Turk Thorac J 2022; 23(5): 307-321 DOI: 10.5152/TurkThoracJ.2022.21029

Original Article

Coronavirus Disease 2019 Pneumonia Scoring System Comparison and Risk Factors

Kerem Ensarioğlu[1], Ayse Kevser Erdöl[1], Bahar Kurt[1], İrfan Şencan[2], İbrahim Hikmet Fırat[1], Melike Bağnu Yüceege[1], Serap Duru Akçalı[1]

[1]Department of Pulmonary Medicine, Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey
[2]Department of Infectious Diseases and Clinical Microbiology, Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey

Cite this article as: Ensarioğlu K, Kevser Erdöl A, Kurt B, et al. Coronavirus disease 2019 pneumonia scoring system comparison and risk factors. *Turk Thorac J.* 2022;23(5):307-321.

Abstract

OBJECTIVE: Coronavirus disease 2019 is a disease caused by severe acute respiratory syndrome coronavirus 2, a novel type of coronavirus, which causes pneumonia in some hosts. No specific scoring method exists for mortality evaluation in novel coronavirus pneumonia. The aim of this study was to investigate factors affecting coronavirus disease 2019 mortality and comparison of pneumonia scoring systems, pneumonia severity index, CURB-65, and MuLBSTA.

MATERIAL AND METHODS: In this single-center clinical study, 151 patients who had been diagnosed with coronavirus disease 2019 infection and pneumonia between March 11 and May 31, 2020, were evaluated retrospectively. Correlation between patients' symptoms, comorbidities, drugs in use, radiological findings, and mortality was investigated. Parameters were also evaluated regarding their contribution to additional treatment requirements and days of fever response.

RESULTS: A correlation between mortality and higher scores of pneumonia severity index, CURB-65, and MuLBSTA was found. When parameters were investigated separately, elevated glucose and urea levels, presence of diabetes, renal failure, hypertension, chronic obstructive pulmonary disease, cerebrovascular events and known malignancies, lymphocyte count, smoking history, radiological findings, and age correlated with mortality.

In addition to these parameters, elevated calcium, potassium, brain natriuretic peptide, troponin, D-dimer, C-reactive protein, HC03, and lactate dehydrogenase levels were found significant regarding mortality. These parameters were not found statistically relevant regarding additional treatment requirement, fever response day, and total treatment duration.

CONCLUSION: A modified version of present pneumonia scoring systems will be required to rigorously evaluate the severity of a patient's condition. A new scoring system that uses components of the present ones may prove useful and with further studies, a similar follow-up algorithm may be created.

KEYWORDS: Clinical Protocol, COVID-19, mortality, pneumonia, scoring methods, risk factor scores
Received: *March 31, 2021* ***Accepted:*** *March 30, 2022* ***Available Online:*** *June 14, 2022*

INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a newly identified type of coronavirus. It was deemed pandemic by World Health Organization, and the first COVID-19 case in Turkey was reported on March 10, 2020. As a novel infection, guidelines and approaches were developed on the road. The same can be said for treatment modalities, as in addition to differences between countries, hospitals within the same city often did not agree on a uniform approach. Patient isolation and follow-up protocols have also changed over time, both with the results of new studies being recently published and according to limitations of healthcare utilities.

As a novel infection, COVID-19 pneumonia has been treated in a quite similar fashion to other viral pneumonia, with key differences being in antiviral treatment and support modalities. Modifications of former treatments and follow-up protocols have been the norm so far, due to limited data available regarding the disease and its progression. The goal behind this study was to evaluate COVID-19 infection and pneumonia, starting from the first patient admitted to our hospital, to have a better understanding of the disease.

The purpose of the study was to lay the foundation of an optimal screening process for pneumonia severity by comparing 3 present scoring systems, pneumonia severity index (PSI), CURB-65, and MuLBSTA, thus eliminating unnecessary hospitalization and determining which patients may require intensive care admission. An additional goal was to evaluate which parameters, ranging from demographic to laboratory markers, have an impact on disease and its response to treatment.[1-3]

Corresponding author: Kerem Ensarioğlu, e-mail: kerem.ensarioglu@gmail.com

MATERIALS AND METHODS

Study Design

In this retrospective study, patients who had been diagnosed with COVID-19 infection between March 11 and May 31, 2020, by real-time polymerase chain reaction (RT-PCR) were investigated. According to hospital policy, sampling had been done from both the nasopharynx and oropharynx with the same swab to increase accuracy. Evaluation of patients was performed only if they had been previously consulted by either Infectious Diseases or Pulmonary Medicine departments.

Patients who had been treated in outpatient care were excluded from the study. Similarly, patients who were diagnosed with COVID-19 during hospitalization for other reasons and then admitted to COVID-19 wards were also excluded from the study. These precautions were taken to ensure an unbiased evaluation regarding treatment response.

The faculty ethics board provided ethics approval (Decision No 90/12 and date June 22, 2020). Patients' data from the hospital management system and the national COVID-19 database were accessed for evaluation. Patients provided written and verbal consent for hospital admission and treatment. A spreadsheet form was utilized for initial data collection, in which demographic information, physical examination, routine blood testing results, radiological findings, and treatment regimens of the patients were present. Physical inspection notes and laboratory results were taken at the time of admission.

Definitions

Coronavirus disease 2019 RT-PCR-positive patients were defined as the study population. Patients with COVID-19 diagnosis and radiological findings, regardless of typical or atypical, were categorized under COVID-19 pneumonia diagnosis. Radiological imaging was performed on every patient, initially with direct chest radiography, and if any pathological finding is present or if the doubt of pneumonia is high, an additional computed chest tomography was requested. As such, the radiological findings section utilizes both imaging modalities in this study. Comorbidities were defined as any illness present upon admission or diagnosed during hospitalization, regardless of the presence of former treatment.

A patient was considered under treatment for a specific drug only if said drug had been used by the patient before admission to hospital. Additional treatment requirement was accepted as either a change of the present treatment regimen and/or addition of a new drug to the current regimen, which includes antiviral drugs and antibiotics.

Progression was defined as clinical worsening of a patient under treatment, which may lead to an intensive care admission. Treatment response was based on multiple parameters, including fever response of patients who had fever upon admission, reduction in inflammatory markers, and improvement in vital signs, with the most important vital sign designated as saturation above 94% in room air.

Statistical Analysis

Before statistical analysis, patients' data were unified in suitable Microsoft Excel documents. Analyses and calculations were then performed by IBM's Statistical Package for the Social Sciences software, version 22, after converting said documents. A patient's data were considered inadequate if a section of the patient's data spreadsheet was missing or was not declared, such as a lack of reported physical inspection notes or inappropriate medical background questioning. In these cases, the data of the patient were removed from the study entirely. A parameter was considered inadequate if, for any reason, it was not reported in more than 10% of the total data. In this case, the parameter itself was removed, and if it had any reliant parameters to it, they were also removed.

Mann-Whitney *U* test was used to distinguish parameters regarding mortality. Pearson's correlation analysis was used to evaluate the pneumonia scoring systems' effect on progression and mortality. Linear multiple regression analyses were performed to investigate factors affecting treatment duration, additional treatment requirement, and treatment response. If a parameter was found relevant after Pearson's analysis, linear regression analysis was utilized to investigate the degree of the parameter's effect.

Hypothesis

The hypotheses of the study can be summed in 2 parts. First, it is assumed that pneumonia scoring systems that include end-organ failure parameters (such as PSI) or are already in use for viral infections (MuLBSTA) will prove superior in terms of evaluating mortality.

Secondly, a correlation is expected between additional treatment requirements and parameters used in the study, such as inflammatory index score, initial vital signs, comorbidities, and C-reactive protein (CRP) level. This correlation is assumed to be present in both COVID-19 infection and in case of the presence of COVID-19 pneumonia.

MAIN POINTS

- Coronavirus disease 2019 (COVID-19) infection may differ from COVID-19 pneumonia in terms of factors affecting prognosis and mortality.
- Pneumonia severity index and MuLBSTA scoring systems perform better at evaluation of mortality in COVID-19 pneumonia, compared to CURB-65. This is attributed to parameters within these scoring systems.
- Additional parameters have been described, mainly increased calcium, potassium, brain natriuretic peptide, troponin, D-Dimer, C-reactive protein, HCO_3, and lactate dehydrogenase levels, that are not present in available scoring systems.
- A revision of available scoring systems or a newly designed system may prove reliable for COVID-19 pneumonia severity evaluation.

RESULTS

A total of 590 patients were evaluated during initial screening, and 181 were found positive for COVID-19 infection and

were included in the study. These patients' records were then investigated, and 30 patients were excluded from the study due to missing data criteria. The remaining 151 patients were then evaluated (Figure 1).

Average age of patients was 50 (±17) years. Patients' age varied between 18 and 91 and had a homogenous spread. Sixty-nine patients (45%) were male and 82 (55%) were female. In symptom evaluation, fever (n = 37, 41%), coughing (n = 80, 53%), and dyspnea (n = 45, 30%) were the most common symptoms. Smoking history evaluation was limited as 50% of patients either could not provide a conclusive history of smoking or were not questioned about it. Of the remaining patients who had been questioned, 59 (76%) were non-smokers. Hypertension (n = 45, 29.8%) and diabetes (n = 25, 16.7%) were the most prominent comorbidities. Treatment for these comorbidities was also the most common, however, at a lower rate (n = 28, 18.5% and n = 11, 7.3%, respectively) compared to diagnoses, indicating that for most patients, treatment of hypertension and diabetes had begun after hospital admission. Pneumonia was present in more than 86 patients (63.2%) and was often bilateral (n = 72, 84.9%). Hydroxychloroquine sulfate was the treatment of choice in 86.8% (n = 131), followed by azithromycin in 42.4% (n = 64) and favipiravir in 37.7% (n = 57).

Treatment was completed with a successful hospital discharge for most patients (78%) within 5 days. The average duration of treatment was 5.87 (±2.01) days, 124 (82.1%) of patients did not require additional treatment, while 8 (5.3%) had additional treatment and the rest 19 (12.6%) required intensive care admission in addition to treatment revision. Eight patients (5.3%) died and all were patients who had additional treatment and were in intensive care units. Oxygen saturation percentage was the only vital sign that was found significant in mortality analysis.

For all patients with COVID-19 infection, white blood cell count (WBC), glucose, urea, creatinine, calcium, potassium, N-terminal pro-hormone brain natriuretic peptide (NT-proBNP), troponin, fibrinogen, D-dimer, CRP, LDH, and serum HC03 levels were found as statistically significant laboratory markers for mortality ($P < .05$). Age, presence of comorbidities (hypertension, renal failure, cerebrovascular event history, known malignancies, diabetes, and chronic obstructive pulmonary disease (COPD)), and drug regimens (antidiabetics and acetylsalicylic acid) were found statistically significant for mortality ($P < .05$) (Tables 1 and 2).

Radiologically, as pneumonia progresses to a diffuse pattern, the need for additional treatment requirement increases. Age, hypertension, known malignancy, and elevated inflammatory markers were found to be relevant regarding increased treatment duration, response of fever, and additional treatment requirements (Table 3).

Pneumonia severity index (55 ± 21 vs. 94 ± 24) and MuLBSTA (6.4 ± 3.6 vs. 12.2 ± 3.5) scores were lower for survivors, compared to CURB-65 (0.86 ± 4.06 vs. 1.75 ± 0.89), in which a significant difference was not observed. For mortality evaluation, higher PSI, MuLBSTA, and CURB 65 scores were found to have a positive correlation with increased

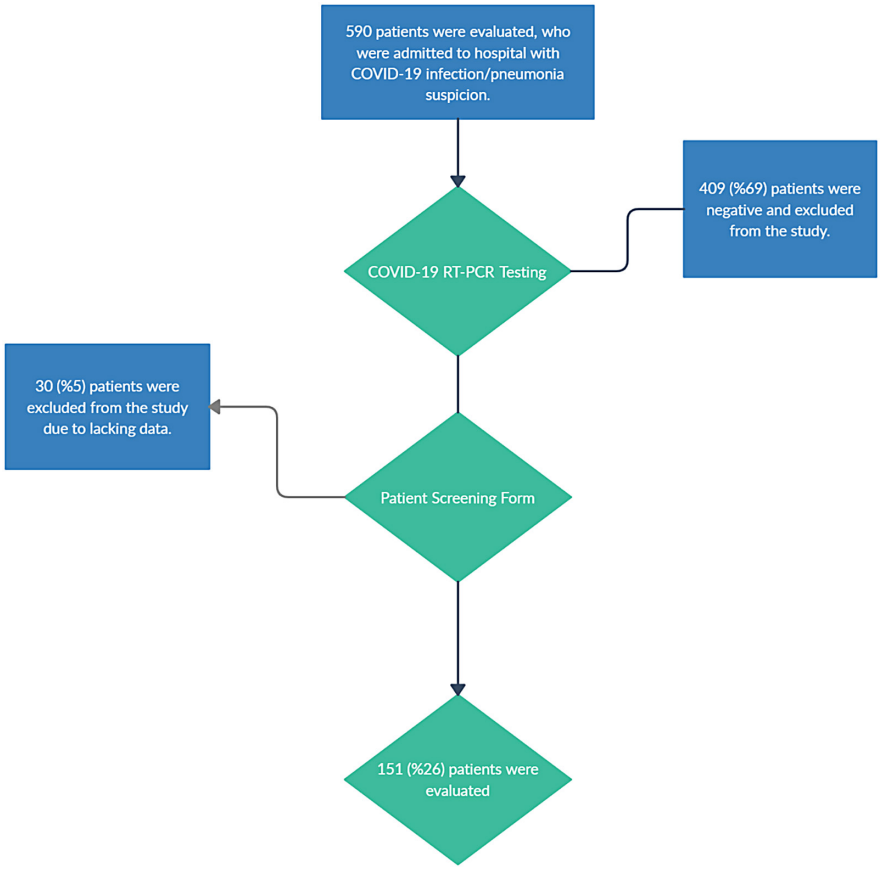

Figure 1. Patient Selection Flow Chart

Table 1. Mann–Whitney *U* Test Results, According to Survival 1

		Number	Median	25th Percentile	75th Percentile	*P*
Systolic T.	Exitus	4	130	112.50	147.50	.328
	Alive	74	120	110.00	130.00	
Diastolic	Exitus	4	76.5	63.25	80.00	.458
	Alive	74	80	70.00	87.75	
Mean	Exitus	4	2.67	81.33	102.50	.945
	Alive	74	93.33	83.33	100.00	
Pulse rate	Exitus	3	80	64.00		.209
	Alive	93	87	80.00	97.50	
Saturation	Exitus	3	87	18.00		.021
	Alive	104	95	93.00	96.00	
Fever	Exitus	4	36.55	36.13	36.90	.286
	Alive	105	36.8	36.45	37.20	
Respiratory rate	Exitus	2	23.5	20.00		.217
	Alive	59	20	17.00	22.00	
BCG	Exitus	3				.139
	Alive	85				
WBC	Exitus	8	6.23	4.09	9.30	.255
	Alive	142	4.9	3.81	6.79	
HB	Exitus	8	12.2	9.95	13.20	.026
	Alive	142	13.7	12.50	14.80	
PLT	Exitus	8	168.5	146.50	218.25	.166
	Alive	142	213	169.76	269.75	
NEU%	Exitus	8	84.15	75.50	90.10	<.001
	Alive	142	62.85	51.45	71.67	
LYM%	Exitus	8	8.8	5.43	16.70	<.001
	Alive	142	27.15	18.20	36.80	
NEU#	Exitus	8	4.4	3.55	7.56	.019
	Alive	142	3.21	2.17	4.54	
LYM#	Exitus	8	0.5	0.32	1.20	.002
	Alive	142	1.41	0.97	1.79	
MCV	Exitus	8	87.6	82.70	89.60	.294
	Alive	142	85.25	82.20	87.92	
Glucose	Exitus	8	150	120.25	238.00	.008
	Alive	137	103	91.50	121.00	
Urea	Exitus	8	48.5	38.25	74.60	<.001
	Alive	139	27	21.00	35.80	
Creatinine	Exitus	8	1.08	0.93	2.02	.001
	Alive	140	0.74	0.62	0.93	
Total bilirubin	Exitus	8	0.35	0.21	0.50	.57
	Alive	139	0.4	0.29	0.59	
Direct bilirubin	Exitus	8	0.25	0.14	0.31	.321
	Alive	139	0.19	0.14	0.26	
AST	Exitus	8	30.75	16.50	51.25	.167
	Alive	140	21.6	15.02	28.00	

(*Continued*)

Table 1. Mann–Whitney *U* Test Results, According to Survival 1 (*Continued*)

		Number	Median	25th Percentile	75th Percentile	*P*
ALT	Exitus	8	19.75	15.25	22.50	.845
	Alive	140	19.5	14.00	29.60	
Ca	Exitus	8	8.24	7.66	8.59	.024
	Alive	137	8.72	8.39	9.15	
Na	Exitus	8	136	133.50	139.25	.12
	Alive	140	139	136.00	140.00	
K	Exitus	7	4.31	4.08	4.68	.042
	Alive	140	4.08	3.79	4.35	
Cl	Exitus	7	98	93.00	102.00	.382
	Alive	138	100.5	98.00	103.00	
Procalcitonin	Exitus	8	0.56	0.16	4.77	<.001
	Alive	106	0.06	0.03	0.11	
Ferritin	Exitus	6	311.5	166.93	731.50	.135
	Alive	103	136	57.90	355.00	
BNP	Exitus	7	1766	681.50	3089.00	.004
	Alive	127	42.5	17.99	104.70	
Trop	Exitus	8	0.13	0.03	0.95	<.001
	Alive	129	0	0.00	0.00	
Fibrin.	Exitus	6	600.6	407.50	756.50	.005
	Alive	123	346	290.00	440.00	
Dimer	Exitus	8	0.92	0.35	4.10	.004
	Alive	136	0.27	0.00	0.47	
CRP	Exitus	8	207.49	131.96	273.02	<.001
	Alive	130	10.79	3.09	35.02	
LDH	Exitus	7	279	227.00	466.00	.029
	Alive	135	197	164.00	248.00	
CK	Exitus	8	119.5	40.50	607.50	.385
	Alive	138	74.5	54.00	137.00	
CK-MB	Exitus	8	26	13.20	43.50	.235
	Alive	132	16	13.00	21.00	
Sedimentation	Exitus	1	4			.17
	Alive	61	16	7.00	35.50	
Ph	Exitus	8	7.42	7.33	7.46	.86
	Alive	79	7.4	7.36	7.43	
Lactate	Exitus	8	1.5	1.15	4.55	.752
	Alive	79	1.7	1.30	2.40	
HC03	Exitus	8	21.35	13.10	24.85	.032
	Alive	79	24.7	22.80	26.60	
INR	Exitus	7	1.14	1.03	1.21	.095
	Alive	132	1.04	1.00	1.11	
Total Pro.	Exitus	3	58	50.00		.261
	Alive	79	64.4	60.40	68.60	
Albumin	Exitus	4	30.9	26.45	42.25	.152
	Alive	84	38.6	35.05	42.37	

(*Continued*)

Table 1. Mann–Whitney *U* Test Results, According to Survival 1 (*Continued*)

		Number	Median	25th Percentile	75th Percentile	*P*
GGT	Exitus	2	16.5	16.00		.298
	Alive	75	27	15.00	50.00	
ALP	Exitus	2	57	41.00	16.00	.374
	Alive	73	68	58.50	80.00	
CURB 65	Exitus	8	1	1.00	2.75	<.001
	Alive	79	0	0.00	1.00	
PSI	Exitus	8	94	68.75	118.75	<.001
	Alive	79	52	41.00	65.00	
Mulbsta	Exitus	8	13	11.00	14.50	<.001
	Alive	79	5	5.00	9.00	
Inflam. Ind.	Exitus	8	1118.5	759.25	2009.25	.002
	Alive	142	469	274.75	852.75	

BCG, Bacillus Calmette-Guerin; WBC, white blood cell; HB, hemoglobin; PLT, platelet; NEU, neutrophil; LYM., lymphocyte; MCV, mean corpuscular volume; BNP, brain natriuretic peptide; Trop, troponin; fibrin, fibrinogen; CRP, C-reactive protein; LDH, lactate dehydrogenase; CK, creatinine kinase; Total Pro, total protein; PSI, pneumonia severity index; Inflam. Ind, inflammatory index.

additional treatment requirements and increased mortality. (For mortality, all had $P < .001$ and correlation coefficient was −0.382, −0.383, and −0.434 respectively. For treatment requirement, all had $P < .001$ and correlation coefficient was 0.352, 0.484, and 0.463 respectively.)

The correlation to mortality was more significant with a higher score in PSI and MuLBSTA compared to CURB 65. Pneumonia severity index scoring was also observed as more significant for correlation between treatment requirement and a higher score, compared to PSI and MuLBSTA. Thus, it can be assumed that PSI is overall superior at evaluation of treatment and mortality, followed by MulBSTA which is only superior in the prediction of mortality compared with CURB-65 (Tables 4, 5, and 6).

In linear multiple regression analysis, fever, additional treatment requirement, and total treatment duration have not been found statistically correlated with patients' age, smoking history, inflammatory index, WBC, CRP, procalcitonin, and D-dimer ($P = .894$, adjusted $R^2 = -0.297$, $P = .184$, adjusted $R^2 = 0.208$ and $P = .409$, adjusted $R^2 = 0.057$, respectively).

Regarding patients with pneumonia, a positive correlation between treatment duration and antihypertensive usage was observed in linear multiple regression analysis, as patients under calcium channel blocker treatment had a longer treatment duration ($P = .043$, correlation coefficient = 0.219 and $P = .003$, correlation coefficient = 0.314).

Additional treatment requirement for patients with pneumonia was found statistically relevant with age, inflammatory index, procalcitonin, D-dimer, lymphocyte count, and CRP levels, with the highest correlation being seen with CRP elevation ($P < .001$, $P = .026$, $P = .008$, $P = .034$, $P < .001$, $P = ,001$, respectively, and correlation coefficients were 0.348, 0.241, 0.310, 0.236, −0.416, and 0.351 respectively). Individual parameters were investigated with separate linear regression models for these results.

DISCUSSION

The success of PSI and MuLBSTA's scoring regarding mortality evaluation can be attributed to their individual parameters' role in patient prognoses, as seen in validation analysis. This observation suggests that patients with higher scores should be candidates for hospitalization/intensive care admission. The same cannot be stated for additional treatment requirements, as all 3 modalities were found relevant in the evaluation of treatment. These modalities have been supported in COVID-19 pneumonia evaluation by studies.[4,5] Superiority of PSI over CURB-65 had been reported in a case series by Satici et al.[6] which supports our results.[6] Same study also tried a modified PSI with CRP for evaluation, however, no significant differences were observed compared to non-modified PSI. New scoring system trials with new scoring systems have also been performed, such as Dong Ji and colleagues' study which utilizes age, comorbidities, lymphocyte, and LDH levels.[7] Regarding elevated levels of inflammatory markers, there was no correlation between these and additional treatment requirements, unlike stated in our second hypothesis. This pattern suggests the possibility that, while inflammatory markers certainly play a role in influencing the pneumonia modalities, due to the fact they are either not a part of them, such as in CURB-65, or partly play a role, in case of PSI, their role in the overall prediction of treatment results remain insignificant.

When all parameters affecting mortality are evaluated separately, elevated glucose and urea levels, presence of diabetes, renal failure, COPD, cerebrovascular events, and known malignancies are part of the PSI scoring system, while lymphocyte count, smoking history, and presence of hypertension are exclusive for MuLBSTA. For both scoring systems, age and radiological findings are common parameters. This

Table 2. Mann Whitney *U* Test Results, According to Survival-2

		N	Average	Avg. Order	*P*
Smoking	Exitus	3	0.67	44.83	.533
	Alive	74	0.3	38.76	
Hypertension	Exitus	8	1	120.5	<.001
	Alive	133	0.26	68.02	
Diabetes	Exitus	8	0.63	101.13	<.001
	Alive	130	0.14	67.55	
COPD	Exitus	8	0.13	77.19	.039
	Alive	131	0.02	69.56	
Asthma	Exitus	8	0.13	74.69	.401
	Alive	131	0.05	69.71	
Known malignancy	Exitus	8	0.13	77.63	<.001
	Alive	130	0	69	
Heart failure	Exitus	8	0	67	.573
	Alive	130	0.04	69.65	
Coronary heart disease	Exitus	8	0.25	81.25	.068
	Alive	130	0.07	68.78	
Renal disease	Exitus	8	0.13	77.13	.007
	Alive	130	0.01	69.03	
Cerebrovascular event history	Exitus	8	0.38	92.38	<.001
	Alive	130	0.02	68.09	
Antihypertensive	Exitus	8	0.38	90.31	.158
	Alive	143	0.17	75.2	
Antidiabetic	Exitus	8	0.25	89.38	.048
	Alive	143	0.06	75.25	
Anticoagulant and antiaggregant	Exitus	8	0.25	88.38	.091
	Alive	143	0.08	75.31	
Beta blocker	Exitus	8	0	70.5	.417
	Alive	143	0.08	76.31	
Ace inhibitors	Exitus	8	0.13	80.44	.494
	Alive	143	0.06	75.75	
Calcium channel blockers	Exitus	8	0.25	88.88	.068
	Alive	143	0.07	75.28	
Aspirin	Exitus	8	0.25	89.38	.048
	Alive	143	0.06	75.25	
Spironolactone	Exitus	8	0	75	.737
	Alive	143	0.01	76.06	
Nebulizing treatment	Exitus	8	0	74.5	.68
	Alive	143	0.02	76.08	
Thyroid hormone replacement	Exitus	8	0	74	.633
	Alive	143	0.03	76.11	
Immunosuppression	Exitus	8	0	74.5	.68
	Alive	143	0.02	76.08	
Insulin	Exitus	8	0	75	.737
	Alive	143	0.01	76.06	
Oral antidiabetic	Exitus	8	0.25	90.38	.02
	Alive	143	0.05	75.2	
Anticoagulant	Exitus	8	0	74.5	.68
	Alive	143	0.02	76.08	
Total treatment duration	Exitus	8	8.25	104.5	.008
	Alive	143	5.74	74.41	
Fever response day	Exitus	8	2	91.44	.204
	Alive	143	1.08	75.14	
Additional treatment requirement	Exitus	8	1.75	132.06	<.001
	Alive	143	0.22	72.86	

COPD, chronic obstructive pulmonary disease.

Table 3. Total Treatment Duration, Fever Response Day, and Additional Treatment Requirement Spearman Correlation with Other Parameters

		Total Treatment Duration	Fever Response Day	Additional Treatment Requirement
Age	Correlation coefficient	**0.252****	0.072	**0.357****
	Sig. (2-tailed)	.002	.377	<.001
	N	151	151	151
Smoking	Correlation coefficient	0.125	0.003	0.096
	Sig. (2-tailed)	.279	.978	.408
	N	77	77	77
Hypertension	Correlation coefficient	0.129	0.028	**0.216***
	Sig. (2-tailed)	.129	.741	.010
	N	141	141	141
Diabetes	Correlation coefficient	0.130	0.107	0.090
	Sig. (2-tailed)	.129	.210	.292
	N	138	138	138
COPD	Correlation coefficient	0.055	−0.003	0.063
	Sig. (2-tailed)	.520	.971	.463
	N	139	139	139
Asthma	Correlation coefficient	0.041	0.057	0.049
	Sig. (2-tailed)	.634	.506	.568
	N	139	139	139
Known malignancy	Correlation coefficient	0.171*	−0.054	0.189*
	Sig. (2-tailed)	.045	.526	.026
	N	138	138	138
Heart failure	Correlation coefficient	−0.068	−0.029	0.011
	Sig. (2-tailed)	.431	.736	.894
	N	138	138	138
Coronary heart disease	Correlation coefficient	0.144	0.063	**0.147**
	Sig. (2-tailed)	.093	.464	.085
	N	138	138	138
Renal disease	Correlation coefficient	−0.055	−0.077	0.105
	Sig. (2-tailed)	.522	.368	.220
	N	138	138	138
Cerebrovascular event history	Correlation coefficient	0.023	-0.040	0.089
	Sig. (2-tailed)	.790	.643	.298
	N	138	138	138
Antihypertensive	Correlation coefficient	0.237**	-0.044	0.190*
	Sig. (2-tailed)	.003	.592	.019
	N	151	151	151

(*Continued*)

Table 3. Total Treatment Duration, Fever Response Day, and Additional Treatment Requirement Spearman Correlation with Other Parameters (*Continued*)

		Total Treatment Duration	Fever Response Day	Additional Treatment Requirement
Antidiabetic	Correlation coefficient	0.104	0.029	0.079
	Sig. (2-tailed)	.203	.728	.335
	N	151	151	151
Anticoagulant and antiaggregant	Correlation coefficient	0.099	0.026	0.116
	Sig. (2-tailed)	.228	.753	.157
	N	151	151	151
Beta blocker	Correlation coefficient	−0.013	−0.002	−0.061
	Sig. (2-tailed)	.877	.979	.460
	N	151	151	151
Ace inhibitors	Correlation coefficient	0.081	0.063	0.168*
	Sig. (2-tailed)	.326	.439	.039
	N	151	151	151
Calcium channel blockers	Correlation coefficient	0.285**	-0.083	0.187*
	Sig. (2-tailed)	<.001	.313	.021
	N	151	151	151
Aspirin	Correlation coefficient	0.130	0.060	**0.149**
	Sig. (2-tailed)	.113	.461	.068
	N	151	151	151
SpiroNolactone	Correlation coefficient	0.093	0.068	0.105
	Sig. (2-tailed)	.255	.405	.201
	N	151	151	151
Nebulizing treatment	Correlation coefficient	−0.064	0.034	−0.066
	Sig. (2-tailed)	.434	.675	.420
	N	151	151	151
Thyroid hormone replacement	Correlation coefficient	0.011	−0.013	−0.077
	Sig. (2-tailed)	.891	.875	.349
	N	151	151	151
Immunosuppression	Correlation coefficient	−0.064	-0.091	−0.066
	Sig. (2-tailed)	.434	.267	.420
	N	151	151	151
Insulin	Correlation coefficient	−0.052	0.032	−0.054
	Sig. (2-tailed)	.525	.696	.511
	N	151	151	151
Oral antidiabetic	Correlation coefficient	0.139	0.016	0.113
	Sig. (2-tailed)	.088	.847	.168
	N	151	151	151

(*Continued*)

Table 3. Total Treatment Duration, Fever Response Day, and Additional Treatment Requirement Spearman Correlation with Other Parameters (*Continued*)

		Total Treatment Duration	Fever Response Day	Additional Treatment Requirement
Anticoagulant	Correlation coefficient	−0.064	−0.091	−0.066
	Sig. (2-tailed)	.434	.267	.420
	N	151	151	151
WBC	Correlation coefficient	0.066	**−0.205***	0.023
	Sig. (2-tailed)	.421	.012	.782
	N	150	150	150
LYM#	Correlation coefficient	**-0.174***	**-0.216****	-0.367**
	Sig. (2-tailed)	.033	.008	<.001
	N	150	150	150
Inflam. Ind.	Correlation coefficient	0.072	-0.011	0.200*
	Sig. (2-tailed)	.382	.897	.014
	N	150	150	150
Procalcitonin	Correlation coefficient	**0.231***	0.117	0.371**
	Sig. (2-tailed)	.014	.216	<.001
	N	114	114	114
Dimer	Correlation coefficient	0.108	−0.051	0.249**
	Sig. (2-tailed)	.197	.544	.003
	N	144	144	144
CRP	Correlation coefficient	.286**	0.068	.390**
	Sig. (2-tailed)	<.001	.428	<.001
	N	138	138	138

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).
COPD, chronic obstructive pulmonary disease; WBC, white blood cell; LYM, lymphocyte; Inflam. Ind, inflammatory index; CRP, C-reactive protein.

justifies an evaluation protocol that combines both systems. On the other hand, increased calcium, potassium, BNP, troponin, D-dimer, CRP, HCO3, and LDH levels also play a role in mortality and thus point to the necessity of a different algorithm that must include them.

A machine-learning algorithm had been created by Yan Li et al.[8] which uses similar parameters for mortality prediction. A longer duration of treatment required for patients with antihypertension drug usage was an expected finding, as the presence of hypertension is an often-discussed risk factor for COVID-19 and with reports stating a more severe disease presentation seen in these patients.

Evaluation of parameters affecting additional treatment requirements was planned with the aim of targeting patients who may benefit from an aggressive approach instead of a gradually increasing treatment modality. According to our results, increased inflammatory markers in elderly patients should keep healthcare alarmed for a potential clinical deterioration. Fever appears to be an independent symptom, and thus, unless other findings support it, it should not be the sole marker for treatment response or a need for a revision of the treatment regimen. As stated in Işık's study, fever and other clinical responses may be limited in the elderly population, further supporting the need for a more detailed investigation regimen that relies on available laboratory parameters.[9]

It is our expectation that an evaluation system and/or a pneumonia scoring methodology that includes discussed comorbidities, laboratory results, and medical background history may provide adequate information regarding how and where a patient should be treated. Similar approaches in the evaluation of patients in emergency and outpatient settings had been reported with success, with 1 study relying on PSI scoring alone.[10] Our study has found similar results with the described study, as PSI was found to be reliable in the evaluation of COVID-19 pneumonia. Its superiority over CURB-65, as discussed earlier, is assumed to be caused by its multiparameter evaluation, compared to CURB-65's 5-parameter scoring system. A direct comparison between PSI and MuLBSTA, however, has not been discussed in the literature

Table 4. Spearman Correlation Analysis Results Between Total Treatment Duration, Fever Response Day, Additional Treatment Requirement, and Other Parameters in Patients with Pneumonia

		Total Treatment Duration	Fever Response Day	Additional Treatment Requirement
Age	Correlation coefficient	0.162	−0.089	0.348**
	Sig. (2-tailed)	.136	.416	<.001
	N	86	86	86
Smoking	Correlation coefficient	0.241	0.116	0.185
	Sig. (2-tailed)	.107	.442	.217
	N	46	46	46
Hypertension	Correlation coefficient	0.061	-0.042	0.173
	Sig. (2-tailed)	.588	.710	.123
	N	81	81	81
Diabetes	Correlation coefficient	0.056	0.097	0.002
	Sig. (2-tailed)	.627	.394	.989
	N	79	79	79
COPD	Correlation coefficient	0.061	0.002	0.075
	Sig. (2-tailed)	.591	.986	.513
	N	79	79	79
Asthma	Correlation coefficient	0.047	0.125	0.062
	Sig. (2-tailed)	.681	.269	.583
	N	80	80	80
Known malignancy	Correlation coefficient	0.161	−0.089	0.183
	Sig. (2-tailed)	.157	.433	.107
	N	79	79	79
Heart Failure	Correlation coefficient	−0.132	−0.090	-0.059
	Sig. (2-tailed)	.247	.431	.604
	N	79	79	79
Coronary Heart Disease	Correlation coefficient	0.160	0.005	0.156
	Sig. (2-tailed)	.160	.964	.171
	N	79	79	79
Renal Disease	Correlation coefficient	−0.075	−0.089	0.183
	Sig. (2-tailed)	.513	.433	.107
	N	79	79	79
Cerebrovascular event history	Correlation coefficient	0.005	−0.069	0.061
	Sig. (2-tailed)	.963	.544	.596
	N	79	79	79

(*Continued*)

Table 4. Spearman Correlation Analysis Results Between Total Treatment Duration, Fever Response Day, Additional Treatment Requirement, and Other Parameters in Patients with Pneumonia (*Continued*)

		Total Treatment Duration	Fever Response Day	Additional Treatment Requirement
Antihypertensive	Correlation coefficient	.219*	−0.126	0.168
	Sig. (2-tailed)	.043	.247	.121
	N	86	86	86
Antidiabetic	Correlation coefficient	0.044	0.007	0.037
	Sig. (2-tailed)	.685	.949	.738
	N	86	86	86
Anticoagulant and antiaggregant	Correlation coefficient	0.046	−0.072	0.068
	Sig. (2-tailed)	.677	.508	.534
	N	86	86	86
Beta Blocker	Correlation coefficient	−0.072	−0.080	−0.121
	Sig. (2-tailed)	.509	.467	.269
	N	86	86	86
Ace inhibitors	Correlation coefficient	0.046	-0.016	0.158
	Sig. (2-tailed)	.675	.887	.146
	N	86	86	86
Calcium channel blockers	Correlation coefficient	0.314**	-0.120	0.188
	Sig. (2-tailed)	.003	.272	.084
	N	86	86	86
Aspirin	Correlation coefficient	0.100	-0.020	0.125
	Sig. (2-tailed)	.362	.855	.253
	N	86	86	86
Spironolactone	Correlation coefficient	0.063	0.053	0.076
	Sig. (2-tailed)	.563	.629	.486
	N	86	86	86
Nebulizing treatment	Correlation coefficient	−0.071	**0.188**	−0.072
	Sig. (2-tailed)	.516	.083	.508
	N	86	86	86
Thyroid Hormone Replacement	Correlation coefficient	0.014	0.033	-0.103
	Sig. (2-tailed)	.895	.760	.346
	N	86	86	86
Immunosuppression	Correlation coefficient	−0.101	−0.120	−0.103
	Sig. (2-tailed)	.354	.272	.346
	N	86	86	86

(*Continued*)

Table 4. Spearman Correlation Analysis Results Between Total Treatment Duration, Fever Response Day, Additional Treatment Requirement, and Other Parameters in Patients with Pneumonia (*Continued*)

		Total Treatment Duration	Fever Response Day	Additional Treatment Requirement
Insulin	Correlation coefficient	−0.071	0.089	−0.072
	Sig. (2-tailed)	.516	.414	.508
	N	86	86	86
Oral Antidiabetic	Correlation coefficient	0.073	−0.026	0.065
	Sig. (2-tailed)	.504	.815	.551
	N	86	86	86
Anticoagulant	Correlation coefficient	−0.101	−0.120	−0.103
	Sig. (2-tailed)	.354	.272	.346
	N	86	86	86
WBC	Correlation coefficient	0.152	−0.156	0.105
	Sig. (2-tailed)	.166	.153	.338
	N	85	85	85
LYM#	Correlation coefficient	−0.111	−0.083	−0.416**
	Sig. (2-tailed)	.311	.452	<.001
	N	85	85	85
Inflam. Ind.	Correlation coefficient	0.046	−0.068	0.241*
	Sig. (2-tailed)	.675	.536	.026
	N	85	85	85
Procalcitonin	Correlation coefficient	0.093	-0.073	0.310**
	Sig. (2-tailed)	.441	.543	.008
	N	71	71	71
Dimer	Correlation coefficient	0.013	−0.203	0.236*
	Sig. (2-tailed)	0.911	0.070	0.034
	N	81	81	81
CRP	Correlation coefficient	0.176	−0.123	0.351**
	Sig. (2-tailed)	.109	.265	.001
	N	84	84	84

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).
COPD, chronic obstructive pulmonary disease; WBC, white blood cell; LYM, lymphocyte; Inflam. Ind, inflammatory index; CRP, C-reactive protein.

for COVID-19 pneumonia as of writing this article, and unlike in the case of CURB-65, our study did not reveal a significant superiority of PSI over MuLBSTA.

This might be caused by the specific parameters of MuLBSTA, which might increase its overall power in terms of predicting viral pneumonia over PSI, despite the parameter count of PSI. Separate parameters also have been evaluated for mortality, with most studies focusing on D-dimer levels and supporting an increased mortality in the presence of elevated D-dimer.[11] Neutrophil to lymphocyte ratio, which naturally includes their absolute counts, has been proven to be correlated to mortality, as seen in Liu et al's[12] study. These studies correlate with our results, as described earlier, inflammatory parameters which include D-dimer and absolute WBC count were found to be relevant in the evaluation of patient mortality. Their role, however, remains limited in the prediction of patients' future treatment requirements. Combined, these findings suggest that while these blood testing modalities are required for initial evaluation and hospital admission,

Table 5. Spearman Correlation Analysis Results between Pneumonia Localization, Infiltration Pattern, Additional Treatment Requirement and Mortality

		Localization	Infiltration Pattern	Fever Response Day	Additional Treatment Requirement	Result (Mortality)
Localization (unilateral or bilateral)	Correlation coefficient	1.000	−0.598**	−0.058	**−0.099**	0.135
	Sig. (2-tailed)		<.001	.597	.367	.215
	N	86	86	86	86	86
Infiltration pattern	Correlation coefficient	−0.598**	1.000	0.110	**0.300****	−0.180
	Sig. (2-tailed)	<.001		.311	.005	.097
	N	86	86	86	86	86
Fever response day	Correlation coefficient	−0.058	0.110	1.000	0.189	−0.064
	Sig. (2-tailed)	.597	.311		.081	.558
	N	86	86	86	86	86
Additional treatment requirement	Correlation coefficient	**−0.099**	**0.300****	0.189	1.000	−0.437**
	Sig. (2-tailed)	.367	.005	.081		<.001
	N	86	86	86	86	86
Result (mortality)	Correlation coefficient	0.135	−0.180	−0.064	**−0.437****	1.000
	Sig. (2-tailed)	.215	.097	.558	<.001	
	N	86	86	86	86	86

**Correlation is significant at the 0.01 level (2-tailed).

Table 6. Spearman Correlation Analysis Results Between CURB 65, PSI, and MuLBSTA with Mortality and Additional Treatment Requirement

		Additional Treatment Requirement	Result (Mortality)
CURB 65	Correlation coefficient	**0.463****	**−0.434****
	Sig. (2-tailed)	<.001	<.001
	N	86	86
PSI	Correlation coefficient	0.352**	−0.382**
	Sig. (2-tailed)	<0.001	<0.001
	N	86	86
MuLBSTA	Correlation coefficient	0.484**	−0.383**
	Sig. (2-tailed)	<0.001	<0.001
	N	86	86

**Correlation is significant at the 0.01 level (2-tailed).
PSI, pneumonia severity index.

additional parameters are required for a comprehensive investigation if patients' prognoses are of interest.

To illustrate, we may assume a sample model that evaluates patients under 3 major categories. After an initial vital sign monitorization and physical examination, the medical background should be checked which involves questioning the presence of hypertension, diabetes, renal failure, COPD, cerebrovascular events, known malignancies, and smoking history. Blood sampling should, at a minimum, include routine whole blood work-up, cardiac markers, renal function testing, and inflammatory markers (consisting of CRP, D-dimer, and LDH).

The addition of radiological findings would complete the evaluation "triad," and barring other prominent pathologies a patient may have, these 3 pathways would offer a comprehensive evaluation of the patient and prognosis of COVID-19 infection. If pneumonia is seen, this system will also be adequate in suggesting where the patient should be observed or if the outpatient setting was suitable. A modified version of this investigational method may be used during patient follow-up or when clinical deterioration is seen during hospitalization.

Having a small sample size and being a single-center study are the main limitations of this study. These important limitations were mainly caused by the lack of approval given to multicenter studies when the first draft of this and other similar studies had been created. Considering similar studies have been published in Turkey recently, a new multicenter initiative with more patient participation may overcome these limitations.[13] In further studies, evaluation of patients in intensive care units and at outpatient clinics may alter pneumonia scorings impact on mortality, as this study was limited to patients admitted to wards.

Missing data, with the smoking history being the most prominent, was another major limiting factor. Most of these missing data were seen in the evaluation of patients in a mixed ward setting, where doctors from all specialties were assigned. A coordinated patient follow-up system agreed upon by all departments was later utilized by the hospital administration. Currently, most wards and intensive care units in our hospital possess a similar patient record system, which is based on a modified version of the pulmonary medicine ward patient record.

Treatment modalities were limited in this study, as its duration was from the outbreak of COVID-19 to the beginning of June. The current treatment regimen varies from the reported one, as of now, a regimen of steroids is being suggested, depending on the patient's condition, with the addition of remdesivir in select patients.

CONCLUSION

Due to the increased number of patients globally, a standardized approach for COVID-19 pneumonia and COVID-19 infection is required. Such methodological approach would not only inform healthcare providers about prognoses of patients and whenever hospital admission is required but also it will lessen the burden on healthcare systems, as follow-up testing may be limited to parameters that are proven to be cost-effective.

A new scoring system for pneumonia with the discussed parameters above and a universal follow-up algorithm that dictates where and when to perform certain tests will alleviate many problems encountered during COVID-19 pandemic.

Ethics Committee Approval: This study was approved by Ethics committee of Faculty of Health Sciences, (Approval No: 90/02, 22.06.2020).

Informed Consent: Both verbal and written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – B.K.; Design – B.K.; Supervision – İ.H.E., M.B.Y., S.A.D.; Data Collection: A.K.E, Analysis and Literature Review – K.E.; Writing – K.E., A.K.E.; Critical Review – B.K., İ.H.K., M.B.Y., S.A.

Declaration of Interests: The authors have no conflict of interest to declare.

Funding: The authors declared that this study has received no financial support.

REFERENCES

1. Lim WS, van der Eerden MM, Laing R, et al. Defining community acquired pneumonia severity on presentation to hospital: an international derivation and validation study. *Thorax*. 2003;58(5):377-382. [CrossRef]
2. Fine MJ, Auble TE, Yealy DM, et al. A prediction rule to identify low-risk patients with community-acquired pneumonia. *N Engl J Med*. 1997;336(4):243-250. [CrossRef]
3. Guo L, Wei D, Zhang X, et al. Clinical features predicting mortality risk in patients with viral pneumonia: the MuLBSTA score. *Front Microbiol*. 2019;10:2752. [CrossRef]
4. Du RH, Liang LR, Yang CQ, et al. Predictors of mortality for patients with COVID-19 pneumonia caused by SARS-CoV-2: a prospective cohort study. *Eur Respir J*. 2020;50. [CrossRef]
5. Tusha J, Khanam V, Tegeltija V, Kumar S. The MuLBSTA Score: predicting risk of mortality and disease severity in patients with COVID-19 pneumonia. *Chest*. 2020;158(4):300. [CrossRef]
6. Satici C, Demirkol MA, Sargin Altunok ES, et al. Performance of pneumonia severity index and CURB-76 in predicting 30-day mortality in patients with COVID-19. *Int J Infect Dis*. 2020;98: 84-89. [CrossRef]
7. Ji D, Zhang D, Xu J, et al. Prediction for progression risk in patients with COVID-19 pneumonia: the CALL score. *Clin Infect Dis*. 2020;71(6):1393-1399. [CrossRef]
8. Yan L, Zhang HT, Goncalves J, et al. An interpretable mortality prediction model for COVID-19 patients. *Nat Mach Intell*. 2020;2(5):283-288. [CrossRef]
9. Erdem AB, Oğüztürk H, Tümer M, Işık B, Kayipmaz AE, Semih K. Reliability of the pneumonia severity score (PSI) index in patients diagnosed with COVID-19 pneumonia to determine outpatient discharge. *Signa Vitae*. 2020. [CrossRef]
10. Isik AT. Covid-19 infection in older adults: A geriatrician's perspective. *Clin Interv Aging*. 2020;15:1067-1069. [CrossRef]
11. Zhang L, Yan X, Fan Q, et al. D-dimer levels on admission to predict in-hospital mortality in patients with Covid-19. *J Thromb Haemost*. 2020;18(6):1324-1329. [CrossRef]
12. Liu Y, Du X, Chen J, et al. Neutrophil-to-lymphocyte ratio as an independent risk factor for mortality in hospitalized patients with COVID-19. *J Infect*. 2020;81(1):e6-e12. [CrossRef]
13. Doganci S, Ince ME, Ors N, et al. Prognostic nutritional index for COVID-19 prognosis and a new pre-prediction scoring model for in- hospital mortality: experiences from Turkey, Single Center retrospective cohort analysis. *SSRN Electron J*. 2020. [CrossRef]