

The relationship between umbilical cord blood pH and cardiac findings in neonates admitted to neonatal intensive care unit

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ABSTRACT

Background: Determining the umbilical cord blood pH can be used for predicting of different serious damages in neonates. This study aimed to examine the relationship between umbilical cord pH and neonatal cardiac findings.

Methods: In this descriptive cross-sectional study, 600 neonates (52.7% boys and 47.3% girls) who admitted to the NICU of Akbarabadi Hospital were considered. Umbilical cord pH was measured immediately after the birth and the basic demographic and clinical data of newborns were recorded. Echocardiography was performed for all infants and the relationship between umbilical cord pH and echocardiographic findings was assessed.

Results: The mean of umbilical cord pH in male and female neonates was 7.28 and 7.24, respectively ($p = 0.004$). Decreased gestational age ($p = 0.003$), birth weight ($p < 0.001$), Apgar scores ($p < 0.001$) and hypotension ($p < 0.001$) were significantly associated with umbilical cord blood acidosis. The mean of umbilical cord pH in single and twin infants was 7.26 and 7.22, respectively ($p = 0.026$). The mean of umbilical cord pH in neonates without pulmonary support was significantly higher than neonates with pulmonary support (7.34 vs 7.23; $p < 0.001$). Decreased umbilical cord pH was significantly associated with patent ductus arteriosus ($p < 0.001$), mitral regurgitation ($p = 0.006$) and pulmonary arterial hypertension ($p < 0.001$). A significant trend was observed for lower mean cord blood pH value in newborns with PFO than subjects without PFO (7.25 ± 0.11 vs 7.29 ± 0.06 ; $p = 0.003$).

Conclusion: Decreased umbilical cord pH can be considered as an important risk factor for developing heart failures in newborns.

Keywords: umbilical cord blood pH, cardiac findings, neonates, NICU

Introduction

Cord-blood metabolic acidosis is a condition in which umbilical cord blood pH and base excess is decreased. It is considered as one of the most important factors affecting the development and health of newborns (1). Recent evidence has revealed that an umbilical cord pH ≤ 7 significantly increases the risk of neonatal mortality and neurological damages. An umbilical cord blood pH ≤ 6.8 significantly enhances the probability of neonatal death by 1400 times (2). Perinatal asphyxia is a major cause of hypoxia, respiratory acidosis during labor and birth and consequently neonatal death (3). If hypoxia is prolonged, anaerobic metabolism results in lactic acidosis (4), and other serious adverse effects such as neurological disorders (5), hypoxic-ischaemic encephalopathy (6), seizures (7), delayed development (8) and cerebral palsy (9) in newborns. Therefore, measurement of asphyxia is critical to prevent the

adverse effects of acidosis on health of newborns. Determination of umbilical blood pH and PCO_2 is

extremely useful tool for the diagnosis of birth asphyxia and different abnormalities in newborns (10). Its analysis can provide important information about the past, present and possibly the future condition of the infant.

Since cord-blood metabolic acidosis caused by asphyxia may have adverse effects on neonatal health, a growing number of studies have been focused to examine the relationship between umbilical cord pH changes and involvement of various organs in newborns. Recent studies have found an association between decreased cord blood pH and the incidence of heart failures in neonates. Umbilical cord blood acidosis has been suggested to be correlated to cardiac

findings, including pulmonary arterial hypertension (PAH), mitral regurgitation (MR), tricuspid regurgitation (TR), myocardial ischemia (MI), and patent ductus arteriosus (PDA) (11-13). However, there are very limited studies that examined the effect of umbilical cord blood acidosis on neonatal cardiac findings. For this reason, cardiac findings in infants with asphyxia have received less attention in medical centers. Due to the importance of umbilical cord blood pH, we designed this study to investigate the relationship between umbilical cord blood pH and cardiac findings in neonates who admitted to neonatal intensive care unit (NICU) at Akbarabadi Hospital (Tehran, Iran).

Methods

Patients

In this case-control study, all newborns who admitted at NICU in Akbar-Abadi Hospital (Tehran, Iran) during 2019-2020 were entered into the study. The study was approved by the Ethics Committee of Iran University of Medical Sciences. All parents signed a consent letter before the study. Umbilical cord blood pH was measured immediately after the birth. A checklist was provided in which information on basic demographic and clinical data of all neonates such as gestational age, sex, birth weight, type of delivery, Apgar scores, duration of admission at NICU, need of mechanical ventilation, respiratory support, and mother's underlying diseases were recorded. Neonates with identified sepsis were excluded from the study. Echocardiography was performed for all selected neonates and parameters such as patent ductus arteriosus (PDA), pulmonary arterial hypertension (PAH), heart rate (HR), systolic and diastolic pressures, tricuspid regurgitation (TR), and patent foramen ovale (PFO) were evaluated. Eventually, the relationship between umbilical cord blood pH with basic demographic and echocardiographic findings in neonates was evaluated.

Statistical analysis

All data were analyzed by SPSS software (IBM, version 19). Quantitative data was presented as Mean \pm SD. Chi-Square test was used to compare the percentage or frequencies of qualitative data between two groups. Comparison of the mean of parametric data between two groups was analyzed using independent student sample-t test. Pearson correlation test was used to examine the relationship between quantitative variables, while Spearman correlation test was used to evaluate the association between two ranked variables. A linear regression model was performed to consider the effect of independent variables on dependent

parameters. In this study, $p < 0.05$ was considered statistically significant.

Results

The basic demographic and clinical data of all neonates are shown in Table 1. In total, 600 neonates (52.7% boys and 47.3% girls) with a mean gestational age of 34.26 ± 18.01 weeks and birth weight of 2117.34 ± 915.39 g were entered into the study. More than half of the neonates (76.7%) were born by cesarean method. There was no significant difference in the mean of gestational age between boys and girls (34.96 ± 24.54 weeks vs 33.47 ± 3.96 weeks; $p=0.47$).

The mean of umbilical cord blood pH in all patients was 7.26 ± 0.1 . The frequency of newborns with asphyxia, acidic and normal umbilical cord blood pH was 24% ($n=144$), 32.3% ($n=194$) and 43.7% ($n=262$), respectively. A significant correlation was found between umbilical cord blood pH with gender, gestational age, birth weight, Apgar scores, and number of babies. The mean of umbilical cord blood pH in boys was significantly lower than girls (7.24 ± 0.11 vs 7.28 ± 0.09 ; $p=0.004$). Decreased gestational age ($p=0.003$; Fig. 1), birth weight ($p<0.001$; Fig. 2), Apgar 1 ($p<0.001$; Fig. 3) and Apgar 5 ($p<0.001$; Fig. 4) scores were significantly associated with a decrease in umbilical cord blood pH. The mean of umbilical cord blood pH in twin neonates was significantly lower compared to single newborns (7.22 ± 0.06 vs 7.26 ± 0.1 ; $p=0.026$). Neonates with respiratory supports exhibited lower umbilical cord blood pH than those without respiratory supports (7.23 ± 0.1 vs 7.34 ± 0.05 ; $p<0.001$).

78.8% (504 neonates) exhibited positive cardiac findings. TR (35.3%), PFO (30.9%), PDA (29.1%), and PAH (6.3%) were the most common cardiac findings in newborns. The relationship between umbilical cord blood pH and cardiac findings is shown in Table 2. Neonates who had positive cardiac findings under echocardiography exhibited lower cord blood pH value than those without cardiac findings (7.24 ± 0.1 vs 7.33 ± 0.07 ; $p<0.001$). Neonates with hypotension showed lower cord blood pH value compared to those with normal blood pressure (7.14 ± 0.11 vs 7.29 ± 0.07 ; $p<0.001$). A significant trend was observed for lower mean cord blood pH value in newborns with PFO than subjects without PFO (7.25 ± 0.11 vs 7.29 ± 0.06 ; $p=0.003$). The mean value of cord blood pH in neonates with PDA and PAH was significantly lower than newborns without these abnormalities ($p<0.001$).

Discussion

In this study, we considered the relationship between umbilical cord blood pH and the prevalence of cardiac findings in neonates admitted to NICU. Our data revealed that decreased gestational age, birth weight, and Apgar scores were the associated risk factors for reducing umbilical cord blood pH in newborns. Rezaei *et al.*, (14) showed that the umbilical cord blood pH was significantly associated with Apgar scores. Another study reported that a decrease in Apgar scores is significantly associated with reduced umbilical cord blood pH (15). Furthermore, we found that the probability of decreased umbilical cord blood pH in twin babies and male neonates was significantly high. Similarly, Akbarian *et al.*, (16) showed that umbilical cord blood acidosis is higher in multiple births. We also found that neonates under mechanical ventilation had significantly lower umbilical cord blood pH than those without needing of respiratory support. Therefore, these data indicate that parameters such as gestational age, gender, number of births, birth weight, Apgar scores and needing of mechanical ventilation are important risk factors for decreased umbilical cord blood pH in newborns.

In this study, we evaluated the relationship between umbilical cord blood pH and cardiac findings in neonates. We found a significant relationship between decreased umbilical cord blood pH and the prevalence of heart failure. For example, a decrease in umbilical cord blood pH was significantly associated with higher risk of PDA, TR, PAH, PFO, hypotension and reduced heart rate in newborns. Our results indicate that decreased umbilical cord blood pH is an important risk factor leading to heart failures, and therefore, its measurement and management is valuable for preventing heart problems in newborns. In this regard, there are some studies that examined the relationship between reduced umbilical cord blood pH and the occurrence of abnormalities in neonates; however, the number of studies that considered the association between umbilical cord pH and cardiac findings is very limited. In a meta-analysis study, Malin *et al.*, (17) examined 481,753 preterm neonates and found a significant association between decreased umbilical cord pH with mortality rate, hypoxic ischemic encephalopathy (HIE), intraventricular hemorrhage (IVH), periventricular leukomalacia (PVL) and cerebral palsy in these subjects. Ranjit (11) reported that changes in pH led to cardiac abnormalities such as TR, transient mitral regurgitation, transient myocardial ischemia, and persistent PAH in neonates. Similarly, our results showed that decreased umbilical cord pH was significantly associated with higher prevalence of TR and PAH in neonates. Singh *et al.*, (13) examined the echocardiographic findings of 152 newborns with

asphyxia. They demonstrated that a decrease in umbilical cord pH was significantly associated with cardiac involvement in 32% of newborns. The most important cardiac findings in neonates with asphyxia were PAH, PDA, atrial septal defect, and PFO. In our study, cardiac involvement was found in 78.8% of neonates and TR, PFO, PDA, and PAH were the most common cardiac findings in newborns. In another study, Dattilo *et al.*, (18) evaluated the echocardiographic findings of preterm neonates with asphyxia. They found that asphyxia was associated with TR, mitral regurgitation, myocardial ischemia and PAH. Shahidi *et al.*, (12) assessed the echocardiographic results of 29 term neonates with asphyxia. They found that a decrease in umbilical cord pH was significantly associated with hemodynamic and anatomical cardiac complications such as myocardial dysfunction, pulmonary hypertension, and open arterial conduction. These findings are in accordance with the results of our study. In our research, decreased umbilical cord pH was significantly correlated to cardiac findings which emphasize the importance of umbilical cord pH as a risk factor for the occurrence of heart failures in newborns.

Conclusion

The results of our study showed that decreased umbilical cord pH can be considered as an important risk factor in the development of heart failure, including PDA, TR PFO, PAH, hypotension and reducing heart rate in newborns admitted to the NICU. Moreover, factors such as gender, gestational age, birth weight, Apgar scores, number of births, and needing of respiratory support are the most important risk factors associated with reducing umbilical cord pH. Therefore, considering these risk factors and consequently the pH of the umbilical cord is necessary to prevent heart failures in newborns.

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Table 1: Basic demographic and clinical data of all neonates

Parameters	Results
Sex	
Boys	316 (52.7%)
Girls	284 (47.3%)
Age at admission time (day)	3.99 ± 2.4
Gestational age (weeks)	34.26 ± 18.01
Birth weight (g)	2117.34 ± 915.39
Delivery type	
Cesarean	460 (76.7%)
Vaginal delivery	124 (23.3%)
Apgar 1	7.04 ± 2.06
Apgar 5	9.01 ± 1.16
Birth number	
Single	524 (87.3%)
Twin	76 (12.7%)
Mechanical ventilation	
Yes	438 (68.4%)
No	202 (31.6%)

Table 2: The relationship between umbilical cord blood pH and cardiac findings

	pH	p-value
Cardiac findings		
Yes	7.24 ± 0.1	<0.001
No	7.33 ± 0.07	
Hypotension		
Yes	7.14 ± 0.11	<0.001
No	7.29 ± 0.07	
PFO		
Yes	7.25 ± 0.11	0.003
No	7.29 ± 0.06	

TR			
Yes	7.25 ± 0.08	0.38	
No	7.26 ± 0.1		
PDA			
Yes	7.19 ± 0.11	<0.001	
No	7.29 ± 0.07		
PAH			
Yes	7.16 ± 0.14	<0.001	
No	7.27 ± 0.09		

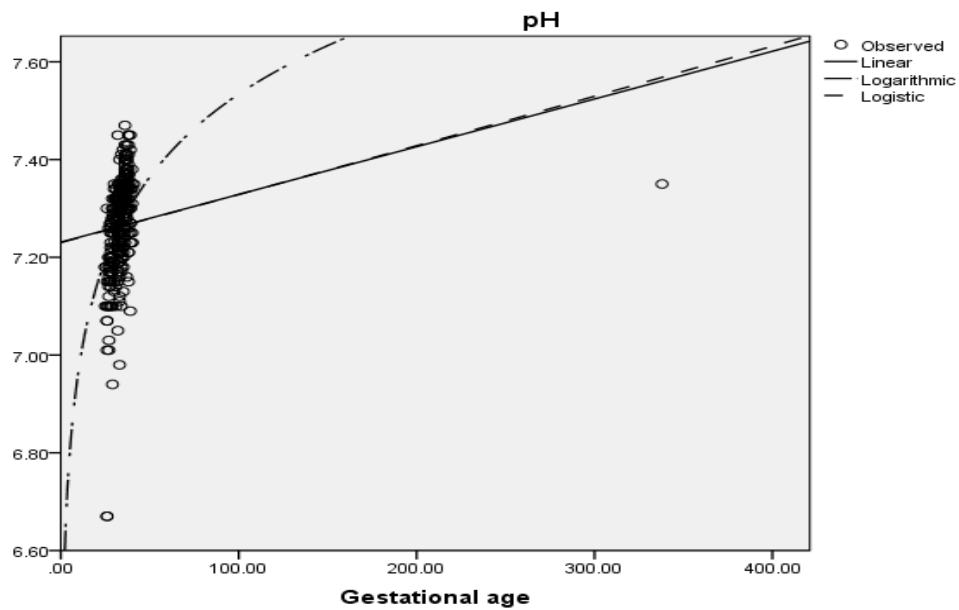


Figure 1: Correlation between gestational age and cord blood pH value. Increased gestational age was significantly associated with higher cord blood pH value ($p=0.003$).

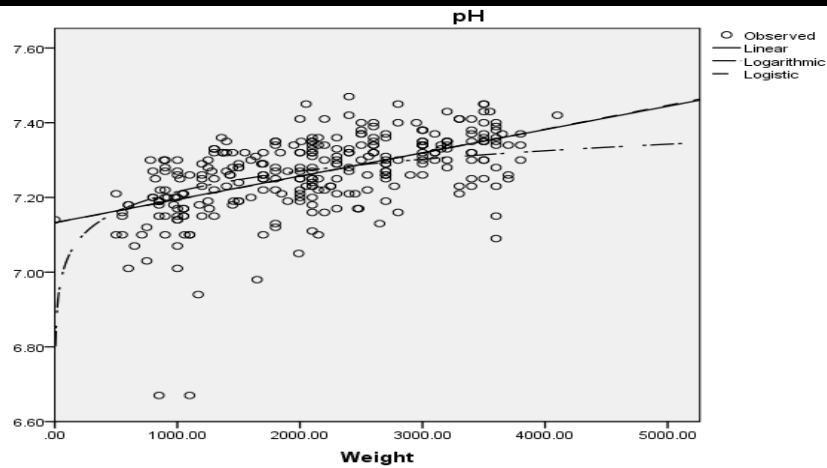


Figure 2: Correlation between birth weight and cord blood pH value. Increased birth weight was significantly associated with higher cord blood pH value ($p < 0.001$).

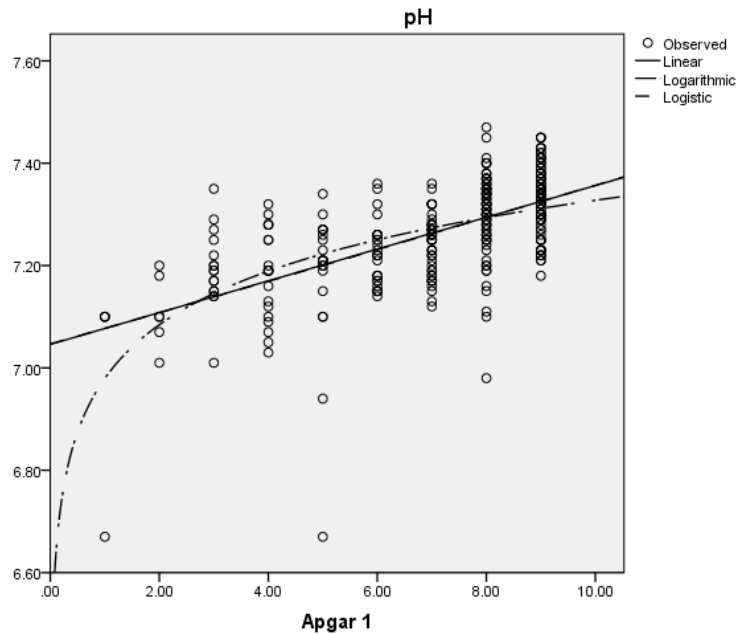


Figure 3: Correlation between Apgar 1 score and cord blood pH value. Increased Apgar 1 score was significantly associated with higher cord blood pH value ($p < 0.001$).

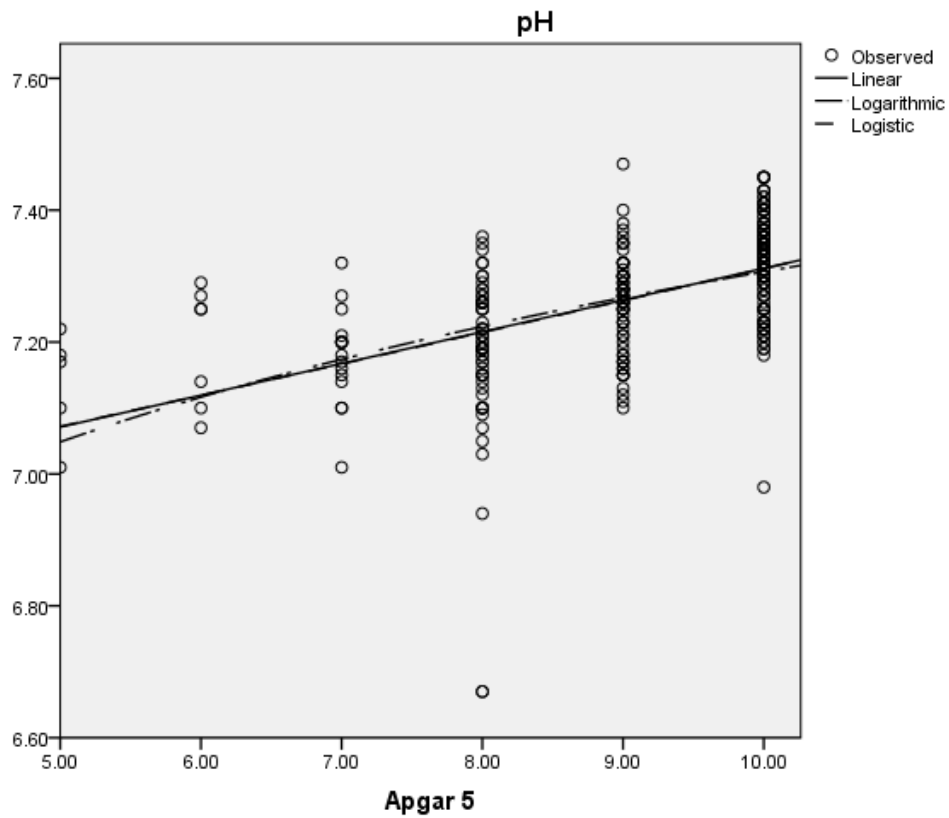


Figure 4: Correlation between Apgar 5 score and cord blood pH value. Increased Apgar 5 score was significantly associated with higher cord blood pH value ($p < 0.001$).