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ORIGINAL ARTICLE

To Predict Mortality of Critically Ill Neonates Admitted in Intensive Care Unit (ICU) of a Tertiary Care Pediatric Hospital

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Abstract

Background*: Critically ill neonates who need intensive care are vulnerable to various derangement. Early and prompt recognition of these predictor helpful to care and their correction improves survival of these neonates.*

Objective*: To predict mortality of critically ill neonates admitted in ICU.*

Methods*: This observational study was carried out at NICU of Dhaka Shishu (Children) Hospital from January 2015 to July 2015. Total 121 neonates were enrolled according to inclusion criteria and analyzed their valuable biochemical profile specially electrolyte and blood gas status as a part of proper management as well as to predict their outcome.*

Results*: Among critically sick neonates, perinatal asphyxia was common disorder followed by sepsis. Biochemical profile specially electrolyte and acid-base disruption play important role to the outcome of critically sick neonates. Low pH, low potassium and high base-deficit level were found to have significant consequence.*

Conclusion*: Perinatal asphyxia constitute major cause of admission of critically sick neonates. Early detection of electrolyte and acid-base status is helpful to care and overall survival of these neonates. Mortality was the highest among neonatal sepsis followed by perinatal asphyxia. Metabolic acidosis and hypokalaemia were the predict or of outcome of these such neonates.*

Keywords*: Mortality, acid-base, electrolyte status.*

Introduction

Critically ill neonates commonly have acid-base and electrolyte disorder,a valuable predictor to a paediatrician about patient assessment, therapeutic decision and prognosis of the patient.[1] These occur in a variety of conditions and may remain unrecognized leading to morbidity and mortality irrespective of the primary disease, need more vigorous measures to reduce mortality in an emergency situation.

Blood gas measurements permitted the diagnosis of metabolic and respiratory acidosis or alkalosis associated with birth process and postnatal adaptation to air breathing.[1-3] The cardiovascular system undergoes changes after birth, respiratory gas exchange begins instead of formerly placental function, must be established by the lungs within minutes. Therefore, frequent and serious difficulties in cardio-respiratory adaptation in perinatal and neonatal periods are not surprising.[4]

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Blood gas analysis provides p^H, PCO_2 from which [HCO_3^-] and base excess (BE) can be derived.[5-8] Moreover, it is easily understandable and widely used at bed side management.[9] This traditional approaches to analysis of acid-base status adapted from Handerson-Hasselbach equation mathematically links the variables of p^H, PCO_2 and bicarbonate concentration [HCO_3^-].[10] The PCO_2 concentration in a given patient reflects the balance between metabolic production of CO_2 and excretion by ventilation. The normal range of PCO_2 after the first hours of life can be considered 35-45 mmHg, desirable CO_2 values for a specific situation may be either higher or lower.Elevation of PCO_2 concentration 10 mmHg decreases p^H by 0.08 while PCO_2 decrease of 10mm Hg increase p^H by 0.08.[11]

Blood gas measurements specially PaO_2 and SaO_2 provide important information about oxygenation but must be combined with other clinical and laboratory profile to assess a comprehensive picture. PaO_2 values vary considerably throughout the day in sick neonates. Hence O_2 supplement much variable in aspect of general condition and different entity. Patient with anaemia may have normal saturation because of cardiac compensation.[11] Pulse oximetry measures peripheral O_2 saturation (SaO_2) not PaO_2 and this is relatively insensitive to detecting hyperoxaemia. Values of PaO_2 and SaO_2 may be lower in premature caused by reduced lung function.[12]

Marked structural and functional difference in children in comparison to adults, so atelectasis develop quickly resulting in rapid-onset of hypercarbia and hypoxia. Chest wall is compliant and respiration is less efficient; the respiratory center is immature, hypoxia and hypercarbia lead to decreased respiratory drive. In addition they have reactive vascular bed to maintain blood pressure until late, therefore one cannot rely on hypotension to diagnose shock as in adults.[13] Identify the presence of metabolic acidosis, the categorization ends with a broad differential of anion gap (4-12mEq/L). This includes essential electrolytes eg. Cation (Na^+, K^+) and Anion (Cl^-, HCO_3^-).[14] 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 health problems in Bangladesh like other developing countries and a devastating cause of mortality. The acid-base and electrolyte abnormalities are common in perinatal asphyxia and neonatal sepsis.

Sodium and potassium are the major electrolyte in the body regulate the voltage of action potentials in skeletal muscles, nerves and myocardium. They play important role in maintenance of acid-base and fluid balance in the ECF through osmolality. Maintenance of intracellular osmolality is accomplished through sodium-potassium pump (active transport). Bicarbonate is an important electrolyte acts as a buffer to maintain the normal level of acidity (p^H) in the blood and other fluids in the body.[18]

In perinatal asphyxia and neonatal sepsis, syndrome of inappropriate secretion of antidiuretic hormone (SIADH) is a common problem where severe hyponatremia and hyperkalaemia can occur. Hyperkalaemia results from ischaemic insult reflected cellular changes leading to diminished oxidative phosphorylation and ATP production. This energy failure impairs ion pump function resulting in accumulation of intracellular Na^+ and extracellular K^+.[20] If inappropriate fluid-electrolyte and acid-base are replaced serious morbidity can result.Excessive sodium-bi-carbonate, improper preparation of formula feeds, increased insensible water loss specially in premature babies kept under radiant warmers can cause hypernatremia in neonates.[21]

A high index of suspicion, prompt recognition and through understanding of blood gas and common electrolyte abnormalities are necessary to ensure their total correction as well as reduce mortality of critically ill neonates admitted in ICU.[22]

This study was carried out in neonates with various ailments attending ICU at a tertiary care hospital of Dhaka, Bangladesh. The objective was to study acid-base and electrolyte status in critically ill neonates association with primary illness and their impact to predict mortality of these neonates.

Materials and Methods

This observational study was conducted at ICU, Dhaka Shishu (Children) Hospital during the period of January 2015 to July 2015. For each neonate, a detailed history from mother or other care-giver was recorded in a preset questionnaire.

Total 161 neonates admitted during this period among these 40 were excluded from this study due to any congenital anomalies (medical or surgical), Jaundiced due to blood group incompatibilities or received LAMA (Left against medical advice). Before enrollment parent of each child was given a detail explanation about the nature and purpose of the study.

121 neonates were analyzed for electrolyte status, blood gas as well as baseline investigation for proper

management. With all aseptic precaution, blood sample was collected in the disposable syringe.Blood gas analyzer (Gastat-600) based on the principle of potentiometry analyzed p^H, PCO_2respective electrodes. Base excess(BE) and [HCO_3^-] were calculated parameters from p^H and PCO_2were provided by the analyzer. Electrolyte analyzer (Rapid lab-1265) based on the principle of potentiometry analyzed Na^+, K^+, CI^-. Anion gap was calculated from the following formula.[14]$AG=[Na^+ + K^+]- [CI^- + HCO_3^-]$.

Each case was thoroughly examined and follow-up regularly. Definite neonatalsepticaemia was diagnosed by positive blood culture and probable septicaemia was diagnosed by a scoring system[23] or positive CRP. Relevant investigations for diagnosis and follow-up included complete blood count, blood culture, serum electrolyte, blood gas analysis, blood grouping, serum bilirubin andchest X-ray.

Normal range of p^H (7.35-7.45), PCO_2(35-45 mmHg), HCO_3 (23-27 mmol/L), Base excess (<10mmol/L) were considered.[11]Hyponatremia and hypernatremia were defined as serum sodium concentration <130mmol/L[24,25]and >150mmol/L[26,27]respectively. Hypokalaemia and hyperkalaemia were defined as serum potassium level <3.5 mmol/L[15,27]and>6 mmol/L[28,29] respectively.

Unpaired t-test was used to test the significance of difference of acid-base and electrolyte status of critically ill neonates and also the significance of difference among survivors and non-survivors.

Results

This study was carried out on the basis of neonates suffering from a wide variety of ailments attending ICU care (Fig 1) over a period of six months.Among 121, 35.53% perinatal asphyxia, 32.23% neonatal sepsis, 16.53% prematurity, 15.70% pneumonia (Fig 1).

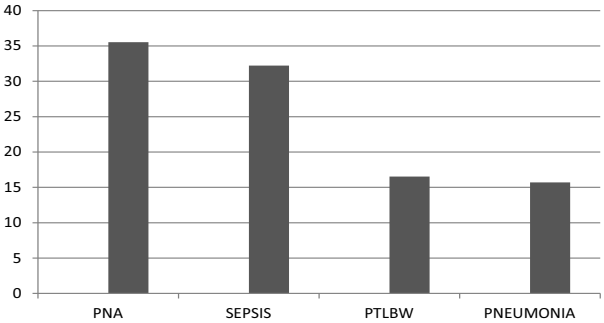

Fig 1 *Disease pattern (%) of Critically sick neonates*

In this study male predominance was found. 84 neonates were male and 37 were female, 2.27:1 (Table I).

On admission blood gas derangement was seen in 78(64.46%) critically sick neonates, 33(42.30%) died (Table II).

Table I
Age and sex distribution of critically sick neonates admitted in NICU

Age distribution (Days)	Sex distribution		Total
	Male (n%)	Female n (%)	n (%)
0 - 2	49(40.50)	24(19.84)	73(60.34)
3 -7	22(18.18)	08(6.61)	30(24.79)
8 - 28	13(10.74)	05(4.13)	18(14.87)
Total	84(69.42)	37(30.58)	121(100.00)

Table II
Disease profile with Acid-Base imbalance (on admission) and percentage of their non-survival (expired)

Primary disease	No. of patient (%)	Acid-Base imbalance (%)	Non-survival among Acid-Base imbalance (%)
Perinatal asphyxia	43(35.54)	27(22.31)	12(44.44)
Neonatal sepsis	39(32.23)	23(19.01)	9(39.13)
Preterm LBW	19(15.70)	15(12.40)	7(46.66)
Others	20(16.53)	13(10.74)	5(38.46)
Total	121(100.00)	78(64.46)	33(42.30)

Table II shows Acid-base status in critically sick neonates. Perinatal asphyxia was common disorder in this group of neonates having acid-base imbalance with the highest mortality.

On admission 91 babies (75.2%) had electrolyte abnormalities 41.32% died (Table III). 23.8% were from hyponatremia, 2.38% from hypernatremia, 14.28% from hypokalaemia, 35.7% were from hyperkalaemia and 23.86% had mixed groups (Table III). Case fatality rate was the highest in those with hypokalaemia (75%) followed by hyponatremia (62.5%), hypernatremia (50%) and lowest with hyperkalaemia (34%). Hypokalaemia was found to have a significantly higher mortality (p=.001) when compared to those with normal electrolyte values and similar underlying disorders (Table III).

K^+ level was found more, Na^+ and initial pH were found less in perinatal asphyxia than sepsis which were statistically significant (Table IV).

Non-survivors had less p^H, less potassium and more base-deficit level than survivors, statistically significant (Table V, Table III).

Overall mortality was the highest among neonatal sepsis (44%) followed by perinatal asphyxia (42%), prematurity (40%), pneumonia (37%) (Fig 2).

Table III

Disease pattern with electrolyte status at admission and mortality statistics (n=121)

Electrolyte status	Survival	Non-survival	Total	Case Fatality (%)	Statistics
Normal electrolyte	22	8	30	26.67	
Perinatal asphyxia	3	2	5	40.00	
Neonatal sepsis	9	4	13	30.76	
Preterm LBW	8	1	9	11.11	
Others	2	1	3	33.33	
Hyponatremia	6	10	16	62.50	p= .032
Perinatal asphyxia	1	6	7	85.71	
Neonatal sepsis	3	2	5	40.00	
Preterm LBW	0	2	2	100.00	
Others	2	0	2	00.00	
Hypernatremia	1	1	2	50	p= 0.744
Perinatal asphyxia	0	1	0	00	
Neonatal sepsis	0	1	1	100	
Others	1	0	1	00	
Hypokalemia	2	6	8	75	p= .001
Perinatal asphyxia	0	1	1	100	
Neonatal sepsis	1	2	3	66.67	
Preterm LBW	0	1	1	100.00	
Others	1	2	3	66.67	
Hyperkalemia	29	15	44	34.09	p= 0.251
Perinatal asphyxia	14	6	20	30.00	
Neonatal sepsis	7	2	9	22.22	
Preterm LBW	4	3	7	42.86	
Others	4	4	8	50.00	
Mixed	11	10	21	47.62	
Perinatal asphyxia	7	3	10	30.00	
Neonatal sepsis	2	6	8	75.00	
Preterm LBW	0	1	1	100.00	
Others	2	0	2	00.00	

Table IV
Acid-Base-Electrolyte parameters in Perinatal Asphyxia and Sepsis (on admission)

	PNA (n=43) Mean±SD	Sepsis (n=39) Mean±SD	p value
pH	7.33± 0.122	7.38± 0.12	**0.042^{s}**
PCO_2(mm of Hg)	32.67± 15.74	29.85± 11.71	0.364^{ns}
HCO_3^- (mmol/L)	16.83±4.91	19.31 ±10.09	0.155^{ns}
BE(mmol/L)	-7.14±5.17	-8.3±17.55	0.681^{ns}
Na^+ (mmol/L)	135.76 ±7.41	140.03 ±9.44	**0.026^{s}**
K^+ (mmol/L)	5.26 ±1.40	4.7 ±1.0	**0.016^{s}**
CI^- (mmol/L)	98.86 ±10.29	102.79 ±15.3	0.176^{ns}
Anion Gap (AG)	25.5±10.25	21.81±14.82	0.193^{ns}

Table IV- Comparative observation of acid-base-electrolyte parameter in major diagnosed critically sick neonates (perinatal asphyxia and neonatal sepsis). Here initial pH and Na^+ were found less, K^+ level was more in PNA than sepsis (statistically significant).

Table V
Pattern of Acid-Base parameters of Critically sick neonates (on admission) among Survivors and Non-Survivors (expired)

	Survivors (n =71) Mean ± SD	Non-Survivors (n =50) Mean ± SD	p value
pH	7.36 ± 0.1	7.3 ± 0.19	**0.011^{s}**
PC02 (mm of Hg)	31.69 ± 11.54	33.63 ± 17.48	0.466^{ns}
[$HC0_3^-$](mmo1/L)	18.03 ± 6.59	17.95 ± 10.4	0.961 ^{ns}
BE	-4.3 ± 6.88	-10.74 ±15.89	**0.004^{s}**

p value reached from unpaired t-test

Table V gives a comparative ongoing observation of blood gas status among survivors and non-survivors of critically sick neonates. Non-Survivors had less pH and more BE level than survivors (statistically significant).

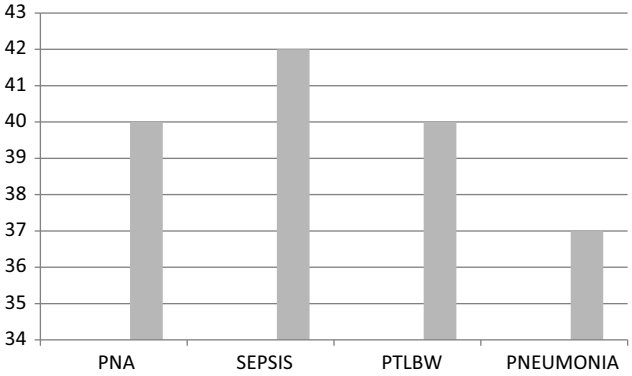

Fig 2 *Disease pattern (%) of non-survivors (expired) among critically sick neonates*

Discussion

This six months prospective study was undertaken in order to document the most common type of diseases with which the sick neonates are admitted in NICU of Dhaka Shishu Hospital and their consequence outcome. The selection was unbiased. The data may therefore be generalized on a population of sick neonates seeking ICU care.

Perinatal asphyxia was common disorder in accordance with the epidemiological pattern observed in this region with the highest mortality followed by sepsis. The patterns of diagnoses in our study are comparable to a similar study done in Lahore, Pakistan.[19]

Among total number of admitted critically sick neonates preponderance of males in this age group consistent with other studies.[20]

In this study critically sick neonates have acid-base abnormalities (64.46%) and **e**lectrolyte imbalance (75%) are discussed as follows to predict their consequence outcome. Acid-base disorders in critically sick neonatal ICU patients predicting survival by the presence of deranged acid-base variables.[26-28]

Metabolic acidosis is one of the most frequent acid-base disorder occurring in non-survivors[29,30] more in perinatal asphyxia[31,32] as this study. An abnormal pH <7.2[33,34] and <7[35] can be used as a predictor factor for unfavorable short term outcome in newborns. In this study lower mean pH in non-survivors was around 7.3.

Consequently, the management of acid-base disorder always demands precise diagnosis and treatment of the underlying disease, it requires steps to combat the deviation to reduce mortality.[36]

Among electrolyte imbalance (75%) in critically sick neonates hyperkalaemia was the commonest (48%). These finding are in contrast to[37,38] who found by hyperkalaemia in 5.4% and 14.4% respectively in ICU admitted neonates.

In 48.7% neonates with hyperkalaemia there was concomitant metabolic acidosis, another important cause. The other possibilities of increased potassium release are tissue destruction, trauma, cephalhaematoma, hypothermia, bleeding, intravascular or extra vascular haemolysis, asphyxia, ischaemia and IVH.[39] Most of these condition were present in our study subjects.

Yuan et al.[17] have found hyperkalemia in 44% of sick neonates which is consistent with the present study.

Hyponatremia was the second most common electrolyte abnormality (13%) noted in this study. In a study conducted in a paediatric ICU, 9.5% of total admissions had hyponatremia.[38]

Hypokalaemia was less common (8.79%), electrolyte abnormality observed in the present study. However, a significantly lower (3.6%)[39] and two higher frequencies (14.8% & 13.9%)[40,37] were observed.

The risk of mortality in our study is significantly higher in patients with hypokalaemia (75%) in comparison to those with normal electrolyte values (26.6%). Higher risk of mortality was also observed in a prospective study of 727 sick children,[40] in contrast lowest mortality with hypokalaemia was reported by Rao et al.[38]

In our study hyponatremia was found to have a significantly higher mortality rate (62.5%) after hypokalaemia which is consistent with other study.[41]

Conclusion

Early detection of blood gas and electrolyte status helpful for overall management and better survival of critically ill neonates. Low p^H, low potassium and more base deficit can predict the mortality in this group of neonates.

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