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Examination of the Relationship between Umbilical Cord Blood Gas Values and Hearing Function in Neonates

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Original Investigation

Abstract

Objective: The aim of the present study was to examine the relationship between the results of the transient otoacoustic emission (TEOAE) test used in neonatal hearing screening and the results of the umbilical cord blood (UCB) analysis in neonates.

Methods: This retrospective study included 209 neonates born in the obstetric unit at the 37th gestational week. Based on the results of the TEOAE test, the neonates included in the study were divided into two groups as the study group composed of those "REFER" (n=141) and the control group consisting those "PASS" (n=68) the test. The UCB sampling procedure was performed on all neonates. In the blood samples, the pH parameters were evaluated by using glass electrodes, and the pCO_2 and pO_2 parameters were evaluated directly by using sensitive electrodes.

Results: When the additional maternal diseases were compared with the TEOAE results, the ratio of hypothyroidism was found to be statistically higher in the study group ($p<0.05$). In terms of the pO_2, pCO_2, HCO_3, and pH values obtained as a result of analyzing the UCB samples, there was no statistically significant difference between the groups ($p>0.05$).

Conclusion: The results of the present study showed that there was no statistically significant difference between the results of UCB analysis and the TEOAE test. However, we believe that conducting a larger study evaluating other parameters and employing UCB analysis would be useful, and UCB evaluation, which is an inexpensive, easy and effective method in determining hypoxia in neonates, might be a significant marker in cases at risk of hearing loss.

Keywords: Hearing loss, hypoxia, umbilical cord blood, otoacoustic emission

Introduction

The prevalence of congenital sensorineural hearing loss (SNHL) is 0.5-5/1000 in neonates. This rate is higher in developing countries (1). Thus, SNHL is one of the most common congenital neurological birth defects (2). Congenital hearing loss negatively impacts the physical and social development of affected children; therefore, it is an economic burden on health-care. For this reason, it is important to diagnose hearing loss in neonates as soon as possible. In Turkey, neonatal hearing screening was first performed by Hacettepe University and Marmara University. Since 2000, it has been widely used (3). Hearing screening starts with the transient otoacoustic emission (TEOAE) test, performed during the first 2-3 days of life, and all newborns are also analyzed for audiological risk factors (4, 5).

Umbilical cord gas analysis yields important information on well being during the peripartum period and then the neurological development afterwards. Today, umbilical cord gas analysis is suggested in high-risk pregnancies and in all deliveries at some centers (6). In early treatment approaches, evaluation of umbilical artery and vein blood gas analysis together with Apgar scoring has gained importance. Umbilical cord blood (UCB) obtained during delivery has long been known to be an objective indicator of the fetal acid-base balance (7).

In 1958, James et al. (8) found that UCB gas could be an indication of preceding fetal hypoxic stress. There are many causes of hearing loss including genetic, vascular injury, trauma, infections, or autoimmune response. All these factors could affect cochlear microcirculation by causing hypoxia and damage in cochlear hair cells and neurons. Despite

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few data available at present, hypoxia could underlie the etiology of deafness (9). Mwaniki et al. (10) reported that hypoxia could lead to hearing loss in newborns.

Most of the studies reporting the results of neonatal hearing screenings examine the demographic characteristics, clinical features, and various genetic risk factors. Our literature review did not reveal any study comparing the results of neonatal hearing screening and UCB. The aim of the present study was to assess the relationship between the results of UCB analysis and the transient otoacoustic emission (TEOAE) test for hearing screening in neonates.

Methods

Study group and design

This retrospective case-controlled study was conducted at Cumhuriyet University Hospital between January 2014 and September 2015. All the patients were informed about the TEOAE test and examination process, and informed consent was obtained from the parents of the participants. This study included 209 neonates born in the obstetric unit at the 37th week of gestation. Based on the results of the TEOAE test, the newborns included in the study were classified into two groups as the study group including those "REFER" (n=141) and the control group including those "PASS" (n=68) the test. Since the cases, whose all data examined can be accessed, were included in the study, the study group consisted of more cases than the control group. Under normal conditions, the number of cases passed from the TEOAE test was considerably higher than the cases failing the test.

Congenital malformation, maternal clinical infection, and the presence of chorioamnionitis were determined as the exclusion criteria.

All the subjects in the study underwent a detailed ear, nose, and throat examination by the same investigator (KD). In our clinic, TEOAE tests are routinely applied to all the neonates within 24-48 hours after birth. In order to ensure that the test results were not affected by conditions such as wax or occlusion/obstruction/collapse of the external auditory canal, an otoscopic examination was carried out prior to testing. Then the TEOAE test was performed in all cases. The screening procedure was conducted at a sound-treated room or in a quiet room close to the department. A commercial device (Maico, ERO Scan Analyzer, GmbH Salzufer, 13/14, 10587, Berlin GE) was used in TEAOE testing and analysis.

Disposable ear tips were used to cover the probe and seal them snugly in the ear canal during testing. When the test was completed, the results displayed on the screen as "PASS" when there was a TEOAE response and "REFER" when there was no response to a stimulus. When a "REFER" result was obtained, the screening test was repeated. The infants who failed TEOAE test were screened once again with otoacoustic emissions and were examined by means of auditory brainstem response (ABR) method. The 3-month-old infants failed from TEOAE test for the second time were excluded from this study.

All the neonates included in the study were evaluated in terms of maternal age, gravidity, and parity as well as sociodemographic data such as delivery method, maternal chronic hypertension, type 2 diabetes mellitus, the presence of hypothyroidism and preeclampsia, intrauterine growth retardation, oligohydramnios, polyhydramnios, and macrosomia.

At our instution, obtaining UCB samples is a routine procedure. Similarly, by using the same method, blood samples were taken from all of the 209 neonates included in the present study. When the cord of the baby was clamped, the UCB sampling procedure was performed. UCB was collected by two doctors (CY, AC) who had equal ability and experience in UCB sampling. Approximately 10 cm of the umbilical cord was clamped and the blood sample was collected by using heparinized blood syringes. The blood gas analysis was performed by using the same device (Radiometer ABL 800 basic, Copenhagen, Denmark) in 15 minutes at the latest. In the blood samples, the pH parameter was evaluated by using glass electrode and pCO_2 and pO_2 parameters while CO_2 and O_2 were evaluated directly by using sensitive electrodes. HCO_3 was calculated based on the Hasselbach equation (11).

The Human Ethics Committee of Cumhuriyet University approved this study in accordance with the Declaration of Helsinki.

Statistical analysis

The data were analyzed by using the Statistical Package for the Social Sciences 22.0 for (IBM Corp.; Armonk, NY, USA). Descriptive statistics were calculated in order to understand the data set (average, standard deviation, min-max, etc.) in the study. Data normality of the variables was verified by using the Kolmogorov-Smirnov test, and it was understood that parametric tests were suitable for the results. Thus, an independent samples t-test was used for continuous data. Differences between categorical variables were analyzed by using the chi-square test. A p-value of less than 0.05 was considered statistically significant.

Results

In the present retrospective case-controlled study, a total of 209 (n=112, 53% female; n=97, 47% male) neonates were enrolled. While the study group consisted of 141 (n=76, 54% female; n=65, 46% male) neonates, the control group consisted of 68 (n=36, 53% female; n=32, 53% male) neonates. The groups were similar in terms of age and gender (p>0.005)

When the groups were compared in terms of maternal age, gravidity, and parity, there was no statistically significant difference between the groups and the groups were homogenous (p>0.005).

Table 1 shows the delivery methods, additional maternal diseases, and pregnancy complications of the cases. When the ad-

ditional maternal diseases and TEOAE results were compared, hypothyroidism was found to be statistically significantly higher in the study group ($p<0.05$).

There was no difference between the groups in terms of delivery methods and pregnancy complications ($p<0.05$).

Table 2 shows the results of the UCB sample analysis of the neonates included in the study. There was no statistically significant difference between the groups in terms of the pO_2, pCO_2, HCO_3, and pH values obtained in UCB sample analyses ($p>0.05$) (Figure 1, 2).

Discussion

The aim of this study was to examine whether or not there was a relationship between the results of the TEOAE test and UCB analysis used in hearing screening in newborns. The results of the present study showed that there was no statistical difference between the results of UCB analysis and the TEOAE test in the study group and the control group.

Table 1. Delivery method, additional maternal diseases, and pregnancy complications

Variable	Study group (n=141)	Control group (n=68)	p
Delivery method			0.430
Vaginal	27 (73.0%)	10 (27.0%)	
C-section	114 (66.3%)	58 (33.7%)	
Additional maternal diseases			0.192
Hypertension	7 (5.5%)	4 (6.0%)	0.366
Diabetes mellitus	12 (9.4 %)	9 (13.4%)	0.513
Preeclampsia	8 (6.3%)	8 (11.9%)	1.000
Hypothyroidism	11 (8.6%)	1 (1.5%)	0.004
Pregnancy complication			0.230
IUGR	9 (6.9%)	4 (6.0%)	0.166
Oligohydramnios	10 (7.7%)	8 (11.9%)	0.637
Polyhydramnios	5 (3.8%)	0	-
Macrosomia	5 (3.8%)	1 (1.5%)	0.102

IUGR: intrauterine growth retardation; C-section: cesarean section

Table 2. Results of UCB sample analysis of neonates according to the TEOAE test

Variable	Study group (n=141) Mean±SD	Control group (n=68) Mean±SD	p
pO_2	29.9±7.8	29.0±7.2	0.605
pCO_2	37.15±4.84	37.95±5.43	0.295
HCO_3	20.8±2.1	20.8±2.6	0.896
pH	7.37±0.030	7.36±0.027	0.089

pO_2: pressure of oxygen; pCO_2: pressure of carbon dioxide; HCO_3: bicarbonate

Apgar scoring is a classical method used to rapidly evaluate the clinical status of a newborn (12). Although it has been used for years, it is known that Apgar scoring alone is not a sufficient parameter in identifying asphyxia in newborns. In addition to all the novel methods, evaluation of umbilical cord gases, Apgar score, seizure, and multiorgan status is still the most frequently used method (12). UCB analysis used in evaluating the acid-base status of a newborn has started to be used widely in recent years (12).

Premature birth (gestational age ≤34 weeks), children from hearing-impaired families, neurological disorders, low birth weight (<1500 g), TORCH infections, hyperbilirubinemia, craniofacial

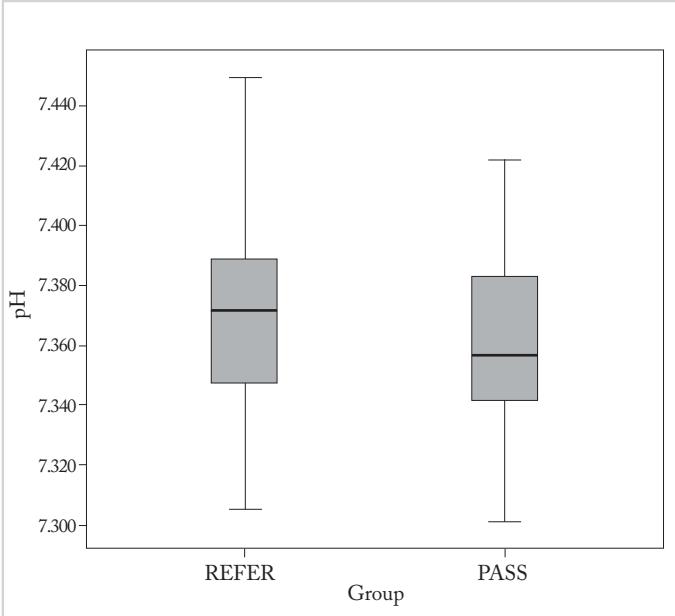

Figure 1. Cord blood gas pH values of those who "PASS" and "REFER" the TEOAE test

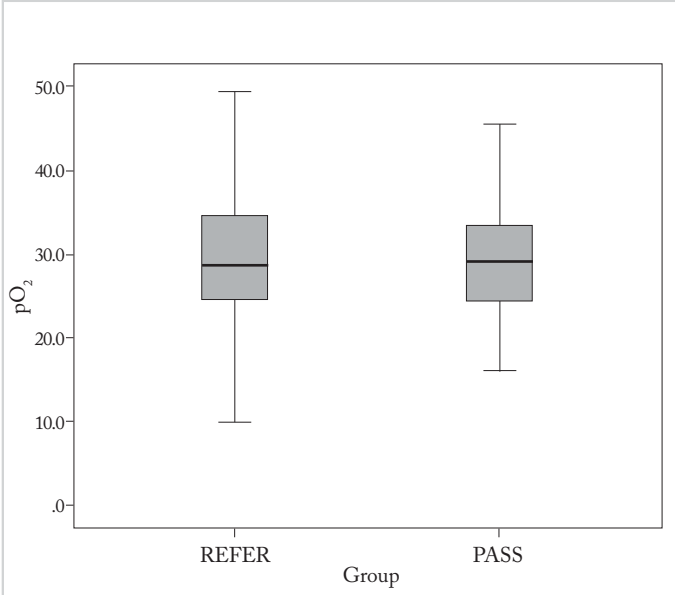

Figure 2. Cord blood gas pO_2 values of those who "PASS" and "REFER" the TEOAE test

anomalies, syndromes known to be associated with hearing loss, and severe birth asphyxia (Apgar score <7 at five minutes) are among the risk factors of hearing loss in neonates (13). It has been long known that hypoxia may have a role in the etiology of hearing loss in neonates.

In our review of the literature, the first one we encountered was the study by Höing (14), in which the histopathological changes in the temporal bones of fetuses who died of chronic asphyxia were shown for the first time. Sohmer et al. (15) reported in 1994 that there could be a relationship between intrauterine hypoxia and hearing loss in neonates.

In an animal study, Sohmer and Freeman (16) examined the hypothesis that fetal sensorineural hearing loss is due to oxygen loss, and their results supported the hypothesis that fetal hypoxia could lead to hearing loss. In a 1995 study on the functional development of auditory sensitivity in the fetus and neonate, Sohmer and Freeman (17) pointed out that a fetus has less oxygen than a newborn during the intrauterine period. This could lead to hypoxia-induced hearing loss, and the increased oxygen content upon birth and transition from placenta to pulmonary oxygenation could enhance auditory sensitivity.

Whether or not there is a relationship between hypoxia and hearing disturbances has been a matter of concern. The relationship between hypoxia and the alteration of the ABR in fetuses has not been clearly known yet. Nishioka et al. (18) examined the influence of hypoxia on the fetal auditory system by analyzing the changes of the ABR, the middle latency response (MLR), and other physiological parameters of fetal goats during extrauterine incubation. A goat fetus can be incubated via an extrauterine incubation system by employing arteriovenous extracorporeal membrane oxygenation in an artificial womb for three weeks (19). Nishioka et al. (18) observed an elongation of latency and decrease in the amplitude of the ABR and MLR waves during hypoxia in fetal goats, which suggested that hypoxia itself affects the auditory system of the fetus.

In adults, hypoxia may frequently lead to damage in the brain but not in the inner ear. Damage in the inner ear is observed in neonates who have hypoxia with inadequate blood supply to inner ear and this may lead to hearing loss and equilibrium disorders. Asphyxiated neonates may have sensorineural hearing impairment at high frequencies (20). Damage to the central nervous system in neonates can be caused by anoxia and hypoxia (21, 22). However, the influence of neonatal asphyxia on the inner ear of the neonate has been reported only by a limited number of authors (23). Koyama et al. (20) have shown that hypoxia and asphyxia may affect the inner ear and balance in neonates.

Conclusion

Consequently, the above-mentioned studies have emphasized that there could be a relationship between hypoxia and hearing loss. The aim of this study was to show the relationship between hypoxia and hearing loss by comparing the results of UCB analysis, regarded as an important marker of intrauterine and birth hypoxia, and the results of the TEOAE test. However, in the present study, the results obtained in UCB analysis showed that there was no statistically significant difference between pO_2, pCO_2, HCO_3, and pH values of those who "PASS" and "REFER" the TEOAE test. We believe that it would be beneficial to conduct a study evaluating other parameters employed in UCB analysis and including larger series. Because UCB analysis is a cost-effective, easy, and effective method in determining hypoxia in neonates, which could be an important indicator in newborns who are at risk of hearing loss.

Ethics Committee Approval: Ethics committee approval was received for this study from the Human Ethics Committee of Cumhuriyet University (Decision no: 2015-12/02; date: 23.12.2015).

Informed Consent: Written informed consent was obtained from the parents of the patients who participated in this study.

Peer-review: Externally peer-reviewed.

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References

1. Cavalcanti HG, Melo LP, Buarque LF, Guerra RO. Overview of newborn hearing screening programs in Brazilian maternity hospitals. Braz J Otorhinolaryngol 2014; 80: 346-53. [CrossRef]
2. Choo D, Meinzen-Derr J. Universal newborn hearing screening in 2010. Curr Opin Otolaryngol Head Neck Surg 2010; 18: 399-404. [CrossRef]
3. Bolat H, Bebitoglu FG, Ozbas S, Altunsu AT, Kose MR. National newborn hearing screening program in Turkey: struggles and implementations between 2004 and 2008. Int J Pediatr Otorhinolaryngol 2009; 73: 1621-3. [CrossRef]
4. Karaca CT, Oysu C, Toros SZ, Naiboğlu B, Verim A. Is hearing loss in infants associated with risk factors? Evaluation of the frequency of risk factors. Clin Exp Otorhinolaryngol 2014; 7: 260-3. [CrossRef]
5. Okhakhu AL, Ibekwe TS, Sadoh AS, Ogisi FO. Neonatal hearing screening in Benin City. Int J Pediatr Otorhinolaryngol 2010; 74: 1323-16. [CrossRef]
6. Ahmadpour-Kacho M, Zahedpasha Y, Hagshenas M, Akbarian Rad Z, Sadat Nasseri B, Bijani A. Short term outcome of neonates born with abnormal umbilical cord arterial blood gases. Iran J Pediatr 2015; 25: e174. [CrossRef]
7. Westgate JA, Garibaldi JM, Grene KR. Umbilical cord blood gas analysis at delivery: a time for quality data. Br J Obstet Gynaecol 1994; 101: 1054-63. [CrossRef]
8. James L S, Weisbrot I M, Prince CE Holaday DA, Apgar V. The acid-base status of human infants in relation to birth asphyxia and the onset of respiration. J Pediatr 1958; 52: 379-94. [CrossRef]

9. Olivetto E, Simoni E, Guaran V, Astolfi L, Martini A. Sensorineural hearing loss and ischemic injury: Development of animal models to assess vascular and oxidative effects. Hear Res 2015; 327: 58-68. [CrossRef]
10. Mwaniki MK, Atieno M, Lawn JE, Newton CR. Long-term neuro developmental outcomes after intrauterine and neonatal insults: a systematic review. Lancet 2012; 379: 445-52. [CrossRef]
11. Kim Y, Massie L, Murata GH, Tzamaloukas AH. Discrepancy between Measured Serum Total Carbon Dioxide Content and Bicarbonate Concentration Calculated from Arterial Blood Gases. Cureus 2015; 7: e398. [CrossRef]
12. Thorpe JA, Sampson JE, Parisi VM, Creasy RK. Routine umblical cord blood gas determinations. Am J Obstet Gynecol 1989; 161: 600-5. [CrossRef]
13. Ohl C, Dornier L, Czajka C, Chobaut JC, Tavernier L. Newborn hearing screening on infants at risk. Int J Pediatr Otorhinolaryngol 2009; 73: 1691-5. [CrossRef]
14. Höing R. Inner ear changes in fetal asphyxia. Laryngorhinootologie 1991; 70: 72-7. [CrossRef]
15. Sohmer H, Geal-Dor M, Weinstein D. Human fetal auditory threshold improvement during maternal oxygen respiration. Hear Res 1994; 75: 145-50. [CrossRef]
16. Sohmer H, Freeman S. Hypoxia induced hearing loss in animal models of the fetus in-utero. Hear Res 1991; 55: 92-7. [CrossRef]
17. Sohmer H, Freeman S. Functional development of auditory sensitivity in the fetus and neonate. J Basic Clin Physiol Pharmacol 1995; 6: 95-108. [CrossRef]
18. Nishioka N, Nishina H, Yoshida K, Kinoshita K, Ehara Y. Effect of hypoxia on the auditory system of goat fetuses during extrauterine incubation. J Obstet Gynaecol Res 2003; 29: 109-14. [CrossRef]
19. Kuwabara Y, Okai T, Imanishi Y, Muronosono E, Kozuma S, Takeda S, et al. Development of extrauterine fetal incubation system using extracorporeal membrane oxygenator. Artif Organs 1987; 11: 224-7. [CrossRef]
20. Koyama S, Kaga K, Sakata H, Iino Y, Kodera K. Pathological findings in the temporal bone of newborn infants with neonatal asphyxia. Acta Otolaryngol 2005; 125: 1028-32. [CrossRef]
21. Souza SWD, McCartney E, Nolan M, Taylor IG. Hearing, speech, and language in survivors of severe perinatal asphyxia. Arch Dis Child 1981; 56: 245-52. [CrossRef]
22. Kaga K, Ichimura A, Kitazumi E, Kodama K, Tamai F. Auditory brainstem responses in infants and children with anoxic brain damage due to near-suffocation or near- drowning. Int J Pediatr Otorhinolaryngol 1996; 36: 231-9. [CrossRef]
23. Amatuzzi MG, Northrop C, Libermann C, Thornton A, Halpin C, Herrmann B, et al. Selective inner hair cell loss in premature infants and cochlea pathological patterns from neonatal intensive care unit autopsies. Arch Otolaryngol 2001; 127: 629-36. [CrossRef]