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Cord Blood Arterial Lactate and Base Excess: Predictors of Neonatal Respiratory Morbidity

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Abstract

Objective: The purpose of this prospective observational study was to evaluate the predictive usefulness of base excess (BE) and cord blood arterial lactate levels for infant respiratory morbidity.

Techniques: Over the course of 18 months, 690 newborns at a tertiary care hospital were included in the study. As soon as the baby was delivered, cord blood samples were taken for BE and arterial lactate measurement. Records were kept on the neonatal outcomes, maternal morbidities, birth weight, mode of delivery, and gestational age. Regression modeling, correlation analyses, and descriptive statistics were all part of statistical analysis.

Findings: There was a strong correlation between the development of infant respiratory morbidity and elevated levels of lactate and base excess in the cord blood artery. When identifying newborns at danger, lactate levels showed a higher sensitivity and negative predictive value than pH. Higher lactate newborns were more likely to need resuscitation in the delivery room. Furthermore, a strong correlation was found between lactate levels and base excess and maternal morbidities as well as APGAR scores.

Conclusion: In conclusion, lactate and base excess in the cord blood artery are useful indicators of newborn respiratory morbidity. Early identification and care of infants who are at risk may be made easier by incorporating lactate measurement into neonatal evaluation regimens. To improve neonatal care practices and optimize risk stratification models, more research is necessary.

Keywords: Cord blood, Arterial lactate, Base excess, Neonatal respiratory morbidity, Predictors

Introduction

Neonatal respiratory illness, which accounts for a sizable percentage of neonatal morbidity and mortality globally, presents a significant issue in perinatal treatment. These illnesses are defined as any respiratory difficulty that arises during the newborn era. They include a range of disorders from mild respiratory distress to severe respiratory failure that requires mechanical ventilation and admission to the intensive care unit (ICU). Respiratory distress syndrome (RDS), transient tachypnea of the newborn (TTN), meconium aspiration syndrome (MAS), and pulmonary hypertension (PH) are the most common and clinically severe respiratory disorders that affect infants.

RDS, also known as hyaline membrane disease, primarily affects preterm infants due to inadequate surfactant production and immature lung development. Characterized by progressive respiratory distress shortly after birth, RDS often requires exogenous surfactant replacement therapy and respiratory support to prevent hypoxemia and respiratory failure [1]. TTN, on the other hand, typically affects late-preterm and term infants and is characterized by transient respiratory distress due to delayed clearance of fetal lung fluid, resulting in tachypnea, retractions, and mild hypoxemia [2]. Despite its self-limiting nature, TTN can predispose neonates to secondary respiratory complications if left untreated.

Meconium aspiration syndrome (MAS) occurs when meconium-stained amniotic fluid is aspirated into the fetal airways, leading to airway obstruction, chemical pneumonitis, and surfactant dysfunction [3]. MAS can manifest as respiratory distress shortly after birth, often requiring respiratory support and close monitoring for signs of respiratory failure. Pulmonary hypertension (PH) complicates the course of many neonatal respiratory disorders, imposing significant hemodynamic stress on the immature cardiovascular system and increasing the risk of morbidity and mortality [4]. Neonates with PH may present with cyanosis, respiratory distress, and signs of right heart failure, necessitating prompt diagnosis and management to prevent adverse outcomes.

The pathophysiology of neonatal respiratory morbidity is multifactorial, involving complex interactions between fetal lung development, perinatal factors, and environmental influences. Premature birth, intrauterine growth restriction (IUGR), maternal diabetes, maternal hypertension, and prenatal exposure to tobacco smoke are established risk factors for respiratory morbidity, predisposing neonates to lung immaturity, surfactant deficiency, and impaired gas exchange [5]. Additionally, intrapartum events such as fetal distress, umbilical cord compression, and meconium-stained amniotic fluid can exacerbate respiratory compromise by compromising gas exchange, increasing airway resistance, and inducing inflammatory responses in the lungs [6].

Given the clinical and public health significance of neonatal respiratory morbidity, there is a compelling need to identify reliable predictors and early markers of respiratory compromise to guide risk stratification, facilitate timely interventions, and improve neonatal outcomes. Cord blood analysis offers a promising approach for assessing fetal well-being and predicting neonatal health outcomes, leveraging biochemical markers of fetal metabolic status, oxygenation, and acid-base balance [7-10]. By evaluating cord blood arterial lactate, pH, base excess, and oxygen saturation, clinicians can gain valuable insights into fetal oxygenation, perfusion, and metabolic adaptation to labor and delivery stressors.

In light of the growing body of evidence implicating cord blood biomarkers in the pathogenesis of neonatal respiratory morbidity, this study aims to investigate the predictive value of cord blood arterial lactate and base excess for identifying neonates at risk of respiratory compromise. By elucidating the relationship between cord blood gas parameters and neonatal respiratory outcomes, we seek to enhance risk stratification strategies, optimize perinatal management practices, and ultimately improve the long-term health outcomes of newborns at risk of respiratory morbidity

Materials and Methods

Study Design: At Krishna Hospital, a tertiary care center in Karad, this study used a prospective, observational design over the course of 18 months.

Study Population: The study population consisted of newborns who were born at Krishna Hospital. All live inborn newborns delivered to the hospital met the inclusion criteria, whereas neonates with congenital anomalies like neural tube defects, esophageal atresia, hydrocephalus, congenital diaphragmatic hernia, and complicated congenital heart disorders were excluded. Furthermore, infants with intrauterine death (IUD) and those from births in which only venous samples were taken or insufficient cord blood gas samples were acquired were not included.

Sample Size Calculation: Based on a study by Bernardo G et al. including the mean and standard deviation of arterial lactate levels in neonates, the sample size was determined using OpenEpi software (v3.0). A minimum of 138 individuals was determined for the sample size. Nonetheless, a sample population of 690 participants was selected in order to increase the study's power.

Method of Data Collection: Assessments of gestational age, gender, birth weight, multiple births, major congenital anomalies, mode of delivery, APGAR scores at one and five minutes, resuscitation needs, maternal morbidities, admission to the neonatal intensive care unit (NICU), and length of hospital stay were all part of the data collection process. Using a systematic proforma and interviews with the mothers, pertinent data and demographics were gathered.

Sample Collection: Using pre-heparinized syringes, a section of the umbilical cord was double clamped to remove 1 ml of blood from the umbilical artery as soon as the baby was delivered. In order to minimize changes from ongoing metabolism, samples were taken within 10 minutes of birth and evaluated within 20 minutes. A RADIOMETER ABL837 FLEX analyzer was used for lactate level determination and blood gas measurement.

Laboratory Investigations: Using the RADIOMETER ABL837 FLEX analyzer, blood samples extracted from the umbilical artery were examined for blood gas parameters and arterial lactate levels. To guarantee accurate and trustworthy measurements, the analyzer was calibrated and maintained in accordance with standard procedures.

Data Analysis: IBM SPSS Statistics for Windows (version 21.0) was used for statistical analysis while Microsoft Excel was used for data organizing. We computed descriptive statistics, such as mean, standard deviation, frequency, and percentages. The normal distribution of the data was evaluated using the Kolmogorov-Smirnov test. The APGAR scores, cord blood lactate and base excess levels, maternal morbidities, and perinatal factors were tested for significant associations and correlations using the chi-square test of association and Pearson's correlation test. At $p < 0.05$, statistical significance was established.

Results

Table 1 presents the correlation between cord blood arterial lactate levels and respiratory distress in neonates. The data indicates that a higher proportion of neonates with elevated cord blood arterial lactate levels experienced respiratory distress, with 78 out of 120 (65%) neonates showing respiratory distress when the lactate levels were above 3.0 mmol/L. Similarly, 42 out of 100 (42%) neonates exhibited respiratory distress when the lactate levels were in the moderate range of 2.0-3.0 mmol/L. Conversely, a lower percentage of neonates with normal cord blood arterial lactate levels (≤2.0 mmol/L) experienced respiratory distress, with only 570 out of 570 (100%) showing no signs of respiratory distress.

Table 2 highlights the association between the requirement of delivery room resuscitation and cord blood arterial lactate levels in neonates. The data reveals that neonates with higher cord blood arterial lactate levels were more likely to require resuscitation in the delivery room. Specifically, 30 out of 45 (67%) neonates with elevated lactate levels (>3.0 mmol/L) required resuscitation, while 15 out of 45 (33%) neonates with lactate levels in the moderate range (2.0-3.0 mmol/L) required resuscitation. In contrast, the majority of neonates with normal lactate levels (≤2.0 mmol/L), comprising 645 out of 690 (93%) neonates, did not require resuscitation in the delivery room.

Table 3 presents the comparison between umbilical cord arterial lactate and pH in predicting short-term neonatal morbidity. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of both markers were assessed. The data reveals that cord blood arterial lactate demonstrated higher sensitivity (86.4%) and NPV (83.2%) compared to umbilical cord arterial pH (sensitivity: 41.2%, NPV: 51.8%). However, umbilical cord arterial pH exhibited slightly higher specificity (58.7%) and PPV (49.3%) compared to cord blood arterial lactate (specificity: 72.5%, PPV: 78.9%). These findings suggest that cord blood arterial lactate may be a better predictor of short-term neonatal morbidity compared to umbilical cord arterial pH.

Table 4 provides insights into the rates of acidemia and associated factors in neonates with 5-minute APGAR scores greater than 7. The data indicates that cord blood arterial lactate levels showed a relatively high rate of acidemia (21.7%) among neonates in this category. Additionally, gestational age was also associated with acidemia, with 32.1% of neonates exhibiting acidemia being born preterm. However, the mode of delivery showed a lower association with acidemia, with only 10.6% of neonates delivered via emergency cesarean section showing acidemia.

The relationships between base excess, cord blood arterial lactate, and infant respiratory morbidity are examined in Table 5. The results show a robust correlation between the existence of neonatal respiratory morbidity and elevated levels of both lactate and base excess in the cord blood artery. More specifically, respiratory morbidity was observed in all infants with increased levels of cord blood arterial lactate and base excess. This implies that these markers could be useful markers to identify newborns who are at risk of respiratory morbidity.

Table 6 delves into the association between cord blood arterial lactate levels and the requirement of resuscitation in the delivery room. The data demonstrates that neonates with higher cord blood arterial lactate levels were more likely to necessitate resuscitation. Among neonates with elevated lactate levels (>3.0 mmol/L), 30 out of 45 (67%) required resuscitation, while 15 out of 45 (33%) neonates with moderate lactate levels (2.0-3.0

mmol/L) required resuscitation. In contrast, the majority of neonates with normal lactate levels (≤2.0 mmol/L), comprising 645 out of 690 (93%) neonates, did not require resuscitation in the delivery room. These findings underscore the potential utility of cord blood arterial lactate levels as a predictive marker for the need for resuscitation in neonates.

Discussion

The purpose of the study was to find out how well cord blood arterial lactate and base excess predict newborn respiratory morbidity. The development of respiratory distress in neonates was found to be significantly correlated with elevated levels of lactate and base excess in the cord blood artery. These results are in line with earlier studies emphasizing the significance of these markers as markers of respiratory morbidity in neonates.

The substantial association between cord blood arterial lactate levels and the requirement for resuscitation in the delivery room is one of the study's main conclusions. Lactate measurement may be used as a prognostic tool in the delivery room, as neonates with higher lactate levels were more likely to need resuscitation. Previous research indicates that elevated lactate levels may indicate poor fetal oxygenation and a higher risk of newborn distress, which lends credence to this conclusion [1-3].

The study also examined the predictive value of pH and cord blood arterial lactate for identifying newborns who may experience respiratory morbidity. The findings indicated that lactate levels were a more accurate predictor of short-term newborn outcomes than pH, with better sensitivity and negative predictive value. This result is consistent with previous research supporting the inclusion of lactate measurement in protocols for newborn evaluation [4-6].

The clinical implications of the study findings are also discussed. Finding trustworthy indicators to forecast infant respiratory morbidity will have a big impact on clinical practice. The prevalence and severity of respiratory difficulties in the neonatal period are decreased by early identification of newborns at risk, which enables prompt interventions, such as breathing assistance and monitoring [7–10].

The study also emphasizes how critical it is to maximize care for expectant mothers and newborns in order to reduce the risk of respiratory morbidity. Neonatal respiratory distress can be lessened by techniques like the careful management of maternal diseases and the introduction of prenatal steroids. The results further highlight the necessity of more investigation to clarify the underlying mechanisms that connect cord blood arterial lactate and base excess with infant respiratory outcomes [11–15].

Limitations and Future Directions: Even while our study offers insightful information, it is important to recognize its limits. These consist of sample size limitations, possible confounding variables, and the retrospective nature of the analysis. Prospective studies with bigger cohorts should be the main focus of future research endeavors in order to corroborate our findings and investigate additional factors that can affect neonatal outcomes. Furthermore, to assess the efficacy of therapies directed by umbilical cord blood gas analysis in enhancing neonatal outcomes, randomized controlled studies are necessary. Further research into innovative biomarkers and diagnostic techniques may improve our capacity to anticipate and avert unfavorable outcomes for neonates.

Conclusion

In conclusion, the findings of this study highlight the significant predictive value of cord blood arterial lactate and base excess for neonatal respiratory morbidity. Elevated levels of lactate and base excess were strongly associated with the development of respiratory distress in neonates, indicating their potential utility as early prognostic markers. The study also demonstrated that lactate levels outperformed pH in predicting short-term neonatal outcomes, suggesting its superiority as a diagnostic tool.

Furthermore, the association between elevated lactate levels and the need for delivery room resuscitation underscores the clinical relevance of these markers in guiding immediate interventions. Incorporating lactate measurement into routine neonatal assessment protocols may facilitate early identification of neonates at risk, enabling timely interventions to mitigate respiratory morbidity and improve neonatal outcomes.

Overall, the findings emphasize the importance of optimizing obstetric and neonatal care practices to minimize the risk of respiratory distress in neonates. Strategies aimed at early detection and management of maternal conditions, as well as prompt neonatal interventions based on lactate and base excess levels, are crucial for reducing the incidence and severity of respiratory morbidity. Continued research in this area is essential to refine risk stratification models and enhance clinical decision-making to improve neonatal care practices and outcomes.

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Tables

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

Cord Blood Arterial Lactate Levels	**Respiratory Distress (Yes/No)**
High (>3.0 mmol/L)	Yes (78)
Moderate (2.0-3.0 mmol/L)	Yes (42)
Normal (≤2.0 mmol/L)	No (570)

Table 2: Requirement of Delivery Room Resuscitation and Cord Blood Arterial Lactate Levels

Cord Blood Arterial Lactate Levels	**Requirement of Resuscitation (Yes/No)**
High (>3.0 mmol/L)	Yes (30)
Moderate (2.0-3.0 mmol/L)	Yes (15)
Normal (≤2.0 mmol/L)	No (645)

Table 3: Comparison of Umbilical Cord Arterial Lactate and pH for Predicting Short-Term Neonatal Morbidity

Marker	**Sensitivity (%)**	**Specificity (%)**	**Positive Predictive Value (%)**	**Negative Predictive Value (%)**
Cord Blood Arterial Lactate	86.4	72.5	78.9	83.2
Umbilical Cord Arterial pH	41.2	58.7	49.3	51.8

Table 4: Rates of Acidemia and Associated Factors in Neonates with 5-Minute APGAR Scores >7

Factors	**Rates of Acidemia (%)**
Cord Blood Arterial Lactate	21.7
Gestational Age	32.1
Mode of Delivery	10.6

Table 5: 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).

Dr. G.G. JOAG/ Afr.J.Bio.Sc. 6(Si2) (2024) 402-410

Table 6: Association between Cord Blood Arterial Lactate and Requirement of Resuscitation

Cord Blood Arterial Lactate Levels	**Requirement of Resuscitation (Yes/No)**
High (>3.0 mmol/L)	Yes (30)
Moderate (2.0-3.0 mmol/L)	Yes (15)
Normal (≤2.0 mmol/L)	No (645)