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Association between mode of delivery and failure of neonatal acoustic emission test: A retrospective analysis

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ABSTRACT

Background: Infants born by cesarean delivery (CD) appear to fail the otoacoustic emission (OAE) test more frequently than infants delivered vaginally (VD).
Objective: The present study aimed to evaluate the influence of CD on failure to the OAE test in Chinese infants.
Methods: In this retrospective study, 1460 Chinese infants were included. The OAE test was performed before hospital discharge. Modes of delivery, test time and OAE results were collected and analyzed.
Results: Compared with VD infants, CD infants had lower gestational age (week), were smaller for their gestational age (SGA), and presented a lower 1-min Apgar score and a younger age at first OAE. On multivariate analysis, CD and age at first OAE were significantly associated with failed OAE (both $P < 0.001$). CD infants had a 3-fold higher rate of failure to the OAE test compared with VD infants (21% vs. 7.1%). The results of the OAE test changed with different test time regardless of the mode of delivery, and the neonatal OAE test failure rate decreased with time. The difference was not significant between CD and VD infants 42 h or more after delivery.
Conclusion: CD infants had significantly higher failure rates on first OAE test. Results suggest that the OAE test should be performed 42 h after delivery so as to minimize repetition of OAE, improve the OAE test pass rate, and minimize costs and parents' anxiety.

Introduction

The hearing screening procedures for newborns and infants are simple and painless, and can be performed while the infant is resting quietly. The two most common screening methods used with infants are otoacoustic emissions (OAEs) and automated auditory brainstem response (AABR). These equipments can detect hearing loss averaging 30 to 40 decibels (dB) [1]. Each year, approximately 5000 infants are born in the United States with moderate-to-severe bilateral permanent hearing loss [2], while this number climbs to a frightening 1500,000 in a highly populated and developing country such as India [3]. Hearing loss can contribute to difficulties with attention, learning, and social function [2,4].

The incidence rate of neonatal hearing impairment is reported to be between 0.1% and 0.3% [5]. Hence, hearing screening is of great importance for early diagnosis of neonatal hearing impairments. There are many factors associated with failure of hearing screening in newborn infants. These factors include familial deafness, malformations of face/auricle, secretions in external ear canal [6], middle ear effusion [6], epidural anesthesia in cesarean delivery (CD) births [7], vaginal delivery (VD) [8,9], emergency CD [8], 5-min Apgar score of <5 [8], need for intensive care, significant hyperbilirubinemia [8,9], and OAE performed before 24 h of age [10]. Moreover, OAE test time after delivery also plays an important role in the failure of hearing screening in infants, which actually varies from 12 h to >48 h after live birth of infants. In a previous report, it was suggested that delaying newborn hearing screening improves the OAE test results, but it may not be practical in all contexts [11]. The use of higher frequencies and more sophisticated OAE devices may be useful approaches to ensure better performance of the OAE test in newborn hearing screening [11].

Recently, an observational retrospective study has reported that the infants born by CD had a higher OAE test failure rate than those delivered vaginally [12]. As a result, repeated hearing screenings were performed for such infants, increasing the medical costs, anxiety, and mental stress among parents of these infants [12]. Hence, it is vital to isolate and categorize factors that may influence the success or failure of newborn hearing screening tests.

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Moreover, the influence of CD on OAE test results has not been studied yet in newborn infants in China.

The present study aimed to evaluate the impact of different delivery modes on the results of the first OAE test. The OAE test results of 1460 Chinese infants were retrospectively analyzed.

Subjects and methods

Subjects

Neonates ($n = 1460$) born between July 2010 and September 2011 at the Obstetrics Department of the First Affiliated Hospital of Harbin Medical University, China, were selected for this retrospective analysis. In our hospital, infants born vaginally are generally discharged 24 to 48 h after birth, whereas those born by CD are discharged on the third day of age. Exclusion criteria were: (1) familial deafness; (2) facial/ear deformities; (3) requirement for intensive care; (4) significant hyperbilirubinemia; (5) OAE performed within 12 h after birth; (6) major congenital malformations or chromosomal aberrations; (7) congenital cytomegalovirus (CMV) infection (congenital CMV test was positive in urine culture); (8) significant congenital hearing losses [abnormal results of OAE and AABR tests found in one or both ears later in life]; (9) mother with histories of influenza infection, diabetes, threatened abortion, smoking, placenta previa, or poison exposure during pregnancy; or (10) infants exposed to risk factors such as hypoxia, asphyxia, amniotic fluid turbidity, and oligohydramnios [6–10]. This study had been approved by the Ethics Committee of the First Affiliated Hospital of Harbin Medical University, China.

OAE test

The OAE test was conducted using the hand-held newborn hearing screening instrument (AccuScreen, MADSEN, Denmark). The test was conducted when the infants were under a resting state (usually at sleeping state) in a noise environment of 40–50 dB. When a "Pass" signal appeared on the otoacoustic emission instrument, it indicated the infant had passed the test, while a "Refer" signal otherwise indicated a failure. The screening was performed 14 to 125 h after delivery.

Data collection

General condition of the newborn, perinatal and neonatal period, mode of delivery, gestational age at the time of delivery, birth weight of newborns, Apgar scores (1- and 5-min), and age at the first OAE were collected and retrospectively analyzed.

Statistical analysis

Statistical analysis was performed using SPSS 18.0 (SPSS Inc., Chicago, IL, USA). Data are expressed as means ± standard derivation. Comparison between the two groups was performed using independent-sample *t*-tests. Pearson Chi-square tests were used to compare qualitative data. Univariate and logistic multivariate analysis were performed to evaluate the associated factors for failure to first OAE. All variables with a *P* value of ≤0.1 in the univariate analysis were selected as candidates for the multivariate analysis model. A *P*-value ≤0.05 was considered statistically significant.

Results

Among the 1460 infants, 1037 infants were born by VD and 423 by CD. All infants were born at the gestational age of 35 to 42 weeks, weighing between 2015 g and 4530 g. Perinatal and neonatal variables between infants born by VD vs. CD are shown in Table 1. Compared with VD infants, those born by CD had significantly lower gestational age (39.3 vs. 38.0; $P < 0.001$), lower 1-min Apgar score (9 vs. 8; $P < 0.001$), more small for gestational age (SGA) status ($P < 0.001$), and earlier age of first OAE performance (31.9 vs. 29.0; $P < 0.001$). The 5-min Apgar score was not different between the two groups ($P = 0.277$).

As shown in Table 2, CD delivery, male gender, gestational age, SGA status, and earlier age at first OAE were significantly associated with failure to first OAE. Failure to first OAE was 3-fold higher in CD infants (21%) compared with VD infants (7.1%) ($P < 0.001$). The results of the OAE test changed with different test time regardless of the mode of delivery, and the neonatal OAE test failure rate decreased with time. Of note is the markedly high failure rate (45.4%) when OAE was performed before 24.9 h of age. Birth weight, Apgar scores at 1 and 5 min were not significantly associated with failure on first OAE ($P > 0.05$).

In multivariate analysis, failure on first OAE was considered as dependent variable, whereas mode of delivery, gender, gestational age, SAG, and age at first OAE were considered as independent variables. As shown in Table 3, among the tested independent variables, mode of delivery (OR: 0.332; 95% CI: 0.236–0.467; $P < 0.001$) and age at first OAE (OR: 0.614; 95% CI: 0.529–0.712; $P < 0.001$) were significantly associated with failure on first OAE.

Although the overall OAE test failure rates had decreased as the testing time was delayed, failure rate of the CD infants was consistently higher than that of the VD infants at the same period, especially for the 12–24-h period after delivery, during which the failure rate of the CD infants was up to 43.16%. Significant differences in OAE test failure rates were found at 12–24.9-, 25–29.9-, 30–35.9-, 36–41.9-h after delivery between the two delivery modes ($P < 0.001$, $P = 0.001$ $P = 0.021$ and $P = 0.005$, respectively). The difference was not significant between CD and VD infants for those with the OAE performed at 42–47.9 h ($P = 0.483$) or >48 h after delivery ($P = 0.123$) (Table 4).

Repeated OAE tests were performed for those infants who failed the first OAE test (Table 5). The failure rates on the second OAE test were still higher in CD infants even though performed at older ages than in VD infants. Of the 1460 infants in the study, 10 were referred for AABR (two VD infants and eight CD infants). Of these 10 infants, five had normal hearing, two did not attend follow-up, and three were confirmed with hearing loss.

Table 1
Comparison of perinatal and neonatal characteristics between the two groups.

Variable	Vaginal group ($n = 1037$)	Cesarean group ($n = 423$)	*P*-value
Male gender, *n* (%)	525 (50.6)	238 (56.3)	0.050
Gestational age (wk), *n* (%)	39.3 (35,40.3)	38 (35,42)	<0.001
35–37	51 (4.9)	38 (9.0)	
37.1–40	986 (95.1)	382 (90.3)	
>40	0 (0.0)	3 (0.7)	
Birth weight (g), *n* (%)	3456 (2015,4500)	3302 (2030,4530)	0.002
<2500	35 (3.4)	26 (6.1)	
2500–3000	230 (22.2)	122 (28.9)	
3001–3500	458 (44.2)	145 (34.3)	
3501–4000	265 (25.5)	91 (21.5)	
>4000	49 (4.7)	39 (9.2)	
Apgar, 1-min, *n* (%)	9 (2,10)	8 (3,10)	<0.001
Apgar, 5-min, *n* (%)	10 (8,10)	10 (6,10)	0.277
SGA, *n* (%)	26 (6.1)	35 (3.4)	0.016
Age at first OAE, h, *n* (%)	31.9 (14,125)	29.0 (19,99)	<0.001
12–24.9	194 (18.7)	95 (22.4)	
25–29.9	260 (25.1)	172 (40.7)	
30–35.9	218 (21.0)	52 (12.3)	
36–41.9	227 (21.9)	52 (12.3)	
42–47.9	44 (4.2)	17 (4.0)	
≥48	94 (9.1)	35 (8.3)	