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Comparison of Arterial Blood Gas Analysis of 206 Critically Ill Survived and Non-Survived COVID-19 patients

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Abstract

Present retrospective was conducted in tertiary care hospital in Aurangabad, Maharashtra; all critically ill patients of COVID 19 admitted in ICU of our hospital, during the duration of three months period were included. We focused on to compare demographic data, clinical presentation, vitals and Arterial Blood Gas (ABG) analysis of all patients Survived and Non-Survived COVID-19 patients.

Anorexia [11 (5.34%)] was the least common symptom. Heart rate was significantly (p value 0.037) increased in non-survived (94.77 ± 14.96) patients at the time of admission. Mean arterial pH was significantly (p <0.0001) lower in (7.0) non-survived compared to survived (7.72), indicating towards acidosis in non survivors. There was a significant difference (p value 0.048) in the partial pressure of oxygen (PO_2), which was more in survived (85.27 ± 48.84 mmHg) than non-survived (74.95 ± 38.28 mmHg). Bicarbonates in survived (21.12 ± 8.78 mmol/L) were significantly (p <0.0001) higher than non-survived (18.34 ± 4.87 mmol /L). Mean oxygen saturation (SO2) in non survivors (84.59 %) was observed to be significantly (p<0.003) lower than in survivors (91.94%). There was significant (p <0.001) difference in anion gap which was higher in non-survivor (7.04 ± 9.37) than survivors (5.14 ± 4.83).

COVID 19 patients are at risk of developing ARDS and sepsis. Metabolic Acidosis was predominantly found among the most common acid-base disorder of Acidosis. A higher arterial pH, higher partial pressure of oxygen, increased bicarbonates and higher oxygen saturation were significantly associated with increased survival. Nevertheless, more studies are needed to investigate the prognostic role of Acid-Base Gas Analysis of critically ill COVID 19 patients.

Keywords: COVID 19, PO_2, CT.

Introduction

The unprecedented pandemic of Coronavirus Disease 2019 (COVID-19) caused bySARS-CoV-2 virus has become rampant globally and is reckoned for human morbidity and mortality in over 223 countries [1,2,3]. SARS-CoV-2 outbreak was declared as Public Health Emergency of International Concern (PHEIC) by World Health Organisation on January 30th, 2020 [2]. The spectrum of severity of COVID-19 illness ranges from asymptomatic carrier state to presentation with mild symptoms of pneumonia to respiratory failure & multi organ dysfunction leading death.

Computed Tomography (CT) of Chest is the most functional diagnostic tool for finding the morphology of lung lesions which appear to correlate with the severity of inflammatory process in COVID-19 pneumonia [4, 5]. Recently, Shang et al. suggested that lung lesions' morphological characteristics on Chest CT may correspond to arterial blood gas (ABG) values [6]. Information concerning acid-base levels, oxygenation and ventilation adequacy is provided by ABG; which is inexpensive, widely available and gives prompt results compared to a Computed Tomography (CT) scan. Moreover, comprehensive use of CT on patients may cause repercussions from increased radiological exposure, while ABG analysis can be performed repeatedly for vigilant monitoring of critically ill COVID-19 patients. Thus, ABG can be considered as a more functional tool for the precursory prognostic assessment of severity of COVID-19 infection.

In COVID-19, due to unrestrained proinflammatory cytokines increase, endothelial activation along with constant hypercogulable process resulting in progressive pulmonary micro embolism which is suggestive of acute arterial hypoxemia shown by abnormal ABG analysis [7]. As carbon dioxide (CO2) diffuses about 20 times more rapidly through tissues than oxygen (O2), compensatory response of the body towards hypoxemia causes increased minute ventilation leading to uncontrolled hypocapnia [8,9]. There is an uncanny emergence of clinical pattern with incongruity between relatively well-preserved lung compliance and a severely compromised pulmonary gas exchange, leading to fatal "happy hypoxemia" without pronounced hypercapnia, and hence no corresponding signs of respiratory distress [10]. Mechanical ventilation is required as lung compliance is affected due to arterial hypoxemia which is one of the chief complications of COVID-19. An astute perception of pathophysiological predictors of respiratory drive and hypoxemia may lead to complete comprehension of COVID-19 clinical presentation at bedside with the help of ABG analysis [8]. Preliminary studies from China & Italy suggest high mortality and concentrated ICU capacity [5, 11].

Meticulous understanding of COVID-19 infection will be beneficial for early identification & triaging of patients at high risk for mortality. Prudent scrutiny should be observed to prevent SARS-CoV-2 virus transmission in susceptible population. Early identification of severity progression in high-risk individuals will be advantageous in reducing COVID-19 mortality. Paraphernalia for prompt detection of the extent of the ongoing inflammatory processes and immediate prediction of COVID-19 severity progression is of utmost necessity for reduction in mortality.

Materials and methods

Aim

To compare the arterial blood gas analysis of Survived & Non-Survived Critically ill COVID-19 patients and assess whether these parameters are of any prognostic value.

Objectives

- To assess the arterial blood gas analysis of Critically ill COVID-19 patients.
- To determine whether ABG analysis parameters are of any prognostic value.

Study design

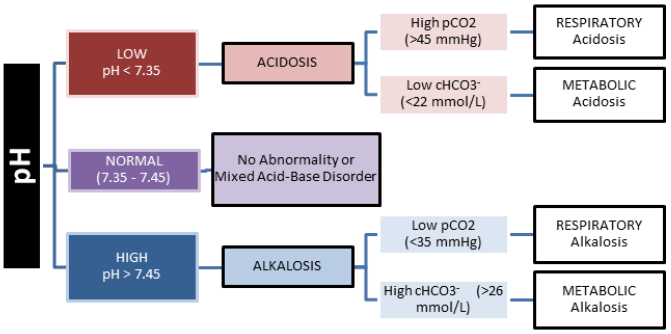
This is a retrospective observational case study of 206 critically ill COVID-19 patients conducted in MGM Medical College & Hospital, Aurangabad, Maharashtra; from the period of 1st May 2020 to 31st July 2020. All diagnosed COVID-19 cases with positive (RT-PCR) reverse transcription-polymerase chain reaction for SARS-CoV-2 virus that were critically ill & required ICU admission; were selected using purposive sampling. COVID-19 ICU patients who were less than 18 years of age at the time of admission or patients who stayed for less than 24 hours in the ICU, pregnant COVID-19 patients requiring ICU and patients who died during ICU stay due to reasons other than complications associated with COVID-19 were excluded.

Approval for the study was obtained from the Institutional Ethical Committee of MGM Medical College and Hospital, Aurangabad, Maharashtra. Written informed consent was taken from the patients or their relative at the time of hospital admission.

Data collection

Medical records of included patients were collected, reviewed and evaluated by three researchers. Data inclusive of age, sex (male, female), area of living (urban, rural), chief complains of patients at the time of admission (fever, anorexia, fatigue, dry cough, diarrhoea, dyspnoea) and vital signs (HR, RR, Blood Pressure, SPO2, BSL) were noted from the patients' records noted at the time of ICU admission. COVID-19 Positivity and survival outcome and complication were discerned from physician documentation on patients' records. Arterial Blood Gas Analysis Report consisting of pH, pO2, pCO2, $cHCO3^-$ was perceived from Clinical Electronic Medical records.

Figure 1: interpretation of arterial blood gas analysis



Statistical analysis

Data was compiled in MS-EXCEL Sheet and for analysis of this data SPSS (Statistical package for social sciences) Version 20th was used. Continuous variables with normal distribution were presented as mean (Standard Deviation [SD]) and compared between survived & non survived groups by using Student's t –tests. A two-sided p value of less than 0.05 was considered to be statistically significant. Categorical Variables were presented as frequency (percentage [%]) & assessed using Pearson $\chi^{2.}$

Observations & results

Table 1: demographic profile of covid-19 ICU patients**.**

Group	Category	Survived [n=103]		Non-survived [n=103]		Total [n=206]	
		No.	%	No.	%	No.	%
Gender	Male	69	66.99	80	77.67	149	72.33
	Female	34	33.01	23	22.33	57	27.67

Age-Group	≤30 years	3	2.91	2	1.94	5	2.43
	31-40	16	15.53	3	2.91	19	9.22
	41-50	26	25.24	17	16.50	43	20.87
	51-60	36	34.95	24	23.30	60	29.13
	61-70	16	15.53	28	27.18	44	21.36
	>70	6	5.83	29	28.16	35	16.99
AGE	Mean±SD	52.52±10.99		61.31±13.52		56.91±12.63	
Duration of Hospital Stay	Mean±SD	7.56±7.34		9.93±6.67		8.24±6.37	
Area of Living	Rural	16	15.53	21	20.39	37	17.96
	Urban	87	84.47	82	79.61	169	82.04

Maximum patients were males [149 (72.33)] compared to females [57 (27.67)]. Of the 206 critically ill patients, mean age of patients was 56.91yrs and mean duration ICU stay of the patients was8.24 days. Maximum patients in our study were the residents of urban area [169 (82.04)].

Table 2: Chief Complains in Covid-19 ICU Patients

Symptoms	Survived [N=103]		Non-Survived [N=103]		Total [N=206]	
	No	%	No	%	No	%
Anorexia	4	3.88	7	6.80	11	5.34
Fatigue	23	22.33	12	11.65	35	16.99
Dyspnoea	85	82.52	93	90.29	178	86.41
Dry Cough	54	52.43	73	70.87	127	61.65
Diarrhoea	9	8.74	8	7.77	17	8.25
Fever	72	69.90	81	78.64	153	74.27
Other	8	7.77	9	8.74	17	8.25

The most common symptoms appearing in critically ill patients were Dyspnoea [178(86.41%)], Fever [153 (74.27%)] followed by Dry cough [127(61.65%)]. Anorexia [11 (5.34%)] was the least common symptom.

Table 3: vitals of covid 19 icu patients

Vitals at the time of icu admission	Survived [n=103]	Non survived [n=103]	Total [n=206]	P-value
Heart Rate	89.69 ± 14.03	94.77 ± 14.96	92.23 ± 14.50	0.037
Respiratory Rate	28.84 ± 7.74	30.27 ± 8.26	29.56 ± 8.01	0.250
Systolic Blood Pressure	137.64 ± 97.95	129.64 ± 19.68	133.64 ± 58.82	0.24
Diastolic Blood Pressure	78.17 ± 9.11	79.72 ± 11.36	78.95 ± 10.23	0.26
Mean Arterial Pressure	107.02 ± 11.90	109.99 ± 14.88	108.50 ± 13.39	0.186
SPO2	86.65 ± 9.87	85.19 ± 12.70	85.92 ± 11.28	0.913
Blood Sugar Level	159.92 ± 73.43	173.38 ± 80.14	166.65 ± 76.78	0.362

Significant difference (p value 0.037) was observed in heart rates of survived and non-survived patients, heart rate was increased in non-survived (94.77 ± 14.96) patients at the time of admission. There was no significant difference observed in the systolic blood pressure, SP02 and respiratory rate of patient.

Table 4: arterial blood gas in covid 19 icu patients

Arterial blood gas	Survived [n=103]	Non-survived [n=103]	Total [n=206]	P- Value
pH (7.35-7.45)	7.72 ± 2.9	7.0 ± 0.17	7.37 ± 1.54	<0.0001
pO2 (mmHg) 80-100 mmHg	85.27 ± 48.84	74.95 ± 38.28	80.11 ± 43.56	0.048
pCO2 (mmHg) 35-45 mmHg	33.27 ± 6.75	36.13 ± 14.47	34.70 ± 10.61	0.978
$cHCO3^{-}$ (mmol/L) 22-26 mmol/L	21.12 ± 8.78	18.34 ± 4.87	39.46 ± 13.65	<0.0001
SO2 % (96 – 100%)	91.94 ± 10.96	84.59 ± 18.63	88.26 ± 14.79	0.003
Anion Gap (mmol/L)	5.14 ± 4.83	7.04 ± 9.37	6.09 ± 7.10	0.001

Mean arterial pH was significantly (p <0.0001) lower in (7.0) non-survived compared to survived (7.72), indicating towards acidosis in non survivors. There was a significant difference (p value 0.048) in the partial pressure of oxygen (pO2), which was more in survived (85.27 ± 48.84 mmHg) than non-survived (74.95 ± 38.28 mmHg). Bicarbonates in survived (21.12 ± 8.78mmol/L) were significantly (p <0.0001) higher than non-survived (18.34 ± 4.87 mmol/L). Mean oxygen saturation (SO2) in non survivors (84.59 %) was observed to be significantly (p value 0.003) lower than in survivors (91.94%). There was significant (p value 0.001) difference in anion gap which was higher in non-survivor (7.04 ± 9.37) than survivors (5.14 ± 4.83). There was no significant difference seen in partial pressure of carbon dioxide (pCO2) in survived and non-survived.

Table 5: interpretation of arterial blood gas in covid 19 icu patients

Interpretation	Survived [n=103]		Non-survived [n=103]		Total [n=206]	
	No.	%	No.	%	No.	%
Acidosis	7	6.80	35	33.98	42	20.39
Metabolic Acidosis	5	11.90	23	54.76	28	66.67
Respiratory Acidosis	2	4.76	6	28.57	8	33.34
Alkalosis	10	9.71	13	12.62	23	11.17
Metabolic Alkalosis	2	8.70	3	13.04	5	21.74
Respiratory Alkalosis	8	34.78	10	43.48	18	78.26
Total	17	16.51	48	46.60	65	31.56

Of the 65 (31.55%) acid base abnormalities found, Acidosis is the most common in our cohort. Acidosis is observed in [42 (20.39%)] patients and more prominent in non-survivors [35 (33.98%)]. Metabolic acidosis was dominant finding [28(66.67%)] among the acidosis found.

Discussion

Many previous studies [12, 13, 14] concluded that males are at higher risk of infection and are usually affected more in comparison to females which is also supported by our study wherein [149 (72.33%)] males are the prominent gender. As age increases the chances of mortality due to COVID-19 also increases, making age an important factor. A study conducted by Yang et al. exhibited that the average age of patients was (59; 7±13.3), wherein maximum patients were in age group 60-69 years [17 (33%)] and age group ≥80 years [2 (4%)] had least patients [13]. In present study, where mean age of all critically ill patients were 56.91 years with maximum patients belonging to age group 51-60 years and least patients in age group ≤30 years, results are very similar to Yang et al. study. This concludes that elderly males are at higher risk of progressing to severe COVID-19 infection.

The most common COVID-19 symptoms in 206 critically ill patients of our cohort were dyspnoea [178 (86.41%)], fever [153 (74.77%) and cough [127 (61.65%)]. In a study conducted on 239 critically ill COVID-19 patients, the most common symptoms were fever 218 (91.2%), cough 178 (74.5%), and dyspnoea 119 (49.79%) [15].

Acid-base abnormalities are very common in critically ill patients and contribute significantly to morbidity and mortality. An acute hyper inflammatory response such as cytokine storm may be responsible for critical illness in various conditions like viral infections, cancer, sepsis, and multi-organ failure. This phenomenon of cytokine storm has also been implicated in critically ill patients infected with SARS-CoV-2 virus of COVID-19 [16, 17].

In the past two decades, the world has seen three coronaviruses emerge and cause outbreaks considerable global health consternation. A new Coronavirus causing respiratory disease that appeared in the Middle East was named MERS-CoV and had the case fatality of 34.4 % [18, 19]. A study conducted by Halim et al. on ICU admitted MERS coronavirus patients found a statistically significant decrease in pH, PaO2, O2 saturation and HCO3 ($P < 0.05$) among the expired group in comparison to the survivors, but no statistical difference regarding PaCO2 ($P > 0.05$) [20]. Similarly in our study, a significant difference was observed among the pH, PaO2, O2 saturation and HCO3 of survived and non-survived patients. Though no significant difference was observed regarding the values of PCO2.Another study of 20 patients with severe COVID-19 infection by Zhang et al. found that blood oxygen saturation and pH value in were significantly ($p < 0.05$) lower in non-survivors compared to that of survivors before and after tracheal intubation, lactate value and PCO2 in non-survivors were higher than survivors ($p < 0.05$) for both times [12].

Diffuse alveolar damage along with interstitial thickening results in compromised gas exchange. There is a disproportional pulmonary gaseous exchange as carbon dioxide diffuses approximately 20 times faster than O_2 in blood, accounting for O_2 exchange being compromised before carbon dioxide removal. Arterial hypoxemia in COVID-19 infection is primarily caused by ventilation perfusion (V/Q) mismatch and thus persistence of pulmonary arterial blood flow to non-ventilated alveoli [7, 21]. In our study, there was significant difference present in values of pH, PaO2, $HCO3^-$ and SO2 between survivors and non survivors. Non survivors tend to have lower pH (7.0 ± 0.17), lower PaO2 (74.95 ± 38.28), lower HCO3 (18.34 ± 4.87) and lower SO2 (84.59 ± 18.63). A higher arterial pH, higher partial pressure of oxygen, increased bicarbonates and higher oxygen saturation were significantly associated with increased survival. The blood gas analysis of 101 non-survived

COVID 19 patients, pH (7.39 ± 0.01), PaO2 was (61.64 ± 3.75) and PaCO2 (36.97 ± 1.24) [22].

As per definition, Oxygen Saturation is the percentage of haemoglobin-binding sites occupied by oxygen, varying according to the arterial PO2, as stipulated by the oxyhemoglobin dissociation curve. There is ±4% difference between the measurement of arterial oxygen saturation by pulse oximetry (SpO2) and CO-oximeters (SaO2) [23]. Higher SpO_2 levels after oxygen supplementation were associated with reduced mortality independently of age and sex [24]. However, in our study, there was no significant difference observed between peripheral oxygen saturation between survived and non -survived patients. SaO2 <90% is traditionally defined as hypoxemia which is an augury of clinical instability and progressive of which is associated with bad prognosis in patients with pulmonary diseases [26]. Mean oxygen saturation (SO2) in non survivors (84.59 %) was observed to be significantly (p value 0.003) lower than in survivors (91.94%). Arterial oxygen saturation (SaO2) measurement provides feasible, economical and non-invasive means to assess blood oxygenation. SaO2 is not widely used in evaluation of the severity in COVID-19 [24].

In present study 206 critically ill patients, maximum patients suffered acidosis [42 (20.39%)] patients with it being more prominent in non-survivors [35 (33.98%)]. This may indicate that non-survivors are more likely to develop acidosis. Metabolic acidosis was dominant finding [28 (66.67%)] among the acidosis found. A study conducted by Gunner son et al. regarding the metabolic acidosis in 851 critically ill patients found that 64% of the patients had metabolic acidosis, in which lactic acidosis was prominent [26]. ABG analysis performed in a patient with SARS-CoV-2 infection may correlate with the magnitude of pulmonary inflammatory process and provide forewarning of the patient's prognosis [27].

Conclusion

Elderly males are at higher risk of progressing to severe COVID-19 infection. COVID 19 patients are at risk of developing ARDS and sepsis; in such condition multiple blood gas analysis may predict worse outcome of critically ill patients. Arterial oxygen saturation (SaO2) measurement provides feasible, economical and non-invasive means to assess blood oxygenation. Metabolic Acidosis was predominantly found among the most common acid-base disorder of Acidosis. A higher arterial pH, higher partial pressure of oxygen, increased bicarbonates and higher oxygen saturation were significantly associated with increased survival. Nevertheless, more studies are needed to investigate the prognostic role of Acid-Base Gas Analysis of critically ill COVID 19 patients.

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