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Alteration of Biochemical Parameters in Patients with Respiratory Acidosis and Alkalosis: A Hospital Based Cross-Sectional Study

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Abstract

Biochemical parameters like pH, pO2, pCO2, HCO3-, TCO2 and SO2 are frequently measured in critically ill patients with respiratory acidosis and alkalosis. These parameters have utmost importance in the assessment of ventilation, oxygenation and acid base status of these patients. The present study was undertaken to determine alteration of different biochemical parameters in patients with respiratory acidosis and alkalosis. This is a hospital based cross-sectional study conducted from May to December 2023, in the Department of Biochemistry, CMCTH. Arterial blood was collected and biochemical parameters like pH, pO2, pCO2, HCO3-, TCO2 and SO2 were measured using automated blood gas analyzer. Statistical analysis was done with SPSS version 21. This study showed that majority of the patients with respiratory acid-base disorder were females (58.1%) and elderly (41.8%). Respiratory acidosis and alkalosis were more common in elderly patients under age group 61-70 years followed by >70 years category. Respiratory acidosis was accompanied by alteration of various ABG parameters like low pH, low pO2, high pCO2, high HCO3-, normal TCO2 and normal SO2 levels while respiratory alkalosis was accompanied by high pH, low pCO2, low HCO3-, low TCO2, normal sO2 and normal pO2 levels. Respiratory acid-base disorders are common in hospital settings with ailing respiratory diseases like COPD, Pneumonia, TB and Sepsis with higher incidences among elderly patients. Respiratory acidosis and alkalosis should be treated promptly giving highest consideration to various biochemical parameters in order to reduce comorbidities and mortalities associated with these conditions.

Keywords: Respiratory Acidosis; Respiratory Alkalosis; ABG; pH

Abbreviations

ABG: Arterial Blood Gas; HCO3: Bicarbonate; pCO_2: Partial Pressure of Carbon Dioxide; pO_2: Partial Pressure of Oxygen; SO_2: Oxygen Saturation; TCO_2: Total Carbon Dioxide.

Introduction

Normal blood pH is maintained within a narrow range of 7.35 to 7.45. Maintenance of blood pH is an important homeostatic mechanism which is done by different buffering

systems of human body. Chemical buffers are the first line of defence against pH shift followed by respiratory and renal mechanism [1]. Arterial blood gas (ABG) analysis is an important tool for investigation and assessment of ventilation, oxygenation and acid-base status of many critically ill patients during acute phase or during periods of clinical stability [2,3].

Pulmonary regulation of acid-base balance operates by retention or elimination of CO_2 either by hypo or hyperventilation [4]. Respiratory acidosis is an acid-base disorder which occurs due to alveolar hypoventilation causing retention of Carbon dioxide (CO_2) eventually leading to increase in arterial partial pressure of CO_2 (pCO_2) [3]. The blood pH falls below 7.35 and there is increased concentration of Carbonic acid (H_2CO_3) in plasma. The opposite is true for respiratory acidosis. It occurs due to hyperventilation resulting in decreased concentration of CO_2 or H_2CO_3 which causes blood pH to raise beyond 7.45 [5,6].

The major effect of acidosis is depression of the central nervous system (CNS). When the pH of the blood falls below 7.35, CNS malfunctions and the individual becomes disoriented and possibly comatose as the condition worsens [7]. A major effect of alkalosis is hyperexcitability of the nervous system. Peripheral nerves are affected first, resulting in spontaneous nervous stimulation of muscles resulting in spasm and tetany, which could even lead to death due to respiratory failure [8]. So, any acute or chronic respiratory illnesses can cause a significant change in ABG values which could lead to potentially life threatening consequences.

This study aims to identify different causes of respiratory acidosis and alakalosis in the hospital settings, assess various ABG parameters which could be altered in patients with respiratory acidosis and alkalosis. So the main objectives of this study is to identify different biochemical ABG parameters and their pattern of changes that define respiratory acidosis and alkalosis and establish their significance in diagnosis and management of the condition.

Materials and Methods

Study Design

This is a hospital based cross-sectional study conducted in the Department of Biochemistry, CMCTH conducted from May to December 2023.

Patient Selection

Patients admitted in different inpatient departments and critical care units suffering from acute or chronic respiratory diseases with acidosis and alkalosis were selected for this study. A total of 86 patients were selected for this study. Out of which, half of them had respiratory acidosis and remaining half had respiratory alkalosis. Arterial blood was collected and biochemical parameters like pH, pO_2, pCO_2, Bicarbonate (HCO_3-), total Carbon dioxide (TCO_2) and Oxygen saturation (SO2) were measured using automated blood gas analyzer. An arterial blood pH values <7.35 and >7.45 were used as a cut-off values for identifying respiratory acidosis and alkalosis respectively.

Ethical Consideration

This study was approved by the institutional ethical committee and informed consent was obtained from all the patients.

Statistical Analysis

Biochemical data were analyzed and interpreted in descriptive statistics (frequency, percentage, mean, standards deviation) using SPSS version 21. Student t test was done to compare mean values and p value less than 0.05 was considered to be statistically significant. All significant findings were presented in form of tables and figure.

Results

Table 1 shows the baseline characteristics of the study subjects. Out of 86 patients, maximum number of patients fall in age group 61-70 years followed by >70 years, 51-60 years and others. Among them 58.1 % were female and 41.8 % were male. This table shows higher percentage of female patients suffering from respiratory acid-base disorder compared to their male counterparts.

Characteristics		Frequency	Percentage (%)
Age group	18-30 years	8	9.3
	31-40 years	10	11.6
	41-50	14	16.3
	51-60 years	15	17.4
	61-70	22	25.5
	>70 years	17	19.7
Sex	Male	36	41.8
	Female	50	58.1

Table 1: Baseline Characteristics of patients.

Table 2 shows the list of different respiratory diseases causing respiratory acidosis and alkalosis. Out of 15 different respiratory diseases, COPD was the major contributing factor (30.2%) followed by septic shock (17.4%), pneumonia (7%), septicemia (7%) followed by others. Lower incidence

of respiratory acidosis and alkalosis (≤1%) were found to be associated with diseases like Meningitis, Bronchial asthma, Pulmonary effusion and Emphysema.

Diagnosis	Frequency	Percentage
COPD	26	30.2
Septic Shock	15	17.4
Pneumonia	13	15.1
Sepsis	7	8.1
Pulmonary Tuberculosis	6	6.9
Acute Febrile illness	5	5.8
Acute Respiratory Distress syndrome	3	3.5
Pleural Effusion	3	3.5
Pulmonary Edema	2	2.4
Scrub Typhus	2	2.4
Pulmonary Thromboembolism	1	1.2
Meningitis	1	1.2
Bronchial Asthma	1	1.2
Emphysema	1	1.2

Table 2: Lists of respiratory disease causing acidosis and alkalosis**.**

Table 3 shows mean values of different ABG parameters in respiratory acidosis and alkalosis. ABG parameters like pH, pO_2 and SO_2 were significantly higher in respiratory alkalosis compared to respiratory acidosis while pH, pCO_2, HCO_3- and TCO_2 were significantly higher in respiratory alkalosis ($p<0.01$). These ABG findings were truly suggestive of respiratory acidosis and alkalosis.

Biochemical Parameters	Respiratory Acidosis (Mean±SD)	Respiratory Alkalosis (Mean±SD)	P value
pH	7.32±0.01	7.48±0.03	<0.0001
pO_2	64.30±4.26	85.66±16.0	<0.0001
HCO_3^-	28.04±5.28	20.07±5.84	<0.0001
SO_2	91.44±7.04	93.83±6.06	<0.05
TCO_2	29.91±6.45	18.02±3.89	<0.0001

Table 3: Mean values of biochemical parameters in respiratory acidosis and alkalosis.

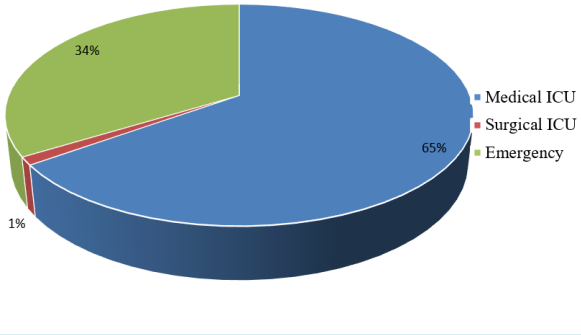

Figure 1: Pie Diagram showing Ward wise Distribution of Patients.

Figure 1 shows Pie diagram of ward wise distribution of patients with respiratory acid -base disorders. Out of 86 patients, 65% were from medical ICU, 34% were from emergency and remaining 1% were from Surgical ICU. This shows that many debilitating medical conditions are the main contributing factor for respiratory acidosis and alkalosis.

Discussion

Respiratory acidosis occurs due to inadequate ventilation resulting in CO_2 retention which eventually leads to increase in pCO_2 and H_2CO_3 concentration in blood. It occurs due to depression of the respiratory center resulting from different pulmonary or neuromuscular disorders. Kidneys try to compensate by excreting more acids in the form of hydrogen and ammonium ions and increase reabsorption of bicarbonate ions [9].

Respiratory alkalosis on the other hand is associated with hyperventilation resulting decrease in pCO_2 and H2CO3 concentration in blood. The causes may be central resulting from head injury and strokes or some common respiratory entities including COPD, pneumonia, pulmonary embolisms and pneumothorax. In respiratory alkalosis, renal mechanism try to maintain physiological pH by decreasing both reabsorption of HCO3- ions and tubular secretion of H+ ions [10].

In the present study, 58.1% of patients suffering from respiratory acidosis and alkalosis were female compared to male (41.8%). This finding shows female preponderance over male which is consistent with the study done by Padmavathi K, et al. [11]. Among different age-groups, most of the patients fall in age-group 61-70 years category (25.5%) followed by >70 years (19.7%) and least number of patients belong to age-group 18-30 years category (9.3%). This result shows that elderly patients are more prone to suffer from different respiratory illnesses causing acidosis and alkalosis compared to young adults. This might be directly related to physiologic decline in the ability to correct acid base imbalances in the elderly patient compared to young adults with better pulmonary compliance and renal compensatory mechanism. Among 15 different respiratory illnesses, COPD is the most common contributing factor for respiratory acid-base disorder (30.2%) followed by Septic shock, Pneumonia and others. This finding is concomitant with the study done by Martinu T, et al. [12].

Table 3 shows mean ABG values in respiratory acidosis and alkalosis. Comparison of ABG parameters show low pH, high pCO_2, high TCO_2 and high HCO_3- in respiratory acidosis compared to high pH, low pCO_2, low TCO_2 and low HCO_3- of respiratory alkalosis. The difference in the mean values is statistically significant with $p<0.05$. Retention of CO_2 is the primary cause for increase in pCO_2 and TCO_2 in respiratory acidosis, which results in excess production of H+ ions resulting acidemia. Hyperventilation with CO_2 wash out is the cause for high pH, low pCO_2 and low TCO_2 in respiratory alkalosis. We also found a significant difference in HCO_3- level in respiratory acidosis and alkalosis ($p<0.05$) which might be due to metabolic compensation provided by the kidneys.

Conclusions

Respiratory acidosis and alkalosis are common clinical entities in patients with acute or chronic respiratory diseases. ABG provides pertinent information related to acid-base balance and oxygenation status This study was an attempt to study different biochemical parameters and their pattern of alteration in respiratory acidosis and alkalosis. All thes ABG parameters and their changes can be explored to diagnose different phases of respiratory acidosis and alkalosis thereby supplementing appropriate diagnosis and management of these conditions.

Conflicts of Interests

Nil

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