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Frequency of Acid-Base Derangements Among the Neonates Admitted to the Intensive Care Unit

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Abstract

Background: Every year deranged acid-base physiology drives admission to a critical care arena for a vast number of neonates. The neonatal intensive care unit is a fundamental sector for the survival of high-risk newborns. The acid-base disorder must always be considered in the clinical setting. The clinician should, in most cases, be able to predict the type of acid-base imbalance before the blood gas is available. Arterial blood gases (ABG-s) are the gold standard for assessing the adequacy of oxygen delivery, ventilation, and pH. This study aimed to assess the frequency of acid-base derangements among neonates admitted to the intensive care unit. **Material & Methods:** This was an observational cohort study that was conducted in the Neonatal Intensive Care Unit (I.C.U.) of Dhaka Shishu Hospital, Dhaka, Bangladesh during the period from October 2009 to September 2010. In total 230 neonates admitted to the Neonatal Intensive Care Unit, after fulfilling the inclusion criteria were enrolled in this study as study subjects. For each baby, a detailed history was recorded in a questionnaire form (enclosed herewith) from the mother or other caregiver. It was filled up by the researcher himself containing history (including antenatal history), physical examinations and laboratory findings. Arterial blood gas analysis was done (in a clinical biochemistry laboratory using an automatic analyzer machine) for each neonate at admission and that report was recorded for this study. **Results:** Among the total study subjects, 127 newborn babies (55.2%) had acid-base imbalances. Mixed acidosis prevailed in the highest frequency (23.9%) Then metabolic acidosis cases were at 17.8% and respiratory acidosis was at 13.9%. Metabolic alkalosis and respiratory alkalosis were absent. Normal blood gas was observed in 44.3% of newborns. All the neonates with pH <7 were dead. After Chi-Square analysis (at df=1), we found a highly significant correlation between mortality outcome with pH <7.35, CO2 >45, HCO3 < 22 mol/l and Base deficit >-10. All modalities of acid-base imbalances were significantly associated with mortality. **Conclusion:** In this study, a significant number of neonates who were admitted to the intensive care unit, can develop acid-base derangement. Mixed acidosis was found in the highest frequency. Metabolic, respiratory and mixed acidosis all has a significant correlation with death in a NICU. Metabolic alkalosis and respiratory alkalosis were found absent at admission.

Keywords:- Frequency, Acid-base derangements, Neonates, ICU, Respiratory acidosis.

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INTRODUCTION

In developing countries, the majority of infant deaths result from infectious diseases, even in the neonatal period 24% of the deaths are caused by severe infections, 29% from PNA, 7% from tetanus, and 24% from complications of prematurity.[1] Bangladesh has made noteworthy progress in child survival over the last few decades with under 5 mortalities declining to 53 per 1000 live births in 2011 from 133 deaths per 1000 live births in 1991, while infant deaths reduced from 87 to 43 per 1000 live births and neonatal deaths declined from 52 to 32 deaths per 1000 live births.[2] Globally the country is 1 of the 7 countries on track to achieve Millennium Development Goal (MDG) 4 for a reduction in child mortality by two-thirds by 2015.[3] About 57% of all under 5 child deaths occur during the 1st 4 weeks of life. This figure is alarmingly high. If the current trend continues, it will be a challenge for us to achieve MDG 4.[4] Mortality rate of Dhaka Shishu Hospital, a tertiary-level pediatric teaching hospital in Bangladesh is 237/1000 admissions.[5] No significant improvement in mortality has been evident for the last 10 years although infection has been addressed adequately.[6] For this reason, attention has been drawn to the fact of acid-base derangements and their outcome as it may be a cause of morbidity and mortality in I.C.U. The goal of critical care is to provide optimal surveillance and support to the developing organ systems of the patients.[7] The care of neonates with life-threatening conditions from birth asphyxia to serious medical illness and recovery from major surgery requires a detailed understanding of human physiology and the pathophysiology of major illness.[8] Acid-base disorders must always be considered for the clinical setting. The clinician should, in most cases, be able to predict the type of acid-base derangement before the blood gas is available. Arterial blood gases (ABGs) are the gold standard for assessing the adequacy of oxygen delivery, ventilation, and pH.[9] Arterial blood gas analysis provides valuable information about gas exchange and perfusion which may not be evident from the physical examination. Although hypoxia may sometimes be detectable by the presence of cyanosis, abnormally high or low levels of oxygen or carbon dioxide and serious acidosis and alkalosis may be present without any specific clinical signs. Such important abnormalities only are assessed by BGA. A blood pH less than normal is called acidemia; the underlying process is acidosis. Similarly, alkalemia and alkalosis refer to the pH >7.45 and the underlying process respectively.[10] While acidosis and alkalosis may coexist, there can be only 1 resulting pH. Therefore, acidemia and alkalemia are mutually exclusive conditions.[11] The approach to acid-base derangements emphasizes a search for the cause, rather than an immediate attempt to normalize the pH. Many disorders are mild and do not require treatment. Further treatment may be more detrimental than the disorder itself. More important is a full consideration of the possible underlying pathologic states, which may facilitate a direct intervention that will benefit the patient more than normalization of the pH would.[12] On the other hand, acute respiratory academia (pCO2 to >60 mm Hg) causes a marked increase in cerebral blood flow. Acute elevations of PaCO2 to >70 mm Hg cause loss of consciousness and seizures. Also, acute hypercapnia causes depression of diaphragmatic contractility.[13] Alkalemia

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appears to increase myocardial contractility, at least to a pH of 7.7; also, hyperventilation can cause a decrease in systemic vascular resistance, although alkalemia can also cause coronary artery spasm with E.C.G. evidence of ischemia. Acute respiratory alkalemia causes a decrease in cerebral blood flow, an effect that lasts only for hours.[14] Deranged acid-base physiology drives admission to a critical care arena for a vast number of neonates. Blood gas measurements and complementary, noninvasive monitoring techniques provide the clinician with information essential to patient assessment, therapeutic decision making and prognostication. Blood gas measurements are vitally important for critically ill neonates but rapidly changing physiology, difficult access to arterial and mixed venous sampling sites and small blood volumes present unique challenges.[15] The objective of this study was to assess the frequency of acid-base derangements among neonates admitted to the intensive care unit.

MATERIAL AND METHODS

This was an observational cohort study. It was conducted in the Neonatal Intensive Care Unit (I.C.U.) of Dhaka Shishu Hospital, Dhaka, Bangladesh during the period from October 2009 to September 2010. In total 230 neonates admitted to the Neonatal Intensive Care Unit, after fulfilling the inclusion criteria were enrolled in this study as study subjects. The study was approved by the ethical committee of the mentioned hospital. Properly written consent was taken from all the participants before data collection. As per the inclusion criteria of this study, ICU-admitted preterm, term, and post-term neonates of both sexes either case of medical and surgical cases having congenital anomalies were included. On the other hand, according to the exclusion criteria of this study, those neonates who discontinued the treatment and neonates whose parents were unwilling to participate were excluded. All the demographic and clinical data of the participants were recorded. Maternal history included-maternal illness (pyrexia), and duration of membrane rupture. Whether foul-smelling P.V. discharge, N.V.D. or C/S, condition of the baby at birth, whether any resuscitation was needed or not. Gestational age was determined from maternal records. The admission weight of the baby was recorded by the electronic weighing machine, history of crying or breathing immediately after birth, apnoea/ cyanosis, convulsion, respiratory distress, reluctance to feed, and bleeding manifestations were also recorded. The presence of perinatal asphyxia was clinically diagnosed by - a history of delayed crying or breathing and the presence of cyanosis immediately after birth. Perinatal asphyxia with complications- was considered as with convulsions &/or with septicemia. A predesigned questionnaire was used in data collection. Analysis was done by employing SPSS Version 15 & Epi Info 7 software packages.

RESULTS

In this study, among the total of 230 participants, 63% were male whereas the rest 37% were female. So male participants were dominating in number and the male-female ratio was 1.7:1. Gestational age was found <37 weeks in 40% of cases and >37 weeks was found in 60% of cases. The age of the majority of the neonates (53%) was <7 days and the weight of the majority of the neonates was >2500 gm.

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According to the distribution of neonates by congenital anomalies, we observed that diaphragmatic hernia was present in the highest number (n=17) of cases as a single congenital anomaly followed by congenital heart diseases (n=16) and tracheoesophageal fistula (n=14). In this study, in analyzing the Frequency of acid-base derangements among the neonates we observed that 127 (55%) neonates had acid-base derangements, while 103 (45%) neonates had no derangements. Among the total participants 99 (43%) neonates had BE within the range of +5 to -5 while 47 (20.4%) neonates had > -12. Among the neonates, 95 (41.3%) had normal pH while 7 (3%) had pH < 7. Among the total participants mixed acidosis accounted for the highest number (n=55) among the acid-base derangements.

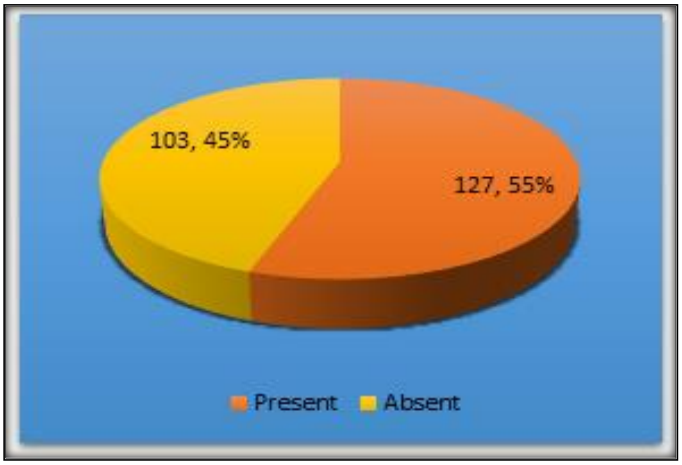

Figure 1: Frequency of acid-base derangements among the neonates (N=230)

The frequency of different types of acid-base imbalance was analyzed and it was observed that 18% of neonates had only metabolic acidosis, 14% of patients had only respiratory acidosis, 24% of patients had combined metabolic & respiratory acidosis and 45% of the total 230 neonates were with normal acid-base balance. Neonates presented with any form of acid-base disorder were significantly associated with mortality (P<0.05). In this study, it was found that improvement was higher in newborns with BE +5 to -5. Survivability was lesser in BE -12 to > -20. There was a highly significant difference between death rates among neonates with acid-base imbalances from those without imbalance (P<0.05).

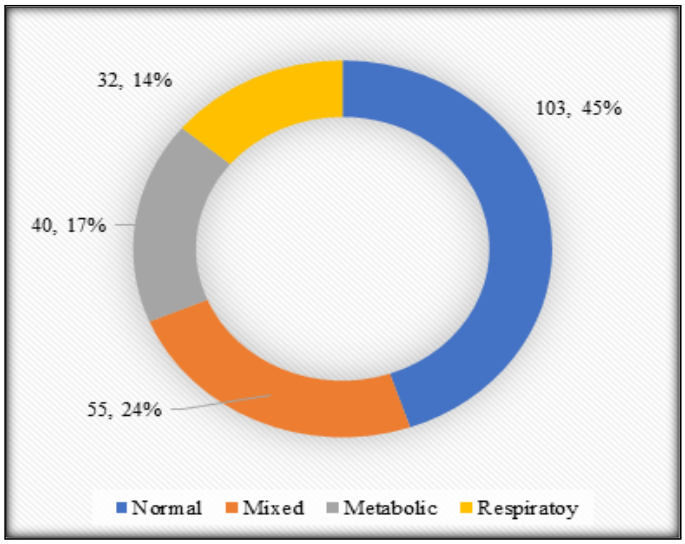

Figure 2: Distribution of neonates by different types of acidosis on admission (N=230)

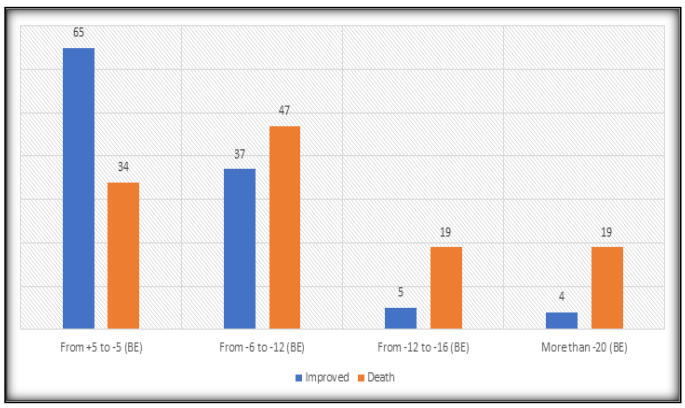

Figure 3: Distribution of neonates with different groups of base excess and outcome (N=230)

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Table 1: Distribution of neonates by gestational age, age and weight (N=230)

Variables		**n**	**(%)**
Gestational age (Week)	<37	92	40
	>37	138	60
Age	<7 days	122	53
	>7 days	108	47
Weight	<2500 gm	87	37.8
	>2500 gm	143	62.2

Table 2: Distribution of the neonates according to p^H group (N=230)

pH Group	**n**	**%**
>7.35	95	41.3
7.25-7.34	57	24.8
7-7.24	71	30.9
<7	7	3

Table 3: Distribution of neonates by the level of BE (N=230)

BE groups	**n**	**%**
+5 to -5	99	43.0%
-6 to -12	84	36.5%
-12 to -16	24	10.4%
> -20	23	10.0%

BE: Base excess/deficit

Table 4: Distribution of neonates with different ABD at admission and their outcome (N=230)

Acid-base derangement		**Outcome**		**Odds ratio**	**Confidence interval**	**P value**
		Death	**Improved**			
Metabolic	Present	30	11	3.06	1.45 – 6.47	<0.001
Acidosis	Absent	89	100			
Respiratory	Present	23	9	2.71	1.19 – 6.16	< 0.02
Acidosis	Absent	96	102			
Mixed	Present	37	18	2.33	1.23 – 4.40	<0.001
Acidosis	Absent	82	93			

Table 5: Distribution of neonates who survived and died by ABD (N=230)

Acid-base derangement	**Outcome**		**Total**	**Odds ratio**	**95% CI**	**P value**
	Improved	**Death**				
Present	38	89	127	5.65	3.22-10.07	0.000
Absent	73	30	103			
Total	111	119	230			

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DISCUSSION

This study aimed to assess the frequency of acid-base derangements among neonates admitted to the intensive care unit. Bangladesh is 1 of the 7 countries on track to achieve Millennium Development Goal (MDG) 4 for a reduction in child mortality by two-thirds by 2015.[15] But the current trend of the neonatal mortality rate is a great hindrance to implementing this target. In this study, in analyzing the Frequency of acid-base derangements among the neonates we observed that 127 (55%) neonates had acid-base derangements, while 103 (45%) neonates had no derangements. The sex distribution of this study was - male 63.5 % (146/230) and females were 36.5% (84/230). The male predominance so far in admission agrees with other studies like Kapil and Bagga (73%),[16] Hossain et al.[17] The main reasons for NICU admission were perinatal asphyxia with complications (24.8%), problems related to preterm low birth weight (20.4 %) and major congenital anomalies (23%) in this study. It was observed that 55.2% of the critically ill newborns treated in the NICU had acid-base derangements and had higher mortality than those without acid-base imbalances. A highly significant correlation was found between mortality outcome and acidosis. Maintenance of the pH of plasma in the range of 7.36-7.45 is essential for health. Recovery is unlikely to occur if the blood pH falls below 6.80 or increases above 7.80.[18] In this study, all the newborns with pH< 7, died. A highly significant correlation was found by trend analysis between acidosis and mortality outcome. About seventy-five percent (74.7%) of neonates were with pH < 7.35, which became a risk factor for the mortality outcome of the patients by univariate odds ratio analysis and stepwise multivariate logistic regression analysis. Hossain et al found (acidemia i.e. pH below 7) as a risk factor for mortality of the patients.[17] Forty-two neonates (18%) had Hypercapnia (pCO2> 50 mm of Hg), which was significantly associated with mortality in this study by both univariate analysis and multivariate logistic regression. Hossain et al,[17] found that pCO2 > 60 mm of Hg had the highest case fatality rate (81%). Hypercapnia results in vasodilatation and increased cerebral blood flow and may be responsible for the raised intracranial pressure. Severe hypercapnia may be a cerebral depressant.[19] Among different modalities of acid-base imbalances, metabolic acidosis was found in 17.8%, respiratory acidosis in 13.9%, and mixed acidosis in 23.9% of patients. Neonates with normal arterial blood gases were 44.3% Significant correlation was observed between metabolic acidosis (measured by HCO3 < 20 mmol/l) with the outcome (death). The degree of metabolic acidosis (> -5 mmol/l) is a determining feature of death in critically ill newborns. In this study, those having a base deficit > -10 had significant mortality outcomes in comparison with having < -10 mmol/l. Base deficit (or excess) is a parameter often used to guide further treatment in acidotic children and is taken as a measure of how sick they are. [20] A significant metabolic acidosis (> 10 mmol/l base deficit) can produce an adverse effect on oxygenation and cardiac output. This may be due to poor peripheral perfusion as a result of hypovolemia or reduced cardiac output, from anaemia, sepsis, or even parenteral nutrition. A pH < 7.15 is associated with reduced myocardial contractility and diaphragmatic activity.[21] Correction of this acidosis can often

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lead to a dramatic improvement. A comparable observation was made by Dalvi et al,[22] who found blood gas abnormality, as an independent risk factor for the mortality outcome of newborn patients in a NICU. Goldstein et al,[23] demonstrated that acidosis predicted poor motor outcomes in very low birth weight infants. Couriel also agrees with this observation, he described pH, pCO2 & base deficit as risk factors for mortality in neonates in a NICU.[24] Mortality was very high in neonates with metabolic acidosis (P value < o.ooo, at df=1). Thirty neonates died among the forty-one neonates having metabolic acidosis. Hossain et al,[17] also found a highly significant correlation regarding this. Low et al,[25] showed a progression of the severity of newborn complications with increasing metabolic acidosis (base deficit > -12). Significant mortality was found in both respiratory and mixed acidosis (combined metabolic and respiratory acidosis) in this study. Acidemia associated with asphyxia inhibits surfactant production,[26] and increases pulmonary vascular resistance.[27] All the findings of this study may be helpful in further similar studies.

Limitations of The Study

This was a hospital-based single-centered study with small-sized samples. Moreover, the study was conducted over a very short period. So, the findings of this study may not reflect the exact scenario of the whole country.

CONCLUSIONS

A significant number of neonates have developed acid-base derangement among the newborns admitted to the intensive care unit. Mixed acidosis was found in the highest frequency. Metabolic, respiratory and mixed acidosis all has a significant correlation with death in a NICU. Metabolic alkalosis and respiratory alkalosis were not found at admission. A significant association between mortality with disease pattern was observed in perinatal asphyxia with complications, preterm low birth with sepsis and congenital anomalies.

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