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CAPRL Scoring System for Prediction of 30-day Mortality in 949 Patients with Coronavirus Disease 2019 in Wuhan, China: A Retrospective, Observational Study

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Abstract

Background: Coronavirus disease 2019 (COVID-19) is a serious and even lethal respiratory illness. The mortality of critically ill patients with COVID-19, especially short term mortality, is considerable. It is crucial and urgent to develop risk models that can predict the mortality risks of patients with COVID-19 at an early stage, which is helpful to guide clinicians in making appropriate decisions and optimizing the allocation of hospital resoureces.

Methods: In this retrospective observational study, we enrolled 949 adult patients with laboratory-confirmed COVID-19 admitted to Tongji Hospital in Wuhan between January 28 and February 12, 2020. Demographic, clinical and laboratory data were collected and analyzed. A multivariable Cox proportional hazard regression analysis was performed to calculate hazard ratios and 95% confidence interval for assessing the risk factors for 30-day mortality.

Results: The 30-day mortality was 11.8% (112 of 949 patients). Forty-nine point nine percent (474) patients had one or more comorbidities, with hypertension being the most common (359 [37.8%] patients), followed by diabetes (169 [17.8%] patients) and coronary heart disease (89 [9.4%] patients). Age above 50 years, respiratory rate above 30 beats per minute, white blood cell count of more than10×10^9/L, neutrophil count of more than 7×10^9/L, lymphocyte count of less than 0.8×10^9/L, platelet count of less than 100×10^9/L, lactate dehydrogenase of more than 400 U/L and high-sensitivity C-reactive protein of more than 50 mg/L were independent risk factors associated with 30-day mortality in patients with COVID-19. A predictive CAPRL score was proposed integrating independent risk factors. The 30-day mortality were 0% (0 of 156), 1.8% (8 of 434), 12.9% (26 of 201), 43.0% (55 of 128), and 76.7% (23 of 30) for patients with 0, 1, 2, 3, ≥4 points, respectively.

Conclusions: We designed an easy-to-use clinically predictive tool for assessing 30-day mortality risk of COVID-19. It can accurately stratify hospitalized patients with COVID-19 into relevant risk categories and could provide guidance to make further clinical decisions.

Keywords: COVID-19; Mortality; Risk factor; SARS-CoV-2

Introduction

As of January 5, 2021 the coronavirus disease 2019 (COVID-19) outbreak has caused 84,474,195 confirmed cases with 1,848,704 deaths reported worldwide.[1]

SARS-CoV-2 can cause multi-system infections in various animals and mainly respiratory tract infections in humans. It is worthy of note that about 14% of SARS-CoV-2 infected patients will progress to severe and critical COVID-19 due to lack of specific therapy and the mortality of critically ill patients is considerable.[2] 61.5% (32/52) critically ill adult patients with SARS-CoV-2 pneumonia had died at 28 days.[3] We previously reported the clinical features for deceased patients with COVID-19 based on the data set from Tongji Hospital in the very earlier stage of the outbreak of Wuhan city.[4] Thus, it is crucial and urgent to develop risk models that can predict the mortality risks of patients with COVID-19 at an early stage. If these factors are clarified, we can identify patients at risk of mortality at early phase to initiate timely treatment and optimize therapy that can improve outcomes.[5] Although three recent studies have analyzed prognostic factors for worse outcomes,[6–8] the

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interpretation of the findings may be limited by the small sample size. Previous report from our hospital has primarily identified potential risk factors for mortality of COVID-19 patients.[9,10] This updated study with the so far largest moderate/severe cohort independently verified the existing risk factors, and further established a potential easy-to-use model to predict the probability of mortality among patients with COVID-19.

Methods

Ethical approval

The study was approved by the Ethics Committee of Tongji Hospital (No. S242), written informed consent was waived by the Ethics Commission of Tongji Hospital for emerging infectious diseases.

Study design and participants

In this retrospective, single-center study, we recruited adult patients (aged ≥18 years) from January 28 to February 12, 2020, at Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology. Tongji Hospital, located in Wuhan, the endemic areas of COVID-19, is the largest medical center for patients with COVID-19 treatment designated by local authority. All patients who were enrolled in this study were diagnosed as COVID-19 according to the guidance released by the Chinese National Health Commission. All patients infected with SARS-CoV-2 were confirmed using quantitative real time reverse transcription polymerase chain reaction. Other respiratory viruses such as influenza virus A, influenza virus B, coxsackie virus, respiratory syncytial virus, parainfluenza virus and enterovirus were ruled out. The clinical data and outcomes were monitored up to March 13, 2020, the final date of follow-up.

Data collection

The medical record information including epidemiological, demographic, clinical manifestation [as shown in Table 1], laboratory data, and outcome data were obtained from electronic

Table 1: Baseline characteristics of patients with COVID-19.

Variables	Total (n=949)	Survival (n=837)	Death (n=112)	P value
Age (years)	64 (51–70)	63 (50–69)	68 (59–77)	<0.001*
19–30	25 (2.6)	25 (3.0)	0 (0)	
31–50	201 (21.2)	195 (23.3)	6 (5.4)	
51–60	168 (17.7)	143 (17.1)	25 (22.3)	
61–70	336 (35.4)	298 (35.6)	38 (33.9)	
>70	219 (23.1)	176 (21.0)	43 (38.4)	
Sex				<0.001*
Male	485 (51.1)	408 (48.7)	77 (68.8)	
Female	464 (48.9)	429 (51.3)	35 (31.2)	
Comorbidities	474 (49.9)	403 (48.6)	71 (64.5)	0.002*
Hypertension	359 (37.8)	310 (37.0)	49 (43.8)	0.178
Diabetes	169 (17.8)	142 (17.0)	27 (24.1)	0.067
Coronary heart disease	89 (9.4)	77 (9.2)	12 (10.7)	0.605
COPD	40 (4.2)	32 (3.8)	8 (7.1)	0.127
Malignancy	23 (2.4)	17 (1.9)	7 (6.2)	0.013*
Chronic kidney disease	18 (1.9)	15 (1.8)	3 (2.7)	0.461
Chronic hepatitis	12 (1.3)	10 (1.2)	2 (1.8)	0.643
Cerebrovascular disease	10 (1.1)	9 (1.1)	1 (0.9)	1.000
Signs and symptoms				
Fever	802 (84.5)	709 (84.7)	93 (83.0)	0.676
Cough	725 (76.4)	645 (77.1)	80 (71.4)	0.193
Dyspnoea	468 (49.3)	394 (47.1)	74 (66.1)	<0.001*
Fatigue	328 (34.6)	281 (33.6)	47 (42.0)	0.090
Onset of symptom to Hospital admission median (days)	11 (8–15)	11 (8–15)	10 (7–14)	0.001*
Heart rate (bpm)	89 (80–101)	88 (80–100)	95 (82–108)	0.001*
Systolic blood pressure (mmHg)	130 (120–143)	130 (120–141)	133 (120–146)	0.138
Respiratory rate (bpm)	20 (20–21)	20 (20–21)	22 (20–30)	<0.001*
Treatments				
Antiviral treatment	903 (95.2)	807 (96.5)	96 (85.7)	<0.001*
Antibiotics	740 (78.0)	634 (75.7)	106 (94.6)	<0.001*
Corticosteroids	320 (33.7)	228 (27.2)	92 (82.1)	<0.001*
Intravenous immunoglobin	194 (20.4)	140 (16.7)	54 (48.2)	<0.001*
High-flow nasal cannula oxygen therapy	26 (2.7)	12 (1.4)	14 (12.8)	<0.001*
Non-invasive mechanical ventilation	75 (7.9)	31 (3.7)	44 (39.3)	<0.001*
Invasive mechanical ventilation	62 (6.5)	7 (0.8)	55 (49.1)	<0.001*
Renal replacement therapy	10 (1.1)	4 (0.5)	6 (5.4)	<0.001*

Data are presented as n (%) or median (interquartile range).
* $P<0.05$.
bpm: Beat per minute; COPD: Chronic obstructive pulmonary disease.

medical records. Laboratory data within 24 hours of admission were collected and described in Table 2. The data were reviewed by a trained team of physicians. The date of disease onset was defined as the day when the patients first became symptomatic. The endpoint was the in-hospital death.

Statistical analysis

Categorical variables were described as frequency rates and percentages, and continuous variables were described using median (IQR). Means for continuous variables were compared using independent group *t* tests when the data were normally distributed; otherwise, the Mann-Whitney test was used. Categorical variables were expressed as numbers (%) and compared by the χ^2 test or Fisher's exact test. The risk factors and corresponding hazard ratios (HRs) were calculated using the Cox proportional hazard model. Cumulative rates of in-hospital death were determined using the Kaplan-Meier method. Receiver operating curve (ROC) analysis was performed to predict a 30-day mortality rate. Statistical analyses were performed using Statistical Package for Social Science (SPSS version 20.0, Chicago, IL, USA) with statistical significance set at two-sided $P < 0.05$.

Results

Presenting characteristics

One thousand four hundred and forty-six hospitalized patients were assessed for eligibility, and 988 of them were laboratory-confirmed SARS-CoV-2 infection. Thirty-nine cases were excluded: pregnant woman ($n=2$), children or adolescents ($n=4$), patients with a history of organ transplantation ($n=3$), cases without completed medical records ($n=5$), with missing data on laboratory examination on admission ($n=25$). Finally, a total of 949 patients were included in this study. Of the 949 patients, 112 died within 30 days of admission [Figure 1]. The distribution of the enrolled patients' age is shown in Table 1. The median age of the SARS-CoV-2 infected patients was 64 years (IQR, 51–70; range, 18–92 years). Compared with patients who survived ($n=837$), patients who died were significantly older (median age, 68 years [IQR, 59–77] *vs.* 63 years [IQR, 50–69]; $P < 0.001$), and 94.6% (106/112) of death patients aged over 50 years. There was a significant difference in the sex ratio between the death group and survivor group ($P < 0.001$). 68.8% (77/112) of deceased patients were male and 31.2% (35/112) were female. Among the 949 patients, 474 (49.9%) patients had underlying diseases including hypertension (359 [37.8%]), diabetes (169 [17.8%]), coronary heart disease (89 [9.4%]), chronic obstructive pulmonary disease (COPD) (40 [4.2%]), malignancy (23 [2.4%]), chronic kidney disease (18 [1.9%]), chronic hepatitis (12 [1.3%]) and cerebrovascular disease (10 [1.1%]). Compared with survived patients, those who died were more likely to have a history of coexisting malignancy [Table 1]. The most common symptoms at onset of illness were fever (802 [84.5%]) and cough (725 [76.4%]). Other common symptoms were dyspnea (468 [49.3%]) and fatigue (328 [34.6%]). The median time from onset of symptoms to admission was 11 days (IQR, 8–15). The time from onset of symptoms to admission of death group was shorter than that of survivor group (10 days [IQR, 7–14] *vs.* 11 days [IQR, 8–15], $P=0.001$), as shown in Table 1. Treatment strategies were different between non-survivors and survivors. Corticosteroids and immunoglobin use were more frequent in death group than survivor group [Table 1].

Vital signs and laboratory parameters

Median heart rate of the death group on admission was significantly higher than that of the survivor group (95 [IQR, 82–108] *vs.* 88 [IQR, 80–100]; $P=0.001$). Meanwhile, the patients in the death group had higher respiratory rate than those in the survivor group (22 [IQR, 20–30] *vs.* 20 [IQR, 20–21]; $P < 0.001$). Our data showed that there was no significant difference in systolic blood pressure between the two groups [Table 1].

We further compared the baseline laboratory data between the patients who died and those who survived. There were significant differences between the survivor group and death group in all laboratory parameters in Table 2 ($P < 0.001$) except for haemoglobin ($P=0.275$). The white blood cell count, neutrophil count, lactic dehydrogenase (LDH), blood urea nitrogen, creatinine and high-sensitivity C-reactive protein in the death group were significantly higher than those in the survivor group, while the lymphocyte count, platelet count, albumin and sodium bicarbonate in the death group were significantly lower than those in the survivor group [Table 2].

Mortality risk analysis

Cox proportional HR for mortality of patients with COVID-19 are shown in Table 3. In the univariate Cox regression analysis,

Table 2: Laboratory findings of patients with COVID-19.

Variables	Normal range	Total ($n=949$)	Survival ($n=837$)	Death ($n=112$)	*P* value
White blood cell count ($\times 10^9$/L)	3.5–9.5	5.49 (4.36–7.18)	5.27 (4.23–6.75)	8.75 (6.17–12.81)	<0.001*
Neutrophil count ($\times 10^9$/L)	1.8–6.3	3.80 (2.67–5.38)	3.58 (2.57–4.86)	7.54 (5.20–11.38)	<0.001*
Lymphocyte count ($\times 10^9$/L)	1.1–3.2	1.04 (0.71–1.43)	1.10 (0.78–1.49)	0.61 (0.43–0.80)	<0.001*
Haemoglobin (g/L)	130–175	127 (116–138)	127 (116–137)	131 (117–143)	0.275
Platelet count ($\times 10^9$/L)	125–350	220 (163–297)	230 (171–304)	162 (123–227)	<0.001*
Albumin (g/L)	35–52	34.3 (31.4–37.8)	34.8 (32.0–38.3)	30.3 (27.9–33.0)	<0.001*
LDH (U/L)	135–225	280 (222–368)	267 (216–332)	487 (394–684)	<0.001*
Sodium bicarbonate (mmol/L)	22–29	23.8 (22.0–25.5)	23.9 (22.4–25.6)	22.4 (20.3–24.9)	<0.001*
Blood urea nitrogen (mmol/L)	3.1–8.0	4.4 (3.4–5.7)	4.2 (3.3–5.4)	6.8 (5.0–10.9)	<0.001*
Creatinine (μmol/L)	59–104	69 (57–85)	68 (56–83)	82 (63–105)	0.009*
High-sensitivity C-reactive protein (mg/L)	NA	27.3 (5.85–70.0)	21.2 (4.8–58.9)	100.2 (57.3–160.3)	<0.001*

Data are presented as median (interquartile range).
* $P < 0.05$.
LDH: lactate dehydrogenase; NA: Not applicable.

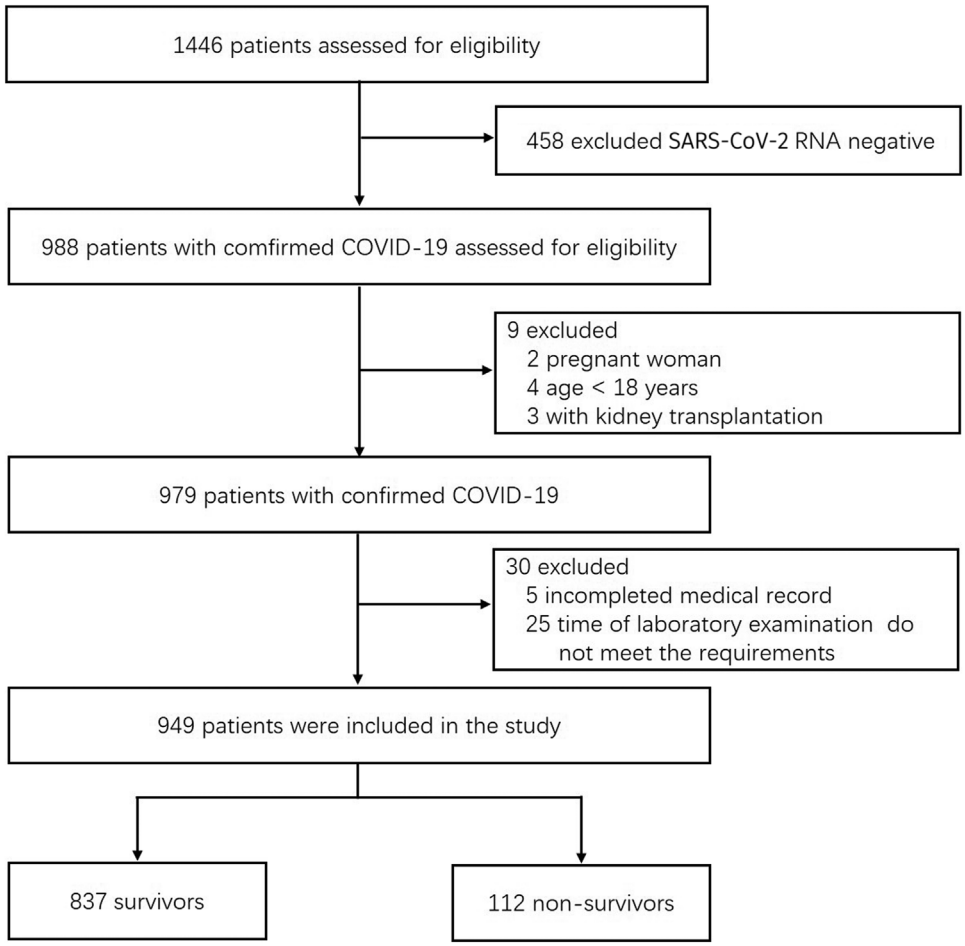

Figure 1: Flow diagram of participant screening.

Table 3: Risk factors associated with mortality among patients with COVID-19.

	Univariate		Multivariate	
Variables	**HR (95% CI)**	***P* value**	**HR (95% CI)**	***P* value**
Age (>50 *vs.* ≤50 years)	5.84 (2.57–13.3)	<0.001*	3.27 (1.41–7.61)	0.006*
Sex (Male *vs.* Female)	2.19 (1.47–3.26)	<0.001*		
Respiratory rate (>30 *vs.* ≤30 bpm)	8.76 (5.44–14.10)	<0.001*	2.23 (1.30–3.82)	0.004*
Hypertension (Yes *vs.* No)	1.30 (0.90–1.89)	0.163		
Diabetes (Yes *vs.* No)	1.50 (0.97–2.32)	0.066		
COPD (Yes *vs.* No)	1.81 (0.88–3.71)	0.107		
White blood cell count (>10 *vs.* $\leq 10 \times 10^9$/L)	9.48 (6.49–13.89)	<0.001*	1.91 (1.10–3.31)	0.022*
Neutrophil count (>7 *vs.* $\leq 7 \times 10^9$/L)	10.46 (7.18–15.22)	<0.001*	2.07 (1.15–3.72)	0.015*
Lymphocyte count (<0.8 *vs.* $\geq 0.8 \times 10^9$/L)	7.10 (4.65–10.84)	<0.001*	1.95 (1.23–3.11)	0.005*
Platelet count (<100 *vs.* $\geq 100 \times 10^9$/L)	5.23 (3.19–8.57)	<0.001*	2.37 (1.39–4.03)	0.001*
Albumin (<35 *vs.* ≥35 g/L)	5.30 (3.65–7.69)	<0.001*		
LDH (>400 *vs.* ≤400 U/L)	13.43 (8.75–20.62)	<0.001*	3.10 (1.83–5.25)	<0.001*
Sodium bicarbonate (<20 *vs.* ≥20 mmol/L)	3.09 (1.98–4.82)	<0.001*		
Blood urea nitrogen (>8 *vs.* ≤8 mmol/L)	7.37 (5.04–10.79)	<0.001*		
Creatinine, μmol/L (>104 *vs.* ≤104 μmol/L)	3.76 (2.45–5.76)	<0.001*		
High-sensitivity C-reactive protein (>50 *vs.* ≤50 mg/L)	8.26 (5.22–13.08)	<0.001*	2.59 (1.56–4.29)	<0.001*

The risk factors and corresponding hazard ratios (HRs) were calculated using the Cox proportional hazard model. Cumulative rates of in-hospital death were determined using the Kaplan-Meier method.
* $P < 0.05$.

bpm: Beats per minute; COPD: Chronic obstructive pulmonary disease; LDH: Lactate dehydrogenase.

Table 4: 30-day mortality in COVID-19 patients with different CAPRL score

Variables	0	1	2	3	≥4
Survival (n=837)	156	426	175	73	7
Death (n=112)	0	8	26	55	23
30-day mortality (%)	0	1.8	12.9	43.0	76.7

CAPRL: High-sensitivity C-reactive protein (C), age (A), platelet count (P), respiratory rate (R) and LDH (L).

age (>50 *vs.* ≤50 years), sex (Male *vs.* Female), respiratory rate (>30 *vs.* ≤30 beats per minute (bpm)), white blood cell count (>10 *vs.* $\leq 10 \times 10^9$/L), neutrophil count (>7 *vs.* $\leq 7 \times 10^9$/L), lymphocyte count (<0.8 *vs.* $\geq 0.8 \times 10^9$/L), platelet count (<100 *vs.* $\geq 100 \times 10^9$/L), albumin (<35 *vs.* ≥35 g/L), LDH (>400 *vs.* ≤400 U/L), sodium bicarbonate (<20 *vs.* ≥20 mmol/L), blood urea nitrogen (>8 *vs.* ≤8 mmol/L), creatinine (>104 *vs.* ≤104 μmol/L) and high-sensitivity C-reactive protein (>50 *vs.* ≤50 mg/L) were associated with 30-day mortality. By multivariate cox regression analysis, we found older age (HR: 3.27, 95% confidence interval (CI): 1.14–7.61), higher respiratory rate (HR: 2.23, 95% CI: 1.30–3.82), elevated white blood cell count (HR: 1.91, 95% CI: 1.10–3.31) and neutrophil count (HR: 2.07, 95% CI: 1.15–3.72), declined lymphocyte count (HR: 1.95, 95% CI: 1.23–3.11), declined platelet count (HR: 2.37, 95% CI: 1.39–4.03), elevated LDH (HR: 3.10, 95% CI: 1.83–5.25) and high-sensitivity C-reactive protein (HR: 2.59, 95% CI: 1.56–4.29) were independently significant in predicting the 30-day mortality risk.

In order to develop a simple and useful clinical predicting tool, risk factors were selected to analyze their association with the mortality based on the rank order of HRs. Therefore, the top five ranked risk factors: age, LDH, high-sensitivity C-reactive protein, platelet count and respiratory rate were included in current secondary analysis. A 5-point risk score (CAPRL) was derived to predict 30-day mortality risk (high-sensitivity C-reactive protein (C) [>50=1], age (A) [>50=1], platelet count (P) [<100=1], respiratory rate (R) [>30=1] and LDH (L) [>400=1]). The 30-day mortality was 0% and 1.8% for 0-point and 1-point patients, respectively [Table 4]. However, the probabilities for patients' death with 2, 3, ≥4-points were 12.9%, 43.0%, and 76.7%, respectively [Table 4]. Kaplan-Meier analysis revealed higher CAPRL score was associated with higher fatality rate [Figure 2].

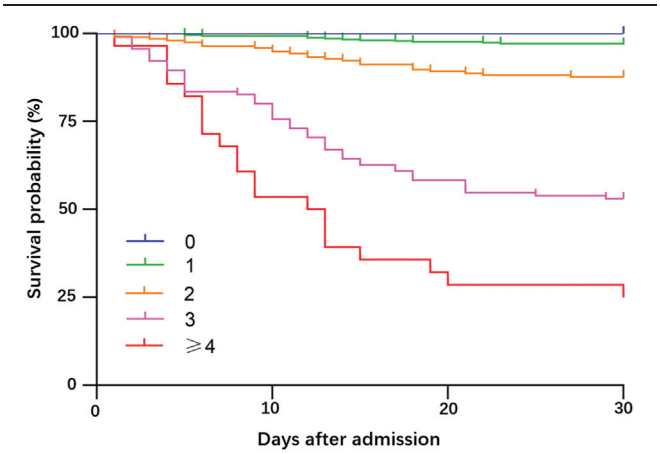

Figure 2: Cumulative Kaplan-Meier 30-day survival curve in patients with different CAPRL scores. CAPRL: High-sensitivity C-reactive protein (C), age (A), platelet count (P), respiratory rate (R) and LDH (L).

The ROC curve was utilized to evaluate the accuracy of CAPRL score that predicts death caused by COVID-19. The area under curve (AUC) values of CAPRL score to predict 30-day mortality were 0.887. The ROC curve of CAPRL score was shown in Figure 3.

Discussion

In this retrospective cohort study, we clarified the risk factors for 30-day mortality in patients with COVID-19 in Wuhan who were hospitalized in Tongji Hospital. The independent risk factors were age above 50 years, respiratory rate of higher than 30 beats per minute, white blood cell count of more than 10×10^9/L, neutrophil count of more than 7×10^9/L, lymphocyte count of less than 0.8×10^9/L, platelet count of less than 100×10^9/L, LDH of more than 400 U/L and high-sensitivity C-reactive protein of more than 50 mg/L. Importantly, we proposed the CAPRL scoring system by incorporating five significant risk factors of 30-day mortality. The predictive performance of the CAPRL score is solid, as evidenced by Kaplan-Meier analysis and ROC analysis. To our knowledge, this is the largest case series study to date in which the risk factors associated with mortality in COVID-19 patients are explained in a stepwise manner.

Advanced age was significantly associated with increased risk of fatality in patients with COVID-19, which is consistent with results noted in two recent studies reported by Zhou et al and Wu et al.[6,7] Similarly, older age had been reported as an important

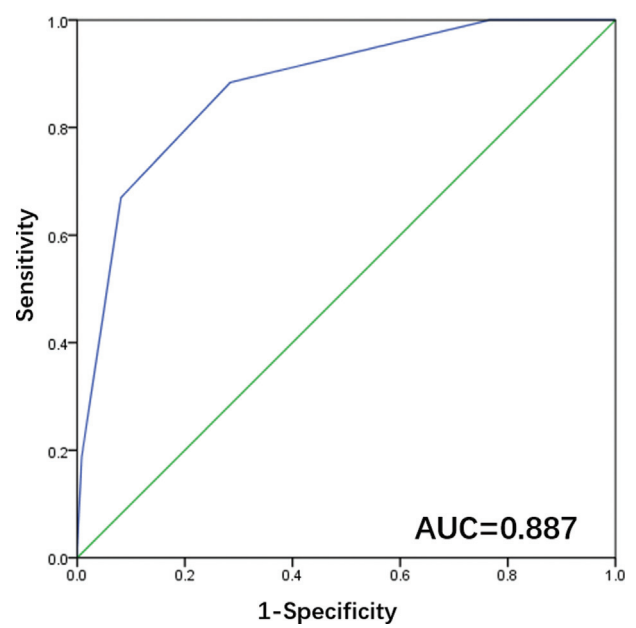

Figure 3: The ability of CAPRL score to predict 30-day mortality of COVID-19 patients. CAPRL: High-sensitivity C-reactive protein (C), age (A), platelet count (P), respiratory rate (R) and LDH (L).

independent predictor of mortality in SARS and MERS.[11,12] Comorbidity may contribute to mortality, 64.5% of fatal cases have underlying medical conditions and 94.6% of fatal cases age above 50 years in the present study. Despite reports that elderly persons may benefit from pre-existing cross-reactive immunity, clinicians should closely monitor and promptly treat elderly hospitalized patients with COVID-19.

The relationship between mortality and respiratory rate on admission was first reported in a survey of 453 pneumonia patients which was published in 1987.[13] The respiratory rate is an integral constituent of established prognostic tools such as the CURB-65 index and quick SOFA (qSOFA) score.[14] We found increased respiratory rate on admission is an independent risk factor for in-hospital mortality in patients with COVID-19. Measuring the respiratory rate on admission is well suited for early risk stratification as increased respiratory rates on admission is associated with significantly increased hospital mortality rates.

Baseline white blood cell and neutrophil count were significantly higher in non-survivors than survivors ($P < 0.001$). Likewise, Wang *et al* observed COVID-10 patients who received intensive care unit (ICU) care had higher white blood cell and neutrophil count than those not admitted to the ICU.[15] By further multivariate analysis, we noted that patients with elevated white blood cell count and neutrophilia had a significantly and independently higher risk of death. Leukocytosis and neutrocytosis are often caused by bacterial infection. In addition, viral respiratory infection has linked to increased incidence of secondary bacterial infections, and the pathogeneses of bacterial and viral coinfections are more complicated and challenging.[16] Despite no bacterial pathogens were detected in these patients on admission, we speculate the SARS-CoV-2-induced secondary bacterial respiratory infection may be a possible reason leading to death in some patients with COVID-19.

Lymphocytopenia is a common and prominent feature of critically ill patients with SARS-CoV and MERS infection which results from apoptosis of lymphocyte.[17,18] Recent data suggested lymphocytopenia was also frequent in patients with COVID-19.[19] Another study suggested lymphocytopenia occurred in more than 80% of critically ill patients but no significant difference was observed between the survivors and non-survivors.[3] However, in the present study, we found non-survivors had more severe lymphocytopenia than survivors. Moreover, our data confirmed that lymphocytopenia ($<0.8 \times 10^9$/L) was associated with death in patients with COVID-19. Of note, the mechanism of lymphocyte deficiency in SARS-CoV-2 infection remains unclear so far. According to previous research of SARS, lymphocytopenia in patients with COVID-19 is likely to result from indirect mechanisms secondary to the viral infection.[20] Basic studies are warranted to further explore the underlying molecular mechanism.

Thrombocytopenia is the another common laboratory characteristic of severe patients with SARS and MERS.[21,22] In this study, we also noted that deceased patients exhibited a prominent decrease in blood platelet counts. This finding is consistent with recent studies reported by Ruan et al and Lippi et al.[23,24] Additionally, we also demonstrated thrombocytopenia ($<100 \times 10^9$/L) is associated with increased mortality risk in COVID-19. In many cases, thrombocytopenia might result from systemic inflammation and infections, including sepsis, bacterial and viral infection.[25] Focusing on the influence of platelets on the course of COVID-19, our data suggested a low platelet count is a surrogate parameter of disease severity and strongly associated with mortality in COVID-19.

The discovery of C-reactive protein was reported in 1930.[26] C-reactive protein parallels the severity of inflammation or tissue injury and is a useful marker for infectious disease, response to therapy, and ultimate recovery.[27] High initial C-reactive protein level had proven to be a significant risk factor associated with poor prognosis for SARS and MERS patients.[28,29] Although majority of patients with COVID-19 had C-reactive protein levels above the normal range,[19] the role of C-reactive protein in predicting the outcome of patients with COVID-19 has not been delineated in previous studies. In our observation, elevated high-sensitivity C-reactive protein level was an independent risk of mortality in patients with COVID-19. However, whether dynamic change of high-sensitivity C-reactive protein level parallels with disease progression of COVID-19 needs further exploration.

High LDH levels are known to be an independent predictor for poor clinical outcome, probably related to tissue destruction from immune hyperactivity.[30] Previous studies provided strong evidence of an increased risk for developing adverse outcomes or acute respiratory distress syndrome in SARS patients with elevated LDH.[31,32] Similar to these studies, we found that a high initial LDH level appeared to be associated with increased mortality in COVID-19 by the multivariate analysis. In another previous study, elevated LDH has also been observed in critical ill COVID-19 patients.[15] In terms of the predictors of 30-day mortality in COVID-19 patients who received appropriate treatment at diagnosis on admission, we clarified several independent factors associated with poor outcomes. Given a weak predictive value was demonstrated when combining all the risk factors together, therefore, we proposed a simple 5-point scoring system composing of high-sensitivity C-reactive protein (C), age (A), platelet count (P), respiratory rate (R) and LDH (L)-CAPRL. All parameters identified in the CAPRL score owns easy access to clinical practice and all examinations are routinely recommended upon patients' admission. ROC and Kaplan-Meier analysis suggests that CAPRL score has satisfactory predictive capacity in death for patients with COVID-19. A higher CAPRL score might be used as a guidance in predicting disease prognosis, although validation may be required in another larger dataset of patients with COVID-19 in future studies.

In patients hospitalized with COVID-19, the use of dexamethasone resulted in lower 28-day mortality among those who were receiving either invasive mechanical ventilation or oxygen alone.[33] However, in the present study, corticosteroids exerted no positive effects on COVID-19 mortality. There are some possible reasons to explain the inconsistent. Due to death group had more severe signs and symptoms than survivor group when initiating treatment, corticosteroids and immunoglobin use were more frequent in death group than survivor group. Moreover, during the early stage of COVID-19 outbreak, there was no guildline or direct evidence supporting the use of steroids and immunoglobin. Thus, in the present study, nearly all patients hospitalized with COVID-19 received empirical steroids treatment protocol according to individual physician.

The risk factors for short term mortality identified in this study included age, lymphopenia and high LDH level are consistent with those in previous report from our hospital.[9] However, other risk factors respiratory rate, leukocytosis, neutrocytosis, thrombocytopenia and C-reactive protein are first reported in the present updated study. The design of cohort and analysis method

may lead to this difference. Furthermore, an easy-to-use tool were proposed based on risk factors for mortality in our study.

The study has limitations. This was a retrospective case series study that relied on abstracting data from clinical records and patient charts. Accordingly, the retrospective single-center analysis might lead to unavoidable biases in identifying and recruiting participants. In an effort to quickly disseminate information to clinicians worldwide, we only assessed 30-day short-term outcomes of patients with COVID-19. It will be of great importance to perform follow-up evaluation of these patients to determine the long-term repercussions of this critical illness.

Conclusions

In conclusion, COVID-19 is a serious and even lethal respiratory illness and has spread around the world rapidly. Our investigation provided comprehensive study of risk factors for 30-day mortality of patients with COVID-19. The proposed CAPRL score can easily and accurately identify hospitalized COVID-19 patients at high risk for poor outcome and guide clinicians in making appropriate decisions and optimizing the allocation of hospital resources.

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Conflicts of Interest

None.

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