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Original Research Article

Acid based disorders in intensive care unit: a hospital-based study

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ABSTRACT

Background: Acid base disorders are common in the ICU patients and pose a great burden in the management of the underlying condition.
Methods: Identifying the type of acid-base disorders in ICU patients using arterial blood gas analysis This was a retrospective case-controlled comparative study. 46 patients in intensive care unit of a reputed institution and comparing the type of acid-base disorder amongst infectious (10) and non-infectious (36) diseases.
Results: Of the study population, 70% had mixed acid base disorders and 30% had simple type of acid base disorders. It was found that sepsis is associated with mixed type of acid-base disorders with most common being metabolic acidosis with respiratory alkalosis. Non-infectious diseases were mostly associated with metabolic alkalosis with respiratory acidosis. Analysis of individual acid base disorders revealed metabolic acidosis as the most common disturbance.
Conclusions: These results projected the probability of acid bases disorders in various conditions and help in the efficient management. Mixed acid base disorders are the most common disturbances in the intensive care setup which is metabolic acidosis with respiratory alkalosis in infectious diseases and metabolic acidosis is the most common simple type of acid base disorder.

Keywords: Acid base disorders, Arterial blood gas analysis, ICU metabolic disorders, Metabolic diseases

INTRODUCTION

Understanding acid base disorder in various pathological conditions is an asset to physicians in efficient treatment of the critically ill. Acid base disorders reflect the seriousness of the underlying disease that are responsible for morbidity and mortality. Intensivists spend much of their time managing problems related to fluid, electrolytes and blood pH.[1]

Complex acid-base and electrolyte disorders are common in intensive care unit with one study showing 64% of critically ill patients have acute metabolic acidosis.[2] Although in many cases, the acid-base alterations are minimal and self-limited in extreme cases the normal physiological correction does not comes into action and self-limitation doesn't take place, the blood pH progresses in either of the extreme directions rapidly and can lead to significant multi-organ problems.[3]

An acid-base disturbance should alert the clinician to the possible presence of an important underlying condition. Anion gap acidosis represents serious underlying metabolic disorders ranging from sepsis to uremia. Respiratory acidosis and alkalosis are related to ventilation, which is increased by conditions such as sepsis.

Assessment of acid-base disorders usually begins with measurement of arterial blood gas analysis. It is useful to

conceptualize acid-base disorder by a mass action shift of the variable to the right or left in the following relationship:

$$H^+ + HCO_3^- \leftrightarrow H_2CO_3 \leftrightarrow CO_2+H_2O$$

Left shift in case of respiratory acidosis is due to the addition of CO_2, which increases the concentration of hydrogen and bicarbonate concentration. Right shift in case of respiratory alkalosis is due to the removal of CO_2, decreasing the concentration of CO_2, protons and bicarbonate. In metabolic acidosis, there is addition of a proton with an ion other than HCO_3^-, leading to increased concentration of protons and decreased concentration of bicarbonate. Metabolic acidosis can also result due to the removal of HCO_3^- with a cation such as Na+, this in turn increases proton concentration and decreases the HCO_3^- concentration. The vice versa occurs in case of metabolic acidosis, that is, addition of $NaHCO_3$, results in decrease in proton concentration or by removal of H+ with chloride ions resulting in decrease proton concentration and increased HCO_3^- concentration.[4]

The metabolic and respiratory components that regulate systemic pH are described by the Henderson-Hasselbatch equation:

$$pH = 6.1 + \log (HCO3-/PaCO2x0.0301)$$

Sepsis due to neurological, respiratory, gastro-intestinal causes are usually associated mixed metabolic and respiratory disorders more specifically metabolic acidosis +respiratory alkalosis. Whereas severe pneumonia is usually associated with metabolic acidosis+ respiratory acidosis.[5]

In India, the health care system in rural sectors are not as developed on par with the urban hospitals. Therefore, the management in Indian rural set-ups such as primary health centre and rural health centre is burdensome for the physicians. This background is the motivation for this study, which will be of great help for the initial effective management of the underlying condition and the probable metabolic disorder associated with the condition without ABG by the results of present study. The objective was to study the type of acid base disorders in patients admitted in ICU and to compare the types of acid base disturbance in patients among infectious and noninfectious etiology.

METHODS

This was a retrospective study that has been done on 46 patients admitted in intensive care unit in Vinayaka Mission Medical College, a reputed institution in the South Eastern Indian Coast after clearance by the institutional ethical committee. Data regarding patient's age, gender, primary diagnosis, underlying problems and complications was noted on admission. Arterial blood sample was collected from all ICU admitted patients for blood gas analysis. Acid-base imbalance was judged according to the samples taken upon admission. Then, the final diagnosis was documented.

All patients admitted in the intensive care unit, including septicemia of Vinayaka Missions Medical College, Karaikal, between the age group of 30-60years, irrespective of the gender were included in the study. Those patients admitted from other hospitals after treatment between age <30 years and >60 years and all surgical, gynaecological and post-operative patients were excluded.

A retrospective study was conducted over a period of 4 month between June 2018-September 2018. Arterial blood gas analysis collected on admission into the Intensive Care Unit. Analysis were carried out using ABL80 (Automated analyser) ISE (Ion Selective Electrode NU). All data were analysed by SPSS statistical software version 16.0. Statistical measures like frequency and percentage were used for analysed using chi square test. P value <0.05 was taken as statistically significant.

RESULTS

Of the 46 cases of sepsis and non-infectious diseases, 36 patients fell in the group of non-infectious diseases, 10 patients fell in the group of infectious diseases and 3 had sepsis due to infectious diseases (Figure 1).

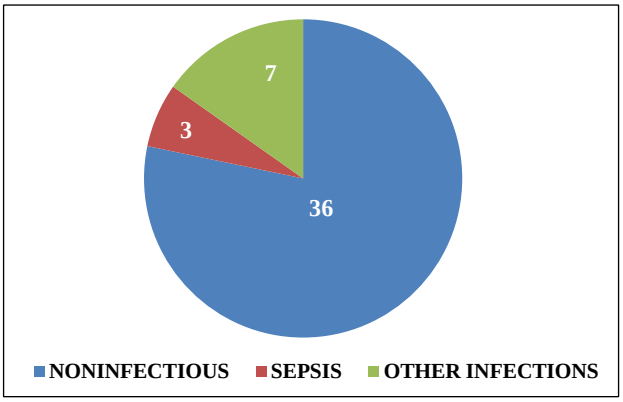

Figure 1: Differentiating infectious from non-infectious cases.

In this study, out of 14 simple acid base disorders 50% (7) were metabolic acidosis, 14% (2) were metabolic alkalosis, 7% (1) were respiratory alkalosis and 29% (4) were respiratory acidosis (Table 1).

Table 1: Simple acid base disorders in study population.

Acid base disorders	Number	Percentage
Metabolic acidosis	7	50%
Metabolic alkalosis	2	14%
Respiratory alkalosis	1	7%
Respiratory acidosis	4	29%

In this study, 32 cases had mixed acid base disorders. Of which 28% (9) were metabolic acidosis with respiratory alkalosis, 19% (6) were metabolic alkalosis with respiratory alkalosis, 34% (11) had metabolic alkalosis with respiratory acidosis and 19% (6) had metabolic acidosis with respiratory acidosis (Table 2).

Table 2: Mixed acid base disorders in study population.

Mixed acid base disorders	No.	%
Metabolic acidosis +respiratory alkalosis	9	28
Metabolic alkalosis +respiratory alkalosis	6	19
Metabolic alkalosis +respiratory acidosis	11	34
Metabolic acidosis +respiratory acidosis	6	19

Of the 10 cases that fell in the infectious diseases, 3 patients that had sepsis who suffered from mixed acid base disorder.

Of the 7 infectious diseases without sepsis, 1 had simple acid base disorder and 6 had mixed acid base disorder. Of the 6 mixed acid base disorder of infectious origin without sepsis, 2 had metabolic alkalosis with respiratory alkalosis and 4 had metabolic acidosis with respiratory alkalosis.

Chi-square test analysis revealed p value as 0.490, which was statistically insignificant (Chi square test value-0.476) (Table 3).

Table 3: Common acid base disorder in infectious.

Infectious cases including sepsis	Acid base disorder type	
Sepsis (3)	Simple (0)	
	Mixed (3)	
Other inf (7)	Simple (1)	
	Mixed (6)	Met. acid +resp. acid (0)
		Met. alk +resp. acid (0)
		Met. alk +resp. alk (2)
		Met. acid +resp. alk (4)

*Chi square test, Chi square test value: 0.476, P value- 0.490 (>0.05)-Insignificant.

In this study, of the 36 non-infectious diseases, 11 had simple acid base disorders and 25 had mixed acid base disorders. Of the 11 simple acid base disorders in non-infectious disease category, 55% (6) had metabolic acidosis, 9% (1) had metabolic acidosis and 36% (4) had respiratory alkalosis. None of the cases had respiratory acidosis.

Of the 25 mixed acid base disorders in non-infectious disease category, 24% (6) had metabolic acidosis with respiratory acidosis, 24% (6) had metabolic acidosis with respiratory alkalosis, 40% (10) had metabolic alkalosis with respiratory acidosis and 12% (3) had metabolic alkalosis with respiratory alkalosis. Chi square test analysis revealed p value as 0.021, which was statistically significant. (Chi square test value- 9.74) (Table 4).

Table 4: Non-infectious diseases and acid base disorders: (n=36).

Non-infectious (N=36)	Type of acid base disorder	Percentage (N=36)
Simple (11)	Metabolic acidosis (6)	55%
	Metabolic alkalosis (1)	9%
	Respiratory acidosis (0)	0%
	Respiratory alkalosis (4)	36%
Mixed (25)	Met. acid + resp. acid (6)	24%
	Met. acid + resp. alk (6)	24%
	Met. alk + resp. acid (10)	40%
	Met. alk + resp. alk (3)	12%

*Chi square test, Chi square test value 9.74, p value-0.021 (<0.05)-Significant.

DISCUSSION

ABG analysis is useful in evaluation of oxygenation (PO2), ventilation (PCO2), acid base status (PH and HCO3) of critically ill patients. PO2 and PCO2 are essential for diagnosis of respiratory failure.[6] It is essential to classify acid base disorders as simple and mixed to find out primary mechanism responsible for disturbance. Through acid base disorders contribute to significant morbidity and mortality, very few studies are available to analyze the profile and cause of acid base disturbance in IMCU/ICU in India. This study has been undertaken to focus on acid base disturbances in infectious diseases in comparison with non-infectious diseases.

In this study of 46 patients, majority were belonging to category of noninfectious etiology, 36 patients (78%). Out of 10 infectious disease category 30% were having sepsis. The findings are also in agreement with another study by Conn HO et al, where infections were responsible in only 4% of the ICU cases (Figure 1).[7]

Out of 30% simple acid base disorder patient, metabolic acidosis was most common (50%). Kiessling SG et al, stated that the most commonly encountered causes of metabolic acidosis in the ICU are renal insufficiency, sepsis and diabetic ketoacidosis.[8] Respiratory alkalosis was seen in only 1 of the 14 patients (7%) with simple acid base disorder. These findings match with the studies of Madias EN et al, according to which study of 13000 ABG samples, respiratory alkalosis was the least common (13%).[9]

As shown in Table 2 of the overall study population, 70% of acid base disturbance were of mixed type, out of which 34% were of metabolic alkalosis and respiratory acidosis type. Second most common mixed acid-base disorder is metabolic acidosis with respiratory alkalosis. Metabolic

alkalosis with respiratory alkalosis and metabolic acidosis with respiratory acidosis share equally with 19%.

All patients suffering from sepsis had mixed acid base balance disturbance. Of the other infectious diseases, 86% were mixed acid base disorder with metabolic acidosis and respiratory alkalosis being the most common (67%). Thomas DD et al, stated that the most common mixed acid base disorders is metabolic acidosis with respiratory alkalosis in ICU sepsis patients, which correlates well with present study.[10] Also Grogan H et al, in their study observed that mixed acid base disorders-metabolic acidosis and respiratory alkalosis was associated with critically ill patients.[11] Fencl V et al, stated that the common cause for the fore mentioned mixed acid base disorder was septic shock and renal failure with sepsis.[12] Out of 36 non-infectious diseases in comparison with acid-base disorder, 25 had mixed acid-base disorder. However, most common mixed acid base disorder in noninfectious etiology patients was metabolic alkalosis and respiratory acidosis (40%-10patients) out of 36 patients. Remaining 11 had simple acid base disturbance with 55% of them being metabolic acidosis. No patients were reported to have isolated respiratory acidosis. The p value using Chi square analysis was 0.021 (<0.05), which was statistically significant (Chi square test value- 9.74). On analysis of acid base disturbances in this study, mixed type of acid base disorder: metabolic alkalosis with respiratory acidosis is the commonest and majority of cases have metabolic acidosis either alone or in combination (48%). Constraint study population is one major limitation of this study as a large study population is required to prove the fore mentioned findings.

CONCLUSION

Mixed acid base disorders are the most common disturbances in the intensive care setup which is metabolic acidosis with respiratory alkalosis in infectious diseases and metabolic acidosis is the most common simple type of acid base disorder. Irrespective of primary pathology, it is the severity of acid base disturbances which determine the prognosis and status of the patient. This study highlights the fact that mixed acid base disorders are the most common in ICU settings and both in infectious and noninfectious patients. This study was conducted as a preliminary study of acid base disorders in ICU settings. More detailed studies in individual disorders and their acid base disturbances are required for better understanding of underlying acid base imbalance caused due to individual disorders.

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