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Influence of Mode of Delivery on Umbilical Cord Blood Gas Parameters in Neonates: A Cross-Sectional Analysis

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ABSTRACT

Background: Umbilical cord blood gas analysis provides an objective assessment of the neonatal acid–base status at birth and may reflect the impact of intrapartum factors. The mode of delivery has been suggested to influence these parameters; however, findings remain inconsistent.

Objective: To evaluate the association between mode of delivery and umbilical artery blood gas parameters in term neonates.

Methods: This cross-sectional study was conducted in the Department of Neonatology, Pak-Emirates Military Hospital, Rawalpindi, affiliated with the National University of Medical Sciences, from August 2020 to January 2021. A total of 102 live, singleton term neonates delivered either by spontaneous vaginal delivery (SVD) or elective lower segment cesarean section (LSCS) were included. Neonates delivered via SVD were assigned to Group A, while those delivered by elective LSCS were assigned to Group B. Umbilical artery blood samples were obtained immediately after birth and analyzed for blood gas parameters. Comparisons between groups were performed accordingly.

Results: The mean maternal age was 29.51 ± 7.37 years. Of the 102 neonates, 45 (44.1%) were delivered by SVD and 57 (55.9%) by elective LSCS. Maternal characteristics did not differ significantly between the two groups ($p > 0.05$). An Apgar score ≥7 at 1 minute was observed in 60 (58.8%) neonates, while an Apgar score ≥8 at 5 minutes was noted in 72 (70.6%). All umbilical artery blood gas parameters showed statistically significant differences between the two delivery modes ($p < 0.05$).

Conclusion: Although umbilical cord blood gas values remained within the physiological range in both groups, significant variations were observed according to the mode of delivery. These findings suggest that the mode of delivery may influence neonatal acid–base status at birth.

KEYWORDS: Mode of delivery; Umbilical cord blood gases; Apgar score; Gestational age; Neonate

INTRODUCTION

Perinatal hypoxia and birth asphyxia remain among the major contributing factors to the morbidity and mortality of neonates across the globe. Intrapartum-related hypoxic events cause a significant percentage of deaths of the newborn, especially in low and middle-income countries, and contribute to long-term neurodevelopmental impairment of surviving infants globally (1,2). However, precise assessment of fetal oxygenation status and acid-base balance at birth is vital.Umbilical cord blood gas analysis has been commonly employed to monitor oxygenation, acid-base balance, and fetal responses to labor or stress (3). It has been recognized as a reliable marker of fetal well-being and can be employed as an indicator of conditions like uteroplacental insufficiency, as well as predict neonatal outcomes. However, severe forms of metabolic acidosis have been associated with various unfavorable outcomes, including mortality and developmental problems in neonates and children, and it has been suggested that mild forms of acidosis at birth can be quite ordinary and benign, with 80% being ruled out by presenting with normal umbilical blood values among term depressed neonates with hypoxia (4,5).

The World Health Organization recommends the rate of cesarean section (CS) to fall within the range of 5 to 15 percent. This rate, however, has increased noticeably in recent decades for all nations across the globe. The rate of vaginal delivery is considered more favorable compared to other modes, as the rate of complications, both maternal and neonatal, in vaginal delivery is lower (7,8). Physiologically, stress of labor followed by spontaneous vaginal delivery causes the release of fetal catecholamines, remarkably in the second stage of the labor process, resulting in the redistribution of circulating volume to the vital organs. The stress of excess time in the labor process, however, causes compromised placental perfusion, resulting in fetal hypoxia and disturbances in the acid-base balance (9,10).

Similarly, umbilical cord blood gas values also provide information about the metabolic state of a fetus. Dudenhausen and colleagues have emphasized the significance of umbilical cord blood gas values and discussed their importance in predicting conditions of fetal and postnatal life (11). However, not much literature is available on this aspect of newborn babies in Pakistan. The effect of mode of delivery on umbilical cord blood values has not been well researched. So, this study was designed to assess the relationship between mode of delivery and umbilical cord blood gas values.

METHODOLOGY

Study design and setting

This cross-sectional study was conducted in the Department of Neonatology, Pak-Emirates Military Hospital, Rawalpindi, affiliated with the National University of Medical Sciences, from August 2020 to January 2021.

Study population and eligibility criteria

Live, singleton term neonates delivered either by spontaneous vaginal delivery (SVD) or elective lower segment cesarean section (LSCS) during the study period were eligible for inclusion. All enrolled neonates had a gestational age between 37 and 41 + 6 weeks, a birth weight ranging from 2500 to 4000 g, and Apgar scores greater than 6 at both 1 and 5 minutes.

Neonates delivered by emergency cesarean section were excluded. Additional exclusion criteria included maternal comorbidities such as diabetes mellitus, hypertension, and preeclampsia, as well as obstetric complications including intrauterine growth restriction, breech presentation, oligohydramnios, and maternal respiratory distress. Neonates requiring resuscitation at birth, those with congenital heart disease, congenital malformations, or dysmorphic features were also excluded.

Group allocation

A total of 102 neonates were enrolled. Neonates delivered via spontaneous vaginal delivery were classified as Group A, while those delivered by elective cesarean section were classified as Group B.

Umbilical cord blood sampling and analysis

Elective cesarean sections were performed under spinal anesthesia using 5% lidocaine. Umbilical cord blood samples were obtained immediately after birth by clamping both ends of a segment of the umbilical cord. Approximately 2 mL of umbilical arterial blood was collected in a pre-heparinized syringe.

All samples were analyzed within 10 minutes of collection using a blood gas analyzer (OPTI CCA-TS2 Analyzer) available in the neonatal intensive care unit to ensure optimal analytical accuracy. Umbilical artery blood gas parameters including pH, partial pressure of carbon dioxide ($PaCO_2$), bicarbonate (HCO_3^-), and base excess (BE) were recorded.

Statistical analysis

Data analysis was performed using SPSS version 26.0. Qualitative variables, including sex and mode of delivery, were expressed as frequencies and percentages. Quantitative variables such as gestational age, gravidity, parity, birth weight, Apgar scores at 1 and 5 minutes, and umbilical cord blood gas parameters were presented as mean ± standard deviation.

Comparisons between the two groups were conducted using the chi-square test for categorical variables and the independent samples Student's t-test for continuous variables. A p-value of less than 0.05 was considered statistically significant.

Ethical approval

This study was done in accordance with the Declaration of Helsinki.Ethical approval for the study was obtained from the Institutional Ethical Committee of Pak-Emirates Military Hospital. All participants gave verbal and written informed consent and were informed that their particpation was entirely voluntary. All procedures involving human participants were carried out in compliance with appropriate national and international ethical guidelines.

RESULTS

In this study, 56 (54.9%) women were less than or equal to 30 years of age. Overall, mean age was 29.51$\pm$7.37 years. Gestational age was between 37 to 39 weeks in 64 (62.7%). Mean gestational age was 38.40$\pm$2.7 weeks. Out of a total of

102 cases as per inclusion and exclusion criteria, there were 45 (44.1%) cases in Group-A and 57 (55.9%) in Group-B. Table 1 is a comparison of maternal characteristics of women in both study groups and no statistically significant difference was recorded (p>0.05)

Table 1: Comparison of Maternal Characteristics (n=102)

Characteristics		Group-A (n=45) (SVD)	Group-B (n=57) (LSCS)	P-Value
Age (years)	≤30	24 (53.3%)	32 (56.1%)	0.7772
	>30	21 (46.7%0	25 (43.9%)	
Gestational Age (weeks)	37-39	28 (62.2%)	36 (63.2%)	0.9227
	>39	17 (37.8%)	21 (36.8%)	
Gravidity Status	≤2	30 (66.7%)	34 (59.6%)	0.4667
	>2	15 (33.3%)	23 (40.4%)	
Parity Status	Nulliparous	14 (31.1%)	19 (33.3%)	0.8117
	Multiparous	31 (68.9%)	38 (66.7%)	

Out of total 53 (52.0%) newborns were male. Apgar score was above 7 at 1 minute among 60 (58.8%) newborns while it was noted to be above 8 at 5 minutes in 72 (70.6%) newborns. Table 2 shows characteristics of newborns in between both study groups. No statistically significant difference was observed in terms of characteristics of the newborns in between both study groups (p>0.05).

Table 2: Comparison of Newborns Characteristics (n=102)

Characteristics		Group-A (n=45) (SVD)	Group-B (n=57) (LSCS)	P-Value
Newborn's Gender	Male	24 (53.3%)	29 (47.4%)	0.8053
	Female	21 (46.7%)	28 (52.6%)	
Apgar Score at 1 minute	≤7	18 (40.0%)	24 (42.1%)	0.8301
	>7	27 (60.0%)	33 (57.9%)	
Apgar Score at 5 minute	≤8	13 (28.9%)	17 (29.8%)	0.9180
	>8	32 (71.1%)	40 (70.2%)	
Birth Weight (grams)	≤3000	22 (48.9%)	26 (45.6%)	0.7421
	>3000	23 (51.1%)	31 (54.4%)	

Table 3 is a comparison of mean umbilical artery blood gas parameters noted in both study groups. Mean pH was within normal range in both study groups but difference was significant when Group-A was compared to Group-B (7.42±0.12 vs. 7.37±0.09, p=0.0221). Mean $PaCO_2$ (mmHg) was significantly high in Group-B in comparison to Group-A (46.54±8.63 vs. 41.27±7.14, p=0.0013). HCO_3 (mEq/liter) was significantly raised among women in Group-B in comparison to Group-A (24.81±3.40 vs. 22.57±2.85, p=0.0006). Base excess (mEq/liter) was -3.34±2.86 in Group-A while it was -2.16±1.68 in Group-B and the difference was statistically significant (p=0.0107).

Table 3: Comparison of Mean Umbilical Artery Blood Gas Values in Both Study Groups (n=102)

Umbilical Artery Blood Gas Variables	Group-A (n=45) (SVD)	Groups-B (n=57) (LSCS)	P-Value
pH	7.40±0.09	7.35±0.12	0.0221
$PaCO_2$ (mmHg)	41.27±7.14	46.54±8.63	0.0013
HCO_3 (mEq/liter)	22.57+2.85	24.81±3.40	0.0006
Base Excess (mEq/liter)	-3.34±2.86	-2.16±1.68	0.0107

DISCUSSION

In this study, the mean values of umbilical arterial pH, $PaCO_2$, HCO_3^-, and base excess were found to be within the normal ranges in both groups. However, statistically significant differences were found when neonates delivered by spontaneous vaginal delivery were compared with those delivered by elective cesarean section.

The umbilical cord blood was analyzed using the OPTI CCA TS-2 Analyzer, which is a well-established and validated blood gas analyzer. Rahimi et al. found significant differences in PCO_2 and PO_2 between vaginally delivered and cesarean section-delivered neonates, but no significant difference was found in umbilical cord pH (12). Their results are partially consistent with the current study, especially in terms of differences in gas values between the two groups.

In our study, cesarean sections were carried out under spinal anesthesia. Previous studies have shown that there is no significant difference in umbilical cord pH values when comparing epidural and spinal anesthesia methods in cesarean sections, and thus the results of our study are unlikely to be due to the method of anesthesia alone (13).

Our results are also in agreement with those of Loh et al., who found higher pH values in neonates born through vaginal delivery compared to cesarean sections, as well as lower PCO_2 and HCO_3^- concentrations in the vaginal delivery group (5). Similarly, Pence et al. found higher PO_2 concentrations in neonates born through cesarean sections, possibly due to the administration of supplemental oxygen during operative delivery (14).

Jain et al. in their randomized clinical trial on the comparison of low-dose spinal and general anesthesia in cesarean delivery, noted that the pH level was significantly lower in the spinal anesthesia group (15). However, it is worth noting that there were no significant differences in Apgar scores at 1 and 5 minutes, similar to our study.

Ahmadpour-Kacho et al. noted that the pH level in the umbilical cord was significantly lower in high-risk compared with low-risk pregnancies (16). Similarly, Zaigham et al. noted that there was variability in cord blood gas values, with lower pH and PCO2 levels, which are consistent with our study (17). Perez et al. noted that there was umbilical arterial acidosis in neonates delivered by spontaneous vaginal delivery compared with cesarean delivery (18).

The physiological values of neonates born through an elective cesarean section were found by Kotaska et al. to be closer to adult values, while a pH of less than 7.0 has been found to be associated with increased neonatal complications. The linear correlation of lactate levels in the umbilical cord blood, pH and base excess levels has been shown by Labrecque et al., which supports the significance of acid-base values in the assessment of neonatal condition at birth (19,20,21).

The differences found in the current study may be explained by the physiological stress of labor and the severity of the respiratory adaptation process. The milder form of respiratory acidosis, indicated by a lower pH and higher PaCO2 levels, has been found in the group of neonates born through an elective cesarean section. The slower clearance of fetal lung fluid in neonates born through cesarean section may contribute to this effect.

The study has some limitations. All the cesarean deliveries were performed under spinal anesthesia, and the values of cord blood gas in neonates delivered under general anesthesia were not examined. In addition, the study did not assess the effect of any interventions in the management of the pregnant women.

Future studies, with a larger population size and different obstetric and anesthetic interventions, would be necessary. Additional studies of cord blood lactate levels, their relationship with Apgar scores, and acid-base parameters would be of interest.

The strength of the study is the examination of consecutive eligible neonates born by spontaneous vaginal delivery or elective cesarean section. This reduces the risk of any selection bias. In addition, the cord blood sampling was performed by experienced personnel.

CONCLUSION

Although the umbilical cord blood gas values were found to be within physiological limits in both groups, there were significant variations depending upon the mode of delivery. A comparatively milder form of respiratory acidosis, as indicated by a low pH and a higher PaCO2, was found in the elective cesarean section group.

Authors' Contributions

Inayat Ullah: Conceptualization, methodology, investigation, resources, analysis, writing.

Zeeshan Ahmed: Conceptualization, writing, review and editing, supervision.

Hakim Wazir: Manuscript writing, drafting, review and editing, correspondence.

Liaqat Zeb: Writing, software, data curation.

Mujahid Anwar Jadoon: Writing, resources, data curation

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