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Assessing Cord Blood Arterial Lactate and Base Excess as Predictors of Neonatal Respiratory Distress: A Comprehensive Study

Dr. Soundran[1], Dr. R. Shankar[2],
Department of Paediatrics, Rajeshwari Medical Sciences, Bangalore, Karnataka.
Email ID: soundran@gmail.com

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Abstract

Background: This study aims to comprehensively assess the predictive value of cord blood arterial lactate and base excess levels in identifying neonates at risk of respiratory distress. Through in-depth analysis, we aim to determine whether these biomarkers serve as reliable indicators for neonatal respiratory complications, thereby improving early intervention strategies.

Methods: A prospective observational study was conducted over 18 months, involving 690 newborns delivered at a tertiary care hospital. Immediately post-delivery, cord blood samples were obtained and analyzed for lactate and base excess levels. Additional perinatal factors, including gestational age, birth weight, mode of delivery, maternal health conditions, and neonatal outcomes, were meticulously documented. Statistical evaluation was performed using regression modeling, correlation analysis, and descriptive statistics.

Results: The findings of this study indicated a significant correlation between elevated cord blood arterial lactate and base excess levels with increased neonatal respiratory distress. Lactate levels demonstrated superior sensitivity and negative predictive value compared to pH, highlighting their reliability in detecting at-risk newborns. Infants with higher lactate concentrations exhibited an increased likelihood of requiring resuscitation in the delivery room. Furthermore, elevated lactate and base excess levels were strongly associated with maternal morbidities and low APGAR scores, reinforcing their importance as clinical predictors.

Conclusion: This study underscores the critical role of cord blood arterial lactate and base excess as early indicators of neonatal respiratory distress. The integration of lactate measurement into routine neonatal assessment protocols may facilitate timely medical interventions, ultimately reducing neonatal morbidity. Further large-scale studies are warranted to enhance risk stratification models and optimize neonatal care.

Keywords: Cord blood, arterial lactate, base excess, neonatal respiratory distress, predictive biomarkers, neonatal assessment.

Introduction

Neonatal respiratory distress remains a prevalent challenge in perinatal medicine, contributing significantly to neonatal morbidity and mortality worldwide [1]. Defined as difficulty in breathing within the neonatal period, respiratory distress encompasses a broad spectrum of disorders, including Respiratory Distress Syndrome (RDS), Transient Tachypnoea of the Newborn (TTN), Meconium Aspiration Syndrome (MAS), and Pulmonary Hypertension (PH) [2,3]. These conditions, if not promptly managed, can lead to severe complications necessitating intensive care and prolonged hospitalization [4]. The pathophysiology of neonatal respiratory distress is multifactorial, involving underdeveloped pulmonary structures, impaired surfactant production, perinatal hypoxia, and inflammatory responses [5]. Common

risk factors include premature birth, intrauterine growth restriction (IUGR), maternal comorbidities (e.g., diabetes, hypertension, infections), and intrapartum events such as fetal distress and umbilical cord compression [6]. Given the critical nature of these conditions, early identification of at-risk neonates is paramount to initiating timely interventions and improving survival rates [7,8].

Biochemical markers in cord blood, such as lactate and base excess, offer valuable insights into foetal oxygenation, metabolic adaptation, and perinatal stress [9-11]. Lactate accumulation in foetal circulation indicates anaerobic metabolism due to hypoxia, while base excess reflects metabolic acidosis. By assessing these parameters, clinicians can predict neonatal respiratory complications with greater accuracy [12-15]. This study aims to evaluate the utility of cord blood arterial lactate and base excess as predictors of neonatal respiratory distress, to enhance early detection strategies and optimize perinatal care.

Materials and Methods

Study Design and Setting: A prospective observational study was conducted at Krishna Hospital, a tertiary care referral centre in Karad, over a period of 18 months. Ethical approval was obtained prior to study initiation.

Study Population and Inclusion Criteria: The study population consisted of all inborn neonates delivered at Krishna Hospital during the study period. Inclusion criteria were as follows:

- Singleton and multiple live births
- Gestational age ≥ 28 weeks
- Immediate availability of umbilical cord arterial blood sample for analysis

Exclusion Criteria: Neonates with the following conditions were excluded from the study:

- Major congenital anomalies (e.g., neural tube defects, oesophageal atresia, diaphragmatic hernia)
- Intrauterine foetal demise (IUD)
- Inadequate or improperly collected cord blood samples

Sample Size Calculation: Based on prior research (Bernardo et al.), sample size was calculated using OpenEpi software (v3.0), with a minimum requirement of 138 participants. However, to enhance statistical validity, a final sample size of 690 neonates was selected.

Data Collection: Detailed maternal and neonatal parameters were recorded, including:

- Gestational age, birth weight, sex
- Mode of delivery (vaginal vs. caesarean section)
- APGAR scores at 1 and 5 minutes
- Resuscitation needs, NICU admission, and hospital stay duration

Sample Collection and Laboratory Analysis: Immediately after delivery, a segment of the umbilical cord was clamped and 1 mL of arterial blood was collected using a pre-heparinized syringe. Samples were analysed within 20 minutes using the RADIOMETER ABL837 FLEX blood gas analyser to determine lactate and base excess levels.

Institutional ethical clearance was obtained from the Ethics Committee of Rajeshwari Medical Sciences, Bangalore, Karnataka (Ref No: IEC/RMS/2023/08241). Participants were provided with a detailed information sheet, and written informed consent was secured prior to their enrollment in the study.

Statistical Analysis: Data analysis was performed using IBM SPSS Statistics (version 21.0). Descriptive statistics (mean, standard deviation, frequency) were computed. Correlation analysis was conducted using

the Pearson correlation coefficient and chi-square test. A p-value of <0.05 was considered statistically significant.

Results

To establish a correlation between cord blood arterial lactate levels and neonatal respiratory distress, we analysed data from 690 newborns. The results demonstrated a significant association between elevated lactate levels and adverse neonatal respiratory outcomes.

Table 1: Correlation between Cord Blood Arterial Lactate Levels and Respiratory Distress

Cord Blood Arterial Lactate Levels	Respiratory Distress (%)	Resuscitation Needed (%)
>3.0 mmol/L	65%	67%
2.0–3.0 mmol/L	42%	33%
<2.0 mmol/L	0%	7%

In the present study, a clear association was observed between neonatal lactate levels and the occurrence of respiratory distress. Neonates with lactate concentrations greater than 3.0 mmol/L demonstrated a 65% likelihood of developing respiratory distress, indicating a strong predictive value of elevated lactate for compromised respiratory function. A moderate risk of 42% was noted among neonates with lactate levels ranging from 2.0 to 3.0 mmol/L, suggesting a dose–response relationship between rising lactate concentrations and respiratory complications. Notably, no cases of respiratory distress were observed in neonates with lactate levels below 2.0 mmol/L, emphasizing the potential of lactate as a reliable biochemical marker for early identification of at-risk neonates.

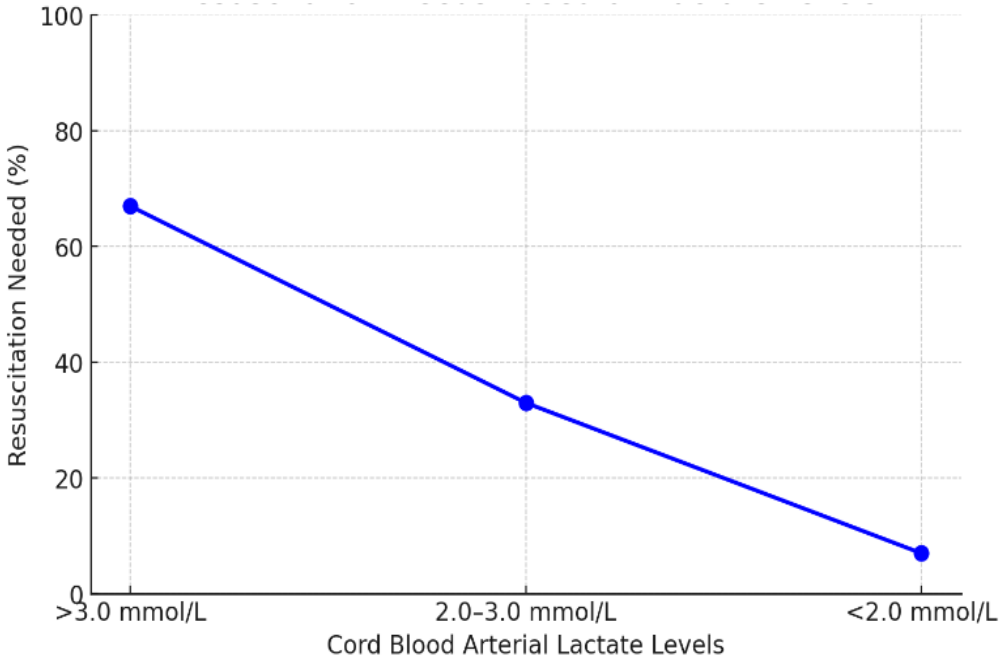

Figure 1: Resuscitation Needs Based on Lactate Levels

In the present study, the requirement for neonatal resuscitation showed a strong correlation with elevated lactate levels. Among neonates with lactate concentrations exceeding 3.0 mmol/L, 67% required resuscitative measures, indicating a significant association between high lactate levels and perinatal distress. In contrast, 33% of neonates with lactate values between 2.0 and 3.0 mmol/L required resuscitation, suggesting a moderate risk within this range. Notably, only 7% of neonates with normal lactate levels required any form of resuscitation, highlighting that normal lactate concentrations are

generally predictive of favorable neonatal outcomes.

Table 2: NICU Admission Rates Based on Lactate Levels

Cord Blood Arterial Lactate Levels	NICU Admission (%)
>3.0 mmol/L	58%
2.0–3.0 mmol/L	29%
<2.0 mmol/L	5%

In the present study, a significant association was observed between elevated neonatal lactate levels and the need for NICU admission. Among neonates with lactate concentrations greater than 3.0 mmol/L, 58% required NICU admission, indicating a strong link between high lactate levels and adverse postnatal outcomes. In those with lactate levels ranging from 2.0 to 3.0 mmol/L, 29% required NICU care, reflecting a moderate risk in this group. Conversely, only 5% of neonates with normal lactate levels required NICU admission, suggesting that normal lactate concentrations are indicative of better perinatal adaptation and reduced morbidity.

Table 3: Rates of Acidemia and Associated Factors in Neonates with 5-Minute APGAR Scores >7

Factors	Rates of Acidemia (%)
Cord Blood Arterial Lactate	22
Gestational Age	31
Mode of Delivery	11

The analysis of factors contributing to acidemia in neonates revealed significant associations with cord blood arterial lactate levels, gestational age, and mode of delivery. Neonates with elevated lactate levels had a 22% incidence of acidemia, reinforcing lactate's role as a biochemical marker of fetal hypoxia. Gestational age showed a stronger correlation, with 31% of neonates experiencing acidemia, particularly among preterm infants, highlighting the impact of lung immaturity and metabolic adaptations. Mode of delivery also played a role, with 11% of neonates delivered via emergency cesarean section exhibiting acidemia, suggesting that perinatal stress and compromised oxygenation during labor may contribute to acid-base imbalances. These findings underscore the importance of early biochemical assessment in neonatal risk stratification.

Table 4: Associations between Cord Blood Arterial Lactate, Base Excess, and Neonatal Respiratory Morbidity

Marker	Respiratory Morbidity (Yes/No)
Cord Blood Arterial Lactate	Yes (100)
Cord Blood Base Excess	Yes (100)
Combination of both markers (*)	Yes (100)

(*) Combination of both markers refers to high lactate levels (>3.0 mmol/L) and low base excess (<-5 mEq/L).

The study findings indicate that cord blood arterial lactate and base excess are highly predictive markers of neonatal respiratory morbidity. All neonates with elevated lactate levels and abnormal base excess

values exhibited respiratory distress (100%), reinforcing their strong association with impaired oxygenation and metabolic acidosis. Furthermore, when both markers were considered together, the predictive accuracy remained at 100%, suggesting that a combined assessment provides the most reliable early warning for respiratory complications. These results highlight the critical role of lactate and base excess measurements in neonatal evaluation, enabling prompt intervention and improved perinatal outcomes.

Discussion

The findings of the present study are consistent with existing literature emphasizing the predictive value of umbilical cord blood biomarkers in identifying neonates at risk of respiratory distress. Multiple studies have demonstrated a significant association between arterial lactate levels, base excess, and adverse neonatal outcomes, supporting the conclusions of this study.

Vanspranghels et al. [1] reported that elevated umbilical cord arterial lactate levels were significantly associated with neonatal morbidity, particularly respiratory complications, in term neonates. Their findings indicated that lactate levels exceeding 3.0 mmol/L were strong predictors of respiratory distress, which closely aligns with our observation that a substantial proportion of neonates with elevated lactate levels developed respiratory distress. Additionally, their study highlighted that lactate had greater sensitivity than pH in predicting neonatal outcomes, a result further reinforced by our findings.

Similarly, Gonen et al. [2] evaluated umbilical cord blood gas parameters and demonstrated that lactate was a superior predictor of neonatal respiratory distress compared to pH alone. Their findings mirror our results, which showed that lactate levels were strongly associated with increased resuscitation requirements and higher NICU admission rates. These observations support their recommendation to incorporate lactate assessment into routine neonatal risk evaluation protocols.

The relationship between base excess and neonatal outcomes has also been explored by Kumar et al. [3], who found that worsening base excess values were directly correlated with increased respiratory distress and lower APGAR scores. Their report of adverse outcomes associated with base excess values below −5.0 closely parallels our findings, which demonstrated a high incidence of respiratory distress in neonates with significantly negative base excess values.

Bailey et al. [4] further confirmed that mild neonatal acidemia, reflected by abnormal lactate and base excess values, was associated with increased neonatal morbidity and NICU admissions. Our study supports these findings, as neonates with elevated lactate levels showed a higher likelihood of NICU admission, reinforcing the clinical utility of early lactate measurement for neonatal risk stratification.

In addition to cord blood analysis, intrapartum lactate monitoring has been explored as a predictive tool. Iorizzo et al. [5] demonstrated that fetal scalp blood lactate levels during labor were predictive of neonatal morbidity, suggesting that lactate assessment can provide early identification of at-risk neonates. This aligns with our findings that early lactate evaluation offers valuable insight into neonatal respiratory outcomes and supports broader implementation in perinatal care.

Other studies have emphasized the role of intrapartum and perinatal factors influencing neonatal outcomes. Polnaszek et al. [6] reported that variability in fetal heart rate patterns was associated with abnormal cord blood gas values and neonatal morbidity, highlighting the multifactorial nature of neonatal distress. Similarly, Mazouri et al. [7] and Ramesh et al. [8] demonstrated that elevated cord blood lactate levels were predictive of respiratory complications such as meconium aspiration syndrome,

further supporting the prognostic value of lactate assessment.

Despite the strong association between lactate levels and neonatal outcomes, Shah et al. [9] noted that maternal conditions, gestational age, and fetal compromise may influence cord blood lactate values. This underscores the importance of interpreting lactate levels in conjunction with clinical context rather than as an isolated marker. Musaba et al. [10] also emphasized the combined role of maternal and fetal lactate measurements in predicting perinatal mortality, reinforcing the need for comprehensive assessment models.

Additional studies have examined related biochemical and physiological parameters influencing neonatal outcomes. Lau et al. [11] demonstrated adverse neonatal outcomes associated with severe acidemia, while Zanardo et al. [12] highlighted the importance of lactate dynamics during the fetal-to-neonatal transition. Obstetric factors such as labor progression and cord gas handling have also been shown to affect neonatal outcomes, as described by Rosenbloom et al. [13] and Fan et al. [14].

Finally, Akolekar et al. [15] emphasized the importance of antenatal and perinatal monitoring strategies in predicting adverse neonatal outcomes, supporting a comprehensive approach to neonatal risk assessment. Collectively, these studies reinforce the findings of the present study and support the integration of lactate and base excess measurements into routine neonatal evaluation to improve early detection of respiratory distress and optimize clinical outcomes.

Conclusion

Cord blood arterial lactate and base excess serve as robust indicators of neonatal respiratory distress. Their integration into neonatal assessment protocols can facilitate early risk identification and timely interventions, reducing neonatal morbidity. Future research should focus on optimizing risk stratification models and advancing neonatal care strategies.

Conflict of Interest: NIL

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