Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.47750/jptcp.2023.30.16.008

Prediction Of Respiratory Morbidities In Neonates Using Cord Blood Arterial Lactate And Base Excess

Aditi D Bakare[1*], J.M Pawar[2], K.Mahendranath[3] ,Shreshta.B.R[4],Subhangi Misal[5]

[1]Junior Resident, Department of Paediatrics, Krishna Institute of Medical Sciences Deemed to be University, Karad, Satara, Maharashtra, India.

[2]Associate Professor, Department of Paediatrics, Krishna Institute of Medical Sciences Deemed to be University, Karad, Satara, Maharashtra, India

[3,4,5]Senior resident, Department of Paediatrics, Krishna Institute of Medical Sciences Deemed to be University, Karad, Satara, Maharashtra, India

***Corresponding author:** Aditi D Bakare, Junior Resident, Department of Paediatrics, Krishna Institute of Medical Sciences Deemed to be University, Karad, Satara, Maharashtra, India.

Submitted: 28 April 2023; Accepted: 12 May 2023; Published: 10 June 2023

ABSTRACT

Background: The umbilical blood gas analysis is a valid tool for the evaluation of neonatal acidemia. Knowledge of the fetal acid-base status and detection of acidemia at the time of delivery can serve as a sensitive and accurate component in the assessment of a neonate's risk of morbidity and death.

Aims and Objectives: To assess the correlation between cord blood arterial lactate levels, base excess in neonates and the development of respiratory distress and the requirement of delivery room resuscitation. To assess whether umbilical cord arterial lactate is superior to pH for predicting short-term neonatal morbidity.

Material and Methods: Study design: hospital based observational study. Sample size:138. Study setting: Labor ward of Krishna Hospital, Karad. Study period: January 2021 to November 2022.Data analysis: SPSS software using relevant statistical method.

Results: 138 neonates were enrolled. Cord blood base excess levels were higher in neonates with respiratory distress and those requiring delivery room resuscitation. However, there was no significant association between cord blood lactate levels and outcomes assessed

Conclusion: Estimation of arterial base excess levels obtained from umbilical cord blood sampling during delivery may serve as a sensitive marker for predicting respiratory morbidities.

Keywords: *Respiratory, Lactate, Prediction, blood*

BACKGROUND

Respiratory disorders presenting as tachypnoea, grunting, nasal flaring, retractions, decreased breath sounds, and cyanosis are one of the most frequent causes of admission to neonatal intensive care units.

A variety of conditions may be responsible for respiratory disorders in neonates, but respiratory distress syndrome, transient tachypnoea of newborn, meconium aspiration syndrome and air leak syndrome are the frequent causes.

Foetal distress has been described as "a condition in which foetal physiology is so altered to make death or permanent injury a likelihood within a relatively short period of time and usually considered to indicate disruption of normal foetal oxygenation, ranging from mild hypoxia to profound foetal asphyxia".[1] WHO states that about 9 million neonates develop birth asphyxia every year, of them 1.2 million die and the same number develop severe consequences like cerebral palsy, epilepsy and delayed developmental milestones. Perinatal asphyxia is a major cause of neonatal and childhood morbidity and mortality.[2]

Umbilical cord blood acid-base analysis provides an objective evaluation of newborn metabolic status. Accordingly, it is recommended that physicians attempt to obtain venous and arterial samples when there is a high risk of neonatal compromise.[3] Cord gas analysis includes direct measurement of pH, pO2, pCO2, and determination of base excess using various algorithms.Umbilical cord arterial pH drops and base excess increases when hydrogen ions from anaerobic metabolism overwhelm the buffer capability of the foetus.[4] Several studies have found links between umbilical arterial acidemia and perinatal morbidity and long-term adverse outcomes.[2]

The developing fetus is dependent on maternal blood supply for oxygenand nutrients.

Umbilical venous cord blood reflects the combined effect of maternal acid-base status and placental function, while arterial cord blood reflects neonatal acid- base status. Therefore, it is vital, that the acid-base parameters (pH, base excess and lactate) derived from arterial rather than venous cord blood are used to assess neonatal condition.

The elements of umbilical cord blood gas, which most commonly are used as a means of identifying neonates who are at risk for adverse outcomes,are pH and base excess. Studies have demonstrated an increased risk of neonatal morbidity when umbilical artery cord pH is ≤7.0.[2,5] Recent studies have also demonstrated that even moderate degrees of foetal acidemia (pH threshold of ≤7.10) may place neonates at risks for adverse outcomes.[6] Base excess is an additional threshold value that is used to indicate the severity andduration of neonatal acidemia. At the time of delivery, base excess levels of ≤12 mmol/L (10%) and ≤16 mmol/L (40%) are associated with moderate-to- severe newborn infant complications.[7]

The APGAR score has been used to assess the condition and prognosis of neonates worldwide for almost 50 years and remains valid.[8] However, some investigators have proposed a combination of arterial base excess (BE) in cord blood combined with the APGAR score as a moreobjective method of assessing newborn adverse events.[9,10] Similarly, assessment of both the APGAR score and pH level was shown to improve the accuracy of predicting neonatal mortality in term and pre- term infants. Moreover, a growing body of evidence has shown that lactate concentrations in cord blood are good for predicting neonatal outcome.[11,12]

Base Excess (BE) is a parameter that evaluates the excess of bases. The reference value is between − 2/+ 2 mmol/l. When this value becomes negative it means that there is a lack of bases and that the patient is in a state of metabolic acidosis. Lactic acid is produced by cellular metabolism and in hypoxic conditions cells can use inefficient energy production causing excessive production or poor excretion of lactate. pH is the result of the balance between lactate that tends to decrease pH and BE which tend to compensate.[16]

Most studies to date have been case-control or have involved specific ''cord gas'' populations leading to relatively small patient numbers and/or a limited ability to report neonatal outcomes in relation to the full range of cord blood gas and pH values evident at birth. Likewise, the analysis of metabolic versus respiratory acidosis has mostly included case-control comparisons that may not reflect their interconnected contributions to neonatal morbidity/mortality, and thus actual predictive value for such within the whole population. There has additionally been little if any study of base excess (BE) values versus respectivearterial values in relation to subsequent neonatal outcome that might provide insight to the relative contributions of placental disease and umbilical flow compromise to foetal acidemia at birth.[9, 1]

A numberof studies suggest that umbilical lactate may be at least equally predictive as pH with the additional advantage of ease of measurement.[7] However, many studies are limited by their retrospective design, small sample sizes, or indirect outcome measures such as APGAR scores.

The objective of our study was to assess the correlation between cord blood arterial lactate levels, base excess (BE) in neonates and the development of respiratory distress and also whether umbilical cord arterial lactate is better than pH for predicting short-term neonatal morbidity. As a secondary outcome we also evaluated the rates of acidemia and associated factors in neonates with 5-minute APGAR scores of >7.

MATERIALS AND METHODS

Participants

A prospective, observational study was conducted over a period of 18 months at a tertiary care hospital (Krishna Hospital, Karad). The study protocol was approved by institutional ethics committee and thestudy was performed in accordance with good clinical practice guidelines. All live inborn neonates born at Krishna Institute of Medical Sciences, Karad, were included. Neonates with congenital anomalies like congenital diaphragmatic hernia, complex congenital heart diseases, esophageal atresia, hydrocephalus, and neural tube defects, IUD, and deliveries where cord blood gas was not obtained, was inadequate, or was only a venous sample were excluded from the study.

Method of Data Collection

The study enrolled a total of 690 neonates. Gestational age was estimated by the assessment of ultrasound examination at first trimester of gestation. The data including, gender, birth weight, multiple births, presence of major congenital anomalies, mode of delivery, APGAR score at 1 and 5 minutes, needfor resuscitation, maternal morbidities, admission to the neonatal intensive care unit (NICU), and days of hospitalization was recorded.

Sample Collection

A segment of cord (minimum length of 10 cm) was double clamped immediatelyafter delivery, excised, placed into a kidney dish and reserved for sampling.1 ml of Blood was taken from the umbilical artery using pre heparinised syringes. Sampling was done within 10min of birth. If this was not possible the cord wasplaced on an ice pack until the samples could be taken. Analysis was done approximately within 20 minutes of delivery; in no case was the delay longer than 30 minutes.

Laboratory Investigations

One ml of blood was collected from the umbilical artery after double clamping in a pre-heparinized syringe immediately after delivery and the sample was sentfor blood gas analysis and lactate level estimation.

Blood samples were analysed in RADIOMETER ABL837 FLEX.

Data Analysis

The documented data was systematically collected and arranged in tabular form and in graphs in Microsoft Excel (version 2021).Statistical analysis was done with Statistical Package for Social Sciences (IBM SPSS Statistic for window, version 21.0. Armonk, NY:IBM Corp.) at 95% CI and 80% power to the study. Descriptive statistics was performed in terms of mean, standard deviation, frequency and percentages. Kolmogorov-Smirnov test was done to check for normal distribution of the data. Chi square test of association, Pearson's Correlation test was applied to check for significant association and correlation between perinatal variables, APGAR values, morbidities and base excess and lactate levels. Statistical significance was kept at $p<0.05$.

RESULTS

- A total of 690 neonates fulfilling the inclusion and exclusion criteria were enrolled in our study. It was observed that among the study participants 52% were male and 48% were female patients respectively with the mean birthweight of 2.50±0.70. Respiratory morbidity was observed in 100 (14.5%) patients amongst which TTN was observed in 65 (65%), RDS was in 25 (25%) and MAS was seen in 10 (10%) patients respectively.

- Mean APGAR at 1 min and 5 min was 7.74±0.58 and 8.97±0.34 respectively. It was observed that PIH was the morbidity observed in most of the mothers (6.5%) followed by anaemia (4.3%), GDM (2.2) and eclampsia (0.7%). It was noted that steroid prophylaxis was delivered to 21% of all participants. Of the 100 babies who developed respiratory morbidities, only 30(30%) had received antenatal steroids.
- It was observed that there was no significant correlation observed between pH and respiratory morbidity while an inverse correlation was observed between lactate levels and respiratory morbidity which was statistically highly significant(R=-0.650;p=<0.001).
- A strong positive correlation was observed between base excess and respiratory morbidity which was found to be statistically highly significant(R=0.713;p<0.001). Based on type of morbidity a statistically highly significant correlation was observed with lactate and base excess respectively**(p<0.001).** There was statistically significant correlation observed between need for resuscitation and pH levels(R=0.215; p=0.012).
- An inverse moderate correlation was observed with lactate levels which was statistically highly significant (R =-0.406; p=0.001). There was moderate statistically highly significant correlation observed between resuscitation and base excess (R=0.463,p=0.001)

TABLE 1: Mean Ph, Lactate And Base Excess Across Different Groups

		Minimum	Maximum	Mean	Sd
PH	**No Morbidity**	7	7.27	7.19	0.08
	TTN	7	7.26	7.20	0.08
	RDS	6.8	7.2	7.07	0.08
	MAS	7	7.04	7.02	0.08
Lactate	**No Morbidity**	3.6	1.7	2.29	0.90
	TTN	2.2	6.4	4.06	0.90
	RDS	2	7	3.76	0.92
	MAS	4.3	4.8	4.55	0.92
Base Excess	**No Morbidity**	-2.1	-6	-4.17	2.00
	TTN	-6	-11	-8.20	2.00
	RDS	-5.9	-12	-8.84	2.00
	MAS	-9.5	-11.5	-10.5	2.00

TABLE 2: Correlation Between Respiratory Morbidity And Ph, Lactate And Base Excess

	pH	Lactate	Base Excess
Pearson Correlation	.158	-.650**	.713**
P Value	.065	<0.001*	<0.001*

TABLE 3: Correlation Between Type Of Respiratory Morbidity And Ph, Lactate And Base Excess

	pH	Lactate	Base Excess
Pearson Correlation	-.039	.621	-.643
P Value	.654	<0.001*	<0.001*

TABLE 4: Correlation Between Resuscitation And Ph, Lactate And Base Excess

	pH	Lactate	Base Excess
Pearson Correlation	.215	-.406	.463
P Value	.012*	<0.001*	<0.001*

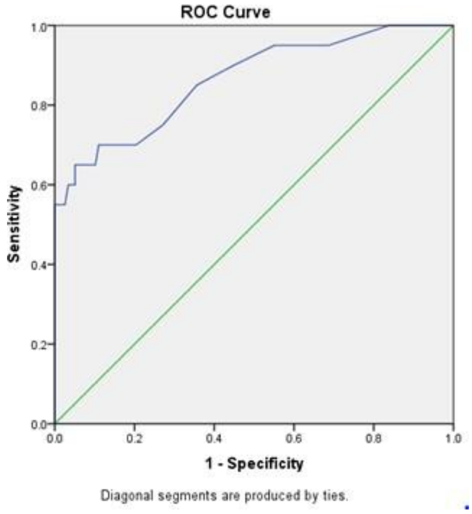

FIGURE 1: Roc Curve For Lactate And RespiratoryMorbidity

The ROC curve showed that lactate was the best predictive of respiratory morbidity with the sensitivity of 86.4%. This was found to be statistically highlysignificant. **(p<0.001)**

TABLE 5: Associations Between Perinatal Variables AndLevels Of Lactate, Base Excess And Ph Under Multiple Regression Models

	Lactate (p value)	**Base Excess (p value)**	**pH (p value)**
SEX	<0.001*	0.002*	0.004*
GA	0.004*	0.026*	<0.001*
B.WT	0.985	0.736	0.868
MODE OF DELIVERY	0.541	1.000	0.945
INDICATION FOR LSCS	0.02	0.03	0.04
PREGNANCY ORDER	0.999	0.992	0.996
MATERNAL MORBIDITY	<0.001*	<0.001*	<0.001*
APGAR @1MIN	<0.001*	<0.001*	<0.001*
APGAR @5MIN	<0.001*	<0.001*	<0.001*

*****Statistical significance at p<0.05

Lactate base excess and pH values were found to be statistically significantly associated with sex, gestational age, maternal morbidity and APGAR values**. (p<0.05)** There was no statistically significant association observed between delivery mode and pregnancy order respectively. **(p>0.05)**

TABLE 6: Associations Between Perinatal Variables And Ttn

	Respiratory Morbidity
SEX	0.52
GA	**<0.001***
B. WT	0.648
MODE OF DELIVERY	0.551
INDICATION FOR LSCS	0.231
PREGNANCY ORDER	0.678
MATERNAL MORBIDITY	0.952
APGAR @1MIN	**<0.001***
APGAR @5MIN	**<0.001***

*****Statistical significance at p<0.05

A statistically significant association was observed between gestational age and respiratory morbidity**. (p<0.05)** APGAR values at 1 min and 5 min were also found to be statistically significantly associated with respiratory morbidity.

DISCUSSION

Due to the advances in reproductive technologies, there has been increasing surveillance of mother and fetus. Accordingly, fetuses who are considered at the risk of stillbirth, intrauterine growth retardation, and intrapartum asphyxia are identified earlier, resulting in more deliveries at 34-36 weeks gestation.[17] Previous studies on the outcomes of infants with respiratory distress have focused mainly on extremely premature infants, further leading to a gap in knowledge and understanding of the physiology andmechanism of pulmonary diseases in late preterm neonates. A large study performed in USA[17] has reported respiratory morbidities in 9% of late pretermbirths and added that this risk decreased with each advancing week of gestationup to 38 weeks.[17]

The present study was conducted to predict the Respiratory Morbiditiesin Neonates Using Cord Blood Arterial Lactate and Base Excess. Umbilical cordblood gas analysis is important to evaluate the newborn acidaemia during childbirth.[18] Actually, the status of the newborn immediately after birth is evaluated through the Apgar score which represents a rapid tool to assess theclinical status of the newborn at 1 min and 5 min after birth.[18] Apgar score also provides an accepted and convenient method to report response to resuscitation when performed.[5 9,18] The score is decided on the evaluation of clinical characteristics, but the score is subjectively assigned. It is also conditioned by maternal sedation or anaesthesia, congenital malformations, gestational age, trauma. [18] The healthy preterm infant without evidence of asphyxia can still receive a low score for immaturity and a low score cannot predict morbidity or mortality for each individual child.[18] In addition to the Apgarscore and blood gas analysis, the lactate analysis is useful to assess the severity and prognosis of neonatal disorders in addition to being a good markerof blood perfusion and respiratory changes [19]

In our study the mean Apgar score at1 min was 7.74 ± 0.58 and at 5 min was 8.9± 0.34. This was found to be statistically significant. (p<0.05) The results showed statistically significant association between Apgar score and pH, lactate and base excessvalues.(p<0.05) The findings of our study were in accordance with the study conducted by Yilmaz A et al [20] where a statistically significant association was observed between APGAR score and UACG parameters (pH, lactate, BE, HCO3, pCO2).[20]

In the current study it was observed that Apgar score was improved at 5min. The similar findings were observed by Mamão L et al [21] and

Bernardo De et al. [18] It is not clear whether infants with moderate acidaemia and Apgar score

≥ 7V should be monitored for the development of adverse neurological outcome. Sabol et al reported that newborns with a good Apgar the score, have a risk of neonatal acidaemia and adverse outcome.[22]

In our study association of pH, lactate and base excess with perinatal variables was also evaluated. The results showed that there was statistically significant association of pH, lactate and base excess with perinatal variables (Gestational age, indication for LSCS, maternal morbidity) and Apgar score respectively. ($p<0.05$) These findings were in consensus with those reported byFuyama Y et al.[23] Fuyama Y et al, Gross TL et al, Levine EM et al and Beeby PJ et al reported that mode of delivery, gestational age can be the predictors for Respiratory Distress Syndrome. In addition it was also reported that pH levels and lactate levels improved the accuracy to predict adverse events in neonates.[23] Hermansen described the "acidosis paradox": newborns without acidaemia at birth could still develop a hypoxic condition. In fact, in newborns with normal pH and catastrophic intrapartum events adverse outcome may occur. 18

pH is an important tool to help health care providers during assistance in the delivery room but also to direct and predict the path of care of the newborn after birth [18] but the superiority of lactate over pH has already been reported inthe literature. [24] In our study a statistically highly significant association of lactate with respiratory morbidity has been observed. It was revealed from ROC curve that the AUC for lactate was 0.864(C.I= 0.7-0.9). Thus, it was statistically highly significant predictor of respiratory morbidity. The superiority of lactate over pH for predicting neonatal morbidity is biologically plausible. Lactate is a direct product of anaerobic metabolism, and animal studies show it is produced earlier during hypoxia and persists longer than low pH. [24] Furthermore, low pH alone indicates respiratory acidosis, which is less deleterious than metabolic acidosis as reflected by high umbilical arterial bloodlactate. Although increased base excess is also a marker of metabolic acidosis, our data suggest that lactate may be a more discriminating predictor of neonatal morbidity. Even if base excess were equivalent to lactate for predicting outcomes, lactate still has the advantage of being measured directly as opposed to base excess that is calculated using algorithms that differ by the gas analyzer used.[24]

Our findings are in accordance with the previous studies which demonstrated umbilical artery base excess (cut off value ≥ 12 mmol/l) as a

reliable indicator of intrapartum asphyxia with best correlation to long term morbidities(64). A study performed by Victory et al. from Canada has shown a significant correlation between umbilical cord base excess values at birth (mean artery BE -5.6±3.0 mmol/l) and adverse neonatal outcomes, such as APGAR score less than 7 at 5 min, NICU admission and the need for assisted ventilation(49,65).Different studies have reported varying mean umbilical arterial lactate values in normal deliveries, ranging from 2.55 to 4.63 mmol/L.[24] The mean lactate concentration among the neonates in our study was 2.54 ± 0.94 mmol/L. The differences may be attributable to studies using hemolyzed or whole blood for lactate analysis and differences in lactate assays. Differences in mode of delivery may also affect lactate levels.[24] The lactate cutoff values proposed for predicting adverse outcomes have also differed between studies, ranging from 3.2 to 10.0 mmol/L. In addition to differences in assays and study populations, these differences may be the result of the varied outcome measures used in these studies.[24]

Our study showed TTN as the most common respiratory morbidity in 65 patients (9.4%) followed by RDS in 25 patients (3.6%), suggesting that lactateand base excess could be a good primary screening tool to identify all newbornsat risk of TTN and RDS. It is plausibly that skin to skin could be performed in these newborns, as this procedure reduces stress and favours the regular transition to extrauterine life. Although there have been numerous studies on markers related to the duration of tachypnoea and its risk factors, to date, thereis no consensus on markers for TTN. With regard to clinical factors, a previousstudy has shown that various antenatal risk factors, such as multiple pregnancies, placenta previa, preeclampsia, gestational diabetes, and premature rupture of the membranes were associated with tachypnoea duration in TTN.[24]

It is thought that asphyxia plays a role in the pathogenesis of TTN by causing pulmonary capillary leak syndrome -in relation to the fact that TTN is known to be a cause of hypoxia.[25] The lower APGAR score in newborns with TTN supports the possible role of hypoxia in this condition; [26] however, the APGAR score is affected by many other perinatal factors.[26]

This study used perinatal variables including lactate, pH and baseexcess levels. Lactate, pH and base excess were found to be of statistical andclinical experience. The results of the study suggest a strict clinical evaluation of the newborns at risk of RDS in the first hours of life, comprising continuous evaluation of SpO2 and heart rate by pulse oximeter, respiratory rate, sucking, colour skin, temperature and the appearance of any breathing difficulties.

STUDY LIMITATIONS

One of the major limitations of this study was the less sample size. Besides, thedata was collected from the single centre due to which it can be difficult to generalize the findings of this study.

Thus in future, multi-centric research should be under taken with larger samplesize to get more significant results.

CONCLUSION

A significant correlation was observed between respiratory distress and lactate and base excess values respectively.

Lactate, base excess and pH can be considered as the predictors of respiratorymorbidity in neonates with cord blood lactate being the most reliable parameter for assessing the respiratory morbidities in neonates.

REFERENCES

1. Tasnim N, Mahmud G, Akram S. Predictive accuracy of intrapartum cardiotocography in terms of fetal acid base status at birth. J Coll Physicians Surg Pak. 2009;19(10):632-5.
2. Malin GL, Morris RK, Khan KS. Strength of association between umbilical cord pH and perinatal and long term outcomes: systematic review and meta-analysis. Bmj. 2010 May 13;340.
3. Umbilical cord blood gas and acid-base analysis. ACOG Committee Opinion No. 348. American College of Obstetricians and Gynecologists. Obstet Gynecol 2006;108:1319–22.
4. Uzan S, Berkane N, Verstraete L, Mathieu E, Bréart G. Acid base balance in the fetus during labor: pathophysiology and explorationmethods [in French]. J Gynecol Obstet Biol Reprod (Paris) 2003;32(suppl):1S68–78.
5. Thorp JA, Dildy GA, Yeomans ER, et al. Umbilical cord blood gas analysis at delivery.Am J Obstet Gynecol 1996;175:517-22.
6. Yeh P, Emary K, Impey L. The relationship between umbilical cord arterial pH and serious adverse neonatal outcome: analysis of 51,519 consecutive validated samples. BJOG 2012;119:824-31.
7. Low JA, Lindsay BG, Derrik EJ. Threshold of metabolic acidosis associated with newborn complications. Am J Obstet Gynecol 1997;177:1391-4.
8. Papile LA. The Apgar score in the 21st century. N Engl J Med. 2001;344:519–520.
9. Sehdev HM, Stamilio DM, Macones GA, Graham E, Morgan MA. Predictive factors for neonatal morbidity in neonates with an umbilical arterial cord pH less than 7.00. Am J Obstet Gynecol. 1997;177:1030– 1034.
10. Casey BM, McIntire DD, Leveno KJ. The continuing value of the Apgar score for the assessment of newborn infants. N Engl J Med. 2001;344:467–471
11. Winkler CL, Hauth JC, Tucker JM, Owen J, Brumfield CG. Neonatal complications at term as related to the degree of umbilical artery acidemia. Am J Obstet Gynecol. 1991;164:637– 641
12. Westgren M, Divon M, Horal M, et al. Routine measurements of umbilicalartery lactate levels in the prediction of perinatal outcome. Am J Obstet Gynecol. 1995;173:1416–1422.
13. Watterberg KL, Aucott S, Benitz WE, Cummings JJ, Eichenwald EC, Goldsmith J et al. The Apgar score. Pediatrics. 2015 ;136(4):819-22. https://doi.org/10.1542/peds.2015-2651.
14. Ehrenstein V. Association of Apgar scores with death and neurologic disability. Clin Epidemiol. 2009;1:45–53 pmid:20865086.
15. Tataranno M, De Bernardo G, Trevisanuto D, Sordino D, Riccitelli M, Buonocore G, Perrone S. Differences between umbilical blood gas in term and preterm newborns. Electron Physician. 2019;11(2):7529–35. https://doi.org/10.19082/7529.
16. Pramod S, Gunchan P, Sandeep P. Interpretation of arterial blood gas. Indian J Crit Care Med. 2010;14(2):57–64. https://doi.org/10.4103/0972-5229.68215.
17. Syed, F., Kini, S., Edward Lewis, L., Bhat Y, R., Purkaystha, J. Prediction of Respiratory Morbidities in Late Preterm Neonates Using Cord Blood Arterial Lactate and Base Excess.

Iranian Journal of Neonatology IJN, 2019; 10(4): 71-75.
18. Patil SS, Rath S, George CE. Study on umbilical cord arterial blood gas analysis and cord blood lactate levels as predictors for adverse neonatal outcome: an observational study. International Journal of Reproduction, Contraception, Obstetrics and Gynecology. 2018 Apr 1;7(4):1494-501.
19. Cnattingius S, Norman M, Granath F, Petersson G, Stephansson O, Frisell T. Apgar score components at 5 minutes: risks and prediction of neonatal mortality. Paediatr Perinat Epidemiol. 2017;31(4):328–37.
20. Yilmaz A, Kaya N, Ulkersoy I et al. The correlation of arterial cord bloodgas values and apgar scores in term babies without fetal distress and their effects on NICU admissions.2021;(1):1-6.
21. Yilmaz A, Kaya N, Ulkersoy I et al. The correlation of arterial cord bloodgas values and apgar scores in term babies without fetal distress and their effects on NICU admissions.2021;(1):1-6.
22. Sabol BA, Caughey AB. Acidemia in neonates with a 5-minute Apgar score of 7 or greater– What are the outcomes? American journal of obstetrics and gynecology. 2016 Oct 1;215(4):486-e1.
23. Fuyama Y, Shima Y, Shindo F, Nakajima M, Urashima M. Clinical significance of measuring lactate levels in cord blood to predict development of respiratory distress syndrome in neonates. Japan medical association journal. 2005;48(6):268.
24. Tuuli MG, Stout MJ, Shanks A, Odibo AO, Macones GA, Cahill AG. Umbilical cord arterial lactate compared with pH for predicting neonatal morbidity at term. Obstetrics and gynecology. 2014 Oct;124(4):756.
25. Perez Molina JJ, Romero DM, Ramirez Valdivia JM, Corona MQ. [Transient tachypnoea of the newborn, obstetric and neonatal risk factors]. Ginecol Obstet Mex. 2006;74(2):95-103. Victory R, Penava D, Da Silva O, Natale R, Richardson B. Umbilical cord pH and base excess values in relation to adverse outcome events for infants delivering at term. American journal of obstetrics and gynecology.2004 Dec 1;191(6):2021-8.
26. Ekmen S, Doğan E. Prediction of the Course of Transient Tachypnoeaof the Newborn by Blood Laboratory Parameters at the Time of Admission. Iran J Pediatr. 2021;31(3):e112224.