



The Correlation Between Umbilical Cord Blood Gases and Newborn Asphyxia

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Abstract

Objectives: The aim of this study was to investigate the relationship between umbilical cord blood gases and neonatal asphyxia as valuable criteria for fetal distress and labor complications.

Materials and Methods: In this cross-sectional descriptive study of 150 deliveries (101 vaginal and 49 caesarean sections), singleton live-born infants between 34 and 42 weeks of gestation with no major anomalies. They were enrolled from November 2015 to March 2016, in delivery unit of obstetrics and gynecology ward, Imam Hossein Medical Center, Tehran, Iran. Blood samples were taken from umbilical vessels (arterial and venous) following delivery. All infants were monitored for Apgar scores at 1 and 5 minutes.

Results: There were significant differences regarding venous blood lactate ($P < 0.000$) and pH ($P < 0.000$), venous ($P = 0.002$) and arterial ($P = 0.038$) blood base excess and venous ($P < 0.000$) and arterial ($P = 0.002$) blood PCO₂ in samples from fetus with intrapartum distress compared to normal fetus. The mean Apgar score at 1 minute ($P < 0.000$) and 5 ($P < 0.000$) minutes were also significantly lower in the case group compared to the control group.

Conclusions: The results of the present study indicate that lactate analysis, as well as umbilical cord blood analysis, might be useful predictors of fetal asphyxia at delivery. Their potential role as a predictor of prenatal outcome should be evaluated further in future studies.

Keywords: Fetal blood, Umbilical cord blood, Infant, Asphyxia, Prenatal diagnosis.

Introduction

Delivery is a physiologic process and uterine contractions can change the metabolic status via chorionic villus, which leads to an increase in perinatal morbidity and mortality. The most useful parameter for the assessment of newborn infant at delivery time is Apgar score, which was introduced by Virginia Apgar in 1952 (1). Apgar score is a subjective method, which provides no good information about the newborn hypoxia or asphyxia and is associated with a low prognostic value in long-term complications. Therefore, a more accurate and objective method with lower error is desirable.

Although the umbilical blood gases measurement is used in many countries, there are some controversial problems with it (2-4). It is doubted whether the arterial or venous blood gases (VBGs) have a relationship with newborn conditions. For example, Dijkhoorn et al showed that a large number of neurologically abnormal infants have low Apgar scores, but a normal cord arterial pH (2). A later study on more than 150 000 live-born infants by Casey et al reported that when pH fell to 7.0 or less, the likelihood of neonatal death increased by 1400 folds in

term newborns (3). Gjerris et al showed that the presence of lactate in umbilical cord arterial blood could be a more direct and consequently more accurate indicator of fetal asphyxia at delivery than pH assay (4). The purpose of this research was to study the relationship between umbilical cord blood gases analysis and neonatal asphyxia among neonates in Iran.

Materials and Methods

One hundred fifty singleton pregnant women between 34 and 42 weeks of gestation were included in the study at a university general hospital from November 2015 to March 2016. All women in this study were examined at the obstetric clinic and were admitted for delivery. Fetal distress was defined as recurrent late or variable decelerations, with no variability (NICHD definition) (6). Patients were excluded according to the following criteria: gestational age lower than 34 or greater than 42 weeks, severe intrauterine growth restriction, multifetal gestations, intrapartum fever, maternal thyroid disease, confirmed fetus anomaly and stillbirth. Antepartum and intrapartum clinical risk factors such as meconium

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passage were documented. Fetal assessments also included fetal heart rate. Primary outcome measures were umbilical cord blood gas values for acid-base analysis and Apgar score. The secondary outcome measure was fetal lactic acidemia (defined as umbilical arterial lactate >3.9 mmol/L).

Umbilical cord blood gas was supposed to demonstrate the acid-base balance of the neonate at birth when the umbilical flow was blocked by clamping of the cord.

Fetal acidemia was defined as either an umbilical cord arterial pH <7.0 or base deficit ≥12 mEq/L. The umbilical vein is enlarged and wider for sampling rather than the umbilical artery, and when only a unique sample is attainable due to sampling problems, the venous sampling is preferable.

Blood samples were taken from umbilical vessels following delivery by isolating the umbilical cord segment (10-20 cm), with 2 clamps near the neonate and two clamps near the placenta. The cord was then cut between the two proximal and two distal clamps. Arterial and venous samples were drawn from the isolated segments of the cord into a prepared 2 cc syringe containing lyophilized heparin.

The needle was capped and the sample was taken to the laboratory while being kept on ice for further analysis. All babies were monitored for Apgar score at 1 and 5 minutes. The early postnatal adaptation was judged by a neonatologist in the course of 24 hours.

SPSS software version 21.0 (SPSS software, Chicago, USA) was used for data analysis. *P* values less than 0.05 were considered statistically significant. Characteristics of arterial and venous umbilical blood gases and lactate levels were compared by *t* test.

Results

Umbilical cord blood gases from 101 vaginal deliveries and 49 caesarean sections were evaluated. The mean age was 26.72124 ± 5.34 years, with a range of 16 to 42 years (Table 1). The mean gestational age was 37.56 ± 1.9 weeks. The mean birth weight was 3089 ± 573.07 g. One hundred fifty pregnant women between 34 and 42 weeks of gestation entered the study and categorized in two groups as follows: group A had intrapartum fetal distress and group

Table 1. Demographic Characteristics of Patients

Variable (N = 150)	
Mean age (y)	26.72 ± 5.34
Fetal weight at birth	3.089 ± 573.07
Gestational age (wk)	37.56 ± 1.90
APGAR.1	8.34 ± 1.47
APGAR.5	9.64 ± 0.82
Amniotic fluid	
Clear	130 (86.7%)
Thin meconium	11 (7.3%)
Thick meconium	6 (4.0%)
Bloody	3 (2.0%)
Kind of anesthesia	
No anesthesia	100 (66.70%)
General A	24 (16.0%)
Spinal A	26 (17.30%)
Delivery route	
Cesarean	49 (32.70%)
Vaginal	101(67.30%)

Data reported as mean ± SD or No. (%).

B had normal fetus (without distress). Demographic characteristics were similar among the two groups (Table 1). There were significant differences regarding venous blood lactate (*P*<0.000) and pH (*P*<0.000), venous (*P*=0.002) and arterial (*P*=0.038) blood base excess and venous (*P*<0.000) and arterial (*P*=0.002) blood PCO₂ in samples from the fetus with intrapartum distress, compared to the normal fetus. Accordingly, the mean Apgar scores at 1 (*P*<0.000) and 5 (*P*<0.000) minutes were significantly lower in group A than in group B (Table 2).

Apgar score less than 7 at minute 5 had a statistically significant reverse association with umbilical vein and artery base excess as well as vein PH.

No significant differences were observed regarding arterial lactate and PH, arterial and venous O₂ saturations between the case and the control group.

Discussion

In the present study, there was a significant difference between venous blood lactate, blood pH, venous and arterial blood base excess, and PCO₂ in samples from the fetus with intrapartum distress compared to the normal fetus. Umbilical cord blood is the most objective method

Table 2. The Comparison of Umbilical Cord Blood Gas Values Between the Case and Control Groups

Variable	Venous blood			Arterial Blood		
	Group A ^a	Group B ^b	P Value	Group A	Group B	P Value
pH	7.00 ± 1.04	2.27±0.07	<0.000	7.15±0.1	7.19 ±0.45	0.813
PCO ₂ (mm Hg)	68.99±104.02	44.19±8.42	<0.000	56.38±14.6	46.54 ±9.15	0.002
PO ₂ (mm Hg)	28.30±19.91	29.05±9.54	< 0.050	20.89±10.31	24.96±9.02	0.035
O ₂ saturation	48.88±23.26	42.00±18.44	0.191	28.28±15.24	34.07±22.35	0.567
Lactate	20.96±5.5	9.98±2.76	<0.000	19.88±3.9	19.96±2.98	0.277
Base excess ^c	-8.21±6.69	-4.07±4.32	0.002	10.38±8.4	-4.87 ±5.76	0.038
Apgar 1 min	5.88±2.050	8.81±0.654	P<0.000			
Apgar 5 min	8.50±1.285	9.86±0.451	P<0.000			

^a Group A: had intra partum fetal distress; ^b Group B had normal fetus (without distress); ^c Calculated from data.

of evaluating metabolic status of fetus which is the gold standard evaluation for utero-placental function and fetal acid-base conditions. It can be useful for medical and medicolegal judgments and could differentiate perinatal asphyxia or hypoxia secondary to the birth process from other factors. Fetal oxygenation and pH generally decline during the normal labor (1,7). Apgar scores may be influenced by a variety of factors including, but not limited to, fetal maturity or malformations, maternal medications and infection or another fetal status (4,8,9). The umbilical cord blood pH is estimated based on the existence of respiratory and metabolic acids. PCO₂ spreads easily through the placenta but fixed acids like lactic acid, found in most patients with metabolic acidosis, have a slow flow through the placenta (10). pH is not an optimal measure for assessing the growing exposure to hypoxemia because it does not give a real measure of acidosis. The base excess offers a more direct estimate of metabolic acidosis and is adjusted for discrepancy in PCO₂ (11). In normal labor, the base excess changes by around 1 mmol/L per hour in the second stage (12). In contrast, base excess varies by around 1 mmol/L per 30 minutes, while there are recurrent fetal heart rate decelerations (13). The base excess plays a role as a reliable marker of metabolic acidosis but it is not likely to show if the sample origin is arterial or venous. Severe adverse sequels in neonatal period are rare when the umbilical cord PH is higher than 0.7 or base excess is less acidic than minus 12 mmol/L (14). Therefore, umbilical cord pH or base excess alone are poor prognostic factors of the outcome (15). Lactate is currently measured using numerous blood gas analyses. Since lactate has difficulty crossing the placenta when it is detected in umbilical cord blood, its origin is mainly from the fetus (16). It has been indicated that lactate correlates with both pH and base excess (17). Westgren et al suggested that lactate like both pH and base excess predicts low Apgar scores (18). Chou et al found that the presence of high lactate of over 4.1 mmol/L and high lactate/pyruvate ratio of less than 22, predicts the neonatal encephalopathy with a 100% sensitivity and 95.4% specificity (19). Based on recommendations by American College of Obstetrics and Gynecology, umbilical blood sampling for acid-base analysis should be performed in selected deliveries (5). However, based on the study by Armstrong et al, umbilical cord sampling should be considered in all deliveries (7). Waugh et al surveyed 215 obstetrics units in the United Kingdom and showed that only 3% (n=6) reported no blood gas analysis in their obstetric practice (8).

Cantu et al conducted a retrospective cohort study of 11 455 singleton deliveries. They used VBG instead of ABG to assess fetal status at birth, because of availability. They showed that the VBG-BD was a strong predictor of ABG-BD. A venous BD of ≤ 6.3 was concomitant with <1% chance of an arterial BD ≥ 12 . Adding VBG-BD to pH parameters was a more powerful predictor of ABG-PH than VBG-pH alone. These authors also demonstrated

that the combination of VBG-pH and BD was a more powerful predicting factor of fetal acidemia than the arterial blood gases. This study had a retrospective nature and they used VBG alone without lactate measuring, which was different from our method (20).

Swanson et al evaluated umbilical cord VBG to predict fetal acidemia. They found that umbilical cord venous pH and BD were highly predictive of umbilical cord arterial pH <7.0 and umbilical cord arterial BD ≥ 12 mEq/L. Combination of venous pH and BD was no more predictive than venous BD alone in the prediction of umbilical cord arterial BD ≥ 12 mEq ($P=0.622$). They suggested that umbilical cord venous pH and BD are both highly predictive of fetal acidemia, and may be used to assess the probability of fetal acidemia in the lack of umbilical cord ABG settings. This was an observational study and included more patients compared with our study. However, they did not investigate arterial blood gas values as well as lactate levels (21). In line with our findings, a study on 4910 term deliveries showed that the mean lactate level was approximately 2 times greater among infants with the compound morbidity (6.49 vs. 3.26 mmol/L, $P<0.001$), but the mean pH values were less characteristic (7.19 vs. 7.29, $P<0.001$) (22). The authors suggested that lactate was statistically more prognostic of neonatal morbidity than pH (22). However, they did not investigate preterm births and deliveries occurring without labor. We investigated women between 34 and 42 weeks of gestation and did not have any compound morbidity in preterm newborns. Allanson et al conducted a systemic review and examined the different predictors of fetal asphyxia. They indicated that measuring the umbilical cord lactate is a reliable and efficient method to quantify acidosis and it can be used in the evaluation of neonatal consequences (23).

Tuuli et al designed a prospective cohort study to investigate the role of umbilical venous blood lactate in predicting lactic acidemia in term fetus. They found that venous lactate was a prognostic factor for arterial lactic acidemia. The cut-point of venous lactate for expecting arterial lactic acidemia was 3.4 mmol/L. Venous and arterial lactate predicted the compound neonatal morbidity with similar sensitivity, but venous lactate was a little more specific. They concluded that umbilical cord venous lactate is a potent prognostic factor of umbilical arterial lactate with approximately equal predictive capacity for neonatal morbidity at term (24). Our study is the only study which has compared venous and arterial blood gas values including lactate in patients with intrapartum fetal distress versus normal group, but we did not determine the cut-off point of lactate for lactic acidemia. In addition, they just investigated term delivery whereas we studied term and preterm delivery after 34 weeks.

Based on our knowledge, the present study is the only study which has compared the arterial and venous umbilical cord blood gas analysis and lactate levels in women with intrapartum fetal distress versus normal

delivery. We do not have any national survey on protocols related to the analysis of cord blood at birth in our country like other countries. The normal ranges for umbilical cord blood gases differ based on the definition of normality and the studied population. In one study, using regional anesthesia including spinal anesthesia and sympathetic block was concomitant with increased occurrence of cord blood acidosis, but there was no evidence that this disturbs neonatal outcome (25). However, we did not investigate individual patients who underwent spinal anesthesia during delivery.

The findings in previously published data and also the fact that electronic fetal monitoring is non-specific in the evaluation of fetal status, cord blood gases especially lactate analysis may have some benefits. The sampling technique is simple and has clinical, training and medico legal uses. Lactate analysis as a part of umbilical cord blood gases analysis may play a role in perinatal care in low- and middle-income nations, where the load of both reduced care and poor infant consequences is high. It should be considered that an umbilical cord blood analysis cannot differentiate between primary placental disorders and the indirect effects of maternal acid-base disorders. Our finding might provide a new insight for physicians to perform an umbilical cord blood analysis to identify asphyxia or hypoxic events among newborns in Iran. Since the results of this work might be controversial due to the small number of the patients, we suggest future experiments with higher number of samples in both case and control groups to further evaluate if the umbilical cord blood analysis is informative enough to be used as a clinical routine test for identification of metabolic status among newborns.

Cord blood analysis presents both longitudinal and static measurements of acid-base conditions and might be a valuable tool in predicting the prognosis. Diagnosis of newborns at risk of encephalopathy is mainly important because of decision making for early intervention. Investigating both arterial and venous samples might help in understanding the physiology and cause of acidosis. When combined with other clinical findings, normal arterial and VBG and normal blood lactate are against the presence of intrapartum hypoxia.

Conclusions

The analysis of umbilical cord blood gases is suggested for women with high-risk pregnancy and is performed after all deliveries in some countries. The results of this study indicate that umbilical cord blood analysis, as well as lactate analysis, might be useful predictors of fetal asphyxia at delivery. Their potential role as a tool for predicting the prenatal outcomes should be evaluated in subsequent studies.

Conflict of Interests

Authors declare that they have no conflict of interests.

Ethical Issues

This cross-sectional descriptive study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran (IR. SBMU.RAM. REC.1394.342). Informed consent was received from all patients entering the study.

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