THE CORRELATION OF ARTERIAL CORD BLOOD GAS VALUES AND APGAR SCORES IN TERM BABIES WITHOUT FETAL DISTRESS AND THEIR EFFECTS ON NICU ADMISSIONS

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Abstract

Background Umbilical artery cord blood gas (UACG) values and Apgar scores (AS) are the two parameters that provide the fastest information about the well-being of a baby after birth. We hypothesized that AS may not be sufficient for a complete and correct evaluation of the newborns and UACG should be used routinely for all births even without any signs of fetal distress. Material-methods In this retrospective study, the data of 1781 babies born between January 2018 and December 2019 at Cerrahpasa Faculty of Medicine were analyzed. Newborn with fetal distress, congenital anomalies, severe and moderate acidemia ($\text{pH} \leq 7.1$ at UACG), and pre and postterm newborns are excluded. The UACG and the 1 and 5-minute AS data of 1438 cases were evaluated. Mild acidemia was accepted as a pH between 7.1 and 7.2. Following UACG threshold values were accepted as abnormal $\text{pH} < 7.2$, $\text{BE} < -6$ mmol/l, lactate ≥ 5 mmol/l, $\text{HCO}_3^- < 18$ mmol/l, $\text{pCO}_2 \geq 50$ mmHg. We evaluated the correlation between UACG and 1 and 5-minute AS and their effects on admission to neonatal intensive care unit (NICU). Results There was a significant correlation between both 1 and 5-minute AS and UACG values such as pH, lactate, and pCO_2 ($p < 0.001$). In addition, significant correlation was found between the 5-minute AS below 7 and some UACG abnormal threshold values (pH, HCO_3^- , base excess) ($p < 0.001$). We found that some cases with mild acidemia had a normal 1 and 5-minute Apgar scores ($\text{AS} \geq 7$) in %1.9 and %2 of cases, respectively. A significant correlation was found between admissions to NICU with 1 and 5-minute AS of < 7 ($p < 0.001$). Conclusions The 5-minute AS of 7 or higher may not be sufficient to verify the well-being of a newborn. Relying only on AS, may create the risk of missing some newborns with mild metabolic acidosis. 1 and 5-minute AS could be used as a predictive value for NICU admission. We propose that routine UACG should be evaluated for each birth at term, even without any signs of fetal distress and normal AS.

1. Introduction

The Apgar score (AS) is a simple, reproducible scoring system developed by Virginia Apgar in 1952 to evaluate the postnatal condition of the newborn (1). This scoring is used to quickly assess the clinical condition of the newborn at 1 and 5-minute after birth. AS is obtained from the evaluation of 5 parameters (skin color, heart rate, crying, muscle tone, respiratory activity) (1, 2). Especially a 5-minute AS below 7 indicates an increased risk of neonatal asphyxia (3). This scoring system may be affected by prematurity, congenital anomalies, maternal drug use, and interobserver variability (4). However, recent literature shows that AS is as effective in predicting neonatal well-being as it has been accepted since many years (5). AS may decrease in association to gestational age, but cannot predict morbidity or mortality for each newborn. It is used worldwide to assess the condition of babies immediately after birth and to evaluate the effectiveness of resuscitation. The AS has never been designed to predict the outcome beyond the postpartum period (6).

Umbilical artery cord blood gas (UACG) is used as another method that can help to evaluate the health status of the newborn. UACG allows assessment of the patient's circulation, respiration, metabolic and electrolytic status or hypoxia (7). In UACG, especially pH, base excess (BE), and lactate are evaluated after birth. The reference value for BE is $-2/+2$ mmol/l. When this value is negative, it means that there is a

lack of base and the patient is in a state of metabolic acidosis. Lactate is produced by cellular metabolism in hypoxic conditions, with less energy production, which can lead to overproduction or poor elimination of lactates. Different studies have reported normal umbilical arterial lactate values ranging from 2.55 to 4.63 mmol/L (8). pH is the result of the balance between lactate, which tends to lower the pH, and BE, which tends to stabilize it (9). UACG is important for evaluating neonatal acidemia, but is generally not recommended for every routine delivery. However, routine UACG is recommended for all high risk deliveries (10). In the meta-analysis of Malin GL et al., evaluating the UACG pH value and perinatal and long-term outcomes, it was reported that $\text{pH} < 7.2$ is associated with mortality and morbidity (11).

UACG values and AS are the two parameters that provide the fastest information about the well-being of a baby after birth. We hypothesized that AS may not be sufficient for a complete and correct evaluation of the newborns and UACG should be used routinely for all births even without any signs of fetal distress and normal AS in order not to miss the mild acidemia at birth. We also evaluated the correlation between AS and UACG in all term newborns without any known risk factors causing fetal distress and examined their effects on admission to neonatal intensive care unit (NICU).

2. Material-method

2.1. Patients and data

In this retrospective study, the data of 1781 babies born between January 2018 and December 2019 at Cerrahpasa Faculty of Medicine were analyzed. Newborn with fetal distress, congenital anomalies, severe and moderate acidemia ($\text{pH} \leq 7.1$ at UACG), and pre and postterm newborns are excluded. The UACG and the 1 and 5-minute AS data of 1438 cases were evaluated.

Ethics approval was obtained from Istanbul University-Cerrahpaşa Faculty of Medicine Ethics Committee (reference no:162202).

Cord blood gases were taken into heparinized injectors in the form of at least 1.5 ml of both arterial blood gas without cord clamping. Samples were measured by ABL Flex (Radiometer) within 20 minute.

2.2. Definitions

The diagnosis of intrapartum fetal distress was based on abnormal cardiotocography tracing according to the International Federation of Gynecology and Obstetrics (FIGO) classification system (12). Newborns with a preliminary diagnosis of fetal distress were excluded from the study.

In the literature, a 5-minute AS between 7 and 10 had been determined as a safe range in terms of neonatal encephalopathy and long-term neurological outcomes (13). Therefore in this study, an AS between 7 and 10 was considered as normal and <7 as low.

UACG threshold values indicating perinatal asphyxia had been reported as pH <7.0 and BE <-12 in some Meta analysis (14). In this study, threshold values of severe, moderate and mild acidemia in UACG were accepted as: pH $\leq$ 7.0 and pH between 7.0-7.1, and pH between 7.1-7.2, respectively (3). Cases with a pH value above 7.1 in UACG were included in the study. Abnormal UACG threshold values were accepted as pH <7.2, BE <-6 mmol/l, lactate $\geq$ 5 mmol/l, bicarbonate (HCO₃) <18 mmol/l, partial pressure of carbon dioxide (pCO₂) $\geq$ 50 mmHg according to the previous studies (14-16).

In this study, first we evaluated, the correlation between 1 and 5-minute AS and UACG, then we studied the correlation between low 1 and 5-minute AS (<7) and abnormal threshold values of UACG parameters. The effect of 1 and 5-minute AS and UACG parameters abnormal threshold values on predicting admission to NICU were also investigated.

2.3. Statistical analysis

SPSS v.21 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Continuous variables (Apgare score, pH, lactate, HCO₃, pCO₂, BE) were presented as median (min-max). Categorical variables were presented as frequency and percentage. Spearman correlation was used to determine the correlation between continuous variables and Phi correlation was used to determine the correlation between categorical variables. Significance level was accepted as p <0.05.

3. Results

A total of 1438 full term newborns were enrolled in the study. The study group had median (min-max) gestational age of 38^{6/7} (37^{0/7}-41^{6/7}) weeks and, birth weight of 3270 (2020-5295) g. 698 (48.5%) of the cases were female and 740 (51.5%) male, 366 (25.4%) of the cases were born by normal spontaneous way and 1072 (74.5%) by cesarean.

The mean $\pm$ standard deviation data of all cases were as follows: AS (1-min) 7.65 $\pm$ 1.05, AS (5-min) 8.88 $\pm$ 0.73, pH 7.34 $\pm$ 0.056, lactate (mmol/l) 2.37 $\pm$ 1.68, HCO₃ (mmHg) 21.82 $\pm$ 2.13, pCO₂ (mmHg) 44.27 $\pm$ 7.97, BE (mEq/l) -2.33 $\pm$ 2.59.

3.1. Association between AS and UACG

When the association between AS (1 and 5-minute) and UACG parameters (pH, lactate, BE, HCO₃, pCO₂) was evaluated, significant correlation was found between pH, lactate, pCO₂ and the Apgar score (1 and 5-minute) (p <0.001). This correlation ratio was highest with lactate and least with pH. There was no significant correlation between HCO₃, BE and AS (Table 1).

No association was found between any of the UACG abnormal threshold values (pH, lactate, BE, HCO₃, pCO₂) and 1-minute AS below 7 (Table 2).

A statistically significant correlation between 5-minute AS below 7 and pH, HCO₃, BE abnormal threshold values ($p < 0.001$) were detected. This correlation ratio was highest with pH and least with HCO₃. There was no significant correlation between lactate and pCO₂ abnormal threshold values and 5-minute AS (Table 3). In the evaluation of UACG of patients with 5-minute AS ≥ 7 ; in 92 cases lactate value was ≥ 5 mmol/l, in 28 cases pH value was < 7.2 , in 75 cases HCO₃ value was < 18 mmol/l and in 116 cases BE value was < -6 mEq/l (Table 3).

3.2. Association between AS, UACG and admission to NICU

Indications for NICU admission of our cases were: transient tachypnea of the newborn, feeding intolerance, congenital pneumonia, sepsis, hypoglycemia in 47 (%26.4), 44 (24.7), 38 (%21.3), 27 (%15.1), 22 (%12.3) of cases, respectively. When the correlation between low 1 and 5-minute AS, abnormal UACG values and NICU admissions were evaluated, the 1 and 5-minute AS < 7 were found to be associated with NICU admission ($p < 0.001$) (Table 4).

4. Discussion

4.1. AS and UACG association

In this study, the association between AS and UACG was evaluated in term newborns who were not known to have a fetal distress at prenatal period. We found a correlation between UACG parameters (pH, lactate and PCO₂) and AS both at 1 and 5-minute. A association was also found between low 5-minute AS (< 7) and pH, HCO₃ and BE abnormal threshold values. It is known that pH is the result of the balance between lactate and BE, which tends to stabilize it (9). Similarly, our results showed that pH, one of the UACG parameters, is more important than other parameters to demonstrate mild acidemia. While the 1-minute AS does not provide much information about the long and near term outcomes of the newborn, the 5-minute AS is more valuable. It has been reported that any 1-minute Apgar score between 0–3 does not predict the outcome of the newborn (2). However, a low 5-minute Apgar score clearly indicates an increased relative risk of cerebral palsy, which is reported to be 20 to 100 times higher than that of infants with a 5-minute Apgar score of 7 to 10 (17). A correlation between low 5-minute AS and neonatal hypoxia and mortality is also shown (18, 19). Currently, pH and BE values in UACG are taken into consideration for the determination of newborns who have experienced antenatal hypoxia requiring hypothermia to prevent the poor outcome (14). Similarly, in our study, it was observed that abnormal UACG values of pH, HCO₃ and BE had a association with low 5-minute AS (Table 4).

One of the important findings of this study is the presence of cases with normal AS but abnormal UACG parameters. A recent large-scale study by Sabol et al., showed abnormal results in UACG of newborns with normal AS (3). In this study, 6.6% of cases had an increased lactate level (above 5 mmol/L) and 5.4% had decreased HCO₃ even with a normal 1-minute AS. 2% of the newborns was mild acidotic (pH between 7.1–7.2) and 6.4% had increased lactate levels with normal 5-minute AS. In UACG, pH < 7.0 and/or base deficit < -12 values are generally accepted cutoff values that increase the risk of pathological

acidosis, seizures, neonatal encephalopathy and cerebral palsy (3). If the pH value is higher than 7.2 in UACG, the risk of neonatal encephalopathy is negligible, however, the risk of encephalopathy continues in newborns with a pH below 7.2 (3, 20). In a prospective study by Mousa et al., when the short-term results of cases with pH above and below 7.2 in UACG were examined, it was found that resuscitation, convulsions, hypoxic encephalopathy, hospitalization and hospital stay were longer in cases with UACG pH below 7.2 (21). High lactate values are closely associated with metabolic acidosis, mortality and morbidity and can be used as a predictive marker of end tissue oxygenation (22). It has been reported in previous studies that high lactate value can be regarded as a poor prognostic factor, but a definite cut-off value has not been given (23, 24). For these reasons, newborns with a stable postnatal clinic, normal AS, and abnormal UACGs should be detected and followed closely. We planned another study to evaluate the neurological development of patients with normal Apgar but high lactate levels in their UACG.

The mean pH value in term newborns without any fetal distress was found to be 7.34 ± 0.056 in our study. In previous studies, the pH of UACG in uncomplicated deliveries had been found between 7.24 and 7.27 (25, 26). In addition, in a comprehensive study conducted by Helwig et al., pH: 7.26 ± 0.07 was found in the UACG of 5-minute AS of ≥ 7 term babies (21). In our study, similar to previous studies, the majority of patients (98%) with normal 5-minute AS had a pH value of ≥ 7.2 at UACG. The mean BE value in UACG of term newborns was found to be -2.33 ± 2.59 mEq/l in our study. BE value in UACG in uncomplicated term deliveries had been reported to be between -5.6 and -2.7 mEq/l (16, 27). Similar to previous studies, in our study, BE value in UACG of term newborns with the 5-minute AS value ≥ 7 was found to be ≥ -6 mEq/l in most of the cases (91,9%). In the study of Helwig et al., in newborns with a 5-minute AS ≥ 7 , pCO₂ value had been found to be 53 ± 10 mmHg (16). This value was higher than the mean of our study (44.27 ± 7.97 mmHg). These different results might be attributed to the inclusion of preterm newborns in the study conducted by Helwig et al. In our study, the mean HCO₃ value in UACG of term newborns was found to be 21.82 ± 2.13 mmHg. The normal level of HCO₃ in blood gas is approximately 20 in term newborns (27). In our study, similar to previous studies, we found the HCO₃ value in UACG of term newborns with the 5-minute AS value ≥ 7 to be ≥ 18 mmHg in most of the cases (94,8%).

4.2. Association between AS and UACG admission to NICU

In this study, AS and UACGs of term newborns without any fetal distress during antenatal follow-up were evaluated. A significant correlation was observed both between the 1 and 5-minute AS < 7 and NICU admissions. AS has still its importance for the evaluation of well-being of a newborn (2). In a recently published comprehensive study including low-risk pregnancies, 5 minute AS < 7 was found to be associated with increased risk of admissions to the NICU and poor outcomes (28). Similarly, in our study, we found that AS could be an important indicator for patients who would be admitted to the NICU. On the other hand we found no significant correlation between NICU admissions and acidemia detected in UACG. In a comprehensive study conducted by Yeh et al., in term newborns, a correlation was found between low pH and NICU admission (29). The fact that moderate and severe acidemia cases were excluded in our study might lead to this result. It may also show the importance of AS in the decision of patient hospitalisations.

The main limitation of our study is that it is a retrospective study. The interobserver variability for evaluating the AS can also be considered as a limiting factor. On the other hand the strength of this study seems to be the only study in the literature evaluating the association between UACG and AS in newborns without perinatal risk factors and the effect of this evaluation on hospitalization.

In conclusion, our study showed that AS had still a great importance in evaluating the postnatal well-being of a newborn and their risk of hospitalization. We showed that all newborns without any fetal distress should be evaluated with their UACGs in order not to miss the mild perinatal acidosis and other abnormal parameters. A prospective study evaluating especially the neuromotor development and neurological outcomes of newborns with mild acidemia and lacticemia in their UACG despite normal AS is needed.

Declarations

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Availability of data and materials: The datasets generated and/or analysed during the current study are not publicly available due to our hospital policy but are available from the corresponding author on reasonable request.

Authors' contributions: The authors declare that they have no competing interests.

Ethics approval and consent to participate: Ethics approval was obtained from Istanbul University-Cerrahpaşa Faculty of Medicine Ethics Committee and performed in accordance with the tenets of the Declaration of Helsinki. Written informed consents were obtained from all participants.

Consent for publication: Not applicable.

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Tables

Table 1. General evaluation of the relationship between 1 and 5-minuetes AS with UACG

		Apgar score (1-min)	Apgar score (5-min)
Participants, (n)		1438	1438
		7.6 ± 1.04	8.8 ± 0.71
pH	r	0.092	0.095
	<i>p value</i>	<0.001	<0.001
Lactate (mmol/l)	r	0.119	0.114
	<i>p value</i>	<0.001	0.001
HCO ₃ (mmHg)	r	0.028	0.024
	<i>p value</i>	0.297	0.366
pCO ₂ (mmHg)	r	0.113	0.116
	<i>p value</i>	<0.001	<0.001
BE (mEq/l)	r	0.004	0.017
	<i>p value</i>	0.887	0.524

Spearman correlation. r: 0.01-0.19 very weak relationship, r: 0.20-0.29 weak relationship, r: 0.30-0.39 medium relationship, r: 0.40-0.69 strong relationship, r: ≥0.70 very strong relationship. Dark stained ones are statistically significant (p <0.05).

AS, apgare score; UACG, umbilical arterial blood gas; HCO₃, bicarbonate; pCO₂, partial pressure of carbon dioxide; BE, Base excess.

Table 2. Relationship between 1-minute Apgar score with umbilical artery cord blood gas threshold values

		Apgar score <7	Apgar score ≥7	ø	P value
Sayı, n (%)		159	1279		
pH	<7.2 ≥ 7.2	6 (3,8) 153 (96,2)	24 (1,9) 1255 (98,1)	0.042	0.114
Lactate	<5 (mmol/l) ≥ 5	150 (94,3) 9 (5,7)	1195 (93,4) 84 (6,6)	0.012	0.661
HCO ₃	<18 (mmHg) ≥18	8 (5,0) 151 (95,0)	69 (5,4) 1210 (94,6)	-0.005	0.848
pCO ₂	<50 (mmHg) ≥50	118 (74,2) 41 (25,8)	1001 (78,3) 278 (21,7)	-0.031	0.246
BE (mEq/l)	<-6 ≥ -6	17 (10,7) 142 (89,3)	102 (8,0) 1177 (92,0)	0.031	0.241

Data are given as number (%), Phi correlation. ø: 0.01-0.19 very weak relationship, ø: 0.20-0.29 weak relationship, ø: 0.30-0.39 medium relationship, ø: 0.40-0.69 strong relationship, ø: ≥0.70 very strong relationship. Dark stained ones are statistically significant (p <0.05).

AS, apgare score; UACG, umbilical arterial bloog gas; HCO₃, bicarbonate; pCO₂; partial pressure of carbon dioxide; BE, base excess.

Table 3. Relationship between 5-minute Apgar score with umbilical artery cord blood gas threshold values

		Apgar score <7	Apgar score ≥7	ø	P value
Sayı, n (%)		7	1431		
pH	<7.2 ≥ 7.2	2 (28,6) 5 (71,4)	28 (2,0) 1403 (98,0)	0.130	<0.001
Lactate	<5 (mmol/l) ≥5	6 (85,7) 1 (14,3)	1339 (93,6) 92 (6,4)	-0.022	0.399
HCO ₃ (mmHg)	<18 ≥18	2 (28,6) 5 (71,4)	75 (5,2) 1356 (94,8)	0.072	0.006
pCO ₂ (mmHg)	<50 ≥50	4 (57,1) 3 (42,9)	1115 (77,9) 316 (22,1)	-0.035	0.187
BE (mEq/l)	<-6 ≥-6	3 (42,9) 4 (57,1)	116 (8,1) 1315 (91,9)	0.088	0.001

Data are given as number (%), Phi correlation. ø: 0.01-0.19 very weak relationship, ø: 0.20-0.29 weak relationship, ø: 0.30-0.39 medium relationship, ø: 0.40-0.69 strong relationship, ø: ≥0.70 very strong relationship. Dark stained ones are statistically significant (p <0.05).

AS, apgare score; UACG, umbilical arterial bloog gas; HCO₃, bicarbonate; pCO₂, partial pressure of carbon dioxide; BE, base excess

Table 4. Neonatal Intensive Care Unit admission with Apgar score and umbilical artery cord blood gas relationship

		No NICU Admission	Yes NICU Admission	ϕ	P value
Participant, n		1260	178		
AS (1.dk)	<7	98 (7,8)	61 (34,3)	-0.278	<0.001
	≥ 7	1162 (92,2)	117 (65,7)		
AS(5.dk)	<7	0 (0)	7 (3,9)	-0.186	<0.001
	≥ 7	1260 (100)	171 (96,1)		
pH	<7.2	24 (1,9)	6 (3,4)	-0.034	0.200
	≥ 7.2	1236 (98,1)	172 (96,6)		
Lactate (mmol/l)	<5	1181 (93,7)	164 (92,1)	0.021	0.416
	≥ 5	79 (6,3)	14 (7,9)		
HCO ₃ (mmHg)	<18	62 (4,9)	15 (8,4)	-0.051	0.051
	≥ 18	1198 (95,1)	163 (91,6)		
pCO ₂ (mmHg)	<50	980 (77,8)	139 (78,1)	-0.002	0.929
	≥ 50	280 (22,2)	39 (21,9)		
BE (mEq/l)	<-6	97 (7,7)	22 (12,4)	-0.056	<0.034
	≥ -6	1163 (92,3)	156 (87,6)		

Data are given as number (%), Phi correlation. ϕ : 0.01-0.19 very weak relationship, ϕ : 0.20-0.29 weak relationship, ϕ : 0.30-0.39 medium relationship, ϕ : 0.40-0.69 strong relationship, ϕ : ≥ 0.70 very strong relationship. Dark stained ones are statistically significant (p < 0.05).

AS, apgare score; UACG, umbilical arterial bloog gas; HCO₃, bicarbonate; pCO₂, partial pressure of carbon dioxide; BE, base excess