict of interest: Nil

Abstract:
Introduction: Infant and childhood hearing loss is associated with significant speech and language developmental delays, affecting social and economic outcomes. Low birth weight (LBW) has been indicated as one of the neonatal risk factors for hearing loss; however, an association between LBW and hearing impairment is not well defined.
Methods: This study was carried out from November 2022 to October 2023 among 240 neonates with a mean age of 13.41 days. The cochlear function was assessed using otoacoustic emission screening. Data for the second screening test attempt were considered to guarantee accuracy. All statistical analyses were done using SPSS version 12.0, and comparisons were made by t-test, Mann-Whitney U-test, and analysis of covariance.
Results: Of the total of 240 neonates, 33.75% were less than 10 days old, 63.33% were between 10-24 days, and 2.91% were aged 25-30 days. The mean birth weight was 2320.73 grams. At the initial postnatal screening test, 194 neonates passed while 46 neonates were referred for further assessment, and at follow-up, 188 neonates passed while 51 showed abnormalities that require further evaluation. Only weight showed a significant effect on DPOAE outcome, with very low p-values for both the postnatal and follow-up assessments. No significant associations were identified for sex, presentation, or type.
Conclusion: This study supports the presence of a significant association between low birth weight and hearing impairment thus allows emphasizing the role of weight in audiometric assessments. Future research needs to determine the mechanisms by which low birth weight is associated with hearing loss, study the long-term outcomes of auditory function, and develop targeted interventions. Neonatal hearing screening may be incorporated into public health programs with a view to early detection and management of hearing loss.
Keywords: Neonatal Hearing Loss, Low Birth Weight, Otoacoustic Emissions, Auditory Function, Early Detection, Screening.

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Introduction

Hearing loss in infancy and childhood results in speech and language developmental delays with serious social and economic implications. As such, early detection and intervention could raise the linguistic and communicative competence of children with hearing loss, therefore facilitating their integration into a hearing society [1]. According to literature, congenital hearing loss incidence is estimated to be about 1.5 per 1,000 newborns. It is, in particular, more common in premature infants or those admitted to a neonatal intensive care unit [1].

The overall known causes of congenital hearing loss in neonates and children are genetic and environmental [1]. With increased public awareness of hearing loss, medical systems and innovations in the management of these impairments have sprung up. Early detection through the implementation of screening methods for congenital hearing loss dramatically changed the face of diagnosis and treatment of neonatal and infantile hearing loss [1,2].

The first signs of hearing loss are usually subtle, so routine neonatal screening for this condition is very important to enable early detection. Early diagnosis and intervention significantly affect outcomes in babies with a hearing impairment, minimizing its impact on their social, emotional, cognitive, and language development [2]. Otoacoustic emissions (OAEs) emanating from within the cochlea may be picked up using a special microphone in the external canal. These emissions are a product of the active motion of sensory hair cells in the cochlea as a result of acoustic stimulation. OAE screening is a fast, easy, and noninvasive technique applied in universal newborn hearing screening programs for assessing cochlear function [2,3]. OAE has several advantages such as it is very sensitive and specific thus, it can be relied upon for the diagnosis of hearing impairment. The technique allows for early detection of hearing loss, able to provides an opportunity for intervention to begin early enough. OAE screening is painless, and quick, with an objective assessment of cochlear function [2]. It further aids in the minimization of false-positive rates, mostly for high-frequency DPOAEs, and can easily be integrated into routine healthcare practices to make it easy to streamline the neonatal hearing loss identification process [2,3].

Low birth weight is correlated with several poor outcomes on physiological, psychological, and functional health throughout life. Infants of low birth weight generally have stunted growth and cognitive development in early childhood, which mostly results in lower educational and economic productivity. Further, a high risk of developing cardiovascular diseases, diabetes, and hypertension lurks in LBW individuals later in life [4]. The survival rates of very-low-birth-weight (VLBW) infants have greatly increased due to advances in obstetric and neonatal care. The relation between VLBW and hearing loss remains poorly defined. Poor understanding prevails about how these mechanisms impact VLBW infants. One of the major challenges facing research into these mechanisms at present is that inner ear tissue biopsies cannot be taken, as they would cause immediate and complete hearing loss [5]. This study investigates the effect of birth weight on hearing and fills a gap in understanding the relationship between low birth weight and hearing impairment. This can then give very early detection and intervention strategies for affected infants.

Materials and Methods

Study Design: To assess neonatal hearing using otoacoustic emission screening, a study was conducted on neonates who were found to have probable partial deafness. The population consisted of neonates of different age categories whose antenatal and postnatal histories were well accounted for, together with the absence of postnatal conditions that could affect the result. This study was conducted from November 2022 to October 2023, with a period of one year. In this study, 240 newborns were enrolled. The otolaryngologists who did the hearing tests in this research had adequate knowledge about neonatal screening before the infants were discharged from the hospital. It is explained in the literature what types of screening protocols and techniques are used within the context of the study.

During the screening process, each infant was tested in the cot, and testing commenced with the right ear. To ensure that there were not too many false-positive results, any infants with either equivocal results in the first test or where it failed were subjected to immediate re-testing using TEOAEs. It is only the data of the second screening test attempt that was entered into further analysis; data from the first trial were excluded to ensure accuracy. The noise rejection level was set to an initial 46 dB SPL. This could be increased when noise was excessive to a maximum of 52 dB SPL. Conversely, when noise levels were very low, and data were being rejected minimally, the noise rejection threshold could be lowered down to a minimum 40 dB SPL to maximize data collection.

Inclusion Criteria

- This study included neonates with potential hearing impairments as suggested by the universal newborn hearing screening using OAE.
- Participants were chosen in regards to specific age ranges; however, exact specification in regards to the age range was not stated within the text and should be noted within the specifications of the study criteria.
- Inclusion criteria included newborns with various postnatal courses that could influence the development of hearing.

Exclusion Criteria

- Exclusion of neonates below or above the age limit was done to maintain a homogeneous study population.
- Infants who were measured to have no hearing loss in the OAE screening were also excluded to draw attention to their peers who might have problems.
- With the data these newborns were inconsistent or with incomplete histories of postnatal events; such was included; this might create variability that would confound intended results.

Statistical Analysis: Statistical analyses were carried out using the SPSS version 12.0 statistical software package. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to determine whether the distribution of data was normal. Following verification of a normal distribution, comparisons of independent group mean otoacoustic emission values were done with a two-tailed t-test. For data that was not distributed normally, the Mann-Whitney U-test was used to compare group differences. An analysis of covariance was done to compare the mean otoacoustic measurements between two groups, adjusting for gestational age, as it could affect the outcome of the hearing. Categorical data were compared using Fisher's exact test. Findings were considered to have statistical significance if the probability was less than 0.05 and hence did not occur due to chance.

Results

Table 1 indicates that among the 240 enrolled neonates in the current study, 33.75% of neonates were below 10 days, while 63.33% were between 10 and 24 days; only 2.91% were within the 25-30-day range. The average age of the neonates was 13.41 days with a standard deviation of 6.64 days, indicating a massive concentration of the study population within the first few weeks of life.

Table 1: Age distribution of the included neonates

Age of Neonates	Number of patients	% of patients
<10 days	81	33.75
10-24 days	152	63.33
25-30 days	7	2.91
Mean Age	13.41	-
SD (Age)	6.64	-

Table 2 summarizes the antenatal and postnatal histories of the 240 neonates enrolled in the study. The antenatal history revealed that 11.25% of mothers had suffered from some illness during pregnancy. 2.91% of the mothers had exposure to X-rays while none had infections. In the postnatal history, 92.91% of neonates had a normal first cry. The mean birth weight was 2320.73 grams with a standard deviation of 422.61 grams. Among the postnatal conditions, 56.66% of neonates did not develop any complications; 26.66% had a rash; 9.16%, had jaundice; 3.75%, had convulsions; and another 3.75% had fever.

Table 2: Antenatal and Postnatal History of the included subjects in this study

Antenatal History	Number of patients	% of the patients
illness during pregnancy	27	11.25
Infection during pregnancy	0	0
x-ray exposure during pregnancy	7	2.91
POSTNATAL HISTORY	**Number of patients**	**% of the patients**
First Cry	223	92.91
Birth Weight	2320.73±422.61	
Convulsions, Cyanosis, Jaundice , Fever, Rash		
No postnatal conditions	136	56.66
Rash	64	26.66
Jaundice	22	9.16
Convulsion	9	3.75
Fever	9	3.75

Figure 1 represents the labour duration in two categories: less than 20 minutes and greater than 20 minutes. From the data, it was found that 72 cases had a labour period of less than 20 minutes and 168 cases were in the category of labour from 20 to 40 minutes. The data presented in the figure shows that the average length of labour in the population researched is 24.35±7.45 minutes. Whereas some cases were of even shorter lengths of labour, the range of labour lengths varies due to the many different scenarios found within the study.

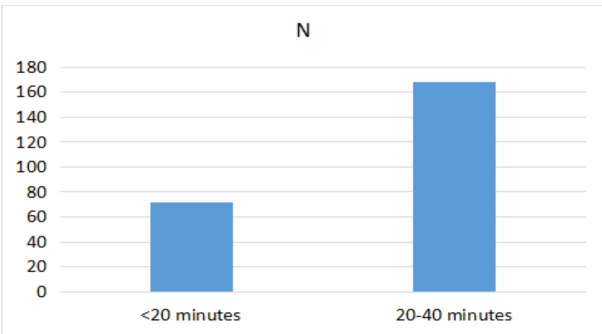

Figure 1: Number of cases in less than 20 minutes and more than 20 minutes

Figure 2 shows the distribution of cases according to gravidity and parity. If one considers the gravidity, the highest number of pregnancies was noted in 145 women who had had a single pregnancy, followed by 94 with two pregnancies, and 72 with three pregnancies. On parity, there were 155 cases of women who had given one live birth, 88 cases of women who gave two live births, and 51 cases of women who gave three live births. The figure also includes nulliparity or the number of women who never had pregnancies or live births. This graph gives the overview of the distribution of pregnancies and live births of the respondents.

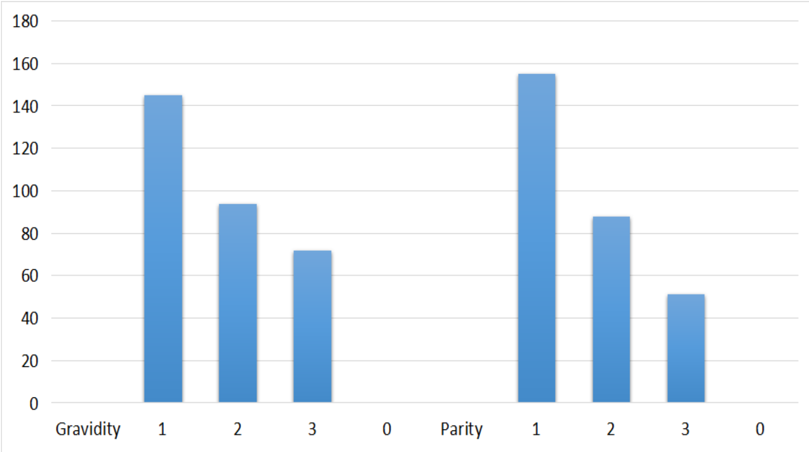

Figure 2: Number of cases indicating gravidity and parity

Figure 3 illustrates the results of the DPOAE tests performed at postnatal and follow-up evaluations, stratified by "Pass" and "Refer". At the initial postnatal screening, 194 had passed, that is, with normal otoacoustic emissions, while 46 were referred for further assessment with abnormal test results. At follow-up screening, 188 had passed with normal emissions, while 51 had abnormal findings that required further evaluation.

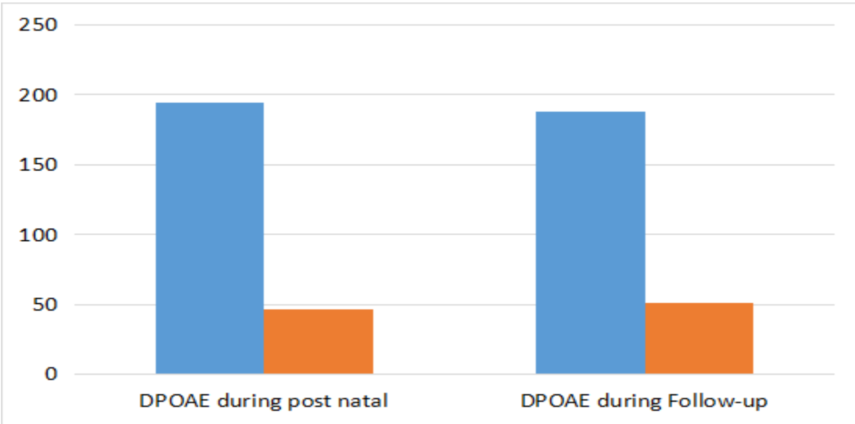

Figure 3: DPOAE test results during post-natal period and during follow-up

Table 3 follows the statistical analysis of DPOAE outcomes during postnatal and follow-up assessments about variables like sex, presentation, type, and weight. The results indicated that sex, presentation, and type had no statistically significant effect on the DPOAE outcomes for both postnatal and follow-up assessments; P-values were way above the 0.05 threshold. Nevertheless, weight had an extremely high significant effect on the results of DPOAE in both evaluations: the F-values were 70.678 ($p < 0.0001$) in the postnatal assessment and 85.921 ($p < 0.0001$) in the follow-up assessment, indicating an interaction between neonatal weight and the results from otoacoustic emissions.

Table 3: Significance findings of each variable concerning DPOAE during post-natal and DPOAE during Follow-up

Parameter	DPOAE during post-natal		DPOAE during Follow-up	
	F	P-value	F	P-value
Sex	2.657	0.1040	0.601	0.4390
Presentation	1.719	0.1910	0.777	0.3790
Type	0.007	0.9330	0.004	0.9470
weight	70.678	0.0000	85.921	0.0000

Discussion

LBW, especially VLBW, is a risk factor for hearing impairment due to multiple factors. VLBW infants are exposed to a variety of risk factors, including prematurity, ototoxic medications, and hospitalization, all of which combine to increase their risk for hearing loss above that of the general newborn population. Specific factors include the aminoglycosides, which produce irreversible cochlear damage resulting from hair cell death and the formation of free radicals, and the loop diuretics, which can potentiate aminoglycoside-induced hearing loss through their effects on the blood-labyrinthine barrier [5]. Other factors that have been identified as contributing to this heightened risk include noise exposure in neonatal intensive care units, which has been shown to cause hearing loss presumably through damage to cochlear structures, and hyperbilirubinemia, which has been shown to selectively affect auditory pathways. Other etiologies include cytomegalovirus infection and hypoxia, primarily through mechanisms involving the cochlea and auditory pathways [5].

Aminoglycoside antibiotics are remarkably potent against infections; however, they may induce irreversible cochlear damage by producing free radicals and thus affecting hair cells, especially at high frequencies. By their effects on the blood-labyrinthine barrier, loop diuretics may potentiate the ototoxicity caused by aminoglycosides, while noise-induced hearing loss is caused by overstimulation of cochlear structures. In particular, it appears that hyperbilirubinemia acts differently on auditory nerve structures based on birth weight and exposure time [5]. The diverse outcomes of hearing loss in infants born VLBW can be attributed to the damage from the infection of cytomegalovirus to the cochlea itself and hypoxia affecting cochlear function secondary to spiral ganglion cell damage and other components of the cochlea. These support further the need for continued research into these mechanisms of injury and how better to monitor and intervene [5].

Akinpelu et al. (2014) aimed to determine the differences in referral rates of OAE screening by various screening protocols. Ten studies were analyzed. It was observed that older age at the initiation of screening, the practice of retesting, and screening at a higher frequency were all associated with lower referral rates. A delay in the initial screen would hence result in a better output of the test, but it is not possible to implement in most situations [3]. Raghuvanshi et al. (2019) assessed the role of otoacoustic emission testing in neonatal screening. The authors screened 1,250 newborns using a portable Interacoustics OAE device in this study. In neonates, however, the OAE test resulted in a sensitivity of 66.7% and a specificity of 98.8% to detect neonatal hearing impairment. Positive and negative predictive values were recorded at 33.3% and 99.7%, respectively. The study also compared the results of OAE with auditory brainstem response tests to conclude that based on the strength of OAE as a robust screening tool, confirmation may be advisable for accurate diagnosis [2].

Gulati et al. (2022) study assessed the predictive validity of either 1-kHz tympanometry or WB acoustic transfer functions in determining the status of the conduction pathway in newborns, categorized as pass or refer following Universal Neonatal Hearing Screening programs. Results showed that; WB acoustic measurements were more efficient at predicting UNHS Distortion Product Otoacoustic Emissions test outcome than 1-kHz tympanometry; WB assessments are quick and objective, and thus may be amenable to being used in combination with UNHS; WB measurements detect changes in sound transmission within the first two days of life; and WB testing documents the high incidence of referral from UNHS due to transient conditions affecting the auditory conduction pathway [6].

A study by Hunter et al. (2018) was conducted to assess noise levels, SNR, and DPOAEs in neonates and infants at two different stimulus levels across a range of frequencies and to explore how test duration, infant condition, testing environment, and age influence these DPOAE values. Results indicated that in most ears of infants, DPOAEs could only be reliably measured at 2.0, 3.0, and 4.0 kHz, but not at 1.0 kHz, where the measurements are not as reliable due to decreased SNRs at lower frequencies. Based on test time and test settings, the inclusion of the 1.0 kHz test frequency in a neonatal screening program may not be indicated. It also found that DPOAEs give accurate results when tests are conducted in typical environments where infants are usually observed, suggesting that newborns can be effectively tested in their most common states of arousal during the perinatal period [7].

A hearing screening was conducted by Jadia et al. (2019) for 1200 WBN newborns and 319 NICU newborns. The gestational average in the case of a NICU group is 34 weeks, with the average weight at birth being 1997 grams. In this case, the ABR technique has been used for newborn babies in the NICU, while the AABR and OAE tests have been practised for the WBN group. Newborns who did not pass the initial hearing screening bilaterally were scheduled for outpatient retesting. If they continued to fail, ABR testing was done. Of the 1,519 newborns screened, 1.2% were found to have some type of hearing impairment. Of the 16 total cases with impairment, 75% were from the NICU and 75% had associated risk factors for their hearing loss. The average age for identifying hearing loss in the WBN group was 12.9 weeks, while the average age for fitting of hearing aids was 16.1 weeks. The WBN infants received hearing aids at a younger age than the NICU babies. From the results, it can be concluded that universal newborn hearing screening indeed identifies hearing loss and provides timely hearing aid fitting of both the NICU and WBN infants. [8].

The early detection of neonatal hearing loss is very important in ensuring effective intervention, which reduces the risks associated with long-term developmental deficits. This would yield an immediate effect on the application of hearing aids or cochlear implants, which are vital for optimum language and cognitive growth. Neonatal hearing loss affects speech, language, and literacy development; therefore, such early detection may reduce the delay in these aspects. Some of the risk factors that signal the condition include low birth weight, ototoxic medications, and prolonged oxygen therapy; hence, early identification will inform appropriate interventions. The timely detection and management of the condition are hence important [9-11].

Future research into the birth weight-neonatal hearing relationship using OAE screening should be based on longitudinal studies through follow-up of the hearing outcome over time in neonates of different birth weights; comparative studies to evaluate the effectiveness of OAE screening about the detection of hearing loss in neonates across different birth weight categories; research into the effect of birth weight discordance in twins on the risk of hearing for understanding the birth weight variability effect; intervention strategies based on birth weight for the risk reduction of hearing loss and resultant outcomes; and combined effects of birth weight and gestational age on neonatal hearing towards understanding the factors that affect hearing development [12-14].

Conclusion

This study evidenced a very close correlation: neonatal hearing loss is a risk if low birth weight is the factor. There was no preponderant association found in the case of sex, presentation, or type of the DPOAE outcomes; however, the weight did show a critical influence over the auditory function. The results indicate that weight is a crucial variable in audiometric assessments. Such future studies should investigate the mechanisms relating low birth weight to hearing impairment, identify the long-term auditory outcomes, and also formulate some targeted interventions. Additionally, neonatal hearing screening can be included in public health programs to enhance early detection and management of neonatal hearing loss.

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