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CT severity score and ABG analysis are the good predictors of mortality in patients with COVID-19 in the tertiary care facility

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Abstract:
Background: *Coronavirus disease 2019 (COVID-19) episode, first revealed in Wuhan, China, has quickly spread throughout the planet just inside a month, causing a worldwide general wellbeing crisis.Predicting the outcomes of COVID-19 cases using different clinical, laboratory, and imaging parameters is one of the most exciting fields of research in this regard. In diagnosis, high resolution computed tomography (HRCT) thorax manifestations can supplement the limitations of real-time reverse transcription-polymerase chain reaction (RT-PCR) assay. The development of Acute respiratory distress syndrome (ARDS) in severe covid-19 patients has been associated with higher mortality as shown in previous literature, and arterial blood gas(ABG) analysis has been proved to be the most crucial measure to define theseverity of ARDS. This study aimed to investigate whether HRCT thorax findings and ABG analysis could predictoutcomes in covid-19 patients.*
Methodology: *This is a retrospective, single-centered, observational study. Data regarding presenting symptoms, co-morbidities, routine laboratory investigations, ABG analysis reports, and HRCT thorax findings of 181 patients with COVID-19 confirmed by nasopharyngeal swab RT-PCR test admitted at Midnapore Medical College & Hospital from 1st July to 15th August 2021 were collected and analyzed.*
Results: *Among 181 patients of mean age 54.28±12.52, 106 were male (58.6%), and 75 were female (41.4%). We have divided all the patients into two groups, non-survivor having 77(42.54%) patients and survivor having 104(57.46%) patients. We found fever is the most common symptom of presentation in patients of the survivor group (94.23%) and shortness of breath (SOB) in patients of the non-survivor group (93.5%). The presence of co-morbidities like Hypertension and Diabetes was significantly higher in the non-survivor than in the survivor group (p-value <0.05). When compared with the survivor group, patients of the non-survivor group were older, had significantly high Total leukocyte count(TLC), serum Urea and Creatinine, d-dimer, and C-reactive protein(CRP), and low serum albumin ($p < 0.05$). In an ABG analysis, we found that the non-survivor group had more hypoxemia,lower ph, lower bicarbonate level, and lower PaO2:FiO2 ratio than the survivor group. All these differences were statistically significant ($p < 0.05$). Regarding HRCT findings, we noticed the most common pattern was ground-glass opacity (86.74%), followed by consolidation (22.65%), interlobar septal thickening (20.99%). In this study, we also found CT severity scores (CTSS) were significantly higher in the non-survivor group (18.40±2.27) than the survivor group (12.24±1.62) and the p-value was <0.05.*
Conclusion: *We may conclude that CT severity score could be an important predictor of mortality in covid-19 patients, and the most characteristic CT finding in covid-19 patients is ground-glass opacity. ABG analysis performed at the bedside can also be used to predict prognosis in covid-19 patients.*
Keywords: *COVID-19, CT severity score, ABG analysis, Survivor, Non-survivor.*

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I. Introduction:

Since December 2019, several cases of pneumonia of unknown etiology have been reported in Wuhan, Hubei province, China, now known as Coronovirus disease 19(COVID-19) (1). COVID-19 is caused by novel SARS-CoV-2 (Severe acute respiratory syndrome coronavirus 2), which is a β-coronavirus (2) and share similar symptoms such as cough, fever, dyspnea and breathing problems and in severe cases, pneumonia, severe acute

respiratory syndrome (SARS), renal failure and death, with SARS-CoV infection (3). SARS-CoV-2 has been seen to be associated mainly with lower respiratory tract infections, just like what has been seen in cases of human severe acute respiratory syndrome (SARS) and middle east respiratory syndrome (MERS)(4). Previous studies have demonstrated the epidemiological, clinical characteristics, and clinical outcomes in patients with COVID-19, ranging from mild to critically ill (5)(6). The most common symptoms are fever, dry cough, shortness of breath(SOB), myalgia, headache, fatigue (7). Some previous studies(8) revealedrisk factors associated with the death of adult inpatients with COVID-19, including older age, high SOFA score, coagulation dysfunction, etc. Increased total leucocyte count(TLC), Neutrophil to lymphocyte ratio(NLR), CRP, D-dimer values, prothrombin time, urea and creatinine, decreased albumin may be indicators of a worse prognosis(9). Severe disease may occur in healthy individuals of all ages; however, it predominantly involves adults of advanced age or those with certain co-morbidities, such as hypertension, cancer, obesity, diabetes mellitus, chronic lung disease, and chronic kidney disease (10). In spite of that, explicit information about mortality risk factors in critically ill patients remains indistinct. In addition, the MuLBSTA score(11)indicated that the multi-lobular infiltrate assessed by chestradiography, or CT imaging is the most important mortality risk factor in viral pneumonia patients. At present, high-resolution computed tomography (HRCT) is considered to be an important imaging diagnostic modality and also plays an important role in the management of patients with COVID-19 (12). A large sample study showed that HRCT has a high sensitivity for diagnosing COVID-19 in the epidemic area(13).However, the predictive value of radiological findings in severe patients with COVID-19 was not reported, and previous studies mainly focused on chest radiography rather than the more practical HRCT imaging(8).

This study aimed to compare baseline clinical findings, arterial blood gas analysis, and HRCT findings between 2 groups of covid-19 positive patients, categorized as survivor and non-survivor.

II. Materials& Methods:

Study Population:

We have selected 205 patients diagnosed with COVID-19 admitted to Midnapore Medical College & Hospital, Paschim Medinipur, West Bengal, from 1st July to 15th August of 2021. Patients were admitted in MATANGINI HAZRA WARD and SARI HDU, which had been deputed for managing mild-to-moderate and severe covid-19 patients, respectively. This categorization of covid-19 patients was done according to the existing government protocol. Of these, eight were excluded due to the lack of laboratory test results and 15 were excluded because of missing CT images, and one patient referred for hematological malignancy was excluded from the study. Finally, 181 patients were included in our study. Among them, 106 were male, and 75 were female. The mean age of the patients was 54.28 ± 12.52(SD). The general clinical characteristics of the patients were collected, including age, gender, clinical symptoms, basic laboratory investigations, ABG analysis reports, and HRCT thorax findings. All the data were collected from the BHTs (bed head tickets) in the record section. For the study purpose, all patients were divided into two groups: Survivor (104 patients, 57.45%) and Death(77 patients, 42.55%).

Study design and Laboratory Investigations:

In this retrospective, single-centered and observational study conducted at Midnapore Medical College and Hospital, Paschim Medinipur, West Bengal, India, from 1st July 2021 to 15th August 2021, written informed consent was waived by the Institutional Research Committee of Midnapore Medical College and Hospital. We included adult patients (>18 years old) with confirmed severe COVID-19 (diagnosed using RT-PCR assay) infection. Mild, Moderate, and Severe COVID-19 was defined as per existing Govt. guidelines. Clinical data includes demographic information (age, gender, date of admission, date of discharge, co-morbidities), medical history, laboratory tests (routine blood tests), ABG reports, HRCT reports, and outcomes (survivor and non-survivor).

Statistical analysis:

This study's data were coded and analyzed using Statistical Package for Social Sciences (SPSS) version 28. Quantitative data of normal distribution were expressed as mean ± SD ($x \pm s$), and independent-sample t-test was used for comparison between groups; categorical data were expressed by percentage (%), and Pearson chi-square test or Fisher's exact test was used for comparison, $p < 0.05$ was considered statistically significant. The Receiver Operating Characteristic (ROC) curve was used for finding the best cut-off point of total chest CTSS in predicting the patients with a higher risk of mortality.

III. Results:

Clinical presentations and Co-morbidities (Table 1) –

All the patients included in our study were covid-19 positive confirmed by RT-PCR. Total 181 patients were divided into two groups, depending on the outcome. 104 patients(57.45%) who were given discharge were included in the Survivor group. The rest of 77 patients(42.55%) had died included in the Non-survivor group. The mean age(±) was 54.28 ± 12.52, andpatients in the Non-survivor group were older than the survivor group. Total male and female participants were 106(58.6%) and 75(41.4%), respectively. In the Non-survivor group, the most common clinical presentation was SOB (93.5%), followed by Fever (87.01%) and Cough (64.93%). In the survivor group, the most common presenting symptoms were fever (94.23%), cough (91.34%), SOB (14.28%). Other symptoms of presentation were Myalgia, Anorexia, Vomiting, sore throat, and diarrhea. The common co-morbidities in order of descending frequencies were –Hypertension (20.99%), Diabetes (12.15%), COPD (3.86%) and Hypothyroidism (3.31%), Chronic renal disease (2.76%). Compared to the survival group, death cases had a significantly higher proportion of hypertension and diabetes; the differences were statistically significant ($p < 0.05$) .

Table 1: **Information of 181 covid-19 patients, clinical presentations and co-morbidities**

Variable	All patients (n = 181)	Non-survivor (n = 77)	Survivor (n = 104)	P value
Age	54.28 ± 12.52	64.22 ± 9.17	46.91 ± 9.12	**<0.001**
Male	106 (58.6%)	46 (59.74%)	60 (33.14%)	
Female	75 (41.4%)	31 (41.26%)	44 (66.86)	
SOB	83 (45.85%)	72 (93.5%)	11 (14.28%)	**< 0.001**
Fever	165 (91.16%)	67 (87.01%)	98 (94.23%)	0.114
Cough	145 (80.11%)	50 (64.93%)	95 (91.34%)	**< 0.001**
Anorexia	12 (6.62)	3 (3.89%)	9 (8.65%)	0.241
Myalgia	11 (6.07%)	6 (7.79%)	5 (4.80%)	0.532
Sore throat	11 (6.07%)	0	11 (10.57%)	0.003
Diarrhea	9 (4.97%)	4 (5.19%)	5 (4.80%)	0.583
Vomiting	6 (3.31%)	3 (3.89%)	3 (2.88)	0.652
Hypertension	38 (20.99%)	27 (35.06%)	11 (10.57%)	**< 0.001**
Diabetes	22 (12.15%)	15 (19.48%)	7 (6.73%)	**0.012**
COPD	7 (3.86%)	5 (6.49%)	2 (1.92%)	**0.137**
Hypothyroid	6 (3.31%)	5 (6.49%)	1 (0.96%)	**0.085**
CKD	5 (2.76%)	3 (3.89%)	2 (1.92%)	**0.652**

Comparison of vitals and laboratory biomarkers between 2 groups (Table 2) –

In our study, we found total leukocyte count(TLC), Urea, Creatinine, C-reactive protein(CRP), and d-dimer were significantly higher in the non-survivor group compared to the survivor group; the differences were statistically significant ($p < 0.05$). Serum albumin level was found to be significantly low in the non-survivor group compared to that of the survivor group (p-value < 0.05). SGOT, SGPT were also compared between the two groups, but the differences were not statistically significant (p-value > 0.05). We also found that patients in the non-survivor group were more tachypneic (mean RR 32.65 ± 4.32) and more hypoxic (mean SPO2 80.44 ± 5.86) than patients of the survivor group, and the differences were statistically significant ($p < 0.05$). When we compared ABG analysis reports between these two groups, we found Non-survivor group had lower pH, pO2, bicarbonate level, and PaO2: FiO2 ratio than the survivor group.

Table 2. **Comparison of vitals, laboratory biomarkers between two groups of COVID-19 patients**

Variable	Non-survivor n = 77	Survivor n = 104	P value
SBP	118.86 ± 17.19	122.63 ± 9.26	0.059
RR	32.65 ± 4.32	17.40 ± 3.70	**<0.001**
SPO2	80.44 ± 5.86	95.06 ± 4.18	**<0.001**
TLC	17.62 ± 2.87	8.15 ± 2.53	**<0.001**
Urea	53.88 ± 12.04	32.43 ± 7.77	**<0.001**
Creatinine	1.55 ± 0.39	0.99 ± 0.16	**<0.001**
SGOT	48.33 ± 6.62	46.41 ± 6.15	0.053
SGPT	47.21 ± 6.41	46.33 ± 6.54	0.368
Albumin	2.56 ± 0.49	3.42 ± 0.41	**<0.001**
D-dimer	3236.21 ± 1156.87	829.92 ± 412.22	**<0.001**
CRP	73.26 ± 23.18	28.94 ± 14.66	**<0.001**
pH	7.32 ± 0.07	7.40 ± 0.07	**<0.001**
PO2	60.21 ± 7.47	75.76 ± 7.12	**<0.001**
PCO2	47.94 ± 5.27	47.14 ± 5.64	0.339
HCO3	21.57 ± 3.94	25.88 ± 5.05	**<0.001**
PaO2:FiO2	130.27 ± 32.37	255.20 ± 48.54	**<0.001**

Comparison of HRCT findings (Table 3) –

In our study, we found that the most characteristic CT thorax findings of COVID-19 after admission were diffuse bilateral Ground Glass Opacity (GGO) (86.74%) and consolidation (22.65%). Consolidation was found to be comparatively higher in deceased patients (26 patients, 33.76%) than the discharged patients (15 patients, 14.42%), whereas GGO was found to be more common in the survivor group (95 patients, 91.3%) than that of in non-survivor group (62 patients, 80.51%). The mean total CT severity score (CTSS) in all patients was 14.86 ± 3.61. The patients in the non-survivor group had higher CTSS than patients in the survivor group (18.40 ± 2.27 vs. 12.24± 1.62, $p < 0.001$). Other less common HRCT findings include Interlobar septal thickening (20.99%), emphysema (11.04%), Crazy paving (7.73%), pleural effusion (4.97%). Among these, crazy paving and pleural effusion were significantly more common in non-survivors than survivors ($p < 0.05$).

Table 3: Comparison of HRCT findings between Non-survivor and Survivor group of Covid-19 patients

Variable	Non-Survivor n = 77	Survivor n = 104	p value
CTSS	18.40 ± 2.27	12.24 ± 1.62	**<0.001**
Left upper lobe	1.91 ± 0.83	1.27 ± 0.50	**<0.001**
Left lower lobe	4.51 ± 0.52	3.24 ± 0.67	**<0.001**
Right upper lobe	2.92 ± 0.92	1.85 ± 0.43	**<0.001**
Right middle lobe	4.38 ± 0.69	2.68 ± 0.68	**<0.001**
Right lower lobe	4.66 ± 0.47	3.20 ± 0.76	**<0.001**
Ground Glass opacity	62 (80.51%)	95 (91.34%)	0.024
Consolidation	26 (36.76%)	15 (14.42%)	0.004
Crazy paving	12 (15.58%)	2 (1.92%)	0.001
Interlobar septal thickening	16 (20.77%)	22 (21.14%)	1.00
Pleural Effusion	7 (9.09%)	2(1.92%)	0.03
Emphysema	10 (12.98%)	10(9.61%)	0.483

The receiver operator characteristic(ROC) curves of CTSS, CRP, and D-Dimer for predicting mortality in Covid-19 patients are presented in figure 1.

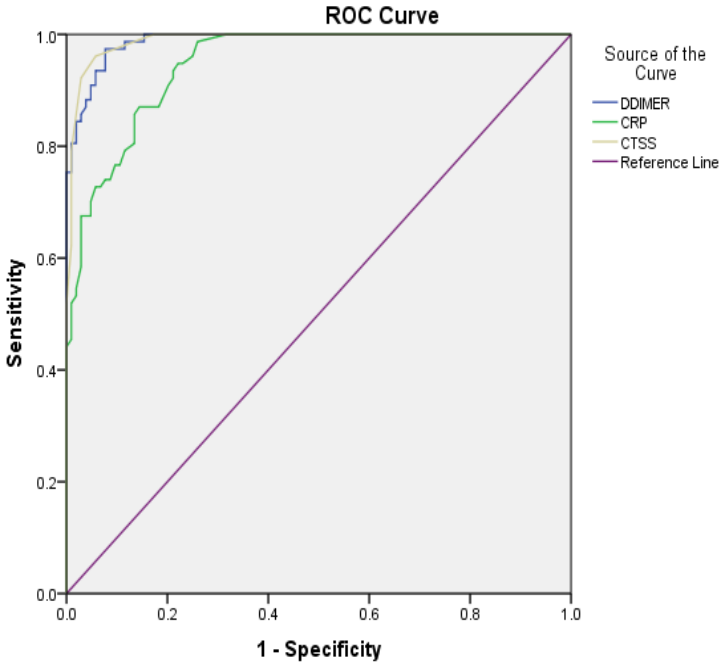

Figure 1: **CTSS, CRP, and D-Dimer prediction of COVID-19 mortality**

Area under curve(AUC) of CTSS, CRP and D-dimer are 0.989, 0.947 and 0.988 respectively. It shows CTSS is a better predictor of mortality in covid-19 patients than CRP and D-dimer.

IV. Discussion:

After the discovery of 1st case of the covid-19 case in Wuhan, China, there have been so many cases of covid pneumonia that occurred by human to human transmission in China and throughout the world and had become a pandemic (14). The presenting symptoms of this disease appeared to be very similar to that of 2003

SARS-CoV, which led to the development of acute respiratory distress syndrome (ARDS) and might cause deathto a number of patients. So we got interested in analyzing HRCT findings and ABG analysis in patients of covid-19 to provide early diagnosis, timely isolation, prompt treatment, and predict the prognosis (15).

In this study, we included 181 patients with RT-PCR confirmed covid-19 of mean age 54.28±12.52; among them, 106 were male (58.6%), and 75 were female (41.4%). As in some previous studies, we found mortality rates are higher in elderly patients (16)(17)(18). Mean age(±SD) in the non-survivor group and survivor group were 64.22±9.17 and 46.91±9.12, respectively. In this study, common symptoms of presentation were – fever (94.23% in survivor and 87.01% in the non-survivor group), SOB (14.28%% in survivor and 93.5% in the non-survivor group), cough(91.34% in survivor and 64.93% in non-survivor group). SOB was found to be significantly higher in the non-survivor group (p-value <0.05), which is also seen in some previous studies(19)(20)(21)(6). In the survivor group, fever was the commonest mode of presentation (22), and other presenting symptoms were anorexia, myalgia, sore throat, diarrhea, and vomiting.

In some previous studies, we have seen hypertension as a risk factor for adverse outcomes of COVID-19 patients; our study shows the presence of hypertension was significantly higher in the non-survivor group compared with the survivor group ($p < 0.05$)(23)(24)(25)(26). Diabetes was present in 15 patients(19.48%) of non-survivor patients and in 7 patients(6.73%) of the survivor group and found to be statistically significant while comparing between two groups ($p < 0.05$)(27)(28)(29). Hypothyroidism was found in 1 patient in survivors and five patients in the non-survivor group and was not found to be significantly higher in the death group ($p > 0.05$)(30). In this study, chronic kidney disease(CKD) and/or Chronic obstructive pulmonary disease(COPD) was not associated significantly with the non-survivor group compared with the other one ($p>0.05$); however, in some previous studies, CKD and COPD had been considered as an important mortality predictor in covid-19 patients (31)(32).

In our study, we found. Total leukocyte count (TLC), C-reactive protein(CRP), and D-dimer were significantly increased in patients of the non-survivor group compared to the survivor group ($P <0.001$), and previous studies also had shown similar results (7)(33)(34)(35)(36). Serum albumin level was found to be significantly lower in the non-survivor group in comparison to the survivor group (37). Multiple previous studies have identified kidney injury(increased urea and creatinine) as a sequela frequently present in the Covid-19 patients with severe disease, many of whom expired(38). In our study, urea and creatinine were significantly higher in the death group compared to the survivor group ($p < 0.001$). The liver enzyme, SGOT, and SGPT were not significantly increased in the non-survivor group compared to the survivor group, but some previous studies had shown the opposite result (39). ARDS characterized by acute, diffuse, inflammatory lung damage is one of the most common causesof respiratory failure in severely ill patients with viral pneumonia(40), and some previous studies documented that ARDS happened to be an independent predictor of high mortality in severe covid-19 patients (41). The severity of the hypoxemia defines the severity of the ARDS: 1> Mild ARDS. The PaO_2/FiO_2 is > 200 mmHg, but ≤ 300 mmHg, on a ventilator with positive end-expiratory pressure (PEEP) or continuous positive airway pressure ≥ 5 cm H_2O, 2> Moderate ARDS—The PaO_2/ FiO_2 is > 100 mmHg, but ≤ 200 mmHg, on a ventilator with a PEEP ≥ 5 cm H_2O, 3>Severe ARDS—The PaO_2/ FiO_2 is ≤ 100 mmHg on a ventilator with a PEEP ≥ 5 cm H_2O(42). When we compared ABG analysis reports of the two groups, we found mean (±SD) pH was lower in the non-survivor group (7.32±0.076) compared to the survivor (7.40±0.07), partial arterial pressure of oxygen (po2) was lower in non-survivor (60.21±7.46) than survivor group (75.76±7.12), Pa02:Fio2 (Fraction of inspired oxygen) ratio was lower in non-survivor (130.27±32.37) compared to survivor (255.20±48.54) group, and Hco3(bicarbonate) level was also lower in non-survivor (21.57±3.94) than survivor (25.88±5.050) and all these findings were statistically significant ($p <0.001$) (43)(44).

The predominant HRCT findings for severe pneumonia patients, defined by the Fleischner Societyglossary, were as following: ground-glass opacities (GGO), consolidation, interlobular septal thickening, crazy pavingpattern, air bronchogram, pneumonectomies, pleural effusion, and pneumomediastinum (25). According to many previous studies hallmark of COVID-19 pneumonia is the presence of bilateral GGOs with or without consolidative areas, with a predominant peripheral, lower lobes, and posterior anatomic distribution(45)(46). In this, we found CT severity score(CTSS) of the covid-19 patients in the non-survivor group (18.40±2.27) were remarkably higher than those in the survivor group (12.24±1.62), and it was statistically significant ($p<0.001$) (20)(47). Ground glass opacity(GGO) was found to be the commonest CT findings in both non-survivor (80.51%) and survivor groups (91.34%), followed by Consolidation, Interlobar septal thickening, and crazy paving(48). Pleural effusion and emphysema were the less common CT findings. Consolidation, Crazy paving, and Pleural effusion were significantly higher in the non-survivor group in comparison to the survivor group (p-value < 0.05) (49)(50). Specifically speaking, each of the five lung lobes was visually scored from 0 to 5 as 0 indicating no involvement;1, < 5% of the lobe (minimal but not normal), 2, 5–25% of the lobe, 3, 26–49% of lobe; 4,50–75% of lobe; and 5,> 75% of lobe and finally, the total CT severity score(CTSS) was calculated by summing the individual lobar scores (range of possible scores from 0 to 25)(25).In our study, we found all five lobes are more involved in the non-survivor group than the survivor group, and the findings were statistically significant ($p < 0.001$). We also noticed that the Left lower lobe(LLL)

was the most common lobe involved in patients of the survivor group, and the Right lower lobe (RLL) was the commonest lobe involved in the non-survivor group.

V. Conclusion:

In conclusion, we can say that CT severity score could be an important predictor of mortality in covid-19 patients. The predominant chest CT finding in covid-19 patients is ground-glass opacity involving both lungs, and multiple lobes, especially the lower lobes are commonly affected.Diabetes and hypertension can be considered as risk factors for the outcome of covid-19 infection, and more intensive attention should be paid to patients with diabetes and hypertension. Also, we conclude raised total leukocyte count, increased CRP, d-dimer, urea, creatinine, and decreased serum albumin are associated with increased mortality risk in COVID-19 patients. Regarding ABG analysis, we conclude that lower pH, lower bicarbonate level, hypoxemia, and reduced PaO2:FiO2 ratio are associated with increased mortality risk.

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