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Efficacy of the quick sequential organ failure assessment for predicting clinical outcomes among community-acquired pneumonia patients presenting in the emergency department

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Abstract

Background: The study aimed to investigate the predictive value of the quick sequential organ failure assessment (qSOFA) for clinical outcomes in emergency patients with community-acquired pneumonia (CAP).

Methods: A total of 742 CAP cases from the emergency department (ED) were enrolled in this study. The scoring systems including the qSOFA, SOFA and CURB-65 (confusion, urea, respiratory rate, blood pressure and age) were used to predict the prognostic outcomes of CAP in ICU-admission, acute respiratory distress syndrome (ARDS) and 28-day mortality. According to the area under the curve (AUC) of the receiver operating characteristic (ROC) curves, the accuracies of prediction of the scoring systems were analyzed among CAP patients.

Results: The AUC values of the qSOFA, SOFA and CURB-65 scores for ICU-admission among CAP patients were 0.712 (95%CI: 0.678–0.745, $P < 0.001$), 0.744 (95%CI: 0.711–0.775, $P < 0.001$) and 0.705 (95%CI: 0.671–0.738, $P < 0.001$), respectively. For ARDS, the AUC values of the qSOFA, SOFA and CURB-65 scores were 0.730 (95%CI: 0.697–0.762, $P < 0.001$), 0.724 (95%CI: 0.690–0.756, $P < 0.001$) and 0.749 (95%CI: 0.716–0.780, $P < 0.001$), respectively. After 28 days of follow-up, the AUC values of the qSOFA, SOFA and CURB-65 scores for 28-day mortality were 0.602 (95%CI: 0.566–0.638, $P < 0.001$), 0.587 (95%CI: 0.551–0.623, $P < 0.001$) and 0.614 (95%CI: 0.577–0.649, $P < 0.001$) in turn. There were no statistical differences between qSOFA and SOFA scores for predicting ICU-admission ($Z = 1.482$, $P = 0.138$), ARDS ($Z = 0.321$, $P = 0.748$) and 28-day mortality ($Z = 0.573$, $P = 0.567$). Moreover, we found no differences to predict the ICU-admission ($Z = 0.370$, $P = 0.712$), ARDS ($Z = 0.900$, $P = 0.368$) and 28-day mortality ($Z = 0.768$, $P = 0.442$) using qSOFA or CURB-65 scores.

Conclusion: qSOFA was not inferior to SOFA or CURB-65 scores in predicting the ICU-admission, ARDS and 28-day mortality of patients presenting in the ED with CAP.

Keywords: Quick sequential organ failure assessment, Community-acquired pneumonia, ICU-admission, Acute respiratory distress syndrome, 28-day mortality

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Background

Community-acquired pneumonia (CAP) is a common infectious disease with high morbidity, mortality and medical costs [1], and is caused by various microorganisms such as bacteria, viruses, chlamydia and mycoplasma outside the hospital. Previous studies reported that approximately 20% of CAP adult patients needed to be hospitalized for treatment, and the mortality is as high as 30–50% [2]. The incidence of severe CAP needing admission to intensive care unit (ICU) is gradually rising due to septic shock and the requirement of invasive mechanical ventilation (IMV) [3]. The evidence has shown that severe CAP can induce the occurrence of acute respiratory distress syndrome (ARDS) which is a life-threatening disease with a present mortality of nearly 40% [4]. Therefore, it is significant for the clinicians to early predict the outcomes of CAP, accurately and objectively assess the severity of the disease to optimize therapeutic strategies.

To date, several assessment tools for CAP patients have been applied in the emergency department (ED), such as the quick sequential organ failure assessment (qSOFA) [5, 6], sequential organ failure assessment (SOFA) [7, 8], and confusion, urea, respiratory rate, blood pressure and age (CURB-65) scores [9–12]. Of these, the qSOFA score is recently developed to predict the death of infected patients which was proposed by the Sepsis-3 group in 2016 [13]. The advantage of the qSOFA score is on the basis of three clinical criteria (respiratory rate, mental status and blood pressure), without the requirement for laboratory tests. To the best of our knowledge, however, the predictive efficacy of these scoring systems on the pneumonia severity has rarely reported among patients with CAP.

Although some reports suggested that the qSOFA score is effective for predicting the mortality in CAP [14, 15], it is uncertain whether the qSOFA score can be used to evaluate other prognostic outcomes, such as ICU-admission and ARDS. Accordingly, we assessed the predictive value of qSOFA score for clinical outcomes in emergency patients with CAP, and the efficacy of the qSOFA score was explored in comparison with other pneumonia severity scoring systems (SOFA and CURB-65 scores) in ICU-admission, ARDS and 28-day mortality.

Methods

Patients

This investigation was conducted at Beijing Chao-Yang Hospital from Nov. 2011 to Sep. 2018. A total of 742 CAP cases were enrolled, containing 462 males and 280 females. The characteristics of patients were recorded including age, gender, past medical history and vital signs. The whole blood leukocyte counts, blood gas indexes, blood biochemistry and X-ray results were detected within 24 h. According to the findings of vital signs and laboratory examination, the qSOFA, SOFA and CURB-65 scores were calculated.

Inclusion and exclusion criteria

Patients who met the following criteria were included: (1) age > 18 years; (2) corresponding to diagnosis criteria of CAP.

Exclusion criteria were: (1) advanced diseases including malignant tumors (advanced or metastasized tumors), end-stage liver or renal disease; (2) hospitalization within 14 days before symptom appearance; (3) cystic fibrosis, active pulmonary tuberculosis, severe immunosuppression, coagulopathy or systemic anticoagulant treatment; (4) pretreatment outside the hospital; and (5) the patients or relatives did not agree to participate in the study.

Diagnosis criteria

Diagnosis criteria for patients with CAP conformed to new infiltration on the chest with at least one of the following symptoms: (1) cough; (2) sputum; (3) dyspnea; (4) core body temperature > 38.0 °C; (5) auscultation with abnormal breath sounds or rales [16].

Berlin diagnostic criteria for ARDS were utilized on the basis of oxygenation index as follows: (1) mild: 200 mmHg < PaO_2/FIO_2 ≤ 300 mmHg; (2) moderate: 100 mmHg < PaO_2/FIO_2 ≤ 200 mmHg; (3) severe: PaO_2/FIO_2 ≤ 100 mmHg. Four ancillary indicators for severe ARDS were considered including radiographic severity, respiratory system compliance (≤40 mL/cm H_2O), positive end-expiratory pressure (PEEP, ≥10 cm H_2O) and corrected exhaled minute volume (≥10 L/min) [17].

In the present study, we conducted a 28-day follow-up research to assess the outcomes. The occurrence of ARDS and 28-day mortality were served as the endpoint events, and ICU admission was also included as an outcome of patients within 72 h of ED visit. Patients who survived after the last follow-up were considered as survivors.

Laboratory examination

Hospitalization within 12 h, 5–10 mL blood was collected in the tubes containing heparin or ethylenediaminetetraacetate (EDTA), then stored at − 80 °C. White blood cell (WBC) were measured via an automated hematology analyzer (Sysmex XS-500i, Sysmex Corporation Kobe, Japan). Plasma lactate (Lac) levels were detected by a blood gas analyzer (GEM Premier 3000, Instrumentation Laboratory, Lexington, MA, USA), and the normal range was 0.7–2.5 mmol/L. The concentrations of serum procalcitonin (PCT) were measured using a BioMerieux Mini VIDAS immunoassay analyzer (Block Scientific, Bohemia, NY, USA), and the limit of detection (LOD) was 0.05 ng/mL. Serum C-reactive protein (CRP) concentrations were analyzed utilizing turbidimetric immunoassay (BNII, Siemens Healthcare Diagnostic, Germany).

Statistical analysis

Statistical analysis was performed using SPSS 16.0 (SPSS Inc., Chicago, IL, USA). Normally distributed data were expressed by mean ± standard deviation (SD), while non-normally distributed data were denoted via median (P_{25}, P_{75}). Mann-Whitney U test was used for the comparison between the two groups, and Kruskal-Wallis one-way analysis was utilized for the multi-group comparisons. Lac, PCT, WBC, CRP, qSOFA, SOFA and CURB-65 scores were analyzed in ICU-admission, ARDS and 28-day mortality, and we mentioned the receiver operating characteristic (ROC) curves and determined the area under curves (AUC). We also calculated the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV). Compared with AUCs, the formula of Z test is: $Z = (A_1 - A_2)/(SE_1^2 + SE_2^2 - rSE_1SE_2)^{1/2}$ ($Z_{0.05} = 1.96$, $Z_{0.01} = 2.58$). The independent predictors of ICU-admission, ARDS and 28-day mortality were confirmed by Binary Logistic regression analysis. All statistical analyses were the two-tailed tests, and $P < 0.05$ was considered statistically significant.

Results

The baseline data of the emergency patients with CAP

A total of 1028 patients from ED were enrolled in this study. Among these subjects, 152 patients with

Table 1 The baseline data of the patients with CAP

Characteristics	ICU (*n* = 174)	Non-ICU (*n* = 568)	*P*	ARDS (*n* = 164)	Non-ARDS (*n* = 578)	*P*	Survivor (*n* = 443)	Non-Survivors (*n* = 299)	*P*
Age, years	70.40 ± 13.46	68.60 ± 13.74	0.128	70.26 ± 14.19	68.67 ± 13.53	0.189	68.23 ± 13.50	70.19 ± 13.90	0.055
Male, %	106 (60.92)	356 (62.68)	0.676	100 (60.98)	362 (62.63)	0.670	268 (60.50)	194 (64.88)	0.227
COPD, %	56 (32.18)	121 (21.30)	0.003	46 (28.05)	131 (22.66)	0.153	90 (20.32)	87 (29.10)	0.006
CVD, %	39 (22.41)	91 (16.02)	0.052	34 (20.73)	96 (16.61)	0.220	78 (17.61)	52 (17.39)	0.940
Hypertension, %	89 (51.15)	254 (44.72)	0.137	79 (48.17)	264 (45.67)	0.572	205 (46.28)	138 (46.15)	0.974
DM, %	68 (39.08)	190 (33.45)	0.173	65 (39.63)	193 (33.39)	0.138	136 (30.70)	122 (40.80)	0.005
CHF, %	86 (49.43)	236 (41.55)	0.067	72 (43.90)	250 (43.25)	0.882	180 (40.63)	142 (47.49)	0.064
CRD, %	27 (15.52)	57 (10.04)	0.046	20 (12.20)	64 (11.07)	0.689	46 (10.38)	38 (12.71)	0.327
Tumor, %	23 (13.22)	55 (9.68)	0.183	24 (14.63)	54 (9.34)	0.051	35 (7.90)	43 (14.38)	0.005
MBP, mmHg	81.91 ± 24.19	92.33 ± 18.88	< 0.001	82.34 ± 23.99	92.02 ± 19.16	< 0.001	92.15 ± 19.83	86.53 ± 21.54	< 0.001
Respiratory rate, beats/min	31.95 ± 7.33	29.72 ± 6.46	< 0.001	32.15 ± 8.30	29.70 ± 6.13	< 0.001	29.91 ± 6.27	30.74 ± 7.37	0.110
Temperature, °C	37.48 ± 1.30	37.41 ± 1.13	0.535	37.69 ± 1.36	37.35 ± 1.10	0.004	37.46 ± 1.14	37.37 ± 1.22	0.305
Heart rate, beats/min	78.11 ± 21.31	107.20 ± 31.20	< 0.001	116.60 ± 21.69	111.70 ± 29.41	0.079	109.30 ± 21.25	115.00 ± 29.64	0.002
PaO_2, mmHg	73.54 ± 34.78	84.15 ± 31.45	< 0.001	66.49 ± 29.17	85.97 ± 32.19	< 0.001	81.92 ± 28.89	81.29 ± 37.37	0.804
Lac, mmol/L	4.47 ± 3.69	2.07 ± 2.05	< 0.001	2.60 (1.50, 5.05)	1.50 (0.90,2.50)	< 0.001	1.50 (1.00, 2.40)	2.00 (1.10,4.20)	< 0.001
PCT, ng/mL	1.50 (0.28, 8.50)	0.28 (0.06, 1.75)	< 0.001	1.62 (0.35, 9.53)	0.27 (0.06,1.68)	< 0.001	0.24 (0.06, 1.44)	1.06 (0.16,6.16)	< 0.001
WBC, $\times 10^9$/L	12.77 (8.23, 18.97)	11.22 (7.99, 15.66)	< 0.001	12.70 (7.73, 17.67)	11.34 (8.11, 15.88)	0.229	12.30 (8.38, 16.82)	12.30 (7.80,15.88)	0.111
PaO_2/FiO_2	199.70 ± 105.10	246.20 ± 104.50	< 0.001	165.40 ± 71.61	255.20 ± 4.42	< 0.001	239.08 ± 96.05	229.76 ± 120.05	0.262
CRP	42.39 ± 5.25	41.59 ± 5.06	0.037	43.09 ± 5.30	41.58 ± 5.06	< 0.001	41.59 ± 5.06	42.39 ± 5.25	0.037
qSOFA score	1.96 ± 0.76	1.35 ± 0.62	< 0.001	1.98 ± 0.70	1.36 ± 0.64	< 0.001	1.38 ± 0.63	1.66 ± 0.77	< 0.001
SOFA score	9.58 ± 5.11	5.38 ± 4.18	< 0.001	9.21 ± 4.85	5.56 ± 4.41	< 0.001	5.66 ± 4.08	7.40 ± 5.45	< 0.001
CURB-65 score	3.16 ± 1.23	2.19 ± 1.19	< 0.001	3.29 ± 1.17	2.17 ± 1.18	< 0.001	2.22 ± 1.20	2.71 ± 1.30	< 0.001

COPD chronic obstructive pulmonary disease, *CVD* Cerebrovascular disease, *DM* Diabetes mellitus, *CHF* chronic heart failure, *CRD* chronic renal dysfunction, *MBP* myelin basic protein, *Lac* lactate, *PCT*: p rocalcitonin, *WBC* white blood cell, *CRP* C-reactive protein, *qSOFA* quick sequential organ failure assessment, *SOFA* sequential organ failure assessment, *CURB-65* confusion, urea, respiratory rate, blood pressure and age

Table 2 Binary Logistic regression analysis of clinical outcomes for CAP patients

	Variables	*β*	*S.E*	Wald	*P*	OR (95% CI)
ICU-admission	WBC	0.017	0.009	3.244	0.072	1.017 (0.999–1.035)
	PCT	−0.004	0.004	1.071	0.301	0.996 (0.987–1.004)
	CRP	0.176	0.024	54.278	< 0.001	1.192 (1.138–1.249)
	Lac	0.204	0.043	22.208	< 0.001	1.227 (1.127–1.335)
	PaO_2	−0.010	0.006	3.578	0.059	0.990 (0.979–1.000)
	PaO_2/FiO_2	−0.001	0.002	0.476	0.490	0.999 (0.995–1.002)
	qSOFA	0.343	0.215	2.547	0.110	1.409 (0.925–2.146)
	SOFA	0.115	0.027	17.518	< 0.001	1.122 (1.063–1.184)
	CURB-65	0.394	0.114	11.956	< 0.001	1.483 (1.186–1.854)
	Constant	−10.900	1.163	87.884	< 0.001	
ARDS	WBC	−0.010	0.012	0.699	0.403	0.990 (0.967–1.014)
	PCT	0.002	0.004	0.169	0.681	1.002 (0.994–1.010)
	CRP	0.031	0.022	1.986	0.159	1.031 (0.988–1.077)
	Lac	0.029	0.041	0.511	0.475	1.030 (0.950–1.116)
	PaO_2	−0.006	0.006	1.108	0.292	0.994 (0.983–1.005)
	PaO_2/FiO_2	−0.010	0.002	26.917	< 0.001	0.990 (0.987–0.994)
	qSOFA	0.473	0.223	4.519	0.034	1.605 (1.038–2.484)
	SOFA	0.090	0.029	9.661	0.002	1.094 (1.034–1.159)
	CURB-65	0.483	0.118	16.712	< 0.001	1.621 (1.286–2.043)
	Constant	−2.787	1.012	7.591	0.006	
28-day mortality	WBC	0.005	0.008	0.487	0.485	1.005 (0.990–1.020)
	PCT	0.004	0.004	1.252	0.263	1.004 (0.997–1.012)
	CRP	0.013	0.016	0.712	0.399	1.013 (0.983–1.045)
	Lac	0.129	0.035	13.619	< 0.001	1.138 (1.062–1.219)
	PaO_2	−0.000	0.004	0.000	0.993	1.000 (0.992–1.008)
	PaO_2/FiO_2	0.000	0.001	0.001	0.969	1.000 (0.998–1.003)
	qSOFA	0.096	0.158	0.367	0.544	1.100 (0.808–1.499)
	SOFA	0.034	0.020	2.833	0.092	1.034 (0.994–1.075)
	CURB-65	0.196	0.081	5.901	0.015	1.216 (1.039–1.424)
	Constant	−2.251	0.706	10.171	0.001	

WBC white blood cell, *PCT* procalcitonin, *CRP* C-reactive protein, *Lac* lactate, *qSOFA* quick sequential organ failure assessment, *SOFA* sequential organ failure assessment, *CURB-65* confusion, urea, respiratory rate, blood pressure and age

Table 3 The characteristics for various predictors of ICU-admission in CAP patients

Variables	AUC (95% CI)	*S.E*	*P*	Cut off	Sensitivity	Specificity	PPV	NPV	LR+	LR-
Lac	0.745 (0.712–0.776)	0.022	< 0.001	2.3	64.37	75.18	43.3	87.3	2.59	0.47
PCT	0.641 (0.605–0.676)	0.023	< 0.001	1.0	50.00	73.98	37.2	82.8	1.92	0.68
WBC	0.563 (0.527–0.599)	0.027	0.019	18.48	28.16	85.21	36.8	79.5	1.90	0.84
CRP	0.721 (0.687–0.753)	0.023	< 0.001	44.01	59.77	75.53	42.8	86.0	2.44	0.53
qSOFA	0.712 (0.678–0.745)	0.021	< 0.001	1.0	70.11	65.32	38.2	87.7	2.02	0.46
SOFA	0.744 (0.711–0.775)	0.021	< 0.001	6.0	67.24	68.84	39.8	87.3	2.16	0.48
CURB-65	0.705 (0.671–0.738)	0.022	< 0.001	3.0	44.25	85.74	48.7	83.4	3.10	0.65

Lac lactate, *PCT* procalcitonin, *WBC* white blood cell, *CRP* C-reactive protein, *qSOFA* quick sequential organ failure assessment, *SOFA* sequential organ failure assessment, *CURB-65* confusion, urea, respiratory rate, blood pressure and age

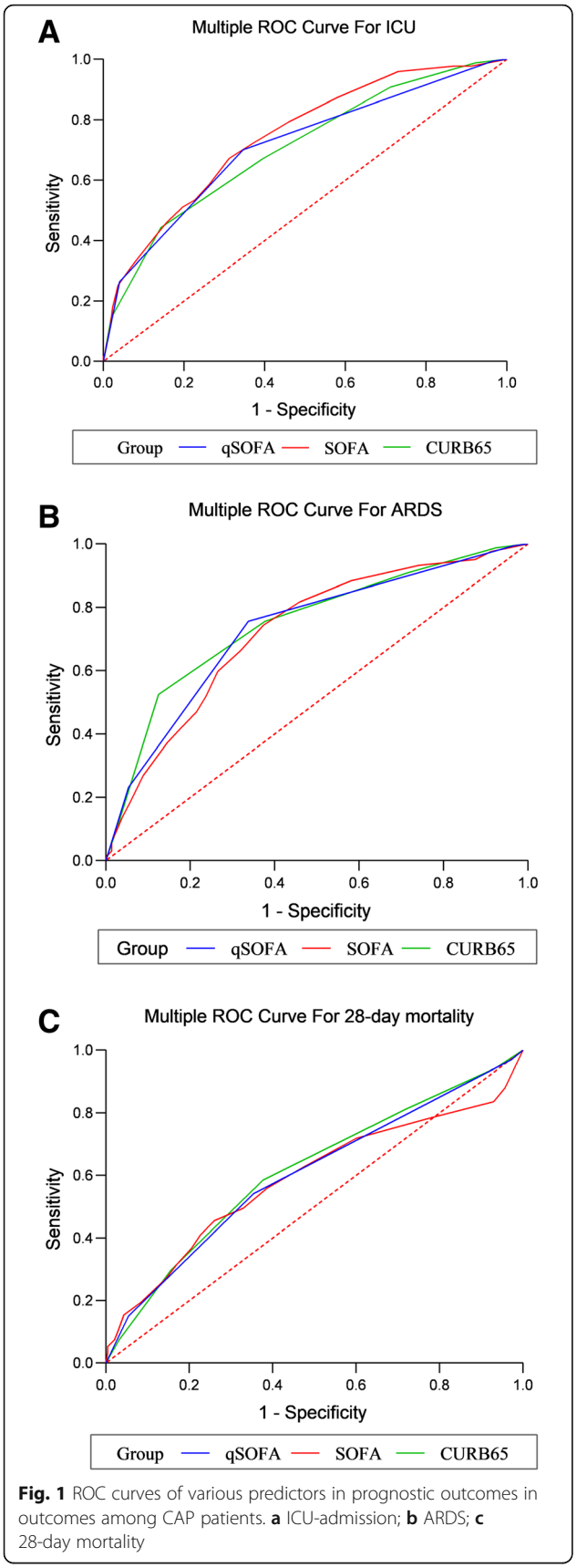

Fig. 1 ROC curves of various predictors in prognostic outcomes in outcomes among CAP patients. **a** ICU-admission; **b** ARDS; **c** 28-day mortality

incomplete clinical data had other diseases except CAP, 61 participants were lost to follow-up, and 73 patients or relatives did not agree to be enrolled. Finally, 742 patients completed 28 days of follow-up. The baseline data of the patients with CAP were shown in Table 1.

In the present study, 742 CAP patients were divided into ICU ($n = 174$) and non-ICU ($n = 568$) admission groups. There were significant differences in chronic obstructive pulmonary disease (COPD) ($P = 0.003$), chronic renal dysfunction (CRD) ($P = 0.046$), MBP ($P < 0.001$), respiratory rate ($P < 0.001$), heart rate ($P < 0.001$), PaO_2 ($P < 0.001$), Lac ($P < 0.001$), PCT ($P < 0.001$), WBC ($P < 0.001$), PaO_2/FiO_2 ($P < 0.001$), CRP ($P = 0.037$), qSOFA score ($P < 0.001$), SOFA score ($P < 0.001$) and CURB-65 score ($P < 0.001$) between ICU and non-ICU admission groups (Table 1).

According to CAP patients with or without ARDS, 742 cases were classified as ARDS ($n = 164$) and non-ARDS ($n = 578$) groups. Obvious differences between ARDS and non-ARDS groups were discovered in MBP ($P < 0.001$), respiratory rate ($P = 0.002$), temperature ($P = 0.004$), PaO_2 ($P < 0.0$ 01), Lac ($P < 0.001$), PCT ($P < 0.001$), PaO_2/FiO_2 ($P < 0.001$), CRP ($P < 0.001$), qSOFA score ($P < 0.001$), SOFA score ($P < 0.001$) and CURB-65 score ($P < 0.001$) (Table 1).

After 28 days of follow-up, we also found that the statistical differences were distinct in COPD ($P = 0.006$), DM ($P = 0.005$) tumor ($P = 0.005$), MBP ($P < 0.001$), heart rate ($P = 0.013$), Lac ($P < 0.001$), PCT ($P < 0.001$), PaO_2/FiO_2 ($P < 0.001$), CRP ($P < 0.001$), qSOFA score ($P < 0.001$), SOFA score ($P < 0.001$) and CURB-65 score ($P < 0.001$) between survivor ($n = 443$) and non-survivor ($n = 299$) groups (Table 1).

Binary logistic regression analysis of the prognostic outcomes for CAP patients

As displayed in Table 2, the results showed that the differences were significant in the CRP level ($P < 0.001$, OR = 1.192, 95%CI: 1.138–1.249), Lac level ($P < 0.001$, OR = 1.227, 95%CI: 1.127–1.335), SOFA ($P < 0.001$, OR = 1.122, 95%CI: 1.063–1.184) and CURB-65 scores ($P < 0.005$, OR = 1.483, 95%CI: 1.186–1.854) on ICU-admission. It was indicated that the CRP level, Lac level, SOFA and CURB-65 scores was the risk factors of ICU-admission among CAP patients. For the occurrences of ARDS, the qSOFA ($P = 0.034$, OR = 1.605, 95%CI: 1.038–2.484), SOFA ($P = 0.002$, OR = 1.094, 95%CI: 1.034–1.159) and CURB-65 scores ($P < 0.001$, OR = 1.621, 95%CI: 1.286–2.043) were the risk factors, while the PaO_2/FiO_2 ratio ($P < 0.001$, OR = 0.990, 95%CI: 0.987–0.994) was as a protective factor among the patients with CAP. The Lac level ($P < 0.001$, OR = 1.138, 95%CI: 1.062–1.219) and CURB-65 scores ($P = 0.015$, OR = 1.216, 95%CI: 1.039–1.424) were the risk factors of the 28-day mortality in CAP patients.

Table 4 The characteristics for various predictors of ARDS in CAP patients

Variables	AUC (95% CI)	S.E	P	Cut off	Sensitivity	Specificity	PPV	NPV	LR+	LR-
Lac	0.690 (0.655–0.723)	0.023	< 0.001	2.1	61.59	69.20	36.2	86.4	2.00	0.56
PCT	0.662 (0.627–0.696)	0.023	< 0.001	0	68.29	59.48	32.5	86.8	1.69	0.53
WBC	0.531 (0.494–0.567)	0.027	0.260	12.6	51.83	58.48	26.2	81.1	1.25	0.82
CRP	0.587 (0.550–0.622)	0.025	0.001	40.8	71.34	42.91	26.2	84.1	1.25	0.67
qSOFA	0.730 (0.697–0.762)	0.021	< 0.001	1.0	75.61	66.26	38.9	90.5	2.24	0.37
SOFA	0.724 (0.690–0.756)	0.022	< 0.001	5.0	74.39	62.63	36.1	89.6	1.99	0.41
CURB-65	0.749 (0.716–0.780)	0.022	< 0.001	3.0	52.44	87.54	54.4	86.6	4.21	0.54

Lac lactate, *PCT* procalcitonin, *WBC* white blood cell, *CRP* C-reactive protein, *qSOFA* quick sequential organ failure assessment, *SOFA* sequential organ failure assessment, *CURB-65* confusion, urea, respiratory rate, blood pressure and age

Prediction of the prognostic outcomes in CAP patients

The predictive analysis of the relevant parameters for CAP patients in various outcomes were depicted in Table 3 4 and 5, and the ROC curves of predictive effects of the scoring systems for CAP patients were shown in Fig. 1. The AUC values of the qSOFA, SOFA and CURB-65 scores for ICU-admission among CAP patients were 0.712 (95%CI: 0.678–0.745, $P < 0.001$), 0.744 (95%CI: 0.711–0.775, $P < 0.001$) and 0.705 (95%CI: 0.671–0.738, $P < 0.001$), respectively. The cut-off values for the qSOFA, SOFA and CURB-65 scores maximizing the composite of specificity and sensitivity in the prediction of CAP patients in ICU-admission were 1.0, 6.0 and 3.0 (Table 3 and Fig. 1a). For ARDS, the AUC values of the qSOFA, SOFA and CURB-65 scores were 0.730 (95%CI: 0.697–0.762, $P < 0.001$), 0.724 (95%CI: 0.690–0.756, $P < 0.001$) and 0.749 (95%CI: 0.716–0.780, $P < 0.001$), respectively (Table 4 and Fig. 1b). After 28 days of follow-up, the AUC values of the qSOFA, SOFA and CURB-65 scores for 28-day mortality were 0.602 (95%CI: 0.566–0.638, $P < 0.001$), 0.587 (95%CI: 0.551–0.623, $P < 0.001$) and 0.614 (95%CI: 0.577–0.649, $P < 0.001$) in turn (Table 5 and Fig. 1c).

Comparison of AUCs for predicting the prognostic outcomes among CAP patients were analyzed in the study. The results revealed that there were no statistical differences between qSOFA and SOFA scores for predicting ICU-admission ($Z = 1.482$, $P = 0.138$), ARDS ($Z = 0.321$, $P = 0.748$) and 28-day mortality ($Z = 0.573$, $P = 0.567$). Moreover, we found no differences to predict the ICU-admission ($Z = 0.370$, $P = 0.712$), ARDS ($Z = 0.900$, $P = 0.368$) and 28-day mortality ($Z = 0.768$, $P = 0.442$) using qSOFA or CURB-65 scores.

Discussion

CAP is one of serious diseases that causes death and threatens human life. Establishment of safe and effective prognostic assessment systems of CAP is important for clinicians. In the present study, we investigated the predictive value of qSOFA for the clinical outcomes including ICU-admission, ARDS and 28-day mortality in emergency patients with CAP, and the efficacy of the qSOFA score was assessed in comparison with CURB-65 and SOFA scores. Our results revealed that qSOFA was not inferior to SOFA or CURB-65 scores in predicting the ICU-admission, ARDS and 28-day mortality of patients presenting in the ED with CAP.

Pneumonia is a common reason for hospitalization [18], and CAP is associated with the high risk of respiratory failure or septic organ dysfunction. The early managements of CAP are also based on severity assessment tools since 2000, including CURB-65 [19–21], pneumonia severity index (PSI) [21–23] and so on. In 2007, the Infectious Diseases Society of America/American Thoracic Society consensus guidelines suggested PSI and CURB-65 scoring systems be used together [24]. Subsequently, newly published guidelines suggested that the

Table 5 The characteristics for various predictors of 28-day mortality in CAP patients

Variables	AUC (95% CI)	S.E	P	Cut off	Sensitivity	Specificity	PPV	NPV	LR+	LR-
Lac	0.611 (0.575–0.646)	0.022	< 0.001	2.3	45.48	73.59	53.8	66.7	1.72	0.74
PCT	0.624 (0.588–0.659)	0.020	< 0.001	0	59.80	62.08	51.3	69.8	1.58	0.65
WBC	0.534 (0.498–0.571)	0.022	0.115	11.68	54.85	54.63	44.9	64.2	1.21	0.83
CRP	0.537 (0.501–0.574)	0.022	0.083	45.3	28.09	78.56	46.9	61.8	1.31	0.92
qSOFA	0.602 (0.566–0.638)	0.019	< 0.001	1.0	54.18	64.56	50.8	67.6	1.53	0.71
SOFA	0.587 (0.551–0.623)	0.022	< 0.001	7.0	45.48	74.04	54.2	66.8	1.75	0.74
CURB-65	0.614 (0.577–0.649)	0.021	< 0.001	2.0	58.53	62.30	51.2	69.0	1.55	0.67

Lac lactate, *PCT* procalcitonin, *WBC* white blood cell, *CRP* C-reactive protein, *qSOFA* quick sequential organ failure assessment, *SOFA* sequential organ failure assessment, *CURB-65* confusion, urea, respiratory rate, blood pressure and age

pneumonia severity can be assessed utilizing the SOFA and qSOFA scores. Nevertheless, the efficacies of these scoring systems for predicting the prognostic outcomes are still matters of controversy in emergency patients with CAP. As we know, the calculation of PSI is really complex that involving 20 parameters [22], which is not suitable for newly admitted patients in ED. The CURB-65 score consists of confusion, urea, respiratory rate, blood pressure and age that is similar with the qSOFA score in components. The SOFA score was proposed by European Society of Intensive Care Medicine (ESICM) in 1994 [25], and was applied for prognostic assessments in sepsis and multiple organ dysfunction, which was associated with the mortality. The qSOFA, incorporating hypotension, altered mental status and tachypnea, was high prediction of mortality in non-ICU settings [26]. In our study, the qSOFA, SOFA and CURB-65 scoring systems were applied for mortality prediction in patients with CAP.

Our findings found that the predictive performances of the qSOFA and CURB-65 scores in ICU-admission, ARDS and 28-day mortality were similar ($P > 0.05$). The qSOFA score is a quick and simple scoring system which is to identify the elevated risks in clinical deterioration, which was associated with ICU-admission in adult ED patients [27]. Goulden et al [28] reported that the efficacy of the qSOFA was as similar as Systemic Inflammatory Response Syndrome (SIRS) and National Early Warning Score (NEWS) for predicting ICU-admission. Early researches mentioned that a positive qSOFA score had high specificity outside the ICU in early detection of ICU admission [14]. Previous studies reported that the CURB-65 score was related to the risk of ARDS in CAP patients, and the development of ARDS risk was prominent when the CURB-65 score was ≥2 [29]. The CURB-65 score contains respiratory rate ≥ 30 beats/min and systolic blood pressure < 90 mmHg or diastolic blood pressure ≤ 60 mmHg, which the thresholds of these indicators were higher than that in qSOFA (respiratory rate ≥ 22 beats/min and systolic blood pressure ≤ 100 mmHg [13]). Compared with the qSOFA score, CURB-65 may miss some potentially dangerous patients in the risk prediction. A recent systematic review suggested that the positive qSOFA score had high specificity in early detection of in-hospital mortality [14]. A multiple-center research discovered that the CURB-65 score had a predictive value of mortality in CAP patients [30]. In the presented study, the predictive values of the qSOFA and CURB-65 scores were similar regarding to the ICU-admission, ARDS and 28-day mortality. The discrepancy may be due to differences in the variables assessed, the patient group and the study design. In consideration of needing quick and effective diagnose in the ED, therefore the qSOFA score may be a useful and practical tool for the early prediction of ARDS and 28-day morality among patients with CAP, and may serve as an early warning signal that CAP is about to worsen in emergency patients.

The superiority of this study was that few previous researches had investigated the predictive value of qSOFA score in comparison with other pneumonia severity scoring systems (SOFA and CURB-65 scores) in the prognostic outcomes containing ICU-admission, ARDS and 28-day mortality for CAP patients, especially in Chinese population. However, there were some limitations that should be warranted caution for interpreting the data. Our investigation was a retrospective study based on a single center. Microbiology, time to initiation of antibiotics and antibiotic choice may be potential confounding variables. The 28-day mortality as a prognostic outcome was assessed, but long-term outcomes were not identified. Thus, prospective multicenter studies with larger samples should be needed for further verification in clinic.

Conclusion

In this study, we found that the predictive effects of qSOFA score were similar with CURB-65 and SOFA scores in ICU-admission, ARDS and 28-day mortality. According to the actual situation of emergency patients, qSOFA score may be an effective and practical tool for the early prediction of ICU-admission, ARDS and 28-day morality among CAP patients in the ED.

Abbreviations

qSOFA: Quick sequential organ failure assessment; CAP: Community-acquired pneumonia; ED: Emergency department; ARDS: Acute respiratory distress syndrome; AUC: Area under the curve; ICU: Intensive care unit; IMV: Invasive mechanical ventilation; EDTA: Ethylenediaminetetraacetate; WBC: White blood cell; PCT: Procalcitonin; LOD limit of detection; CRP: C-reactive protein; SD: Standard deviation; AUC: Area under curves; PPV: Positive predictive value; NPV: Negative predictive value; COPD: Chronic obstructive pulmonary disease; CFD: Chronic renal dysfunction; PSI: Pneumonia severity index; ESICM: European Society of Intensive Care Medicine; SIRS: Systemic Inflammatory Response Syndrome; NEWS: National Early Warning Score

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Authors' contributions

HZ, XQZ and BL designed the study. XQZ drafted and wrote the manuscript. YGL and LJM contributed to collected, analyzed and interpreted the data. HZ and BL critically reviewed, edited and approved the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The data used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Beijing Chao-Yang Hospital (No.2014-KE-124). All written informed consents were obtained from all participants and/or their legal guardians. Firstly, patients who conformed to the inclusion and exclusion criteria were screened in this study. Secondly, we notified patients and/or their legal guardians by telephone and asked for consent, and for those who did not, we waived the use of their data. Thirdly, we sent written informed consents to patients and/or their legal guardians who agreed to participate in the study for signature. Finally, they returned the signed informed consents to us.

Consent for publication

Not applicable.

Competing interests

The author reports no conflicts of interest in this work.

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