

Original Research Article

A study of hearing evaluation for neonate with hyperbilirubinemia using otoacoustic emission and brainstem auditory evoked response

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ABSTRACT

Background: Jaundice is a common condition in newborns, and while most cases are benign, high serum bilirubin levels can lead to kernicterus, causing severe complications like bilirubin encephalopathy and hearing loss. Early detection through routine screening is essential to prevent such complications. One effective screening method is otoacoustic emission (OAE), followed by brain stem auditory evoked response (BERA), to assess hearing loss in neonates with hyperbilirubinemia. This study aimed to determine the incidence of hearing abnormalities in neonates with hyperbilirubinemia, correlate high bilirubin levels with OAE and BERA abnormalities, and evaluate OAE as a mass screening tool for sensorineural hearing loss.

Methods: After institutional ethics approval, 105 neonates meeting inclusion criteria were enrolled. A standard case record was maintained, and OAE testing was conducted before hospital discharge. Infants who failed OAE screening underwent BERA, which was considered the gold standard for diagnosis.

Results: Results showed abnormal OAE in 6 infants and abnormal BERA in 9 infants out of 105 tested.

Conclusions: These findings indicate that OAE is a useful, cost-effective, and quick screening tool for detecting hearing loss in neonates. Since OAE is non-invasive and less time-consuming than BERA, it can be used as an initial screening method. Infants failing OAE screening can then undergo BERA for further evaluation. This study supports the use of OAE for mass screening, ensuring early intervention through hearing aids and infant stimulation, thereby promoting normal language development in affected infants.

Keywords: Hyperbilirubinemia, Otoacoustic emission, Brain stem auditory evoked response

INTRODUCTION

Neonatal hyperbilirubinemia is a common clinical condition affecting newborns, characterized by elevated serum bilirubin levels. While physiological jaundice is usually benign, severe hyperbilirubinemia can lead to kernicterus, a condition associated with neurological damage, including auditory dysfunction.¹ Bilirubin toxicity affects the auditory pathway, particularly the cochlear nucleus and auditory brainstem, leading to hearing impairment in some neonates.² Early detection of such auditory dysfunction is crucial for timely intervention and rehabilitation.

OAEs and BAER or BERA are essential tools for neonatal hearing screening. OAE assesses cochlear (outer hair cell) function, whereas BAER evaluates the auditory nerve and brainstem pathways.³ Studies have shown that neonates with significant hyperbilirubinemia may have abnormal BAER results while maintaining normal OAE, indicating a potential auditory neuropathy spectrum disorder.⁴ This highlights the importance of using both tests for a comprehensive hearing evaluation in jaundiced neonates.

This study aims to assess hearing function in neonates with hyperbilirubinemia using OAE and BAER,

providing insights into bilirubin-induced auditory dysfunction. By comparing these methods, we seek to determine their diagnostic utility in early hearing impairment detection, facilitating prompt intervention and improving long-term auditory outcomes.⁵

METHODS

Study design and period

This is an observational study, was conducted on 105 neonates with hyperbilirubinemia in the neonatal care unit of the department of pediatrics, NMC Raichur, from April to July 2024.

Sampling method and size

A total of 105 neonates were included. The inclusion criteria were all neonate with hyperbilirubinemia being treated in department of pediatrics. Exclusions included neonates on ototoxic drugs, those with major congenital anomalies, and those with a family history of hearing loss.

Execution of study

OAEs and BERA tests were performed. Detailed history, clinical examination, and serum bilirubin levels were recorded. Testing was done in a sound-treated room.

Statistical analysis

Data was analysed using Chi-square and Fisher's exact tests.



Figure 1: OAE testing.

RESULTS

Based on OAE results a total of 99 (94.3%) babies passed the OAE while 6 babies were referred (5.7%).

Table 1: OAE result.

OAE results	No. of patient	Percent (%)	95% CI
Reference	6	5.7	4.37-7.44
Pass	99	94.3	92.55-95.63
Total	105	100	

Table 2: BERA result.

BERA	No. of patient	Percent (%)	95% CI
Fail	9	8.6	6.90-10.60
Pass	96	91.4	84.40-93.10
Total	105	100	

Based on the BERA results a total of 96 (91.4%) babies pass BERA while 9 babies (8.6%) failed the same.

Table 3: Correlation between OAE result with BERA result.

OAE result	No. of babies	BERA result fail	BERA result pass
Refer	6	6	0
Pass	99	3	96
Total	105	9	96

OAE finding are significantly associated with BERA findings with $p < 0.001$.

DISCUSSION

Hearing loss remains a significant yet often overlooked issue in developing countries. It is the most common birth defect, although it is not life-threatening. Early identification and intervention for hearing impairment in neonates are crucial for language and cognitive development. The present study aimed to evaluate hearing in neonates with hyperbilirubinemia using OAE and BERA, as bilirubin toxicity is a known risk factor for auditory dysfunction.

Incidence of hearing loss in neonates with hyperbilirubinemia

In this study, the incidence of hearing loss was found to be 8.6% based on BERA findings, which is significantly higher than the general incidence of 2-4% observed in high-risk infants in developed countries.⁹ This higher incidence could be attributed to factors such as delayed diagnosis, inadequate phototherapy, and limited access to advanced neonatal care in developing settings. Sharma et al has been widely studied on auditory brainstem response in neonatal hyperbilirubinemia and effect of therapy, with some researchers suggesting that bilirubin can cause auditory neuropathy by affecting the cochlear nucleus and auditory nerve.¹¹ However, our study did not find a significant correlation between high bilirubin levels and BERA abnormalities, supporting similar

findings by Mirajkar et al.⁸ This suggests that while hyperbilirubinemia is a risk factor, its impact on hearing may be transient in many cases, and other factors such as genetic predisposition or perinatal insults may play a role.

ABO incompatibility and hyperbilirubinemia

Among the various causes of hyperbilirubinemia, ABO incompatibility was identified as the most common etiology in our study. This finding aligns with the research conducted by Sellouti et al who also reported ABO incompatibility as a leading cause of neonatal jaundice requiring intervention.¹⁰ ABO incompatibility occurs when maternal antibodies cross the placenta and destroy fetal red blood cells, leading to increased bilirubin production. The extent of hemolysis and resulting hyperbilirubinemia can vary, and in severe cases, untreated hyperbilirubinemia may lead to kernicterus, a known cause of auditory dysfunction. Therefore, early screening and management of jaundice in neonates with ABO incompatibility are crucial to prevent long-term complications, including hearing loss.

Comparison of OAE and BERA in neonatal hearing screening

In our study, OAE results showed that 99 (94.3%) neonates passed the test, while 6 (5.7%) were referred. BERA, considered the gold standard for auditory assessment, revealed that 96 (91.4%) babies had normal responses, while 9 (8.6%) failed. The strong association between OAE and BERA findings ($p < 0.001$) supports the validity of OAE as a screening tool. However, OAE had a sensitivity of 66.67% and specificity of 100%, indicating a high false-negative rate. This is consistent with the study by Sanika et al which also found that OAE, while highly specific, had lower sensitivity in detecting hearing loss.¹²

OAE primarily assesses the function of outer hair cells in the cochlea, while BERA evaluates neural conduction along the auditory pathway up to the brainstem. Since bilirubin toxicity can affect the auditory nerve and brainstem more than the cochlea, some neonates with auditory neuropathy may pass the OAE test but fail BERA. This explains the false-negative cases observed in our study. Despite this limitation, OAE remains a valuable screening tool due to its cost-effectiveness, ease of use, and non-invasiveness. It is particularly useful in resource-limited settings where BERA may not be readily available. However, infants who fail OAE should undergo confirmatory testing with BERA to ensure accurate diagnosis.

Clinical implications

Given the significant association between OAE and BERA findings, OAE can be effectively used for initial hearing screening in neonates with hyperbilirubinemia. However, the lower sensitivity of OAE suggests that a

two-step screening approach should be adopted. Infants who fail OAE should be referred for BERA testing to confirm hearing impairment. This approach aligns with the joint committee on infant hearing (JCIH) guidelines, which recommend early screening and follow-up testing for at-risk neonates.¹³

Furthermore, our findings highlight the need for routine bilirubin monitoring and early intervention in neonates with ABO incompatibility to prevent severe hyperbilirubinemia. Phototherapy and exchange transfusion should be initiated promptly in infants with significant jaundice to reduce bilirubin levels and minimize the risk of auditory damage.

Longitudinal follow-up of neonates with hyperbilirubinemia is also essential. Some infants who pass initial hearing screening may develop late-onset auditory dysfunction due to bilirubin deposition in the central nervous system. Therefore, periodic reassessment is recommended, particularly for infants with prolonged or severe hyperbilirubinemia.

Limitations

The limitations of the study were that it was conducted only in one tertiary care center with a small study group and syndromic obesity not excluded.

CONCLUSION

Our study found no significant correlation between high bilirubin levels and BERA abnormalities, indicating that ABR abnormalities from bilirubin toxicity are likely transient. ABO incompatibility was identified as the most common cause of hyperbilirubinemia. While the OAE test showed a sensitivity of 66.67%, it remains a valuable screening tool due to its cost-effectiveness and ease of administration. This study highlights the importance of OAE as an initial screening method. When repeated as necessary and combined with BERA for cases that fail, OAE serves as an effective approach for detecting hearing loss.

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