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Research Article

Role of Electrolyte and Acid-Base Disorder of Critically Sick Neonates at the Time of Admission in a Tertiary NICU as Predictor of their Mortality: A Retrospective Study

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Abstract

Background: Neonatal mortality rate is one of the key indicator in the health status of a nation, and directly reflects prenatal, intra-partum, and neonatal care.

Aim of this study: To find out the association of electrolyte and acid base disorder in critically sick neonates at the time of admission in NICU as predictor of their mortality.

Methods: This retrospective study was conducted in the department of Neonatology, Bangladesh Shishu Hospital and Institute (BSHandI), Sher-E-Bangla Nagar, Dhaka, from January 2023 to June 2023. Total 115 neonates were included in this study having serum electrolyte and arterial blood gas with other basic biochemical parameter analyzed at the time of admission.

Results: Blood pH, HCO_3^-, Base excess were lower, Sodium (Na^+) level and anion gap were higher in non-survivors than survivors group which were statistical significant ($p < 0.05$). No statistical significant different regarding PCO_2, PO_2, potassium (K^+) and chloride level ($p > 0.05$). Multivariable logistic regression analysis identified a higher AG (OR 1.321, 95% CI 1.14-1.53; $p < 0.001$) at the time of admission in NICU as predictor of mortality.

Conclusion: A higher AG (anion gap) at the time of admission in NICU identified as strongest predictor of mortality.

Keywords: *NICU; Electrolyte and Acid-Base Disorder; Mortality Predictor*

Introduction

Neonatal mortality is one of the key indicators in the health status of a nation, directly reflects prenatal, intra-partum, and neonatal care. To improve the quality of neonatal intensive care unit (NICU) care, mortality prediction is important. Neonates can acutely decompensate from a variety of causes. However, they have a limited repertoire of responses to stress and the presenting signs are nonspecific. Therefore, rapid evaluation as well as initial stabilization with proper management of major diagnosed pathological diseases of ill neonates present a special challenge for pediatrician to encounter the compromised condition.

Critically ill neonates commonly have biochemical disorder. Understanding of biochemical abnormalities provide cornerstone to pediatrician about patient assessment, therapeutic decision and prognosis of the patient- a valuable asset for clinical success to neonatal

care [1]. These abnormalities occur in a variety of conditions and may remain unrecognized leading to worse situation irrespective of the primary disease, need more vigorous measures to reduce mortality in an emergency situation. However, estimation of mortality is difficult in critically ill neonates whose condition may deteriorate. There are some invasive methods to assess the status of patients as identify mortality predictors, but these take time to institute and have side effects such as infection. Therefore, it is necessary to identify noninvasive and easy tools for mortality prediction at NICU. The first need of a critically ill neonate is for monitoring of ventilator efficiency in respiratory disorder. Arterial blood gas (ABG) measurement is the gold standard to evaluate the efficiency of ventilation as well as diagnosis of metabolic or respiratory acidosis and alkalosis associated with birth process and postnatal adaptation to air breathing [2-4]. Blood gas analysis provides pH, PCO_2 from which [HCO_3^-] and base excess (BE) can be derived [5] adapted from Henderson–Hasselbalch equation mathematically links the variables of pH, PCO_2 and bicarbonate [HCO_3^-] concentration [6]. PaO_2 provides information about oxygenation, values vary considerably throughout the day in sick neonates as well as variable in machine. PaO_2 may be lower in premature caused by reduced lung function. Hence O_2 supplement much variable in aspect of general condition and different entity. Pulse oximeter uses to measure O_2 saturation (SaO_2). Patient with anemia may have normal saturation because of cardiac compensation [7]. Marked structural and functional difference in children in comparison to adults i.e., children have narrow distal airways with immature respiratory center so atelectasis develop quickly. In critical situation with less compliant chest wall as well as less efficient respiration resulting in rapid onset of hypercarbia and hypoxia lead to decreased respiratory drive. In addition, they have reactive vascular bed to maintain blood pressure, one cannot rely on hypotension to diagnose shock [8]. Anion Gap (AG: 4-12 mEq/L) is a traditional tool to assess acid-base status, is calculated from the difference of essential electrolytes between the measured concentration of serum cation (Na^+, K^+) and anion (Cl^-, HCO_3^-) [9]. Hence both acid-base and electrolyte status provide essential information about critically ill neonates and predict their mortality.

Perinatal asphyxia and neonatal sepsis both are common occurrence in neonates, major devastating health problems with survival in developing countries. Acid-base and electrolyte abnormalities are common who need intensive care [10,11]. Sodium and potassium play important role in maintenance of acid-base and fluid balance in ECF. Bicarbonate is another important electrolyte acts as a buffer [12]. Low level reflects the acid status of blood (e.g. metabolic acidosis). In critically sick neonates, syndrome of inappropriate antidiuretic (SIADH) secretion is a common problem where hyponatremia can occur. Hyperkalemia also occur results from ischemic insult [13]. When oral feeding is difficult or impossible or in cases with excessive gut or even renal loses, monitoring of serum sodium and potassium concentrations are useful [14]. Therefore, electrolyte and acid-base imbalance are replaced timely and appropriately. A high index of suspicion and thorough understanding of common biochemical abnormalities (e.g. electrolyte and arterial blood gas) are necessary to reduce mortality of critically ill neonates admitted at NICU.

Materials and Methods

This retrospective study was conducted at NICU, Bangladesh Shishu Hospital and Institute during the period of January 2023 to June 2023. 115 neonates were analyzed having serum electrolyte and arterial blood gas. Normal range of arterial blood gas e.g. pH (7.35-7.45), PCO_2 (35 - 45 mmHg), PO_2 (80 - 100 mmHg), HCO_3^- (23 - 27 mmol/L), Base Excess (< 10 mmol/L) [6]. Serum concentration of Na^+<130 mmol/L were defined as hyponatremia [15] and > 150 mmol/L as hypernatremia [16]. Hypokalemia as serum potassium level 3 mmol/L [17] and hyperkalemia 6 mmol/L [18] respectively. Anion gap was calculated from the following formula [9]. AG = [$Na^+ + K^+$] - [$Cl^- + HCO_3^-$]. Patients were divided into survivors and non-survivors on the basis of in-hospital mortality. Among 115 neonates, 64 were in survival group and 51 were in non-survival group. SPSS 2025 was used to test the significance difference of biochemical status of critically ill neonates and also the significance difference among survivors and non-survivors.

Results

Table 1 showed clinical baseline of patients in NICU. Median age of admitted neonate was 5 days. Overall, median length of NICU stay 12 days and over-all in hospital mortality was 44.30% (51/115). The most common reason for NICU admission were perinatal asphyxia

(PNA) with neurologic problems (47%) and Low birth weight (LBW) (47%). Table 2 showed comparison of acid-base and electrolyte variables between survivors and non-survivors. Blood pH, HCO_3^-, Base excess were lower and Na^+ level was higher in non-survivors than survivors group also statistical significant ($p < 0.05$). No statistical significant different between survivors and non-survivors regarding PCO_2, potassium and chloride ($p > 0.05$). A higher anion gap was observed, statistical significant ($p < 0.05$). Table 3 showed Logistic regression for serum electrolyte and arterial blood gas (ABG) variables in mortality prediction. In univariate regression, disease pattern as PNA with neurologic problems, respiratory failure, sepsis, post-resuscitation and biochemical status as pH, HCO_3^-, Base excess, Na^+ and AG were statistical significant ($p < 0.05$). Multivariate regression showed a higher AG (anion gap) at admission in NICU identified as strongest predictor of mortality.

Age (days)	Avg. 5 (4-6)
Length of stay in NICU (days)	12 (11-14)
In Hospital mortality, n (%)	51 (44.3%)
Reasons for NICU admission, n (%)	
Respiratory failure	42 (36%)
Perinatal asphyxia with neurologic problems	54 (47%)
Sepsis	42 (36%)
Cardiovascular disorder	14 (12.2)
Renal failure	2 (1.7%)
Gastroenteritis	3 (2.6%)
Post-resuscitation	52 (45.2%)
LBW	54 (47%)

Table 1: *Baseline study population of patients in NICU (n = 115).*

Data expressed as number (percentage) or median value.

Variables	Survivors	Non-survivors	p-value
pH	7.29 ± 0.06	7.24 ± 0.10	0.011*
HCo_3^-,mEq/L	16.07 ± 3.42	12.82 ± 4.68	0.002*
PCO_2	27.05 ± 6.52	42.81 ± 12.29	0.175^{NS}
PO_2	128.33 ± 54.81	115.21 ± 64.47	0.241^{NS}
Base Excess, mEq/L	-8.56 ± 4.07	-12.54 ± 7.94	0.001*
Sodium, mEq/L	138 ± 7.04	144 ± 9.31	0.001*
Potassium, mEq/L	4.72 ± 0.834	4.64 ± 1.35	0.695^{NS}
Chloride, mEq/L	98.79 ± 19.75	101.78 ± 9.95	0.336^{NS}
AG (Anion Gap), mEq/L	18.60 ± 8.74	31.53 ± 7.01	0.001*

Table 2: *Baseline electrolyte and acid-base variables in critically sick neonates.*

*NS = Not significant, *= Significant. p=<0.05 considered as significant.*

Univariate regression			Multivariate regression	
Factor	**OR (95%CI)**	***P***	**OR (95%CI)**	***P***
Respiratory Failure	2.658 (1.218-5.802)	0.014*	10.617 (2.190-51.479)	0.003*
PNA with Neurological problem	2.763 (1.293-5.905)	0.009*	8.024 (0.841-76.589)	0.70^{NS}
Sepsis	2.658 (1.218-5.802)	0.014*	3.076 (0.672-14.087)	0.148^{NS}
Post-Resuscitation	2.350 (1.106-4.992)	0.026*	0.403 (0.044-3.668)	0.420^{NS}
Renal failure	2.110 (0.001-3.110)	0.999^{NS}		
Cardiovascular Disorder	0.460 (0.135-1.562)	0.213^{NS}		
Gastroenteritis	2.200 (0.001-3.210)	0.999^{NS}		
LBW	0.562 (0.267-1.182)	0.129^{NS}		
P^H	0.001 (0.001-0.135)	0.008^{*}	0.149 (0.001-0.865)	0.734^{NS}
HCo_3^-	0.820 (0.738-0.911)	0.001*	1.131 (0.877-1.458)	0.344^{NS}
PCO_2	1.012 (0.987-1.037)	0.351^{NS}		
PO_2	0.996 (0.990-1.003)	0.239^{NS}		
Base Excess	0.890 (0.828-0.957)	0.002*	0.970 (0.794-1.185)	0.765^{NS}
Sodium	1.101 (1.044-1.160)	0.001*	0.906 (0.814-1.009)	0.071^{NS}
Potassium	0.934 (0.665-1.311)	0.692^{NS}		
AG	1.204 (1.125-1.289)	0.001*	1.321 (1.140-1.532)	0.001*

Table 3: *Logistic regression for electrolyte and acid-base variables in mortality prediction.*

OR= Odds Ratio; CI= Confidence Interval; p=<0.05 considered as significant.

*NS= Not significant, *= Significant.*

Discussion

The study was carried out in critically ill neonates. Among the percentage of ill neonates- Perinatal asphyxia (PNA) with neurological problem, LBW, respiratory failure, post-resuscitation status were higher reasons for NICU admission. Previous studies compared biomarkers, such as pH, base excess, or lactate as means of assessing acid-base disorders and predicting prognosis in critically ill patients [19-21]. Therefore, reassessing the clinical application of AG (Anion Gap) to calculate from acid-base and electrolyte disequilibrium is useful and meaningful [22].

The association between lower pH and more base-deficit with death of ill neonates [23,24]. In this study lower mean pH in non-survivors was less than survivors at time of admission. A low pH can be used as a predictor factor for unfavorable short term outcome in newborns [25]. Lekhwani S., *et al.* showed significant correlation between outcome and significant lower value of normal pH were associated with increase patient mortality [26]. This study has shown that metabolic acidosis is one of the most frequent acid-base disorders occurring in non-survivors similar to another which remain a powerful marker of poor prognosis in critically ill patients [27,28]. Similar to the present study, lower pH and higher base deficit in non-survivors compared with survivors at admission. Among electrolyte imbalance, hypernatremia was more in non-survivors than survivors. Respiratory failure, ventilation, anion gap and hypernatremia were significant predictors of mortality among children at Pediatric Intensive care Unit [29,30]. Therefore, management of electrolyte and acid-base disorder always demands precise diagnosis and treatment of underlying disease to combat the deviation to reduce mortality.

AG (Anion Gap) helps to aid the differential diagnosis of metabolic acidosis caused by overproduction or decreased excretion of organic acids. Comparing survivors and non-survivors, we determined that a higher AG at the time of admission at NICU was strongly associated

with in-hospital mortality. In terms of multivariate logistic regression analysis for mortality prediction, a higher AG as well as respiratory failure were identified as predictor of mortality among neonates admitted at NICU (P-value <0.05). A similar study (logistic regression analysis) showed that a higher AG (Anion Gap) on admission was the strongest predictor of in-hospital mortality [31].

Conclusion

A higher AG (Anion Gap) was identified as strongest predictor of mortality at the time of admission in NICU.

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