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Correlation between venous blood gas indices and radiological involvements of COVID-19 patients at first admission to emergency department

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SUMMARY

The purpose of this study was to investigate the relation between venous blood gas and chest computerized tomography findings and the clinical conditions of COVID-19 pneumonia.

METHODS: A total of 309 patients admitted to the emergency department and subsequently confirmed COVID-19 cases was examined. Patients with pneumonia symptoms, chest computerized tomography scan, venous blood gas findings, and confirmed COVID-19 on reverse transcription-polymerase chain reaction (PCR) were consecutively enrolled. Multiple linear regression was used to predict computerized tomography and blood gas findings by clinical/laboratory data.

RESULTS: The median age of patients was 51 (interquartile range 39–66), and 51.5% were male. The mortality rate at the end of follow-up was 18.8%. With respect to survival status of patients pCO_2 and HCO_3 levels and total computerized tomography score values were found to be higher in the surviving patients (p<0.001 and p=0.003, respectively), whereas pH and lactate levels were higher in patients who died (p=0.022 and p=0.001, respectively). With logistic regression analysis, total tomography score was found to be significantly effective on mortality (p<0.001). The diffuse and random involvement of the lungs had a significant effect on mortality (p<0.001, 95%CI 3.853–38.769, OR 12.222 and p=0.027; 95%CI 1.155–11.640, OR 3.667, respectively). With linear regression analysis, the effect of pH and lactate results were found to have a positive effect on total tomography score (p=0.003 and p<0.001, respectively), whereas pCO_2 was found to have a negative effect (p=0.029).

CONCLUSION: There was correlation between venous blood gas indices and radiologic scores in COVID-19 patients. Venous blood gas taken in emergency department can be a fast, applicable, minor-invasive, and complementary test in terms of diagnosing COVID-19 pneumonia and predicting the prognosis of disease.

KEYWORDS: Coronavirus infections. Blood gas analysis. Thorax. Radiology. Emergencies. Mortality.

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INTRODUCTION

New coronavirus disease (COVID-19) is a serious and mortal infectious disease, causing severe acute respiratory distress syndrome[1,2]. Since there is no curative vaccine or medicine yet, using determined measures and early detection tools serve as the gold standard tools against COVID-19. In the Emergency Department (ED), first-level COVID-19 triaging is performed according to clinical and laboratory results. Later, in case of doubt or severe respiratory failure, non-contrast chest computed tomography (CT) as a second-level triage complementary diagnostic tool is recommended[3-5]. However, a significant proportion of patients admitted to the ED with suspected COVID-19 are reported as COVID-19 negative[6], and the risk of radiological exposure and misdiagnosis should be considered[7,8]. Several point-of-care molecular devices are currently being integrated for fast and accurate diagnosis of SARS-CoV-2 infections[9]. It is valuable with respect to determining lungs involvement patterns of COVID-19 pneumonia and giving information about the disease prognosis through chest CT[10-12]. Evaluation of blood gas parameters is an indispensable approach in the differential diagnosis of respiratory complaints in ED, and venous blood gas (VBG) analysis has been increasingly adopted in those departments as much as arterial blood gas (ABG)[13]. Both chest CT and ABG analysis were evaluated in one study; mild-moderate correlation was found between chest CT findings and ABG indices in patients with COVID-19 pneumonia[14]. In another study, COVID-19 patients presented a positive correlation between increased pulmonary inflammatory volume on CT and low ABG indices[14,15]. Since ABG analysis is a more invasive procedure, VBG analysis as an initial assessment is accepted in the evaluation of acute respiratory complaints; there is no significant difference in many arteriovenous parameters (PH, pCO_2, Bicarbonate)[16,17].

Although there is no recommendation for routine use of venous blood gas assessment in COVID-19 patients, it may be effective in to manage the disease and determine the prognosis, as venous blood gas can be a simple, fast, cheap, and practical method at the first admission in emergency services during the COVID-19 pandemic process. The aim of this study is to investigate whether there is a correlation between the VBG indices and total chest CT scores (TCTS) in patients with COVID-19 pneumonia at admission to ED and whether they will determine the disease prognosis.

METHODS

A retrospective analysis was performed on 309 COVID-19 patients who were admitted to our academic hospital, from March 20, 2020 to May 20, 2020. Patients with pneumonia symptoms, chest CT scan, and confirmed COVID-19 on reverse transcription-polymerase chain reaction (RT-PCR) nasopharyngeal (NP) swabs were consecutively enrolled. The study was conducted in accordance with the Declaration of Helsinki, and after approval of the ethics committee of our university`s Faculty of Medicine (No.: 61522473/050.01.04/282). Patients aged >18 years, with simultaneous RT-PCR, chest CT, and VBG were included in the study. Patients with negative RT-PCR for SARS-CoV-2 with nasopharyngeal swabs, pulmonary edema, chronic obstructive pulmonary diseases, malignancy, congestive heart disease, liver dysfunction, acute/chronic kidney injury, and incomplete clinical data were excluded. During the specified study period, a total of 643 inpatients were examined, and only 309 patients were included considering the exclusion criteria. The demographic characteristics of the patients, such as age, gender, admission complaints, comorbid status, as well as biochemical parameters, venous blood gas indices and chest CT findings were recorded.

CT protocol and scoring

All patients underwent unenhanced CT with a 64-slice multi-detector CT (MDCT) scanner (Toshiba Aquilion) when they came to clinical attention due to pneumonia symptoms. All images reviewed by one radiologist independently blinded to the clinical information. CT visual quantitative evaluation was based on summing up the acute lung inflammatory lesions involving each lobe. Percentage of involvement in each lobe was recorded, as well as the overall lung "total severity score (TSS)". Each of the five lung lobes was assessed for percentage of the lobar involvement and classified as none (0%), minimal (1–25%), mild (26–50%), moderate (51–75%), or severe (76–100%), with corresponded score as 0, 1, 2, 3, or 4. TSS was reached by summing the five lobe scores (range from 0 to 20)[9].

Statistical analysis

Statistical analysis was performed with SPSS Statistics (IBM Corporation, Somers, NY) software, version 22). The normality of the distribution of continuous variables was determined using the Kolmogorov–Smirnov test. The continuous variables were expressed as median and interquartile range, depending on the normality of their distribution. Categorical variables are interpreted as frequency tables. The Mann–Whitney U test was used to compare the variables that were not normally distributed. Categorical features and relations between groups were assessed with an appropriate chi-square test. While investigating the associations between non-normally distributed and/or ordinal variables, the correlation coefficients and their significance were calculated with Spearman`s test. A multiple linear regression model was used to identify independent predictors of total CT scores. The model fit was assessed using appropriate residual and goodness-of-fit statistics. Logistic regression was conducted to assess whether predictor variables, such as some laboratory findings and demographic data, significantly predict mortality. The statistically significant two tailed p-value was considered as <0.05.

RESULTS

The median age of patients was 51 (IQR: 39–66). There were 159 (51.5%) female and 150 (48.5%) male patients. The diagnosis of all patients was confirmed with RT-PCR NP swabs. The most common symptoms at admission to ED were fever (63.8%), cough (54.4%), and shortness of breath (31.1%). Among the chronic concomitant diseases, hypertension, and diabetes mellitus (DM) were recorded the most frequently with 29.4% and 18.1%, respectively. At the end of follow-up, 58 patients died (18.8%). These and other baseline clinical and laboratory findings are summarized in Table 1.

When blood gas indices and TCTS values of patients were evaluated with respect to survival, pCO_2 and HCO_3 levels were found to be higher in the surviving patients (p<0.001 and p=0.003, respectively), whereas PH and lactic acid levels were higher in patients who died (p=0.022 and p=0.001, respectively). TCTS results were significantly higher in the group who died (p<0.001) (Table 2). The logistic regression analysis was done to evaluate the effect of TCTS and distribution pattern of lesions in lung parenchyma on mortality; TCTS was found to be statistically significantly effective on mortality (p<0.001, 95%CI 1.165–1.325; OR 1.243). Whereas no death was observed in the centrally located group of lung lesions (n = 8), the effect of peripherally located lesions on mortality was not significant (p=0.275, 95%CI 0.598–6.072, OR 1.906). However, the diffuse localization of lesions (p<0.001, 95%CI 3.853–38.769, OR 12.222) and random localization (p=0.027, 95%CI 1.155–11.640, OR 3.667) had a significant positive effect on mortality (Table 3).

With correlation analysis, a significant positive correlation was found between pH (Figure 1A) and lactate (Figure 1B)

Table 1. Clinical findings and laboratory features of the study population.

Characteristic	Results (n=309)
Age, years old*	51 (39–66) (range:17–91)
Gender, F/M (%)	159/150 (51.5/48.5)
Initial symptom, positive	
Fever	63.8
Cough	54.4
Dyspnea	31.1
Weakness	24.3
Sore throat	12.0
Diarrhea	3.9
Loss of taste	4.5
Anosmia	7.4
Headache	5.2
Diarrhea	3.9
Chronic diseases, positive	
Diabetes	18.1
Hypertension	29.4
Heart Disease	10
Diagnostic method	
Nasopharyngeal RT-PCR	100%
Pulmonary involvement, n (%)	251 (81.2)
Bilateral involvement	213 (68.9)
Unilateral involvement	38 (12.6)
Diffuse located	52 (18.8)
Peripherally located	115 (37.2)
Random located	76 (24.6)
Centrally located	8 (2.6)
Mortality, n (%)	58 (18.8)

Table 2. Comparison of blood gas results, demographic features, and total CT scores, according to survival conditions

	Results*		*p*-value
	Dead (n=58)	Alive (n=251)	
Age, years old	71.5 (64.0–81.0)	47 (36.0–62.0)	<0.001
Gender, F/M (%)	24/34 (41.4/58.6)	126/125 (50.2/49.8)	0.226
pH	7.40 (7.35–7.45)	7.38 (7.35–7.41)	0.022
pCO_2	40.2 (36.1–45.6)	45.4 (40.5–49.0)	<0.001
HCO_3	23.4 (21.4–25.4)	24.80 (23.3–26.0)	0.003
Lactate	2.10 (1.60–3.05)	1.60 (1.20–2.10)	<0.001

*The results for continuous variables were expressed as median (interquartile ranges), since they are not normally distributed.

Table 3. Logistic regression analysis of the pulmonary involvement pattern on mortality

	OR	95%CI	p-value
Pulmonary involvement pattern			
No involvement, ref* (n=58)	1	–	–
Diffuse involvement (n=51)	112.222	3.853–38.769	<0.001
Peripheral involvement (n=115)	1.1.906	0.598–6.072	0.275
Random involvement (n=76)	3.3.667	1.155–11.640	0.027
Central involvement (n=8)	0 (no death)	–	–

*Accepted as a reference category.

levels of TCTS, whereas a significant negative correlation was found between pCO_2 (Figure 1C) levels ($p<0.001$). No correlation was found between TCTS and other parameters, such as HCO_3 and PO2 ($p>0.05$). In addition, by linear regression analysis; pH and lactate results were found to have a positive effect on TCTS ($p=0.003$ and $p<0.001$, respectively), whereas pCO_2 was found to be negatively effective ($p=0.029$).

DISCUSSION

In the present study, a correlation between simultaneous venous blood gas (VBG) indices taken at the time of first admission to the emergency department and TCTS in patients diagnosed with COVID-19 disease was shown. Besides that, when the first admission VBG and TCTS are evaluated together, they determine and provide significant information about the prognosis of the disease. For the first time, a mild-to-moderate relation between ABG and chest CT findings in COVID-19 patients has been shown[14].

These results may be important in determining the prognosis and hospitalization indicators of the first admitted patients in the EDs. However, since taking ABG is a more invasive procedure, VBG analysis is preferred as an initial procedure to assess acute respiratory failure[16,17].

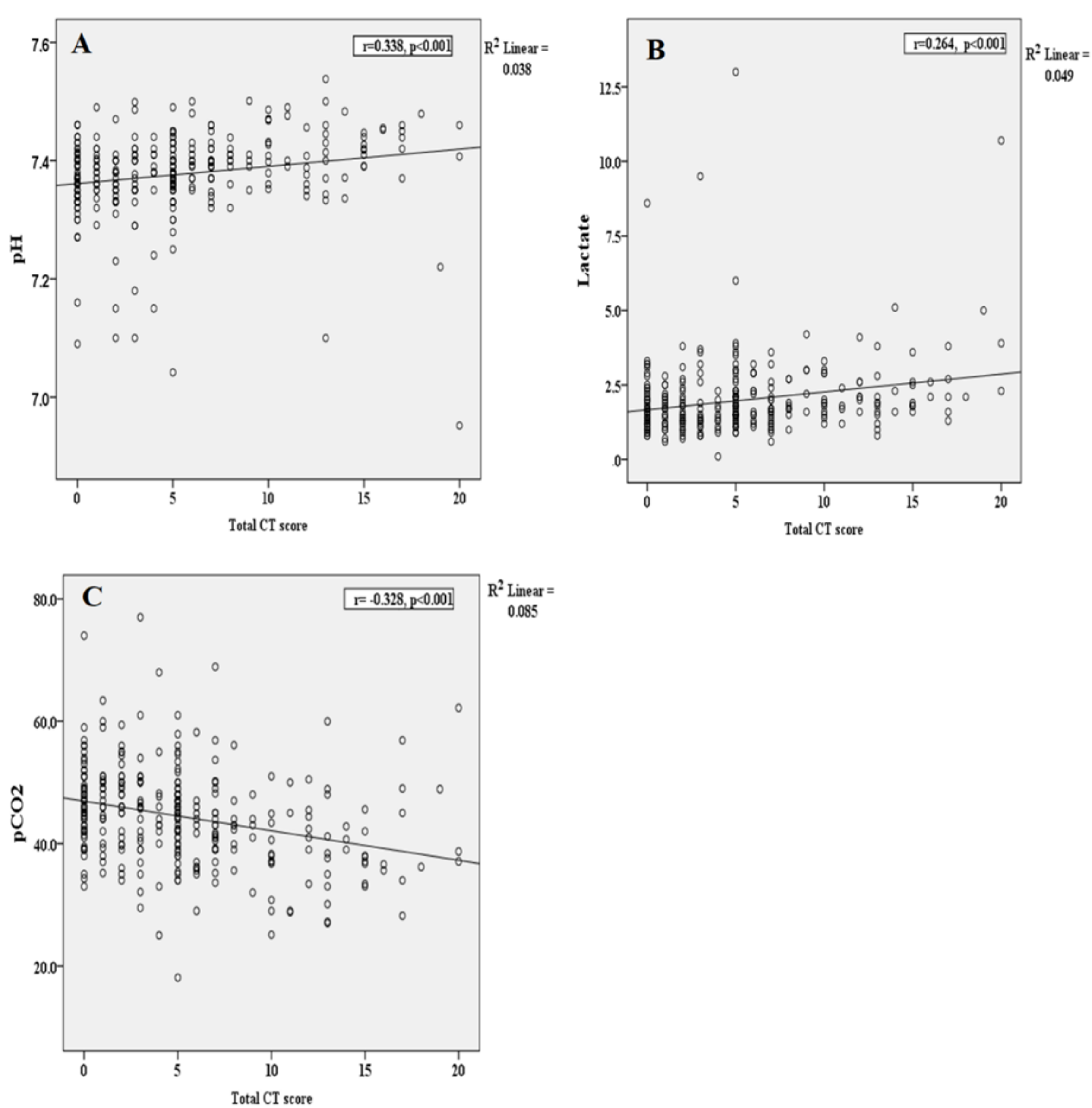

Figure 1. Correlation analysis of pH (A), lactate (B), and pCO_2 (C) with total CT score

Studies have shown that the levels of arteriovenous parameters with respect to power of hydrogen (PH) are very close to each other and interchangeable at about 0.03–0.04[13]. Similarly, there is little difference in pCO_2 and bicarbonate levels and 95% limits of agreement are very wide precluding clinical interchangeability[13].

CT scanning provides important bases for early diagnosis and treatment of COVID-19. CT imaging presentations of COVID-19 pneumonia are mostly patchy ground glass opacities in the peripheral areas under the pleura, with partial consolidation, which will be absorbed with formation of fibrotic stripes if improved[18,19]. In the present study, a significant effect of the distribution pattern of the disease on the lung parenchyma on mortality was found. Radiological lesions, which are in peripheral and of diffuse involvement, were shown to be more prominent in patients who died. A positive correlation between VBG parameters and TCTS parameters was also observed. Whereas a significant positive correlation was detected between pH and lactate levels of TCTS, a significant negative correlation between pCO_2 levels was found ($p<0.001$). To the best of our knowledge, this is the first time a significant relation between VBG indices and radiological findings in COVID-19 patients has been demonstrated. The findings of abnormal VBG detected in COVID-19 patients may be an indicator of the emergence of an inflammation, thus giving an idea about the disease prognosis. To support results herein, Shang et al.[14] reported similar results between ABG indices -but not VBG- and radiological parameters. VBG indices may be more advantageous than ABG, because it is less invasive and has a simple technique acquisition.

The main limitation of this study is not prospective, controlled and randomized study.

In conclusion, COVID-19 pneumonia is still not controlled worldwide. Since the results of RT-PCR nasopharyngeal test taken from suspected patients in ED cannot be obtained very quickly, radiological imaging supplying faster results is frequently used. A correlation between VBG parameters and radiological findings was found in these patients. In the presence of suspected disease in ED, VBG can be a complementary test not only in diagnosing of COVID-19 pneumonia, but also predicting the prognosis of the disease, as it is a cheap, simple, and non-invasive method.

AUTHOR CONTRIBUTIONS

HD: Conceptualization, Methodology, Formal Analysis, Writing – Original Draft, Writing – Review & Editing. **AK:** Conceptualization, Methodology, Formal Analysis, Writing – Original Draft, Writing – Review & Editing. **FG:** Conceptualization, Methodology, Formal Analysis, Writing – Original Draft, Writing – Review & Editing. **SS:** Data Curation. **SY:** Data Curation. **AT:** Data Curation, Conceptualization, Software, Validation. **ESC:** Data Curation, Conceptualization, Software, Validation. **NF:** Data Curation, Conceptualization, Software, Validation. **CV:** Data Curation, Conceptualization, Software, Validation. **OK:** Supervision. **TD:** Supervision. **HD:** Validation, Visualization, Writing – Original Draft, Writing – Review & Editing.

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