CORRELATION BETWEEN UMBILICAL ARTERIAL BLOOD GAS PARAMETERS AND APGAR SCORE IN HIGH-RISK PREGNANCY

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ABSTRACT

BACKGROUND
According to literature, only few studies are available on correlation of umbilical artery blood gas parameters and Apgar score in high-risk pregnancy. Due to paucity of studies, we have done this study in South Indian population, particularly Puducherry for early and better detection of high-risk newborns with metabolic acidaemia.
The aims of this study are-
1) To compare the 1 and 5 minutes, umbilical arterial blood gas parameters between high- and low-risk pregnancies,
2) To compare the correlation between 1 minute Apgar score and umbilical arterial blood gas parameters, 5 minutes Apgar score and umbilical arterial blood gas parameters in high- and low-risk pregnancies.

MATERIALS AND METHODS
This was an analytical comparative study performed on 150 mother-foetal pairs during June 2016 to May 2017 at SLIMS, Puducherry. Apgar score at 1 and 5 minutes after birth was taken and umbilical cord blood gas analysis was done immediately after birth in both groups. Mothers who came with labour pain were divided into high and low risk, if they have had any perinatal risk factors. Other data like gestational age, birth weight, need for resuscitation and admission to the newborn ward or Neonatal Intensive Care Unit were gathered for comparison between the two groups. All the data were statistically analysed using SPSS software.

RESULTS
There were no significant differences in mean birth weight, gender and mode of delivery between high-risk and low-risk mothers. Significant differences were observed in 1 and 5 minutes Apgar score, umbilical artery blood pH, pCO_2, pO_2, Base excess, HCO_3- between high-risk and low-risk mother-baby pairs. According to the Spearman's Rho correlation coefficient, there were statistically significant positive correlation ($p < 0.05$, r= 0.2 - 0.4) between 1 minute Apgar score and pH, pO_2, pCO_2 and Base excess in high-risk pregnancy, but there was no significant correlation between Apgar score at 1 and 5 minutes and umbilical blood gas parameters in low-risk group (r < 0.2, P > 0.05).

CONCLUSION
Our study highlights a correlation between 1 minute Apgar score and umbilical artery blood gas parameters in high-risk pregnancy. So we recommend assessing umbilical blood gas analysis in neonates born to high-risk mothers to detect metabolic acidaemia earlier.

KEYWORDS
Umbilical Arterial Blood Gas Parameters; Apgar Score; Metabolic Acidaemia.

BACKGROUND
When oxygen supply to the foetus is significantly disrupted, tissue oxygenation deprivation develops, acids begin to accumulate and acidaemia develops. Apgar score[1] has been used for assessment of asphyxia, predict neurological damage and vitality of a neonate during the first and fifth minute of life by the following clinical signs: heart rate, respiratory effort, muscle tone, reflex irritability and colour. Umbilical cord blood gas analysis was taken immediately after birth seem to be the most objective determination of the foetal metabolic condition at the time of birth.[2][3,4,5]

Correlation between Apgar score and umbilical artery blood gas parameters helps in better detection of high-risk newborns with metabolic acadaemia.[6,7]

Need of Study
We have gone through medical literature (PubMed, Google Scholar) and found paucity of studies available about correlation between umbilical arterial pH and Apgar score in high-risk and low-risk pregnancies.[7] We to our surprise found that no Indian studies are available in the literature reporting on correlation between umbilical artery gas parameters and Apgar score at 1 and 5 minutes in high-risk and low-risk pregnancies. Due to paucity of studies in the literature, we have done this study in Indian population for early and better detection of high-risk newborns with metabolic acidaemia.

Aims and Objectives
1.   To compare-

a.   1 minute Apgar score between high- and low-risk pregnancies.
b.   5 minutes Apgar score between high- and low-risk pregnancies.
c.   Umbilical arterial blood gas parameters between high- and low-risk pregnancies.
2.   To compare the correlation between-
a.   1 minute Apgar score and umbilical arterial blood gas parameters in high- and low-risk pregnancies.
b.   5 minutes Apgar score and umbilical arterial blood gas parameters in high- and low-risk pregnancies.
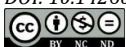
MATERIALS AND METHODS
This was an analytical comparative study conducted at Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry during June 2016 to May 2017 after approval from Ethical and Scientific Committee. Study population consisted of neonates born to mothers who were admitted with risk factors. At the time of admission, they were assigned to high- or low-risk group according to whether or not they had any perinatal risk factor. High-risk pregnancy was defined as a pregnant mother who is at risk to deliver a neonate with birth asphyxia according to the definition by American Academy of Paediatrics.[6] All mothers who delivered a baby with a major congenital anomaly or had intrauterine foetal death (IUFD) were excluded from the study.

Sample Size
Considering alpha error of 0.05 and power of study of 80%, the sample size required to detect a correlation coefficient of 0.2 was calculated by using the following formula-

$$n = \frac{2\, Z^2_{(1-\alpha)/2}\, \sigma}{d^2}$$

where n is the minimum sample size required from each of the population to estimate the difference between two means μ_1 and μ_2 with $1-\alpha$ is 95% confidence interval.
$Z_{1-\alpha/2}$ - table value from standard normal distribution corresponding to area $1-\alpha/2$
σ - standard deviation of a response variable (Assumed to be same in study population).
d - the precision required on either side of true difference $(\mu_1-\mu_2)$.

Methodology
Immediately after delivery, umbilical cords were clamped on both ends and an arterial blood sample was collected anaerobically in a pre-heparinized insulin syringe. Blood gas parameters like pH, pCO_2, pO_2, Base excess and HCO_3- were measured at 37^0C by pH and gas analyser. The gas analysis was done within 30 minutes after sampling. Values from the umbilical cord artery provide the most accurate information regarding foetal and newborn acid-base status. APGAR score was assessed by a paediatrician at 1st and 5th minute after birth. Advanced resuscitation means that a baby required positive pressure ventilation, chest compression and/or drugs administration. All resuscitated babies were transferred to neonatal intensive care unit for post resuscitation care. Foetal distress was defined by an umbilical cord pH < 7.2.

Following Data were entered in the Predesigned Data Entry Form
a.   Mother's details include Age, Obstetric index and Risk factors.
b.   Baby's details include Gestation, Birth weight, Apgar score at 1 and 5 minutes and Umbilical cord blood gas parameters like pH, pCO_2, pO_2, HCO_3– and Base excess.

Statistical Analysis
IBM SPSS statistical software version 21© was used for statistical analysis. Baseline maternal and neonatal parameters like parity, gender of the baby, mode of delivery, birth weight, risk status and Apgar score at 1 and 5 minutes were taken as explanatory parameters. Arterial blood gas parameters like pH, pCO_2, pO_2, HCO_3– and Base excess were taken as outcome parameters. Descriptive analysis of all the explanatory and outcome parameters was done. All the categorical variables were presented in frequencies and percentages. The numerical variables were presented as mean values along with their standard deviation. The association between explanatory and outcome parameters was assessed by calculating Spearman's Rho correlation coefficient and mean differences; 95% CI and p-value for all the parameters were assessed by using appropriate statistical tests like chi-square test or independent sample T test analysis. Descriptive analysis of other relevant parameters was also presented appropriately.

RESULTS

Variables		High-Risk Group (n= 73)	Low-Risk Group (n= 77)	P-Value
Mean Birth weight of the Neonates (Grams)		2970	3082	0.089
Neonates Gender	Male	39 (53.4%)	39 (50.6%)	0.734
	Female	34 (46.6%)	38 (49.4%)	
Obstetric Status	Primigravida	31 (42.5%)	32 (41.6%)	0.910
	Multigravida	42 (57.5%)	45 (58.4%)	
Mode of Delivery	NVD	33 (45.2%)	50 (64.9%)	0.112
	LSCS	25 (34.2%)	16 (20.8%)	
	VACUUM	10 (13.7%)	7 (9.1%)	
	FORCEPS	5 (6.8%)	4 (5.2%)	
Need for advanced resuscitation		5 (6.8%)	0 (0%)	0.020
Need for NICU admission		18 (24.7%)	0 (0%)	< 0.001

Table 1. Demographic Characteristics of Neonates of High- and Low-Risk Groups

NVD- Normal Vaginal Delivery; LSCS- Lower Segment Caesarean Section; NICU= Neonatal Intensive Care Unit

Table 1. shows statistically there was no significant difference in the demographic variables like mean birth weight and gender of the neonates as well as parity of the mother and mode of delivery between high- and low-risk pregnancy, whereas need for advanced resuscitation and

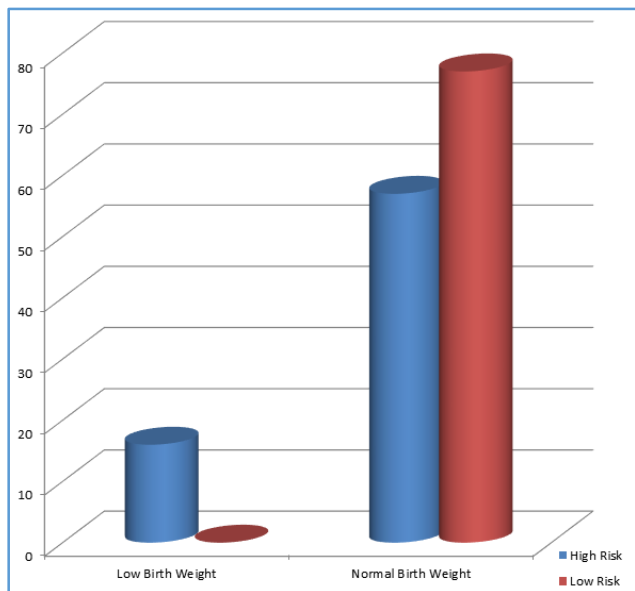NICU admission was present only in neonates born to high-risk pregnancy, which was statistically significant.

Figure 1. Low and Normal Birth Weight Babies among High- and Low-Risk Groups (N= 150)

The proportion of low birth weight infants was 21.9% in the high-risk group, whereas all the infants in the low-risk category were having normal birth weight (Fig. 1).
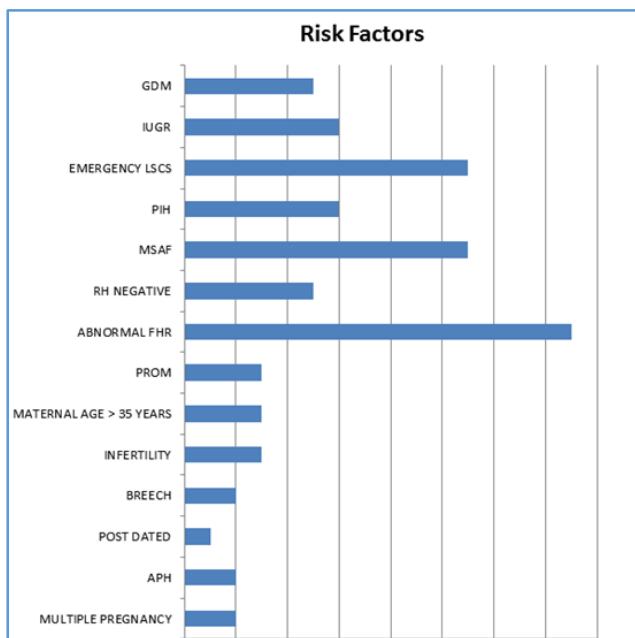

Figure 2. Frequency of High-Risk Factors in the Pregnant Women (N= 150)

The frequency of each of the high-risk factor was presented in Fig. 2. Abnormal FHR (Foetal Heart Rate), MSAF (Meconium-Stained Amniotic Fluid) and Emergency LSCS were common high-risk factors present in our study group.

Category	Mean	Mean difference	P-value	95% CI Lower	95% CI Higher
Apgar at 1 Minute					
High risk	6.95				
Low risk	7.83	-0.886	< 0.001	-0.987	-0.785
Apgar at 5 Minutes					
High risk	8.10				
Low risk	9.08	-0.982	< 0.001	-1.073	-0.891
Table 2. Comparison of Apgar Score between High-Risk and Low-Risk Pregnancies (N= 150)					

The mean 1 minute Apgar score was 0.88 (95%, CI -0.98 to -0.78) lesser and mean 5 minutes Apgar score was 0.98 (95%, CI -1.07 to -0.89) lesser in high-risk neonates compared to low-risk neonates. Both these differences were statistically significant with a p-value less than 0.001 (Table 2).

Category	Mean	Mean Difference	P-value	95% CI Lower	95% CI Higher
pO_2					
High risk	15.23				
Low risk	20.00	-4.767	<0.001	-5.784	-3.750
pCO_2					
High risk	60.44				
Low risk	50.52	9.919	<0.001	8.688	11.150
Ph					
High risk	7.13				
Low risk	7.28	-0.148	<0.001	-0.160	-0.135
HCO_{3-}					
High risk	16.82				
Low risk	21.51	-4.685	<0.001	-5.374	-3.995
Base Excess					
High risk	-8.58				
Low risk	-4.35	-4.225	<0.001	-4.786	-3.663
Table 3. Comparison of ABG (Arterial Blood Gas) Parameters between High-Risk and Low-Risk Pregnancies (N= 150)					

The arterial pCO_2 was higher and all the other parameters including pH, pO_2, HCO_{3-} and base excess were lower in high-risk group neonates. All these differences were statistically significant with a p-value of less than 0.01. The corresponding mean differences and their 95% Confidence Interval were shown in Table 3.

Parameters	High-Risk Group Correlation coefficient (r)	High-Risk Group P-value	Low-Risk Group Correlation coefficient (r)	Low-Risk Group P-value
Apgar score 1 minute- pH	0.391	0.001	0.325	0.004
Apgar score 1 minute- pO_2	0.388	0.001	0.190	0.098
Apgar score 1 minute- BE	0.341	0.003	0.129	0.264
Apgar score 1 minute- pCO_2	0.243	0.039	0.173	0.061
Apgar score 1 minute- HCO_{3-}	0.137	0.246	0.164	0.155
Table 4. Comparison of Correlation of 1 Minute Apgar Score and ABG Parameters in High-Risk and Low-Risk Pregnancies (N= 150)				

There were statistically significant (p < 0.05) weak positive correlation (r= 0.2 - 0.4) between 1 min Apgar score

and pH, pO_2, pCO_2 and BE (Base Excess) in high-risk pregnancy, while in low-risk pregnancy there was statistically significant weak positive correlation between 1 min Apgar score and pH only (Table 4).

Parameters	High-Risk Group		Low-Risk Group	
	Correlation Coefficient	P-value	Correlation Coefficient	P-value
Apgar score at 5 minutes- pH	0.277	0.018	0.133	0.062
Apgar score at 5 minutes- pO_2	0.022	0.852	0.041	0.726
Apgar score at 5 minutes- BE	0.147	0.216	0.057	0.620
Apgar Score at 5 minutes- pCO_2	0.139	0.242	0.124	0.284
Apgar score at 5 minutes- HCO_3-	0.099	0.402	0.186	0.068

Table 5. Comparison of Correlation of 5 Minutes Apgar Score and ABG Parameters in High-Risk and Low-Risk Pregnancies (N= 150)

There was a statistically significant weak positive correlation (r = 0.2 - 0.4) between 5 min APGAR score and pH in high risk pregnancy, while in low risk pregnancy there were no statistically significant correlation between 5 min APGAR score and any of the umbilical artery blood gas parameters (Table 5).

DISCUSSION

This was an analytical comparative study done during June 2016 to May 2017 at Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry. Target population includes all term pregnant mothers with their newborn. Study population was newborns delivered to mothers with risk factors based on inclusion and exclusion criteria. This study was done to correlate Apgar score and Umbilical arterial blood gas parameters in high- and low-risk newborns at birth. This may be the first Indian study to observe the correlation between Apgar score and Umbilical arterial blood gas parameters.

Demography

In our study, 150 pregnancies were enrolled. Out of them 63 (42%) were primigravida and 87 (58%) were multigravida. High-risk and low-risk pregnancies were in 73 (45.2%) and 77 (64.9%) respectively, whereas Kacho MA et al[7] also divided Demographic variables into high-risk and low-risk groups.

High Risk Factors

In our study, high-risk group included pregnancy with one of the risk factors as mentioned earlier. This risk factor inclusion criterion was similar to studies done by Kacho MA et al[7] and Goldaber KG et al.[8]

The predominant risk factors seen in our study according to frequency are as follows: Abnormal FHR, MSAF and Emergency LSCS. This was partially similar to study done by Kacho MA et al,[7] which also showed Emergency LSCS as the most common risk factor followed by MSAF and PROM.

In our study, the least common risk factors were multiple pregnancies and post-dated pregnancy. This finding was

similar to study done by Kacho MA et al,[7] which showed multiple pregnancies as of the least risk factors.

Mode of Delivery

In our study, normal vaginal delivery was the predominant mode of delivery in both high-risk (45.2%) and low-risk groups (64.9%). Other modalities of deliveries like LSCS, Vacuum and Forceps are also almost similar in both high-risk and low-risk group. But in low-risk group they are due to maternal indications like poor maternal effort, failed induction and maternal concern towards safe confinement. There was also no statistical significant difference between high-risk and low-risk pregnancies in the various modes of deliveries (p > 0.05). This may be the first study to compare the mode of deliveries between high- and low-risk groups. None of the studies compared the mode of deliveries between high- and low-risk groups. But Rahmanian K et al[9] compared mode of deliveries (Elective Caesarean Section and Normal Vaginal Deliveries) with 5 mins Apgar score and found that there were no significant difference between two mode of deliveries.

Gender

In our study, 78 (52%) were male babies and 72 (48%) were female babies. There was no statistically significant difference in gender of the babies between high-risk and low-risk group (p > 0.05). Similar observations were seen in Kacho MA et al[7] study.

Birth Weight

In our study, all 16 (10.7%) low birth weight (< 2.5 kgs) newborns belonged to high-risk group and the mean birth weight was lower in high-risk group compared to low-risk group and this observation was in concordance with Kacho MA et al[7] study.

Gestational Age

Our study was done in term babies only. Similar observations were seen in Kacho MA et al,[7] Anyaegbunam A et al,[10] Locatelli A et al[11] and Modarressnejad V et al[5] studies, whereas Manganaro R et al[12] studied in both term and preterm infants.

Advance Resuscitation

Out of 73 babies who were delivered to high-risk mothers, 5 (6.8%) required advanced resuscitation in our study which was almost similar to Kacho MA et al[7] study who observed 3 (6.12%) high-risk newborns required advanced resuscitation. In this study, none of the low-risk group newborns required advanced resuscitation which was in concordance with Kacho MA et al[7] study.

In our study, we found that there was a significant difference between high-risk and low-risk babies who required advanced resuscitation which was dissimilar with Kacho MA et al[7] study who showed no significant difference between high-risk and low-risk babies who required advanced resuscitation.

NICU Admission

In our study 18 (12%) babies required NICU admission, all of which belonged to high-risk group. None of the babies in low-risk group required NICU admission and this difference was statistically significant (p < 0.05). Out of 18 NICU admissions 7 (38.9%) were admitted for respiratory distress, 5 (27.8%) for post resuscitation care, 4 (22.2%) for sepsis and 2 (11.1%) for hypoglycaemia.

In Kacho MA et al[7] study, 3 (6.12%) high-risk group babies required NICU admission which was not similar to our study, but no low-risk babies required NICU admission which was same as in our study.

In a study by Manganaro R et al,[12] 10/613 infants (1.6%) required NICU admission. Out of them, 7 (70%) were admitted either for respiratory distress or for birth asphyxia. This finding was similar to our study, where most of the admissions were due to respiratory distress and post resuscitation care (66.7%).

Newborns with both abnormal pH and 5 mins Apgar had the highest incidence of NICU admissions, which was seen in Anyaegbunam A et al[10] study.

Apgar Score

In our study, the Mean (SD) Apgar score at 1 and 5 minutes were low in high-risk group compared to low-risk group, which was similar to Kacho MA et al[7] study in which there were statistically significant difference in 1 minute and 5 minutes APGAR scores between high-risk and low-risk groups.

In a study by Manganaro R et al[12] demonstrated that 1 min Apgar score was more influenced by the mode of delivery and by gestational age and 5 mins Apgar score had a high concordance with metabolic acidaemia. In our study both 1 and 5 mins Apgar scores were not much influenced by mode of delivery, whereas both 1 and 5 mins Apgar scores were influenced by abnormal pCO_2 and HCO_3- values.

Modarressnejad V et al[5] showed that low 1 min Apgar score was significantly related to acidaemia.

Umbilical Cord Blood Gas Analysis

In our study Umbilical artery parameters like pH, pO_2, pCO_2 and HCO_3- values are statistically significant between high- and low-risk pregnancies which was in concordance with Kacho MA et al[7] study, whereas in addition BE was also statistically significant in our study which was not seen in Kacho MA et al[7] study.

Correlation between Apgar Score and Umbilical Cord Blood Gas Analysis

In the literature, only few studies (Kacho MA et al,[7] Manganaro R et al[12]) had correlated Apgar scores at 1 minute and 5 minutes with Umbilical artery parameters. Kacho MA et al[7] showed that significant correlation between Apgar score at 1st and 5th minute and the umbilical cord pH concluded that a combination of Apgar score and umbilical cord pH measurement in high-risk pregnant mothers could better detect jeopardised baby, whereas Manganaro R et al[12] observed that low Apgar scores with metabolic acidaemia have the highest incidence of NICU admission and poor neonatal outcome.

Two studies (Fields LM et al[2] and Boehm FH et al[13]) had correlated 1 minute Apgar score with Umbilical artery pH and showed that metabolic acidaemia was seen in 46% and 87.5% of newborn babies respectively.

In a study done by Manganaro R et al,[12] found that metabolic acidaemia is associated with low 5 minutes Apgar score.

The studies by Anyaegbunam A et al,[10] Locatelli A et al[11] and Sykes GS et al[14] also showed that metabolic acidaemia is associated with low 5 minutes Apgar score.

Studies done by Raafati SH et al,[15] Kaveh M et al[16] and Garzoli E et al[17] showed that there is no positive correlation between Apgar score and Umbilical artery acidaemia with mode of delivery. In our study, Apgar score and Umbilical artery blood gas values were not influenced by mode of delivery.

Studies done by Gilstrap LC et al[18,19] and Honjo S et al[20] had correlated umbilical artery acidaemia with abnormal foetal heart rate in the second stage of labour. This is similar to our study, in which 90% of cases with abnormal heart rate had acidaemic arterial blood gas values.

CONCLUSION

Our study highlights a correlation between 1 minute Apgar score and umbilical artery blood gas parameters in high-risk pregnancy. So, we recommend assessing umbilical blood gas analysis in neonates born to high-risk mothers to detect metabolic acidaemia earlier.

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