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ARTERIAL BLOOD GAS (ABG) STATUS AMONG NOVEL CORONAVIRUS DISEASE-2019 (COVID-19) PATIENTS IN CRITICAL CARE SETUP

Medical Science

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ABSTRACT

The Coronavirus disease of 2019 (COVID-19) is brought on by the SARS-CoV-2 virus which spreads through the respiratory droplets. This virus infection has the potential to cause lung conditions like pneumonia and acute respiratory distress syndrome (ARDS), in most severe cases. As the severity of COVID-19 progress, many patients require intensive care admission. In managing and predicting the prognosis in ICU, numerous research have examined laboratory biomarkers; however, very few have examined arterial blood gas, acid-base, and blood pressure patterns. Disorders of the acid-base balance can exacerbate a number of diseases, and on rare circumstances, the aberration may be so severe that it constitutes a threat to life. So we aimed to evaluate the arterial blood gas and acid-base patterns, blood pressure results, and their relationships to the outcomes of COVID-19 patients admitted to an intensive care unit. This is a single-center prospective, observational study 49 patients were included. Results indicated that most of the patients (85.8%) were having low arterial partial pressure of oxygen (PaO2), 55.1% were showing low PaCO2 which indicates hyperventilation, 40.8% were into Metabolic Acidosis (40.8%) and many of them were having high Lactate levels (75.5%). In our study, all patients experienced various acid–base alterations. Compensation Metabolic Acidosis and Compensation Respiratory Alkalosis were the most common acid–base disorders in this group of patients. Respiratory Alkalosis, Compensation Metabolic Acidosis, Compensation Respiratory Acidosis & pH values were statistically significant ($P<0.05$). Hence we conclude that ABG is the most important investigation in critically ill patients. Arterial Blood Gas abnormality may point to underlying pathology and analysis may be beneficial for predicting outcomes and risk stratification.

KEYWORDS

Arterial Blood Gas, SARS-CoV-2, COVID-19, Critically ill, ARDS

INTRODUCTION

The Coronavirus disease of 2019 (COVID-19) is brought on by the SARS-CoV-2 virus which spreads through the respiratory droplets. This virus infection has the potential to cause lung conditions like pneumonia and acute respiratory distress syndrome (ARDS), in most severe cases. Other potential COVID-19 consequences are sepsis, hypercoagulopathy, and multi-organ failure can injure the lungs and other organs permanently [1].

As the severity of COVID-19 progress, many patients require intensive care admission leading to frequent Arterial blood gas (ABG). Acid-base imbalances are common in severely ill patients and reveal the severity of the underlying pathologic process. The majority of acid-base changes are modest, infrequently symptomatic, and have the little propensity to interfere with organ homeostasis. On the other hand, significant changes in the acid-base balance may have detrimental effects on multiple organs [2]. It has been difficult to assess the prevalence and consequences of acid-base imbalance in COVID-19 patients [3]. The virus's affinity for the lungs and kidneys might conceivably cause recurrent acid-base changes as a result of pneumonia and kidney damage, respectively [4&5].

The renin-angiotensin system (RAS) is impacted by COVID-19 because the angiotensin-converting enzyme 2 (ACE2) is the point of entry for SARS-CoV-2. When SARS-CoV-2 enters the cell, ACE2 is downregulated while the traditional RAS pathway, which produces angiotensin II and aldosterone, is upregulated. The renal processing of hydrogen (H+) and bicarbonate (HCO_3^-) is impacted by angiotensin II and aldosterone, which may result in acid-base abnormalities. As COVID-19 becomes more severe, many patients must be admitted to the intensive care unit (ICU), which necessitates periodic arterial blood gas (ABG) analysis [6, 7&8]. SARS CoV-2 can cause the cytokine storm in a subset of patients, resulting in high levels of inflammatory mediators in COVID-19-infected patients, which was linked to greater severity and mortality [7&8].

The COVID-19 patients who are critical may have characteristics resembling those of acute respiratory distress syndrome, including diffuse alveolar damage, increased pulmonary inflammation, high levels of systemic pro-inflammatory cytokines, micro thrombosis, and thick mucus secretions in the airways. An elevated alveolar-to-arterial oxygen gradient, which denotes either ventilation-perfusion mismatch or intrapulmonary shunting, is frequently linked to hypoxemia with COVID-19 [9].

Analysis of arterial blood gas is a crucial routine inquiry to track patients' acid-base balance and the efficiency of gas exchange. Many diseases can be made worse by disorders of acid-base balance, and on rare occasions, the anomaly may be so severe that it poses a threat to life [10]. So we aimed to evaluate the arterial blood gas and acid-base patterns, blood pressure results, and their relationships to the outcomes of COVID-19 patients admitted to an intensive care unit.

METHODOLOGY

It is a single-center prospective, observational study of patients of COVID-19 that admitted to the ICU at Sree Balaji Medical College and hospital from 26th May 2021 to 24th September 2021. All the patients were over the age of 18 years and were included irrespective of possible underlying disorders. At the time of admission, measurements of arterial blood gas, serum electrolytes, renal function, and vitals were taken. In this study, the patients were diagnosed with Covid-19 through RT-PCR tests and other imaging modalities like Chest X-ray, High Resolution Computed Tomography (HRCT) chest. After getting the patients' consent, ABG analysis was performed and relevant

investigations were carried out to monitor the outcome.

On the specialized point-of-care ABG analyzer Gem Premier 3000, ABG analyses were carried out. The partial pressure of oxygen (pO2) and lactate is calculated amperometrically, while the partial pressure of carbon dioxide (pCO2) and pH is calculated potentiometrically. The parameters HCO3 and Base Excess (BE) are calculated. With the help of the onboard Intelligent Quality Management system, the instrument is regularly submitted to internal quality monitoring.

Data were collected and descriptive statistics were calculated through SPSS. Turkey's post hoc test was used to evaluate categorical and continuous variables between groups after the chi-squared and one-way ANOVA.

RESULTS

Overall, 49 patients were included in our study. Most of the participants (27%) were belonging to the age group of 45-54, followed by 55-65 years old (25%). The majority of the participants in the study were males (57%) and females (43%) (Fig.1 &2).

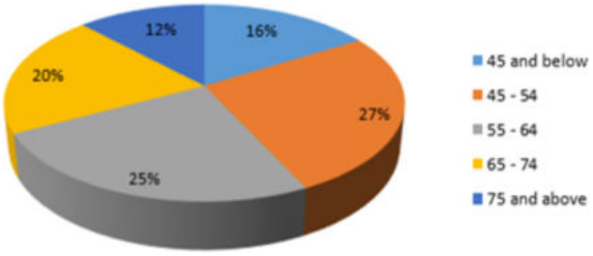


Figure 1: Age-wise Distribution

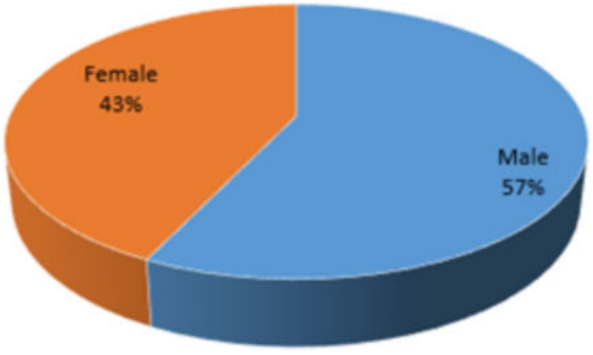
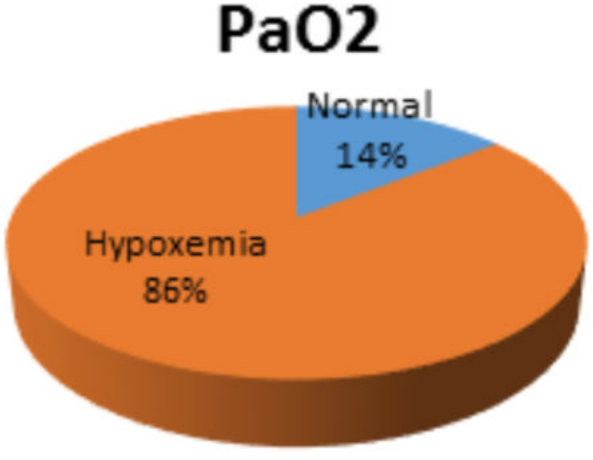


Figure 2. Gender Wise Distribution

Table 1: PaO2 Status Of The Patients, N=49

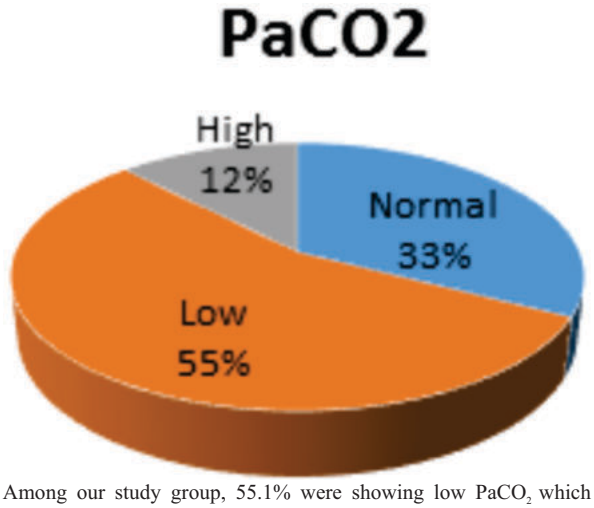
PaO2		
	Frequency	**Percent (%)**
Normal	7	14.3
Hypoxemia	42	85.8
Total	49	100.0



In our study majority of the patients were having low arterial partial pressure of oxygen (PaO2) (85.8%), due to pneumonia, ARDS, and required oxygen therapy and 14.3% had normal PaO2.

Table 2: PaCO2 Status Of The Patients, N=49

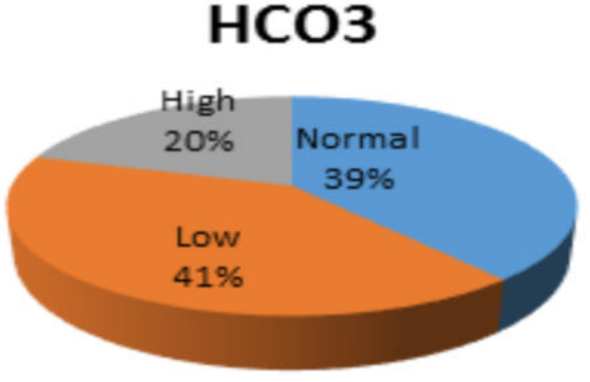
PaCO2		
	Frequency	**Percentage (%)**
Normal	16	32.7
Low	27	55.1
High	6	12.2
Total	49	100.0



Among our study group, 55.1% were showing low $PaCO_2$ which indicates hyperventilation, secondary to COVID-19 Pneumonia. Whereas 12.2% showed type 2 respiratory failure ($PaCO_2$ high) due to underlying chronic obstructive pulmonary disease (COPD).

Table 3: HCO3 Status Of The Patients, N=49

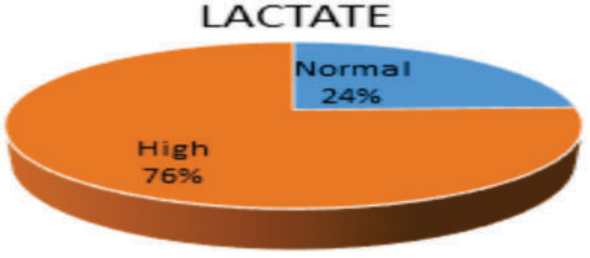
HCO3		
	Frequency	**Percent (%)**
Normal	19	38.8
Low	20	40.8
High	10	20.4
Total	49	100.0



Most of the patients showed Metabolic Acidosis (40.8%), due to dehydration and acute kidney injury and 38.8 % of the patients were having normal pH, and 20.4% had Metabolic Alkalosis also.

Table 4: LACTATE Status Of The Patients, N=49

LACTATE		
LACTATE	**Frequency**	**Percent (%)**
Normal	12	24.4
High	37	75.5
Total	49	100



Most of the patients have high Lactate levels (75.5%), due to hypoxemia, poor tissue perfusion, and sepsis. It is an important marker of early organ failure.

Table 3 – ABG - Distribution Of Acid-base Disorders In Patients

	Frequency	Percent (%)
Respiratory Acidosis	1	2.04
Metabolic Alkalosis	2	4.08
Respiratory Alkalosis	7	14.29
Compensation Metabolic Acidosis	11	22.45
Compensation Respiratory Acidosis	4	8.16
Compensation Respiratory Alkalosis	8	16.33
Normal PH	16	32.65
Total	49	100

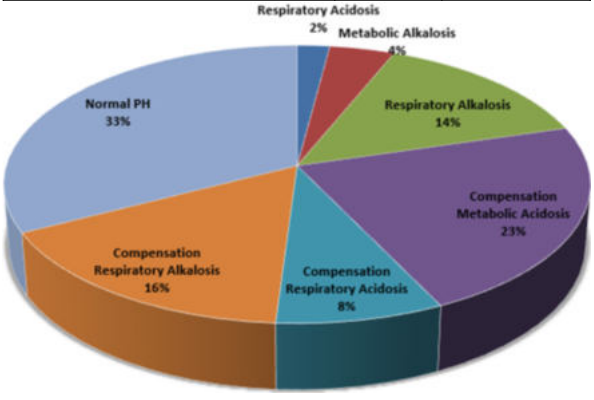


Figure 3: ABG - Distribution Of Acid-base Disorders In Patients

Maximum participants were having normal pH (33%), followed by Compensation Metabolic Acidosis (23%) due to dehydration, sepsis, cytokine storm, and acute kidney injury, and Compensation Respiratory Alkalosis (16%) commonly observed due to hyperventilation syndrome which can lead to hypocapnia. Anxiety and panic attitude towards COVID, ARDS with or without sepsis, pulmonary embolism, and excess mechanical ventilation are all this factor that can be responsible for hyperventilation. Additionally, metabolic acidosis with or without respiratory compensation may be present as the condition progresses and the work of breathing increases, the PCO2 begins to rise this lead to respiratory acidosis (2%) (Figure 3).

Table 1:- Characteristics Of Patients According To Their Acid-base Balance

		Mean	95% Confidence Interval of the Difference		P - Value
			Lower	Upper	
Metabolic Alkalosis	PH	6.49	6.36	6.62	0.001
	SPO2	92.5	73.44	111.56	0.01
	LACTATE	0.35	-6.64	7.34	0.639
	P/F RATIO	269.5	-105.33	644.33	0.069
	PCO2	39.5	-4.97	83.97	0.056
	PO2	64	-24.94	152.94	0.069
	HCO3	29.95	-12.62	72.52	0.071
Respiratory Alkalosis	PH	6.49	6.46	6.53	<0.001
	SPO2	94.71	91.35	98.08	<0.001
	LACTATE	0.83	0.19	1.47	0.019
	P/F RATIO	204.71	70.35	339.08	0.01
	PCO2	29.43	26.46	32.39	<0.001
	PO2	74	53.95	94.05	<0.001
	HCO3	22.14	20.89	23.40	<0.001
Compensation Metabolic Acidosis	PH	6.33	6.27	6.38	<0.001
	SPO2	92.45	87.35	97.56	<0.001
	LACTATE	1.42	0.70	2.14	0.001
	P/F RATIO	213.45	154.46	272.45	<0.001
	PCO2	25.91	21.17	30.65	<0.001
	PO2	92.64	62.43	122.84	<0.001
	HCO3	12.99	10.04	15.95	<0.001
Compensation Respiratory Acidosis	PH	6.28	6.21	6.34	<0.001
	SPO2	84.25	47.82	120.68	0.005
	LACTATE	2.2	-3.89	8.29	0.334
	P/F RATIO	230	103.19	356.81	0.01
	PCO2	64	48.36	79.64	0.001
	PO2	89.75	9.74	169.76	0.038
	HCO3	29.23	24.51	33.94	<0.001
Compensation Respiratory Alkalosis	PH	6.43	6.41	6.45	<0.001
	SPO2	94.29	89.51	99.07	<0.001
	LACTATE	1.33	0.02	2.63	0.047
	P/F RATIO	397.25	316.08	478.42	<0.001
	PCO2	28.88	26.33	31.42	<0.001
	PO2	110.5	64.89	156.11	0.001
	HCO3	18.81	17.60	20.02	<0.001
Normal pH	PH	6.42	6.40	6.43	<0.001
	SPO2	88.31	81.74	94.89	<0.001
	LACTATE	0.93	0.30	1.55	0.006
	P/F RATIO	206.81	130.86	282.76	<0.001
	PCO2	37.68	36.05	39.31	<0.001
	PO2	67.5	46.99	88.01	<0.001
	HCO3	23.67	22.20	25.14	<0.001

During Arterial Blood Gas Analysis 7 components (PH, SPO2, LACTATE, P/F RATIO, PCO2, PO2, HCO3) were analysed. We have found that Metabolic Alkalosis PH, SPO2 were statistically significant but the other components were not statistically significant.

In Respiratory Alkalosis, Compensation Metabolic Acidosis, Compensation Respiratory Alkalosis and Normal pH, all the 7 components were statistically significant ($p<0.05$). Under Compensation Respiratory Acidosis except Lactate all other components were statistically significant ($p<0.05$).

DISCUSSION

The primary symptom of this illness, pneumonia, is almost always identified in COVID-19-positive hospitalized patients. It typically shows up as bilateral, peripheral, ground-glass opacities that may or may not be linked with consolidations predominantly in basal regions [11]. Because extensive pneumonia affects pulmonary gas exchange and changes minute ventilation. During the COVID-19 outbreak, various studies have evaluated the role of lab biomarkers in the management and prognosis of COVID-19 patients, however to the best of our knowledge, there are very few studies are done regarding ABG, acid-base patterns, and their association with the outcomes in COVID-19 patients admitted to ICUs. Arterial blood gas (ABG) analysis is an important part of diagnosing and managing a patient's oxygenation status and acid–base balance.

In this study of critically ill COVID-19 patients admitted to ICU, with swab tests confirmed COVID-19, the majority were male patients. The most common age group to be affected was 45-54 years (27% of patients) followed by (25% of patients) in the age group of 55-64 years. All the patients in this study had abnormal arterial blood gas, suggesting that the homeostasis of various vital organs which maintains acid-base balance was affected.

Morne C Bezuidenhout et al[12], the majority of the patients presented with alkalemia during the presentation and further progressed into acidosis. Jitendra Lakhani et al[13], found that mixed disorder is common (respiratory acidosis with metabolic acidosis) during admission and follow-up.

Our study results showed that 23% of the patients had respiratory alkalosis with compensation metabolic acidosis. Initially, these patients had hypoxemia due to impaired gaseous exchange followed by decreased renal net acid excretion with a resulting decrease in serum bicarbonate as a compensatory mechanism. Hypocapnia appears to be a bad prognostic indicator in critically ill patients. 16% of patients had metabolic acidosis with compensation respiratory alkalosis. As several studies suggest, Metabolic acidosis is a common acid-base disorder that is fatal.

Other metabolic abnormalities such as 14% of patients had respiratory alkalosis, 8% of patients had the compensation of respiratory acidosis, 4% of patients had metabolic alkalosis and 2% of patients had respiratory acidosis.

In our study, all patients experienced various acid–base alterations.

Compensation Metabolic Acidosis and Compensation Respiratory Alkalosis were the most common acid–base disorders in this group of patients. Respiratory Alkalosis, Compensation Metabolic Acidosis, Compensation Respiratory Acidosis & pH values were statistically significant.

Hence, ABG is an essential tool to identify and monitor the progression of respiratory failure and other acid-base disorders.

CONCLUSION

In conclusion, Hypoxia and Lactic acidosis is a prominent features of COVID-19 patients, and acid-base imbalances were prevalent in individuals who were admitted to the hospital due to COVID-19 symptoms. Various acid-base changes occurred in them. In our study group of patients, metabolic and pulmonary alkalosis were the most prevalent acid-base abnormalities. Our data suggests that ABG is the most important investigation in critically ill patients. Arterial Blood Gas abnormality may point to underlying pathology and analysis may be beneficial for predicting outcomes and risk stratification. To support our findings, further research on the arterial ABG analysis and the acid-base state of COVID-19 patients is required.

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