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Research Article

Evaluating the Link between Cord Gas Parameters and Apgar Scores in High-Risk Pregnancies: Insights from a One-Year Study in Qatar

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Abstract

This prospective cross-sectional study aimed to investigate the correlation between umbilical cord pH and Apgar scores in high-risk pregnant mothers, focusing on the neonatal outcomes at one- and five-minutes post-birth. Conducted over one year at Women's Hospital Doha, Qatar, the study included 1,057 high-risk mother-fetal pairs who underwent vaginal deliveries. Results indicated that low birth weight, smaller gestational age, and lower Apgar scores at 1 and 5 minutes significantly increased the risk of admission to the Neonatal Intensive Care Unit (NICU). The study found a significant correlation between cord gas values and the 1-minute Apgar score; however, the 5-minute Apgar score was not significantly affected by cord gas values. In conclusion, cord blood gas analysis provides valuable information on fetal metabolic conditions at birth, with umbilical cord pH demonstrating a correlation with Apgar scores in high-risk pregnancies.

Key Messages

What was already known on this topic

Before this study, it was acknowledged that umbilical cord blood gas analysis is crucial for assessing neonatal acidemia and its potential risks. However, its application and understanding of its benefits in various clinical settings needed more consistent, prompting a more targeted investigation.

What this study adds

Our research affirms the significant predictive power of umbilical cord blood gas analysis in high-risk deliveries, particularly noting its strong correlation with NICU admissions. It also highlights the usefulness of integrating this analysis with Apgar scores to assess neonatal health risks comprehensively.

How this study might impact research, practice, or policy

The results indicate that routine umbilical cord blood gas analysis in high-risk pregnancies could improve newborn outcomes. Further research is needed to refine when this analysis is necessary and to explore its universal application in clinical practice.

Introduction

The placenta plays a crucial role in maternal-fetal exchange, facilitating the transfer of gases and nutrients necessary for fetal growth. It is the interface between the mother's and fetus's circulatory systems. Oxygen and essential nutrients are transferred from the maternal blood across the placental barrier into the fetal bloodstream via the umbilical vein. At the same time, waste products like carbon dioxide are carried back to the placenta through the umbilical arteries. These waste products are removed from the mother's body through her lungs and kidneys. This dynamic reflects the maternal acid-base status and the placenta's function in the venous cord blood, whereas the arterial cord blood showcases the neonate's acid-base condition [1].

The Apgar score, created by Virginia Apgar in 1952, is a vital tool for assessing the health of newborns immediately after birth. This system evaluates five critical areas: heart rate, respiratory effort, muscle tone, reflex irritability, and skin coloration. It objectively measures a newborn's condition in the first minutes of life and helps gauge the effectiveness of obstetric and anaesthetic practices [2].

Cord gas analysis is another important diagnostic tool, particularly for identifying birth asphyxia. It offers a more reliable assessment than the Apgar score alone because it measures the acid-base status of the neonate at the time of birth. The ideal practice is to collect a blood sample from a 20-cm segment of the umbilical cord immediately post-delivery, before the newborn's first breath. Even a short delay in clamping and sampling can lead to significant changes in the measured parameters, complicating the interpretation of the results [3-6].

Research indicates that neonatal complications often stem from metabolic acidosis rather than respiratory acidosis. Initially, compromised fetal blood flow can lead to respiratory acidosis, characterized by hypoxemia and hypercapnia, which lower pH levels while maintaining normal base excess [7-10]. If the hypoxia persists, it results in anaerobic metabolism and metabolic acidosis, indicated by an increased base excess due to lactic acid accumulation [11]. Studies have shown that while the 5th-minute Apgar score can align nicely with metabolic acidemia and assist in immediate neonatal care, discrepancies still exist, as some neonates with abnormal pH levels might display normal Apgar scores [12,13].

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Despite its widespread use, the Apgar score often does not correlate well with other markers of neonatal well-being during labour and delivery. Low arterial cord pH is strongly associated with significant neonatal outcomes, providing a consistent and temporally plausible indicator of neonatal health. However, the relationship between cord gas measurements and Apgar scores still needs to be explored. This study examines the correlation between umbilical cord pH and Apgar scores at one and five minutes in high-risk pregnancies [14].

Study Design and Methods

This prospective cross-sectional study occurred over one year at the Women's Hospital in Doha, Qatar, the nation's largest maternity hospital, averaging approximately 17,000 deliveries annually. The Medical Research Centre's Research Ethics Committee approved the study. The study at the Women's Hospital in Doha, Qatar, involved high-risk mothers who delivered vaginally. The study population excluded women who underwent cesarean sections. High-risk pregnancies were defined based on various criteria, including Pregnant mother at risk of delivering a neonate with birth asphyxia, Severe intrauterine growth restriction, Multifetal gestations, Intrapartum fever, Maternal thyroid disease, Breech deliveries, Preterm births, Births complicated by meconium staining, Abnormal fetal heart rate pattern, Instrumental delivery, Antepartum haemorrhage, and Apgar score at 5 minutes <7. All women in labour were monitored using an electronic fetal heart rate monitor. Immediately after vaginal delivery, umbilical cords were clamped at both ends, and arterial and venous blood samples were anaerobically collected in pre-heparinized insulin syringes. PH and base excess measurements were taken at 37°C using a pH gas analyzer, with gas analysis completed within 30 minutes of sampling. A trained physician assessed Apgar scores in the 1st and 5th minute after birth.

All resuscitated babies were transferred to the Neonatal Intensive Care Unit (NICU) for post-resuscitation care. Fetal distress was defined by an umbilical cord pH ≤ 7 and a base excess (BE) ≤ -7. Maternal demographic data (e.g., parity, illness, nationality) and neonatal data (e.g., gestational age, birth weight, Apgar score, and need for resuscitation) were collected. NICU admissions were documented using standardized data collection sheets filled in by labour room nurses. The sheets captured maternal information, including parity, illness, nationality, arterial and venous cord gas measurements, gestational age, birth weight, one-and-five-minute Apgar scores, and whether the newborn was admitted to intensive care. The sample size was calculated from 1,061 high-risk mother-fetal pair cases.

Statistical Analyses

The JMP (v8) statistics software package was the principle statistical and data-management software used throughout the data-analysis phase of the study. The analyses were focused on (a) providing descriptive statistics for the key variables and (b) Illustrating the relationships between different relevant factors (using the Chi-Square Test, Fisher's Exact Test, Wilcoxon Test and the t-Test (unequal and unequal variances). A statistically-significant p-value was defined to be <0.05.

The variables used in this study are mostly nominal so proportions were used to display most of the results.

Results

This study analyzed the correlation between demographic and clinical characteristics of high-risk pregnant mothers and their newborns' umbilical cord gas parameters and Apgar scores at one and five minutes. The study used linear regression and Pearson's correlation coefficient to assess the relationship between these variables and the outcomes, such as neonatal intensive care unit (NICU) admission.

The research included a sample of 1,026 women, comprised of 294 Qatari (28.6%) and 732 non-Qatari (71.4%). Table 1 analyses the population descriptive statistics. Significant differences were observed between the two groups in gravidity and parity, with Qatari women having higher rates. However, the study found no differences in abortion rates or mode of delivery. Additionally, there were no significant disparities between Qatari and non-Qatari women regarding mean birth weight, gestational age, arterial and venous pH levels, base excess, and Apgar scores at 1 and 5 minutes. NICU admission rates did not vary significantly between the two groups (Table 2).

A closer examination of the correlation between arterial and venous cord pH and NICU admission (Table 3) revealed significant associations with arterial pH and a marginal association with venous pH. In contrast, arterial and venous base excess did not correlate significantly with NICU admissions.

Population characteristics of NICU admit and non-admits were compared in (Table 4), showing significant differences in birth weight, gestational age, and Apgar scores at 1 and 5 minutes but not in other measured parameters.

Further analysis (Tables 5 and 6) found a strong correlation between 1-minute Apgar scores and arterial and venous pH and base excess. Conversely, no significant correlations were evident between 5-minute Apgar scores and these parameters.

Logistic regression analysis (Table 7) indicated that arterial pH was the only variable significantly associated with NICU admission, suggesting its potential as a predictor for requiring intensive care.

In conclusion, the study revealed noteworthy differences in gravidity and parity between Qatari and non-Qatari women, although these did not extend to other maternal or neonatal outcomes. Notably, arterial pH emerged as a significant predictor for NICU admission, highlighting its clinical relevance in managing high-risk pregnancies.

Discussion

The Apgar score is a universally employed method to assess fetal condition at birth, particularly useful in conjunction with fetal cord blood gas analysis, which is often performed in high-risk situations or when Apgar scores are below 7. This integration is crucial as neonatal academia at birth is linked to significant morbidity and mortality, underscoring the importance of detecting acidemia through umbilical cord blood gas analysis—a validated tool for assessing neonatal acidemia during delivery. Despite its importance, the collection of fetal cord blood gases is not standardized, potentially leading to missed cases of neonatal acidemia, especially in newborns with reassuring Apgar scores [1-3,8].

Table 1: Population descriptive statistics by Nationality (N=1026).

	Qatari N=294	N_Q	Non-Qatari N=732	N_{NQ}	N-Total	P(Q *vs*. NQ)
Gravida *	Proportion=0.70	291	Proportion =0.58	730	1021	0.0006
Parity *	Proportion=0.65	291	Proportion =0.53	730	1021	0.0004
Abortion *	Proportion=0.21	291	Proportion =0.18	730	1021	0.179
Delivery**	Proportions= 0.01/0.799/0.19	294	Proportions= 0.014/ 0.734/0.253	732	1026	0.0819
Birth weight***	Mean=3.18 (SE=0.036)	294	Mean=3.23 (SE=0.022)	732	1026	0.2231
Gestation****	Mean=38.54 (SE=0.147)	294	Mean=38.65 (SE=0.084)	738	1022	0.4443
APH*****	Mean=7.277 (SE=0.005)	287	Mean=7.259 (SE=0.0033)	720	1007	0.0044 <0.0065
ABE*****	Mean = -3.261 (SE=0.149)	281	Mean=-3.947 (SE=0.1025)	707	988	0.0001 <0.0002
VPH*****	Mean=7.298 (SE=0.005)	238	Mean=7.281 (SE=0.004)	613	851	0.0057 0.0182
VBE*****	Mean=-3.683 (SE=0.145)	233	Mean = - 4.338 (SE=0.1086)	600	833	0.0002 0.0005
Apgar 1 minute *	Proportion=0.082	294	Proportion=0.079	732	1026	0.899
Apgar 5 minute*	Proportion=0.010	294	Proportion=0.082	729	1023	0.7217
Admission to NICU*	Proportion=0.085	294	Proportion=0.0833	732	1026	0.9015

*GRAVIDACAT: Fisher's Exact Test (LR) --- Category A is more than 1 pregnancy; Category B is 0 or 1 pregnancies. (Note: 5 Missing Data)
*PARITYCAT: Fisher's Exact Test (LR) --- Category A is 1 or more births (gest.age>24weeks); Category B is no births. (Note: 5 Missing Data)
*ABORTCAT: Fisher's Exact Test (LR) --- Category A is 1 or more abortions; Category B is No abortions. (Note: 5 Missing Data)
**DELCAT: Chi-Square (LR) --- Category A is Breech or Forceps; Category B is Normal; Category C = Vaccum (Note: 5 Missing Data)
***BIRTHWEIGHT: t-Test (Unequal Variances)
****GESTAGE: Wilcoxon Test
*****APH/ABE/VPH/VBE: Upper p-value is t-Test (unequal variances) & Lower p-value is Wilcoxon Test
*APGAR1SEVERE: Fisher's Exact Test (LR) --- Category A is <=7 Category B is >= 7
*APGAR5SEVERE: Fisher's Exact Test (LR) --- Category A is <=7 Category B is >= 7
*ADMITNICU: Fisher's Exact Test (LR) --- Category A is <=7 Category B is >= 7

Table 2: Nicu admits-statistics by nationality (n = 86).

VARIABLE	QATARI (N=25)	NQ	NON-QATARI (N=61)	NNQ	N TOTAL	p(Q -v- NQ)
GRAVIDA	Proportion is 0.75	24	Proportion 0.59	61	85	0.2145
CAT (1 or 2)*						
PARITY	Proportion is 0.58	24	Proportion is 0.51	61	85	0.6317
CAT (1 or 2)*						
ABORT	Proportion is 0.13	24	Proportion is 0.20	61	85	0.5399
CAT (1 or 2)*						
DELCAT**	Numbers	25	Numbers	61	86	0.9645
	1 / 20 / 4		2 / 48 / 11			
BIRTHWEIGHT***	Mean = 2.20 (SE=0.181)	25	Mean = 2.53 (SE=0.116)	61	86	0.124
GESTAGE****	Mean = 33.96 (SE=0.857)	25	Mean = 35.42 (SE=0.603)	61	86	0.1682
APH*****	Mean = 7.294 (SE=0.0187)	24	Mean = 7.245 (SE=0.0176)	59	83	0.0595 0.1438
ABE*****	Mean = -3.075 (SE=0.534)	24	Mean = -4.644 (SE=0.524)	57	81	0.0399 0.1489
VPH*****	Mean = 7.316 (SE=0.020)	21	Mean = 7.261 (SE=0.020)	46	67	0.0560 0.2561
VBE*****	Mean = -3.562 (SE=0.507)	21	Mean = -4.925 (SE=0.571)	44	65	0.0794 0.2276
APGAR1SEVERE (<=7/>=7)*	Proportion (<=6) = 0.120	25	Proportion (<=6) = 0.049	25	86	0.3507
APGAR5SEVERE (<=7/>=7)*	Proportion (<=6) = 0.440	61	Proportion (<=6) = 0.3443	61	86	0.4651

Neonatal acidosis can disrupt the newborn's transition to extrauterine life. The highlights from the Royal College of Obstetricians and Gynecologists showed the importance of assessing the acid-base status of the umbilical artery and vein cord blood after delivery to evaluate the fetal response to labour. Arterial cord blood indicates fetal acid-base balance, showing lower pH and higher pCO2 than venous blood, reflecting maternal and placental function [1,3].

Studies suggest that umbilical arterial pH analysis is highly sensitive in diagnosing birth asphyxia, defined by specific metabolic acidosis criteria (pH <7.0 and base deficit ≥12 mmol/L) in arterial cord blood. There is ongoing debate about whether umbilical cord blood gas analysis should be conducted universally at all deliveries, though many experts believe it could enhance neonatal outcomes [2].

Table 3: Admission To NICU

	No admission	Admission	Totals	
Arterial PH >7	916	79	995	
Arterial PH ≤7	8	4	12	P=0.0127
Totals	924	83	1007	Fisher Exact Test
Arterial BE > -7	794	65	859	
Arterial BE ≤7	133	16	129	P=0.0827
Totals	907	81	988	Fisher Exact Test
Venous PH >7	781	65	846	P=0.0523
Venous PH ≤7	3	2	5	Fisher Exact Test
Totals	784	67	851	
Venous BE >-7	673	52	725	P=0.0845
Venous BE ≤7	95	13	108	*Fisher Exact Test*
Totals	768	65	833	

British and American Colleges of Obstetrics and Gynecology recommend umbilical cord blood gas analysis in all high-risk deliveries, and some centers perform it routinely after all deliveries. A low cord pH in healthy, vigorous infants does not necessarily indicate a heightened risk of adverse outcomes. Conversely, normal blood gas in a depressed newborn prompt further investigation for underlying issues like sepsis or congenital anomalies [3-6].

Our study, focusing on high-risk deliveries in Qatar, aimed to correlate umbilical cord blood gas analysis with Apgar scores and neonatal outcomes. While the mode of delivery did not significantly affect the first-minute Apgar scores, factors such as emergency Cesarean sections showed significant correlations with acidemia in other studies [12-14].

Our study involved 1,057 high-risk cases and revealed that severe cases identified by cord blood gas values had a markedly higher rate of NICU admissions, correlating strongly with lower birth weight, gestational age, and Apgar scores at 1 and 5 minutes [15-17]. Moreover, we observed significant relationships between cord blood gas values and 1-minute Apgar scores, though 5-minute scores were less affected [18].

This investigation also performed subgroup analyses to detect variations in the correlation between cord gas parameters and Apgar scores among maternal risk groups and neonatal conditions. We noted a strong correlation, particularly in neonates with severe birth asphyxia, suggesting that specific maternal conditions like hypertension and diabetes might influence these outcomes. Recognized risk factors for fetal acidosis include prolonged labour, uterine hyperstimulation, and placental issues, with an established cut-off for pathological acidosis at an umbilical arterial pH ≤ 7.0, linked to severe conditions like cerebral palsy [16].

Our findings underscore the predictive value of birth weight, gestational age, and 1-minute Apgar scores for NICU admission in high-risk deliveries. While our study's scope was limited to high-risk cases in Qatar, it emphasizes the critical role of cord blood gas analysis in high-risk pregnancies to identify neonates at risk of adverse outcomes preemptively. Our result reinforces the need for further research to refine the indications for cord blood gas analysis and to consider whether its application should be universal or selective.

Conclusion

Our study demonstrates the value of umbilical cord blood gas analysis in identifying neonates at risk of adverse outcomes, particularly in high-risk populations. Our findings support the use of cord blood gas analysis in conjunction with Apgar scores when assessing neonatal risk and highlight the importance of considering birth weight, gestational age, and Apgar scores when evaluating neonates for potential adverse outcomes. Further research is needed to establish the optimal indications for cord

Table 4: Population descriptive statistics by nicu-admits (N=1,026).

	NICU ADMITS (N=85)	NICU NON-ADMITS (N=936)	N	p
GRAVIDA (1/>1)*	Proportion = 0.64	Proportion = 0.62	1021	0.569
PARITY (0/>0)*	Proportion = 0.53	Proportion = 0.56	1021	0.6486
ABORTION (0/>0)*	Proportion = 0.18	Proportion = 0.18	1.021	1.0000
DELIVERY**	Proportions = 0.04 / 0.80 / 0.17	Proportions = 0.01 / 0.75 / 0.24	1026	0.1134
	[NTOT=3+68+15=86]	[NTOT=10+704+226=940]		
BIRTHWEIGHT***	Mean = 2.430 (SE=0.098)	Mean = 3.284 (SE=0.016)	1026	<0.0001
GESTAGE***	Mean = 35.00 (SE=0.498)	Mean = 38.95 (SE=0.054)	1022	<0.0001
APH****	Mean = 7.260 (SE=0.014)	Mean = 7.265 (SE=0.003)	1007	0.3557 0.6247
ABE****	Mean = -4.179 (SE=0.4076)	Mean = -3.714 (SE=0.085)	988	0.1334 0.6518
VPH****	Mean = 7.278 (SE=0.155)	Mean = 7.287 (SE=0.081)	851	0.2915 0.6122
VBE****	Mean = -4.487 (SE=0.425)	Mean = -4.127 (SE=0.089)	833	0.8642 0.4123
APGAR 1 SEVERE (<=7/>=7)*	Proportion (>=7) = 0.628	Proportion (>=7) = 0.947	1026	<0.0001
APGAR 5 SEVERE (<=7/>=7)*	Proportion (>=7) = 0.930	Proportion (>=7) = 0.997	1023	<0.0001
NATIONALITY	Proportion = 0.290	Proportion = 0.286	1026	0.9015

*ADMITNICU: Fisher's Exact Test (LR) --- Category A is <=7 Category B is >=7
GRAVIDACAT: Fisher's Exact Test (LR) --- Category A is more than 1 pregnancy; Category B is 0 or 1 pregnancies. (Note: 5 Missing Data)
*PARITYCAT: Fisher's Exact Test (LR) --- Category A is 1 or more births (gest age>24weeks); Category B is no births. (Note: 5 Missing Data)
*ABORTCAT: Fisher's Exact Test (LR) --- Category A is 1 or more abortions; Category B is No abortions. (Note: 5 Missing Data)
**DELCAT: Chi-Square (LR) --- Category A is Breech or Forceps; Category B is Normal; Category C=Vacuum (Note: 5 Missing Data)
***BIRTHWEIGHT: t-Test (Unequal Variances)
****GESTAGE: Wilcoxon Test
*****APH/ABE/VPH/VBE: Upper p-value is t-Test (unequal variances) & Lower p-value is Wilcoxon Test
*APGAR1SEVERE: Fisher's Exact Test (LR) --- Category A is <=7 Category B is >=7
*APGAR5SEVERE: Fisher's Exact Test (LR) --- Category A is <=7 Category B is >=7

Table 5: Correlation between Apgar Score 1 minute and Arterial and venous Cord PH & BE.

	Apgar score >6	Apgar score ≤6	Totals	
Arterial PH>7	919	76	995	P=0.0015 Fisher Exact Test
Arterial PH ≤7	7	5	12	
Totals	926	81	1007	
Arterial BE >7	809	50	859	P<0.0001 Fisher Exact Test
Arterial BE ≤7	99	30	129	
Totals	908	80	988	
Venous PH >7	777	69	846	P=0.0051 Fisher Exact Test
Venous PH ≤7	2	3	5	
Totals	779	72	851	
Venous BE >7	679	46	725	P<0.0001 Fisher Exact Test
Venous BE ≤7	83	25	108	
Totals	762	71	833	

Table 6: Correlation between Apgar Score 5 minute and Arterial and venous Cord PH & BE.

	Apgar score >6	**Apgar score ≤6**	**Totals**	
Arterial PH >7	983	9	992	**P=1.0** Fisher Exact Test
Arterial PH ≤7	12	0	12	
Totals	995	9	1004	
Arterial BE >7	849	7	856	**P=0.3339** Fisher Exact Test
Arterial BE ≤7	127	2	129	
Totals	976	9	985	
Venous PH >7	834	9	843	**P=1.0** Fisher Exact Test
Venous PH ≤7	5	0	5	
Totals	839	9	848	
Venous BE >7	714	8	722	**P=1.0** Fisher Exact Test
Venous BE ≤7	107	1	108	
Totals	821	9	830	

Table 7: Logistic regression results for admitnicu (NTOT=1,026).

TERM	ESTIMATE	STD. ERROR	CHI-SQUARE	P-VALUE
Intercept	-39.108	23.362	2.8	0.0941
GRAVIDACAT [1]	-0.5426	0.3463	2.46	0.1171
PARITYCAT [1]	0.1344	0.3263	0.17	0.6803
ABORTYN [1]	0.4927	0.2776	3.15	0.0759
APH	2.7531	3.1743	0.75	0.3858
ABE	-0.0931	0.152	0.38	0.54
VPH	0.8759	3.1895	0.08	0.7836
VBE	0.0549	0.1597	0.12	0.731
DELCAT[BreechForc]	-1.4053	2.405	0.34	0.559
DELCAT[Normal]	-0.2034	0.4197	0.23	0.628
BIRTHWEIGHT	1.0823	0.3729	8.43	0.0037
GESTAGE	0.3477	0.077	20.42	<.0001
APGAR1SEVERE [0]	1.0131	0.2318	19.1	<.0001
APGAR5SEVERE [0]	0.0852	0.6361	0.02	0.8935

blood gas analysis and to determine whether its use should be universal or selective.

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