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Umbilical Cord Blood Gas Analysis in Preterm Infants and Its Comparison with Apgar Score

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Abstract: Intrapartum asphyxia is the most common cause of preterm death. Apgar scores are routinely used to assess early neonatal status, but less meticulous in the preterm neonate because of developmental immaturity. Umbilical artery blood gas analysis may provide solid grounds against any supposed link between intrapartum events and poor neonatal outcome. The objectives of the study were to estimate the arterial blood gas analysis through umbilical cord sampling from preterm infants and to correlate with the Apgar score. This was the cross-sectional study conducted at the tertiary care teaching hospital. Preterm babies delivered by cesarean section and vaginal delivery were included in this study which includes the sample size of 48 cases. Apgar score at 1 and 5 minutes after birth was taken and umbilical cord sampling were done for the estimation of arterial blood gas analysis in the preterm neonates. The parameters like gestational age and birth weight were also included in the study. In preterm babies, arterial blood pH was highly correlated to 5th minute Apgar score (r = 0.76) and poorly correlated with 1st minute Apgar score (r = 0.21) and neonatal outcome using Pearson's correlation. Cord blood gas analysis is required to complete the picture and reflect the oxygenation of the fetus during labor.

Keywords: Asphyxia, Apgar score, Blood gas analysis, Cord blood, Hypoxia, Preterm.

INTRODUCTION

In India, the causes of neonatal deaths are prematurity, birth asphyxia, low birth weight, neonatal infections and birth trauma [1]. Perinatal asphyxia and congenital malformations are the two significant causes of neonatal mortality [2] according to the data from the "Million Death Study from India".

Preterm birth is the most prevalent obstetric complication associated with significant neonatal morbidity and mortality. The World Health Organization (WHO) defines Preterm delivery (PTD) as delivery before 37 weeks of gestation, which is reported in completed weeks. PTD is further divided into subcategories: < 28 weeks is defined as extremely preterm; 28 to 32 weeks is very preterm; and 32 to 37 weeks is moderate to late preterm [3]. Preterm infants have been frequently reported to the sequelae such as respiratory distress syndrome, retinopathy of prematurity, neuro-developmental abnormalities, cognitive deficit, lifelong vision and hearing impairment [4]. Neonatal asphyxia (NA) is more commonly observed in preterm babies. Perinatal Asphyxia usually occurs if the period of delivery is prolonged, despite improvements in perinatal care.

Asphyxia occurs due to impairment of blood-gas exchange which results in hypoxemia and hypercapnia. The severe fetal hypoxia and the resultant decreased blood flow to the organs results in a series of biochemical changes in the body and land up in multi organ dysfunction [5]. The lack of proper monitoring, timely and appropriate intervention and neonatal resuscitation are responsible for the poor neonatal outcome. The Apgar score is assessed at one and five minutes after delivery and it is considered to evaluate the physical condition of newborn infants. In the past decades, Apgar score alone has been widely applied for the diagnosis of asphyxia. The Apgar score comprises of 5 components: (1) color; (2) heart rate; (3) reflexes; (4) muscle tone; and (5) respiration [6]. The Apgar score has some limitations. The Apgar score is influenced by maternal sedation or anesthesia, gestational age, congenital malformations, birth trauma, and interobserver variability [6]. The Apgar score depends upon the physiologic maturity of the newborn. The Apgar score is influenced by alterations in normal transition. Lower oxygen saturations in the

first few minutes does not require intensive administration of supplemental oxygen; the Neonatal Resuscitation Program targets for oxygen saturation are 60% to 65% at 1 minute and 80% to 85% at 5 minutes [7]. Sometimes, the healthy preterm infant with absence of asphyxia may obtain a low score, because of immaturity [6]. Even though the Apgar score is useful to identify the presence of respiratory depression in neonates, it cannot identify its etiology and pathophysiology. Its accuracy in diagnosing asphyxia is affected by the gestational age and it is not feasible for neonates upon endotracheal intubation and positive-pressure ventilation [8]. Studies have shown that one-minute Apgar score is useful for rapid assessment of the neonate, but it is poorly correlated with other indicators of intrauterine wellbeing [9]. To diagnose asphyxia, it is found to be inappropriate to use an Apgar score alone. Some study had identified that the combinations of umbilical arterial blood pH values and Apgar scores were helpful to diagnose the birth asphyxiated infants.

Umbilical cord blood remains in continuity with placenta hence it demonstrates the progressive change in acid-base status. Prolonged labor, meconium stained amniotic fluid, abnormal fetal heart rate, low Apgar score and arterial blood pH less than 7 or base excess (BE) greater than 12 mmol/L are the indicators which is used to diagnose the perinatal asphyxia. The guidelines of the American Academy of Pediatrics (AAP) and the American College of Obstetrics and Gynecology (ACOG) [6] has quoted the criteria to diagnose asphyxia are profound metabolic or mixed acidemia (pH <7.00) in umbilical artery blood sample, persistence of an Apgar score of 0–3 for longer than 5 min, neonatal neurologic sequelae like hypotonia, seizures, coma etc., and multiple organ involvement. Among the umbilical arterial blood gas parameters, pH is most important. BE and pCO_2 are helpful to identify the nature of acidosis. Umbilical cord blood gas investigations may confer forewarning of preceding fetal hypoxic stress and also helps in the diagnosis of birth asphyxia in newborns at preterm and yield relevant information regarding the type and cause of acidemia. Cord blood gas analysis can serve as supportive evidence against any dubious association between intrapartum events and poor neonatal sequelae. Hence, the cord blood gas analysis in all high-risk deliveries has been recommended by the British and American Colleges of Obstetrics and Gynecology. Still in many hospitals, the diagnosis of 'intrapartum asphyxia' has been made primarily on the basis of the Apgar score. Among these indicators, umbilical cord arterial blood gas analysis acts as a simple, accurate and reliable tool. The present study was undertaken to elucidate the significance of umbilical cord blood gas analysis in diagnosing asphyxia in preterm babies among the pregnant women seeking routine antenatal care at a tertiary care teaching hospital.

Aim and objectives

- To estimate the arterial blood gas (ABG) analysis (pH, pCO2, pO2, bicarbonate and base excess) of umbilical cord in preterm infants.
- To correlate the cord blood gas analysis of preterm infants with Apgar score.

MATERIALS AND METHODS

This was the cross-sectional study conducted in the tertiary care teaching hospital. The study period was 6 months in the year 2015. Women of 18-35 years of age with gestational age of 33 - 35 weeks were included in this study. Totally 56 individuals admitted for the delivery, with or without labor pain were selected. Women who delivered babies by cesarean section (CS) and vaginal delivery were included in this study. Women with known systemic illness, coronary heart disease, mental illness, respiratory or renal disease, placenta previa and major congenital anomaly were excluded from this study. Out of 56, eight preterm infants were excluded based on exclusion criteria. Hence, the sample size which includes 48 cases. Demographic data like gestational age, birth weight and other relevant details were collected using questionnaire and obtained from medical records. Informed written consent was obtained from the study group after explaining the procedure. Total confidentiality of individual was assured. This study was approved by the Institutional ethics committee. Immediately after delivery, umbilical cord was isolated by using 4 Howard Kelly Forceps and the cord was clamped immediately after delivery at both ends. Then 5 ml of arterial cord blood has been collected in heparinized syringes as per the guidelines of NCCLS (National Clinical Chemistry Laboratory Standards). Blood gas analysis and pH were analyzed as soon as possible under suitable precautions. pH, BE, PCO_2, pO_2 and HCO_3^- were measured at 37˚C in ABG analyzer (Roche Diagnostics). Quality control solution has been run automatically in Arterial Blood Gas analyzer. Routine calibrations were run by every 4 hours. Cord arterial samples with pO_2 greater than 5.0 kPa were excluded from the study and were likely to have been affected by the presence of an air bubble in the specimen. Apgar score was assessed by some trained personnel at 1st and 5th minute after birth. Fetal distress was defined by cord blood pH of < 7.2 and an Apgar score of < 7. Based on the definition, the study group was divided into Asphyxiated group and non-asphyxiated group. Statistical analysis was performed using SPSS version 21. The continuous variables are expressed as the mean and standard deviation. The two groups were compared using Student's *t*-test. Pearson correlation was done to correlate the Apgar score and blood gas analysis. Statistical analysis was performed using the software Statistical Package for the Social Sciences (SPSS) 21.0 for Windows. $P < 0.05$ was considered statistically significant.

RESULTS

The demographic characteristics like maternal age, birth weight, gestational age and mode of delivery during delivery are shown in the Table-1. The study group was categorized into 19 Asphyxiated group and 29 non-asphyxiated groups. Out of 48 preterm, 29 newborns delivered by caesarian section and 19 delivered by normal vaginal delivery. Among these, asphyxia was diagnosed in 14 and 10 newborns of CS and vaginal delivery respectively. Birth weight < 2500 gm and > 2500 gm were considered as Low birth weight (LBW) and Normal birthweight babies respectively.

Mean pH, pCO_2, pO_2, $HCO_3^-$and BE values of the study group were analyzed and given in the Table 2. The Apgar score at 1 and 5 minutes in asphyxiated group were significantly lower than in the non-asphyxiated group (Table 2). In asphyxiated babies, blood gas analysis pH is highly correlated to 5th minute Apgar score (r = 0.86) and poorly correlated with 1st minute Apgar score (r = 0.31) and neonatal outcome.

Table-1: Demographic profile of study group

Variables	Asphyxiated	Non-asphyxiated	`p` value
Maternal age (Years)	28.60 ± 4.217	23.7 ± 4.473	0.134
Gestational age (weeks)	32.75 ± 1.10	33.1± 0.96	0.07
Birth weight (Kg)	2.3 ± 0.50	2.6± 0.31	0.04*
Mode of delivery (n) Cesarean Section Vaginal	 14 10	 15 9	 0.14 0.10
Presentation n (%) Vertex Breech	 14 (73.6%) 5 (26.3%)	 25(86.2%) 4 (13.8%)	 0.06 0.10

*-Significant, n – Number

Table-2: pH, Blood gas, bicarbonate and Apgar scores of Asphyxiated and Non- asphyxiated preterm (Mean ± SD)

Variables	Asphyxiated	Non- asphyxiated	`p` value
pH	6.30 ± 0.02	7.28 ± 0.03	0.02*
pCO2	59.93 ± 2.10	39.75 ± 1.15	0.01*
pO2	19.05 ± 5.03	18.15 ± 3.08	0.11
HCO_3^-	16.01 ± 0.07	24.25 ± 1.09	0.04*
Base excess	-13.14 ± 1.21	2.5 ± 0.5	0.001*
1st minute Apgar	6.55 ± 1.50	6.50±0.50	0.12
5th minute Apgar	6.85 ± 0.25	9.50 ± 0.50	0.001*

*-Significant

Table-3: pH, Blood gas, bicarbonate and Apgar scores of preterm based on birth weight (Mean ± SD)

Variables	Preterm		`p` value
	LBW	**NBW**	
pH	6.80 ± 0.28	7.30 ± 0.04	0.01*
pCO2	56 ± 7.35	40 ± 1.45	0.001*
pO2	19 ± 2.15	18 ± 2.83	0.09
HCO_3	18. 05 ± 2.93	23.15 ± 1.43	0.01*
Base excess	-12.28 ± 1.42	2.57 ± 1.25	0.01*
1st minute Apgar	7.38 ± 0.16	7.20 ± 1.47	0.10
5th minute Apgar	7.57 ± 0.84	9.25 ± 1.26	0.001*

*-Significant, LBW-Low birth weight; NBW-Normal birth weight

Table-4: Pearson`s correlation between Cord arterial blood gas analysis and Apgar score

	r	p
1st minute Apgar	0.21	0.04
5th minute Apgar	0.76	0.001

DISCUSSION

Our study was focused to find out the correlation of Arterial cord blood gas analysis and Apgar scores in preterm babies irrespective of the outcome of complications during delivery. We have grouped our study by two ways: by correlating blood gas and pH values with Apgar score and by comparing the values with asphyxiated and non-asphyxiated newborn. Asphyxia is defined as the combination of the hypoxemia and metabolic acidosis [8]. In our study, 48.3% of CS and 52.6% of vaginal delivery infants suffered from asphyxia. Low birth weight babies also suffered from neonatal acidemia. Mean pH, bicarbonate values and pCO_2 of asphyxiated group and non-asphyxiated group were 6.30 ± 0.02; 7.28 ± 0.03, 16.01 ± 0.07; 24.5± 1.09, 59.93 ± 2.10; 39.75 ± 1.15.

In our study, mean umbilical artery blood pH in asphyxiated neonates was significantly lower than in non-asphyxiated neonates with p value of 0.02. The expert group [8] decided to use pH <7.15 as the umbilical arterial blood gas parameter for NA diagnosis. Isolated respiratory acidosis of fetus is commonly the consequence of impairment of the uteroplacental or fetoplacental blood flow. Anaerobic glycolysis results in progressive metabolic acidosis. Consequently, most severe fetal acidosis is mixed [10, 11]. In the present study, pH < 6.30, HCO_3^-< 16 mmol/L were highly suggestive of metabolic acidemia. In our study, the BE (-13.4) also provide a reliable measure of metabolic acidosis. The base excess provides a more linear measure of the degree of accumulation of metabolic acid and is adjusted for variation in pCO_2 [12]. Using Pearson's correlation coefficient, pH of asphyxiated babies was highly correlated with 5th minute Apgar score (r = 0.76) and poorly correlated with 1st minute Apgar score (r = 0.21). In our study 30% of newborn with low Apgar had acidemia. Locatelli A *et al*., [13] proposed that only 38% of newborn with low Apgar scores had metabolic acidosis [9]. Chen ZL *et al.*, [14] found that it Apgar score has high sensitivity and low specificity, and the false positive rate can be up to 50-80 [8]. According to Svenvik M *et al*., [15] there was no significant difference observed in Apgar score between spontaneous vaginal birth and elective CS or emergency CS which was highly correlated with our study (Table 1). Based on the studies of Alfirevic Z *et al*., [16], no significant difference was found between elective caesarean section and vaginal delivery with respect to birth injury to infant (risk ratio (RR) 0.56) or birth asphyxia (RR 1.63). Armstrong L *et al*., [17] studies mentioned that cord blood analysis was the most objective way to assess fetal metabolic condition at birth and promising associations have been suggested between umbilical artery pH and clinically important neonatal outcomes. According to the study of Pitsawong C *et al*., [18], prematurity possesses increased risk of developing birth asphyxia, (CI 95% 0.19-0.58) [19]. Pre-term infants addressed numerous morbidities which includes organ system, immaturity particularly immaturity of lung causing respiratory failure. The rates may be higher in developing than developed countries because of the higher prevalence of risk factors that predisposes to prolonged labor, as well as the lack of appropriate interventions. It was also observed that there was significant difference in umbilical artery blood gas values according to birth weight group (Table-3).

The results of umbilical cord arterial blood gas analysis at birth is a gold standard that reflects the blood gas and acid-base status immediately and it provides the key for analyzing the perinatal adverse events and neonatal status. However, since Apgar score can generally reflect the clinical manifestations of neonates with respiration, circulation, and CNS depression, the current Expert Consensus still includes it as a major indicator for assessing NA; together with umbilical arterial pH [8]. Therefore, it has been widely accepted that umbilical cord arterial blood gas analysis should be added for neonates with low Apgar score to increase the accuracy of an NA diagnosis. The limitations of our study are that paired umbilical arterial and venous samples were not taken to interpret. The more sample size would be needed to examine these outcomes meaningfully.

CONCLUSION

Our study concludes that preterm infants are more prone to cause acidemia with pH of 6.80 and BE of -13.14. The acidosis which is analyzed by umbilical artery ABG at birth is a predictor of asphyxia, and hence it can be included as potentially useful test in the preterm deliveries. Cord blood gas analysis is required to complete the picture and reflect the oxygenation of the fetus during labor.

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