

Research Article

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pH disorders and mortality in surgical intensive care unit patients

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ABSTRACT

Background: The pH determines the presence of acidemia or alkalemia. If the body has compensated for the disorder, the pH may be in the normal range. Human blood normally has a pH of 7.35-7.45 ($H^+ = 35-45 \text{ nmol/L}$), so is slightly alkaline. If blood pH is below the range of <7.35 , there is acidemia. If it is above the normal range of >7.45 , there is an alkalemia. The objective of this study was to investigate association of mortality with the acid-base disorders in surgical ICU patients.

Methods: The study was a prospective, observational study, conducted on the 167 patients admitted in Surgical ICU over a period of eighteen months (January 2014 to June 2015) in Department of Surgery, Mathura Das Mathur Hospital attached to Dr. S. N. Medical College, Jodhpur, Rajasthan, India. pH values were noted at different times. Acidemia and alkalemia were compared in survivors and non survivors.

Results: At admission, acidemia was seen in 26.3% patients and alkalemia in 15% patients. During ICU stay, the prevalence of acidosis and alkalosis increased. In non survivors, before death, acidemia was present in 41.9% and alkalemia in 26.9% patients.

Conclusions: Focusing on pH, in surgical ICU, mortality was shown to be had a U-shaped relationship with pH. Both acidemia and alkalemia are independently associated with high mortality in surgical ICU patients. Mortality is not affected by type (respiratory or metabolic) of acid base disorders. Further studies are needed to find if this association is causal or merely a reflection of differences in severity of illness.

Keywords: pH, ICU, Acidemia, Alkalemia

INTRODUCTION

The pH determines the presence of acidemia or alkalemia. If the body has compensated for the disorder, the pH may be in the normal range. Human blood normally has a pH of 7.35-7.45 ($H^+ = 35-45 \text{ nmol/L}$), so is slightly alkaline. If blood pH is below the range of <7.35 , there is acidemia. If it is above the normal range of >7.45 , there is an alkalemia.¹

Acidemia leads to hyperkalemia, delayed emergence of anesthesia, dyspnea, respiratory muscles fatigue, hypotension, bradycardia, and hypovolemia. On the other hand, alkalemia results into hypokalemia, postoperative

muscle relaxation, restlessness, low cerebral blood flow, low coronary perfusion pressure, and the increase of airway resistance.^{2,3}

METHODS

The present study is a prospective observational study conducted on the patients admitted in Surgical ICU over a period of eighteen months (January 2014 to June 2015) in department of surgery, Mathura Das Mathur Hospital attached to Dr. S. N. Medical College, Jodhpur, Rajasthan, India.

All the patients admitted in the surgical ICU were selected. The study group was informed regarding the aim of study and informed consent was taken. pH values were noted at different times (at the time of admission in ICU, after 24 hours, after 48 hours, after 72 hours and at the time of shifting to general ward in survivors and before death in expired patients). pH <7.35 was considered as acidemia and >7.45 as alkalemia. pH was further divided into respiratory and metabolic acid-base abnormalities. Acidemia and alkalemia were compared in survivors and non survivors.

The data of all patients was collected on prepared proforma and was analyzed by using appropriate statistical tests.

RESULTS

Table 1: pH levels in surgical ICU.

pH	Normal (pH 7.35-7.45)	Acidemia (pH<7.35)	Alkalemia (pH>7.45)
At admission	98 (58.7%)	44 (26.3%)	25 (15%)
At 24 hours	68 (41.5%)	58 (35.4%)	38 (23.2%)
At 48 hours	58 (42%)	49 (35.5%)	31 (22.5%)
At 72 hours	45 (37.2%)	46 (38%)	30 (24.8%)
At the time of shifting to ward	47 (63.5%)	13 (17.6%)	14 (18.9%)
Before death	29 (31.2%)	39 (41.9%)	25 (26.9%)

The study included 167 patients, admitted with various surgical conditions in Surgical ICU. Of the total patients, 44.3% survived and 55.7% expired. At admission, pH

was within normal range in 58.7% patients, acidemia in 26.3% patients and alkalemia in 15% patients. During ICU stay, acidemia and alkalemia was increased. At the time of shifting to ward, pH was within normal range in 63.5% patients, acidemia in 17.6% and alkalemia in 18.9% patients. In expired patients, before death, pH was within normal range in 31.2% patients, acidemia in 41.9% and alkalemia in 26.9% patients. The difference in the incidence of acidemia and alkalemia was statistically significant between survivors and non survivors ($p<0.05$) (Table 1).

At admission, respiratory acidemia was present in 11.3% and metabolic acidemia in 15%. During ICU stay, the incidence of metabolic and respiratory acidemia was increased. In survivors at the time of shifting to ward, respiratory acidemia was seen in 5.4% and metabolic acidemia was in 12.2%, while in expired group before death, respiratory acidemia was present in 14% and metabolic acidemia in 27.9%. Metabolic and respiratory acidemia was more in expired group compared to survivors but this was not statistically significant ($p>0.05$) (Table 2).

At admission, respiratory alkalemia was seen in 3.6% and metabolic alkalemia in 11.4%. During ICU stay, the incidence of metabolic and respiratory alkalemia was increased. In survivors at the time of shifting to ward, respiratory alkalemia was seen in 6.7% and metabolic alkalemia was present in 12.1%, while among non survivors before death, respiratory alkalemia was found in 8.6% and metabolic alkalemia in 18.3%. Metabolic and respiratory alkalemia was more in non survivors compared to survivors but this was not statistically significant ($p>0.05$) (Table 2).

Table 2: Different types of acid-base disorders in surgical ICU.

pH	pH <7.35	pH <7.35	pH >7.45	pH >7.45
	PACO ₂ >45 Respiratory Acidemia	HCO ₃ < 22 Metabolic Acidemia	HCO ₃ >26 Metabolic alkalemia	PACO ₂ <35 Respiratory alkalemia
At admission	19 (11.3%)	25 (15%)	19 (11.4%)	06 (3.6%)
At 24 hours	23 (14%)	35 (21.3%)	23 (14%)	15 (9.1%)
At 48 hours	15 (10.9%)	34 (24.6%)	19 (13.8%)	12 (16.5%)
At 72 hours	18 (14.9%)	28 (23.1%)	20 (16.5%)	10 (4.1%)
At the time of shifting to ward	04 (5.4%)	09 (12.2%)	09 (12.2%)	05 (6.7%)
Before death	13 (14%)	26 (27.9%)	17 (18.3%)	08 (8.6%)

DISCUSSION

We found that acidemia and alkalemia in surgical ICU patients are associated with significantly increased ICU mortality and mortality is not affected by type (respiratory or metabolic) of acid base disorders. Our

observations are in accordance with prior experimental studies showing adverse effects of acid-base abnormalities. Acute acidemia causes depression of cardiac contractility and diaphragmatic contractility. It can develop confusion, headache, loss of consciousness and seizures. Alkalemia appears to increase myocardial

contractility, decrease in systemic vascular resistance, and coronary artery spasm with ECG evidence of ischemia. It can cause causes confusion, myoclonus, asterixis, loss of consciousness and seizures.¹

In previously published studies, mortality has ranged from 16% to 57% among hospitalized patients with acid-base disturbances. In our study, the mortality rate for patients with acidemia was 41.9% and with alkalemia was 26.9%.⁴⁻⁶

Previously reported case series have emphasized that mortality rate affected with metabolic and respiratory cause of acidemia and alkalemia. In our study, mortality rate was not affected by respiratory or metabolic cause.⁴⁻⁶

There was a U shaped association between achieved pH and mortality with higher mortality in patients with either low or high pH. Limitation of our study is that, it could not demonstrate that acid-base status per se rather than the underlying disease was the main independent predictive factor in patient outcome. Nevertheless, observational studies cannot completely overcome the problem of residual confounding, which can be better addressed by randomized controlled trials.

CONCLUSION

Both acidemia and alkalemia are associated with increased mortality in surgical ICU patients.

Mortality rate is unaffected by type (metabolic and respiratory) of acid-base disorders.

Further studies are necessary to find out whether the association between outcome and pH disorders is causal

and association is independent of comorbid conditions and severity of disease.

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Ethical approval: The study was approved by the institutional ethics committee

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