

## ACID BASE DISORDERS IN MEDICAL I.C.U AND THEIR RELATION WITH THE PATIENT OUTCOME IN A TERTIARY HEALTH CARE CENTRE

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### Abstract

**Background:** Acid-base abnormalities are common in critically ill patients. There has been substantial progress in the acquisition of scientific knowledge of blood gas transportation and the various acid base abnormalities. Many mathematical equations, algorithms and compensatory mechanisms have been developed in the recent past for better understanding of the metabolic disorders. All this helps us to broaden our knowledge of the various acid base disorders, early recognition and prompt management and further treatment. This knowledge will be of great help for initial effective management of the underlying condition in the rural health care centre and also help us to know the probable outcome of the patients. The aim was to study acid base disorders in medical I.C.U and their relation with the patient outcome in a tertiary health care centre. The objectives was to study patient's clinical profiles in medical intensive care unit patients, to study the pattern of acid-base disorders in medical intensive care unit patients & to determine the effect of acid-base disorders and their correlation with the outcome in patients admitted to medical intensive care units. **Materials and Methods:** The present study is cross-sectional, observational, single centre which included all the patients admitted in medical I.C.U fulfilling the inclusion criteria, in the department of General medicine, Dr. Susheela Tiwari Government hospital and associated Government medical college Haldwani. After enrolling patients for the study after informed and written consent, their socio-demographic data (name, age, sex, address, etc.) and clinical data (detailed physical examination and provisional diagnosis) was recorded. Arterial Blood samples were collected in a pre-heparinized syringe on the day of admission from mainly radial artery, if not feasible brachial and femoral artery were used under all aseptic precautions in supine position. Cartridge based Blood gas analyzer – “GEM PREMIER 3000” was used for data collection. **Result:** Total 130 eligible patients were taken where 76 were male and 54 females with mean age  $50 \pm 18.71$ . Mean pH in the study group is 7.31, with standard deviation of 15.18. Acidosis was present in 46.69% and 22.30% had alkalosis. Patient with acidosis had more mortality rate 30.64%. overall 35 patients expired showing mortality of 26.92%. Respiratory failure was present in 86 patients, type 2 respiratory failure being most common. **Conclusion:** Simple acid base disorder was the most common, comprising respiratory acidosis. Among the mixed disorders, metabolic acidosis with respiratory acidosis and metabolic acidosis with respiratory alkalosis were prevalent. Significant association was present with respiratory failure. Poisoning was the most common acid base disorder in our study followed by COPD (chronic obstructive pulmonary disease). The mortality was most severe in extremes of acidemia. The management in Indian rural setups such as primary or tertiary health care centres is difficult for physicians due to the non-availability of many resources.



## INTRODUCTION

Acid-base abnormalities are common in critically ill patients.<sup>[1]</sup> A small difference in the correction of anion gap, different types of analytical processes, and the basic approach used to diagnose acid-base aberrations can lead to markedly different interpretations and treatment strategies for the same disorder. Complex acid-base and electrolyte disorders are common in intensive care units with one study showing that 64% of critically ill patients have metabolic acidosis.

The assessment of acid-base disorder usually begins with the measurement of four important values: pH, partial pressure of oxygen (pO<sub>2</sub>), partial pressure of carbon dioxide (PaCO<sub>2</sub>), and bicarbonate (HCO<sub>3</sub><sup>-</sup>) and the base deficit. To maintain homeostasis the body has to keep [H<sup>+</sup>] ions concentration at 40 Nanomoles/L.<sup>[2]</sup> In the absence of any physiological stress, the pH of the human body ranges from 7.35 – 7.45, with the average at 7.40 as pH at this level is ideal for many biological processes, one of the most important being the oxygenation of the blood and ionization of biochemical reactions. A blood pH less than normal (normal range 7.35 – 7.45) is called acidemia; the underlying process being called acidosis. In the same way, Alkalemia and Alkalosis refer to the pH and underlying process respectively. Due to the importance of sustaining the pH levels in a narrow range, the body contains compensatory mechanisms. While an acidosis and an alkalosis may coexist, there can be only one resulting pH. Therefore, acidemia and alkalemia are mutually exclusive conditions.<sup>[3]</sup>

The metabolic and respiratory pathways that regulate systemic pH are described by the Henderson – Hasselbalch equation:<sup>[4]</sup>

$$\text{pH} = 6.1 + \log (\text{HCO}_3^- / \text{PaCO}_2 \times 0.03) \text{ OR}$$

$$\text{pH} = \text{pKa} + [\text{HCO}_3^-] / 0.03\text{PaCO}_2$$

**Alternatively, H<sup>+</sup> ions can be expressed directly as:**

$$\text{H}^+ = 24 \times (\text{PaCO}_2 / \text{HCO}_3^-)$$

**There are four main types of acid-base disorders:**

1. Metabolic acidosis
2. Metabolic alkalosis
3. Respiratory acidosis
4. Respiratory alkalosis

If one of these conditions occurs, the human body induces a counterbalance called a compensatory mechanism. The primary change in PaCO<sub>2</sub> can cause acidosis or alkalosis by cellular buffering and renal adaptation.<sup>[5]</sup> A primary change in the plasma HCO<sub>3</sub><sup>-</sup> as a result of metabolic or renal factors results in compensatory changes in ventilation that blunt the changes in blood pH. Acid-base disorders contribute importantly to patient morbidity and mortality, especially in critically ill.<sup>6</sup> Therefore, it is essential to recognize and properly diagnose acid-base disorders and understand their impact on organ function.

In India, the healthcare system in rural sectors is not at par with the urban hospitals. Therefore, the management in Indian rural setups such as primary or tertiary health care centres is difficult for physicians due to the non-availability of many resources. This background is the motivation for this study, which will be of great help for the initial effective management of the underlying conditions and probable metabolic disorder associated with the respective condition without the availability of ABG in the rural health centre, by the results gathered from the present study, which is to study the acid-base disorders in medical I.C.U. and its relation with the outcome.

The present study was done to study the acid base disorders in medical I.C.U and their relation with the patient outcome in a tertiary health care centre. The objectives were to study patient's clinical profiles in medical intensive care unit patients, to study the pattern of acid-base disorders in medical intensive care unit patients and to determine the effect of acid-base disorders and their correlation with the outcome in patients admitted to medical intensive care units.

## MATERIALS AND METHODS

After obtaining approval from Institutional Ethical Committee, the present Cross sectional Observational Study was conducted at Government Medical College and associated Dr. Susheela Tiwari Government Hospital, Haldwani. This study was conducted from January 2021– September 2022.

### Study population

All the patients admitted to medical I.C.U. in the Department of General Medicine, Dr. Susheela Tiwari Government Hospital, and associated Government Medical College, Haldwani, fulfilling the inclusion criteria, i.e., patients aged more than 16 years having an acid-base disorder and willing to participate in the study and giving consent, were included in the study population.

### Methodology

After enrolling patients for the study after informed and written consent, their socio-demographic data (name, age, sex, address, etc.) and clinical data containing detailed physical examination, investigation including and Complete Blood Count, Liver Function Test, Kidney Function Test, Serum Sodium and Serum Potassium, Fasting Blood Glucose, Post-prandial Blood Glucose, coagulation profile, serology (HBsAg, Anti HCV, HIV1 and 2), arterial blood gas analysis(ABG) and provisional diagnosis was recorded. Arterial Blood samples were collected in a pre-heparinized syringe on the day of admission from mainly radial artery, if not feasible brachial and femoral artery were used under all aseptic precautions in supine position. Cartridge based Blood gas analyzer – “GEM PREMIER 3000” was used for data collection. Type of acid base disorder, base deficit/excess, anion gap, type of

respiratory failure and mortality/ survival were recorded.

### Statistical analysis

Data was described in terms of range, mean, +/- standard deviation (SD), frequencies (number of cases), and relative frequencies (percentages) as appropriate. A comparison of quantitative variables between the study groups was done using the student t-test. For comparing categorical data, the Chi-square (X<sup>2</sup>) test was performed. A probability value (p-value) less than 0.05 was considered statistically significant.

The data entry was done in the Microsoft EXCEL spreadsheet. All statistical calculations were done using SPSS 21 (Statistical Package for the Social Science) version statistical program for Microsoft Windows.

## RESULTS

In the study group of 130 patients, maximum patients admitted were male; mean age group was of 47-56 years with 24 patients, in which 15 were male. The largest age group for male patients with acid base disorder were in age group 47-56 years along with 67-76 years showing that more I.C.U admissions were in this age group with a value of 15. Youngest patient being 16 year female in age group of 16 – 26 and oldest patient being 90 years old female in age group of >86 years. The mean age in the study group was 50 years ±18.71.

**Table 1: Gender distribution in different age group:**

Age group	Male(x)		Female(Y)	
	N	n%	N	n%
16-26	8	10.52	12	22.22
27-36	13	17.10	8	14.81
37-46	10	13.15	8	14.81
47-56	15	19.73	9	16.66
57-66	11	14.47	7	13.00
67-76	15	19.73	5	9.25
77-86	4	5.26	4	7.40
>86	-	-	1	1.85
Total	76	100	54	100
Mean±SD	50.18±18.72 years			

**Table 2: Correlation between pH and mortality**

Metabolic disorder	Acidosis		Alkalosis		Normal	
	N	N%	N	N%	N	N%
Number of patients	62	47.69	29	22.30	39	30
Mortality	19	30.64	8	27.58	8	20.51
p-value	0.690					

In the study of 130 patients admitted 62 (47.69%) had Acidosis and 29(22.30%) had alkalosis. Patient with acidosis had more mortality rate 19(30.64%) out of the 62 patients with acidosis expired during the study. 8(27.58%) patients having alkalosis collapsed. 39 patients had their pH within the range mostly due to some compensatory mechanism of which 8(20.51%) expired. There was no significant difference in the Mortality between Acidosis, Alkalosis and Normal groups though the mortality was higher among Acidosis group followed by Alkalosis group followed by Normal group.

**Table 3: Outcome in Acid Base Disorder**

Acid base disorder	Outcome		Total
	Expired	Survived	
Simple	17 (25.0%)	61 (75.0%)	78
Mixed	18 (34.6%)	34 (65.4%)	52
Total	35	95	130
p-value	0.046*		

As per outcome, mortality was significantly more among Mixed disorder compared to Simple disorder.

**Table 4: Correlation of the Acid Base Disorder with Respiratory Failure, Ph and Type of Disorder**

Type of disorder	Type of Respiratory failure		pH		Type of disorder		Mortality in the disorders
	Type 1	Type 2	Acidosis	Alkalosis	Simple	Mixed	
COPD	1	21	17	3	18	5	2
Sepsis	-	3	1	-	1	3	1
Poisoning	6	14	16	3	10	16	8
CKD	2	5	7	3	6	7	7
DKA	-	1	2	-	2	-	-
Snake Bite	-	-	1	-	2	2	-
CAD	1	11	3	4	11	2	2
AKI	1	3	3	-	-	5	1

CNS	-	5	2	3	4	6	4
CLD	2	4	3	6	9	2	4
Miscellaneous	4	9	7	6	15	4	6
Total	17	76	62	29	78	52	35
p-value	0.193		0.048*		0.047*		0.106

Acidosis was significantly more among the patients with COPD and Poisoning. Simple disorder was significantly more among the patients with COPD and CAD whereas Mixed disorder was significantly more among the patients with poisoning. Mortality did not have significant association with type of disorder though it was more among poisoning, CKD and CLD patients.

## DISCUSSION

This study aims to know about various acid base disturbances in the patients admitted in medical I.C.U in tertiary care centre of the state and see the correlation between the acid base disturbance and outcome of the patients admitted in ICU.

### Sociodemographic profile

In our study, males were maximum in number accounting for 58.46% among the study population as compared to females 41.54%. Similar results have been seen by Sasirekha et al,<sup>[7]</sup> there were 63 males and 37 females. Majority of the study participants (18.46%) belonged to 47-56 yrs of age, followed by 27-36 years (16.15%) with the mean age being 50 years±18.71. The findings are similar to previous studies by Sasirekha et al.<sup>8</sup> and Shreewastav RK et al.<sup>[9]</sup>

### Clinical profile

Patients with different etiology were admitted in the medical I.C.U. Broadly they were categorised as patients with poisoning, stings and bites, metabolic derangements involving different organs, neurological, cardiac and others category. Most commonly admitted patients belonged to the category of poisoning constituting 20% followed by patients having chronic obstructive pulmonary disease (17.69%), chronic kidney disease (CKD) and coronary artery disease (CAD) each with 10% patients, chronic liver disease (8.46%), cerebrovascular accident (5.3%), 3.07% patients with septicaemia and snake bite and 1.53% patients with Meningitis/Encephalitis and Diabetic ketoacidosis (DKA). Other patients admitted had acute kidney injury (AKI) (3.84%), seizure disorder (0.76%), hanging and drowning (2.30%) and (0.76%) patient respectively and other miscellaneous (11.53%) patients comprising gastroenteritis, pancreatitis, anemia, etc.

### Pattern of Acid base disorder

In the study group, 60% had simple metabolic disorder whereas 40% had mixed metabolic disorders. Most common acid base disorder was Respiratory acidosis (38.46%), 29.48% had Respiratory alkalosis, 16.66% had metabolic alkalosis and 15.38% had metabolic acidosis. More number of male and female patients had respiratory

acidosis, which is consistent with Tripathi.<sup>[10]</sup> where the study showed respiratory acidosis and metabolic alkalosis as common metabolic disorders. Among mixed acid base disorders, 52 patients were admitted in medical I.C.U. The combination of metabolic acidosis with respiratory alkalosis was most common with 30.76% patients, followed by metabolic acidosis and respiratory acidosis (26.92%). Metabolic Alkalosis with Respiratory Acidosis (13.46%) and Triple acid base disorders and metabolic alkalosis with respiratory alkalosis (9.61%) patients in each group. About (47.69%) had Acidosis and (22.30%) had alkalosis. Of 62 patients with acidosis, 30.64% expired during the study, 27.58% patients expired. The p-value was not significant showing that the mortality is not dependent on the type of acid base disorder but since there were a greater number of patients who had acidosis more mortality was found in this group. Patients with extremes of acidemia and alkalemia eventually collapsed showing that patient if have severe acidosis or alkalosis will always have high mortality, as seen in the study conducted by Gunnerson K J et al,<sup>[11]</sup> where metabolic acidosis patients have high mortality. There was also a study conducted by Bezuidenhout M C et al,<sup>[12]</sup> found that higher pH and low partial pressure of oxygen in arterial blood on ABG analysis were significantly associated with survival.

### Acid base disorders and their correlation with the outcome:

Poisoning has always been pointed as one of the leading causes of death throughout the world and is the most common disorder.<sup>[13]</sup> Pesticides are routinely used in India for farming. Also, in the hilly areas of Kumaon and Garhwal region, where the soil is fertile for cultivation purpose there is easy availability or over the counter of prescription of chemical poisons for the same purpose which are abused for suicidal and homicidal purpose and even can get ingested or inhaled accidentally.

Organophosphorus poisoning (11 cases) was the most common type of poisoning seen in our study followed by Aluminium phosphide (Celphos) present in 5 cases. Other type of poisoning comprised of corrosives and unknown substances. Most of the patients had metabolic acidosis either simple or mixed with the mortality rate of 30.76%. This correlates with the study done by Dhake V N and Sasirekha et al.<sup>[14,15]</sup>

Type 2 respiratory failure was commonly seen in the poisoning cases. Due to the poisons, there is central respiratory depression, weakness of the muscles of respiration and bronchospasm causing Type 1 respiratory failure. Bana et al,<sup>[16]</sup> found that Type II respiratory is the most common type of failure occurring in OPC poisoning and treatment of choice

is ventilator support. In Organophosphorus poisoning patients with respiratory failure showed increased mortality than those without respiratory failure. In these patients the respiratory failure is exacerbated by the development of pulmonary edema and retention of increased amount of respiratory secretions. A clear airway, effective removal of respiratory secretions and correction of hypoxia are utmost necessary while using endotracheal intubation and assisted ventilation if necessary.

In our study, chronic obstructive airway disease constitutes the second most common disorder consisting 23 patients, 18 had simple metabolic disorder and 5 had mixed. 14 out of 23 patients having chronic obstructive pulmonary disease had simple Respiratory Acidosis, contributing to 60.8 %. 2 patients in COPD category expired, showing a mortality rate of 8.69%. Type 2 respiratory failure was more common. The study findings were consistent with Cosimo Marcello Bruno,<sup>[17]</sup> showing respiratory acidosis is a common acid base disturbance in COPD, followed by metabolic alkalosis and respiratory acidosis in chronic cases due to renal compensation. Death in COPD is due to respiratory failure on invasive ventilation is an important recent advance in the management of patients with acute respiratory failure complicating COPD.<sup>[18]</sup>

Chronic kidney disease (CKD) is a condition in which there is progressive decline in the renal function due to the progressive loss of nephrons. As there is progression of the disease, the complication and metabolic deregulations increase. In our study, 13 patients had chronic kidney disease (CKD); of which 7 patients had expired; 2 patient had type I respiratory failure and 5 had type 2 respiratory failure. Metabolic acidosis with respiratory alkalosis was the most common mixed acid base disorder seen. Of the 7 patients (53.84%) who expired 4 had pH <7.2 and had respiratory failure hence showing metabolic acidosis being common and grave prognostic indicator.

In patients with coronary artery disease (n=13), 2 patients expired showing mortality of 15.38%. Simple acid base disorder was the most common disorder present in the CAD patient group with metabolic alkalosis and respiratory acidosis contributing equal and main metabolic disorder in the group. 4 patients had congestive cardiac failure out of which three had metabolic alkalosis as the primary disorder with compensatory respiratory acidosis. The presence of respiratory acidosis component is consistent with Avery WG et al,<sup>[19]</sup> which showed that respiratory acidosis with metabolic acidosis is common later.

In the patients having chronic liver disease, out of 11 patients 4 expired showing the mortality rate of 36.36%. 6 patients had respiratory failure, type 2 respiratory failure being the most common. 6 patients had alkalosis and 3 patients had acidosis. 2 Patient had mixed acid base disorders and 9 had simple acid base disorder, respiratory alkalosis being most

common. This is consistent with Vanamee P et al,<sup>[20]</sup> which shows respiratory alkalosis as most common disorder in hepatic coma.

In current study, 10 patients with neurological disorders were admitted in the medical ICU. 4 Patients expired showing mortality of 40%. Mixed metabolic disorders were common seen in 6 patients of which 3 had metabolic alkalosis with respiratory alkalosis. This is consistent with the study conducted by Sasirekha k et al.<sup>[21]</sup>

Acute kidney injury is defined as the abrupt loss of kidney functions that results in decline in GFR, increase in serum creatinine by >0.3mg/dl within 48 hrs or an increase in serum creatinine to  $\geq 1.5$  times the base line within the last 7 days or a decrease in urine output of <0.5ml/kg/h for 6 hrs. This results in an increase in an elevation of serum blood urea nitrogen (BUN), creatinine and other metabolic products that are normally excreted by the kidneys. In this study, 5 patients admitted in medical I.C.U had acute kidney injury out of which one expired showing the mortality rate of 20%. Metabolic acidosis with respiratory alkalosis being the most common, followed by metabolic acidosis and respiratory acidosis and metabolic acidosis with respiratory acidosis and metabolic alkalosis. 4 patients had respiratory failure, Type 2 respiratory failure being the most common. It has been found that development of respiratory failure in acute kidney injury is a devastating consequence that greatly increases patients' mortality which can be greater than 80%.

In sepsis, 25% had simple acid base disorder and 75 % had mixed acid base disorder. The most common acid base disorder is mixed metabolic acidosis with metabolic and respiratory alkalosis, closely followed by the simple respiratory acidosis. Simon Kru et al.<sup>22</sup> showed that metabolic alkalosis is the most common acid base disorder seen in sepsis. My study shows metabolic alkalosis in the mixed form. Out of 4 cases 1 had expired, accounting for a mortality rate of 25%.

The onset of hypoxia indicates severe disease and high risk for ARDS. This has been proved in our study which shows major acid base disturbance in sepsis is respiratory alkalosis with metabolic acidosis and alkalosis; 1 patient of 3 who had type 2 respiratory failure expired thus providing hypoxia is a marker of severity of illness. The alkalemic pH is associated with high mortality.

Several studies have shown that alkalemia is associated with high mortality in the medical I.C.U patients. Studies by Anderson L E, Henrich WL,<sup>[23]</sup> have shown the death rate is higher among the medical patients with alkalemia and mixed metabolic and respiratory alkalosis appears to be associated with a poor prognosis. It is evident that the patient dies because of the complex disturbances that result from multiple organ system failure.

Diabetic ketoacidosis, a grave complication of diabetes mellitus occurs due to decreased insulin or insulin resistance resulting in the production of high

levels of ketone bodies. In our study, Simple acid base disorder is the most common abnormality seen. Underlying sepsis precipitating DKA can cause respiratory Alkalosis apart from neurogenic hyper ventilation.

In the miscellaneous group, the mortality rate was 31.57 % and 13 out of 19 patients had respiratory failure out of which 9 were type 2 respiratory failure. The patients had simple acid base disorders commonly, respiratory acidosis and alkalosis being most common. Miscellaneous groups included hanging, drowning, anaemia, pancytopenia, pancreatitis, acute febrile illness with pulmonary tuberculosis, pulmonary artery thromboembolism, systemic sclerosis, motor neuron disease and cases with systemic hypertension and diabetes mellitus with recurrent hypoglycaemia.

## CONCLUSION

The most prevalent kind of acid base disease was simple acid base disorder, which included respiratory acidosis. In patients with mixed diseases, metabolic acidosis combined with respiratory acidosis and metabolic acidosis combined with respiratory alkalosis were the most common combinations. It was also found that there was a significant relation with respiratory failure. In our research, poisoning was the acid base ailment that occurred most often, followed by COPD (chronic obstructive pulmonary disease). There was a significant correlation of acidosis with death rate. Because there aren't many resources available in rural areas of india so it might be challenging for medical professionals to administer facilities in primary or tertiary health care centres. Thus this and other similar studies can be helpful for the physicians to manage the patients at rural level.

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