Original Article

Contribution of Quick Sequential Organ Failure Assessment Score Combined with Electrocardiography in Risk Stratification of Patients with Acute Pulmonary Embolism

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Abstract

Background: The quick Sequential Organ Failure Assessment (qSOFA) score emerged recently. We investigated its contribution to risk stratification in acute pulmonary embolism (PE) by combining with electrocardiography (ECG).
Methods: Acute PE patients diagnosed in Beijing Chao-Yang Hospital, Capital Medical University, from 2008 to 2018 were retrospectively studied and divided into high- and low-risk groups by imaging and biomarkers. The ECG scores consisted of tachycardia, McGinn-White sign ($S_1Q_3T_3$), right bundle branch block, and T-wave inversion of leads V_1–V_3. A new combination of qSOFA scores and ECG scores by logistic regression for predicting high-risk stratification patients with acute PE was evaluated by a receiver operating characteristic curve.
Results: Totally 1318 patients were enrolled, including 271 in the high-risk group and 1047 in the low-risk group. A combination predictive scoring system named qSOFA-ECG = qSOFA score + ECG score was created. The optimal cutoff value for qSOFA-ECG was 2, and the sensitivity, specificity, positive predictive value, and negative predictive value were 81.5%, 72.3%, 43.2%, and 93.8%, respectively. For predicting high-risk stratification and reperfusion therapy, the qSOFA-ECG is superior to PE Severity Index (PESI) and simplified PESI.
Conclusions: The qSOFA score contributes to identify acute PE patients with potentially hemodynamic decompensation that need monitoring and possible reperfusion therapy at the emergency department arrival when used in combination with ECG score.

Key words: Electrocardiography; Emergency; Pulmonary Embolism; Quick Sequential Organ Failure Assessment

Introduction

Acute pulmonary embolism (PE), which can rapidly lead to right ventricular (RV) strain, is a potentially lethal in the emergency department (ED). It is still a challenge to reduce mortality and improve prognosis through rapid and accurate diagnosis and management.[1,2] The status of RV in response to the PE-induced acute pressure overload can be reflected by electrocardiography (ECG). Data from these published studies summarized that tachycardia, McGinn-White sign ($S_1Q_3T_3$), right bundle branch block (RBBB), and T-wave inversion of leads V_1–V_3 (TWI) are the most predominant signs of RV strain.[3,4]

The quick Sequential Organ Failure Assessment (qSOFA) score emerged as a tool to identify septic patients with a high risk of short-term death in the ED[5] and achieved greater prognostic accuracy.[6,7] The three clinical criteria including respiration, stability of circulation, and status of consciousness from the qSOFA score were all included in the eleven independent predictors of 30-day mortality from the PE Severity Index (PESI).[8] However, the qSOFA score is more simple and familiar than the original PESI and simplified PESI in the ED.[9]

Having a time-effective evaluation method is imperative to risk stratify patients and determine those requiring more intensive treatment or monitoring. We hypothesized that the combination

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of qSOFA score and ECG parameters could identify the acute PE patients at a risk of hemodynamic collapse at the ED arrival and investigated the scheme efficacy in this study.

Methods

Ethical approval

This study was designed as a retrospective observational study and was approved by the Institutional Review Board and Medical Ethics Committee of Beijing Chao-Yang Hospital, which is a comprehensive university hospital with an annual census of approximately 250,000 ED visits. Given the retrospective study design and the fact that data analysis was performed anonymously, this study was exempt from obtaining informed consent from patients.

Patient selection

Patients diagnosed with acute PE in Beijing Chao-Yang Hospital (Beijing, China) from January 2008 to January 2018 were included in the original cohort without geographical limitations. All admitted patients should meet one of the diagnostic criteria: (i) A filling defect in the pulmonary artery was detected by computed tomography pulmonary angiography (CTPA); (ii) High probability was indicated by ventilation/perfusion (V/Q) scintigraphy; (iii) Echocardiography findings of RV dysfunction in suspected acute PE patients with hemodynamic instability. The following patients were excluded from this study: (i) Missing important medical records; (ii) Diagnosed with acute PE and received preliminary treatment at another hospital but were transferred to our hospital for further management; (iii) With previous cardiac dysfunction (NYHA classification III or IV); (iv) With a history of severe chronic obstructive pulmonary disease, pulmonary hypertension, or chronic cor pulmonale. Medical records were independently reviewed by two physicians.

The quick Sequential Organ Failure Assessment score

The qSOFA score was calculated by assigning patients 1 point for each of the following: systolic blood pressure ≤100 mmHg (1 mmHg = 0.133 kPa), respiratory rate ≥22 breaths/min, or altered mental status documented by the physician (Glasgow Coma Scale [GCS] score ≤13 in the original study[5] or <15 according to the definitions for sepsis and septic shock set by the Third International Consensus;[10] the latter criterion was adopted in our research).

Electrocardiography capture and definition of the electrocardiography score

CardiMax FX-7402 type 12 channel automatic analytical ECG recorders (Futian Electronic Medical Instrument Co., Ltd., Beijing, China) were used, and the paper speed was set at 25 mm/s. The ECG most proximate to the time of symptom onset was captured for use in the research, analyzed by ECG analysts, and checked by the authors. Based on the Daniel score,[3] a classical and authoritative ECG scoring system, tachycardia, $S_1Q_3T_3$, RBBB, and TWI were determined from the ECG. The ECG score was calculated by assigning patients 1 point for each of the four parameters.

Definitions for grouping

According to the *2014 ESC Guidelines on the diagnosis and management of acute pulmonary embolism*,[11] hemodynamically unstable patients with shock or hypotension should immediately be identified as high-risk cases; low-risk patients are indicated by a PESI[8] Class I or II or a simplified PESI[9] of 0. Normotensive patients with PESI ≥ Class III or simplified PESI ≥1 are constituted an intermediate-risk group. Of these patients, who display evidence of both RV dysfunction by echocardiography and elevated cardiac biomarker levels should be classified into an intermediate-high-risk category, needing close monitoring to permit early detection of hemodynamic decompensation and potential rescue reperfusion therapy;[12] the rest belong to an intermediate-low-risk group and do not require monitor or thrombolysis. In this study, we redefined two groups: acute PE patients with hemodynamic instability (high risk) or at risk of hemodynamic collapse (intermediate to high risk), who need close monitoring at the ED arrival, were separated into a high-risk group; and the rest of the acute PE patients, who were considered low or intermediate to low risk and could thus access a routine procedure without close monitoring, were included in the low-risk group.

Imaging of the right ventricle by echocardiography or computed tomography pulmonary angiography

The study required that patients suspected or diagnosed with acute PE undergo echocardiography (by Philips EPIQ 7C, Philips Healthcare, Andover, MA, USA) within 24 h. Positive imaging findings of RV dysfunction should fulfill at least one criterion among the following: RV dilation; an increased RV/left ventricular diameter ratio (in most studies, the reported threshold value was 0.9, which was used in this study); hypokinesia of the free RV wall; increased velocity of the jet of tricuspid regurgitation; and decreased tricuspid annulus plane systolic excursion. The diagnostic reports were provided by the Cardiac Ultrasonography Department and the Radiology Department of Beijing Chao-Yang Hospital.

Biomarkers of myocardial injury

Elevated cardiac troponin I plasma concentrations of 0.09 ng/ml were considered as the optimal cutoff values for myocardial injury.[11] The reagents for cardiac troponin I were produced by Siemens Healthcare Diagnostics Inc. (New York, USA), and the bloodwork results were provided by the Clinical Laboratory Department of Beijing Chao-Yang Hospital.

Data collection

The following data were recorded: demographic properties (sex, age), comorbidities, venous thrombosis risk factors, vital symptoms, vital signs, ECG parameters, echocardiography, CTPA, biomarkers (cardiac troponin I), received reperfusion therapy, and hospital mortality. The PESI, simplified PESI, qSOFA, and ECG scores were calculated.

Statistical analysis

SPSS 21.0 software was used for statistical analysis of the results (IBM SPSS Statistics for Windows, version 21.0; Armonk, NY, USA). The results are presented as the mean ± standard deviation (SD) for continuous variables with a normal distribution, as the median (interquartile range) for continuous variables with a nonnormal distribution, and as numbers (percentage) for categorical variables. The independent samples *t*-test, the Mann-Whitney *U*-test, and the Chi-squared test were used for comparisons of the continuous variables with a normal distribution, continuous variables with a nonnormal distribution, and categorical variables between the high-risk group and the low-risk group. Independent predictors were analyzed with a multivariate logistic regression model. The test efficiency was evaluated using an area under the receiver operating characteristic curve (AUC). Then, the optimal cutoff values, sensitivity, specificity, positive predictive values, negative predictive values, likelihood ratios and odds ratios of the qSOFA score, the ECG parameters, and their combination predictive values were calculated for the overall data set. A difference was considered statistically significant when $P < 0.05$.

Results

Patient characteristics

Of the total 1681 patients, 1470 (87.45%) met the criteria for acute PE; 1382 (94.01%) of these patients were diagnosed by CTPA, 83 (5.65%) were diagnosed with high probability by V/Q scan, and 5 (0.34%) were diagnosed by echocardiography. Of these 1470 patients, 152 (10.34%) were excluded from the study: 44 were missing important medical records, 33 had received preliminary treatment for acute PE at another hospital and were transferred to our hospital, 31 had previous cardiac dysfunction, 41 had a history of severe chronic obstructive pulmonary disease and chronic cor pulmonale, and 3 had primary pulmonary hypertension [Figure 1]. Thus, 1318 (89.66%) patients were included in the study, including 271 (20.56%) in the high-risk group and 1047 (79.44%) in the low-risk group. The baseline characteristics of the study cohort are described in Table 1.

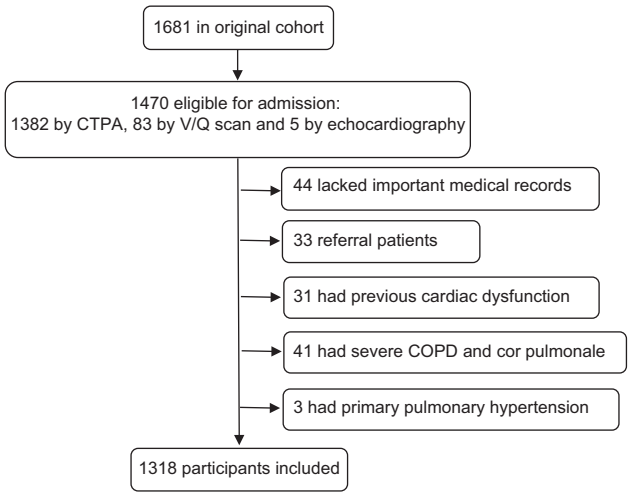

Figure 1: Flowchart of participant selection. CTPA: Computed tomography pulmonary angiography; COPD: chronic obstructive pulmonary disease.

Comparison of the quick Sequential Organ Failure Assessment score and electrocardiography score between the high-risk group and the low-risk group

The ratio of patients with respiratory rate ≥22 breaths/min, systolic blood pressure ≤100 mmHg, and GCS <15 in the high-risk group was higher than that in the low-risk group. The ratio of patients with 0 score of qSOFA was higher in the low-risk group than that in the high-risk group, while the ratio of patients with scores of 1, 2, and 3 was higher in the high-risk group than it was in the low-risk group. The ratio of patients with tachycardia, $S_1Q_3T_3$, RBBB, and TWI in the high-risk group was higher than that in the low-risk group. The ratio of patients with 0 score of ECG was higher in the low-risk group than that in the high-risk group, no significant difference of patients with 1 score was found between the two groups, and the ratios of patients with scores of 2 and 3 were higher in the high-risk group than those in the low-risk group [Table 1].

Efficiency evaluation of combined quick Sequential Organ Failure Assessment score and electrocardiography score for predicting high-risk stratification

The AUCs of the qSOFA score, respiratory rate ≥22 breaths/min, systolic blood pressure ≤100 mmHg, and GCS <15 for predicting high-risk stratification were 0.681 (95% confidence interval [*CI*]: 0.643–0.719), 0.628 (95% *CI*: 0.591–0.666), 0.608 (95% *CI*: 0.567–0.649), and 0.537 (95% *CI*: 0.497–0.577), respectively. The AUC of the qSOFA score was larger than that of each parameter from it ($Z = 5.519$, $P < 0.001$; $Z = 5.036$, $P < 0.001$; $Z = 8.422$, $P < 0.001$).

The AUCs of the ECG score, tachycardia, $S_1Q_3T_3$, RBBB, and TWI for predicting high-risk stratification were 0.786 (95% *CI*: 0.756–0.815), 0.552 (95% *CI*: 0.512–0.592), 0.621 (95% *CI*: 0.582–0.661), 0.615 (95% *CI*: 0.574–0.656), and 0.681 (95% *CI*: 0.644–0.719), respectively. The AUC of the ECG score was larger than that of each parameter from it ($Z = 15.663$, $P < 0.001$; $Z = 10.850$, $P < 0.001$; $Z = 10.778$, $P < 0.001$; $Z = 6.660$, $P < 0.001$).

In the multivariate logistic regression model, the respiratory rate ≥22 breaths/min, systolic blood pressure ≤100 mmHg, GCS <15, tachycardia, $S_1Q_3T_3$, RBBB, and TWI were identified as independent variables to predict high-risk stratification in patients with acute PE ($P < 0.05$) [Table 2]. There was no collinearity between these independent variables. We calculated a new combination predictive scoring system named qSOFA-ECG, and the equation was as follows: qSOFA-ECG = qSOFA + ECG. Hosmer–Lemeshow goodness-of-fit statistic was 7.815, $P = 0.252 > 0.20$, and the model fitted the original data better. The AUC of qSOFA-ECG was significantly larger than that of the qSOFA score ($Z = 9.762$, $P < 0.001$) and ECG score ($Z = 3.725$, $P < 0.001$) [Table 3 and Figure 2]. The optimal cutoff values, sensitivity, specificity, positive predictive values, negative predictive values, and likelihood ratios of the qSOFA score, ECG score, and qSOFA-ECG score are described in Table 3.

Table 1: Baseline characteristics of patients with acute PE

Characteristics	Total (n = 1318)	High-risk group (n = 271)	Low-risk group (n = 1047)	Statistics	P
Age (years), median (P_{25}, P_{75})	64 (53, 72)	64 (54, 73)	63 (52, 72)	1.741*	0.082
Sex (female), n (%)	709 (53.8)	151 (55.7)	558 (53.3)	0.509†	0.476
Comorbidity and risk factors, n (%)					
Chronic respiratory disease‡	87 (6.6)	13 (4.8)	74 (7.1)	1.801†	0.180
Hypertension	564 (42.8)	116 (42.8)	448 (42.8)	0.000†	0.996
Coronary heart disease	192 (14.6)	33 (12.2)	159 (15.2)	1.566†	0.211
Auricular fibrillation	52 (3.9)	9 (3.3)	43 (4.1)	0.351†	0.554
Stroke	85 (6.4)	20 (7.4)	65 (6.2)	0.490†	0.484
Diabetes mellitus	167 (12.7)	27 (10.0)	140 (13.4)	2.260†	0.133
Active cancer	110 (8.3)	22 (8.1)	88 (8.4)	0.023†	0.879
Deep venous thrombosis	615 (46.7)	154 (56.8)	461 (44.0)	14.163†	<0.001
Postoperative convalescence	73 (5.5)	21 (7.7)	52 (5.0)	3.186†	0.074
Lower limb fractures	97 (7.4)	33 (12.2)	64 (6.1)	11.612†	0.001
Symptoms, n (%)					
Chest pain	323 (24.5)	54 (19.9)	269 (25.7)	3.869†	0.049
Dyspnea	845 (64.1)	188 (69.4)	657 (62.8)	4.103†	0.043
Hemoptysis	123 (9.3)	10 (3.7)	113 (10.8)	12.835†	<0.001
Syncope	142 (10.8)	55 (20.3)	87 (8.3)	32.171†	<0.001
Vital signs, median (P_{25}, P_{75})					
Heart rate (beats/min)	80 (72, 90)	85 (78, 96)	80 (70, 88)	6.649*	<0.001
RR (breaths/min)	20 (20, 22)	22 (20, 24)	20 (20, 22)	8.041*	<0.001
SBP (mmHg)	125 (112, 138)	120 (100, 134)	127 (115, 139)	−4.681*	<0.001
qSOFA parameters, n (%)					
RR ≥22 breaths/min	514 (39.0)	161 (59.4)	353 (33.7)	59.742†	<0.001
SBP ≤100 mmHg	139 (10.5)	75 (27.7)	64 (6.1)	106.097†	<0.001
GCS <15	24 (1.8)	21 (7.7)	3 (0.3)	62.950†	<0.001
qSOFA score, n (%)					
0	742 (56.3)	90 (33.2)	652 (62.3)	73.906†	<0.001
1	489 (37.1)	119 (43.9)	370 (35.3)	6.779†	0.009
2	73 (5.5)	48 (17.7)	25 (2.4)	96.629†	<0.001
3	14 (1.1)	14 (5.2)	0	49.864†	<0.001
ECG parameters, n (%)					
Tachycardia	115 (8.7)	46 (17.0)	69 (6.6)	29.147†	<0.001
$S_1Q_3T_3$	373 (28.3)	129 (47.6)	244 (23.3)	62.631†	<0.001
RBBB	128 (12.0)	82 (30.3)	76 (7.3)	107.932†	<0.001
TWI	413 (31.3)	163 (60.1)	250 (23.9)	131.621†	<0.001
ECG score, n (%)					
0	556 (42.2)	22 (8.1)	534 (51.0)	162.333†	<0.001
1	526 (39.9)	121 (44.6)	405 (38.7)	3.197†	0.074
2	183 (13.9)	93 (34.3)	90 (8.6)	119.117†	<0.001
3	47 (3.6)	29 (10.7)	18 (1.7)	50.504†	<0.001
4	6 (0.5)	6 (2.2)	0	18.657†	<0.001
Reperfusion therapy§, n (%)	95 (7.2)	95 (35.1)	0	395.540†	<0.001
Mortality, n (%)	9 (0.7)	9 (3.3)	0	30.285†	<0.001

*Z values of the nonparametric test for continuous variables; †The χ^2 values of the Chi-square test for categorical variables; ‡Chronic respiratory disease includes mild and moderate chronic obstructive pulmonary disease, bronchiectasis, and interstitial lung disease; §Reperfusion therapy includes thrombolysis and percutaneous catheter-directed removal of obstructing thrombi. 1 mmHg = 0.133 kPa. RR: Respiratory rate; SBP: Systolic blood pressure; GCS: Glasgow Coma Scale; qSOFA: Quick Sequential Organ Failure Assessment; ECG: Electrocardiography; $S_1Q_3T_3$: McGinn-White sign; RBBB: Right bundle branch block; TWI: T-wave inversion of leads V_1–V_3; PE: Pulmonary embolism.

Comparing the quick Sequential Organ Failure Assessment-electrocardiography against the Pulmonary Embolism Severity Index and simplified Pulmonary Embolism Severity Index in distinguishing high-risk and low-risk stratification

In the whole study cohort, all of the 9 dead patients were assigned qSOFA-ECG ≥2, PESI ≥ Class III, and simplified PESI ≥1. There was no death in the low-risk acute PE patients with qSOFA-ECG <2, or PESI < Class III, or simplified PESI <1. No significant difference was found between the qSOFA-ECG and the PESI or simplified PESI in identifying patients at high or low risk of early death. Of the 95 patients who accepted reperfusion therapy, 89 (94%) had a qSOFA-ECG ≥2, 48 (51%) had a

Table 2: Independent predictors of high-risk stratification for patients with acute PE

Variables	β	SE	Wald	*P*	*OR*	95% *CI*
RR ≥22 breaths/min	0.833	0.165	25.370	<0.001	2.300	1.663–3.180
SBP ≤100 mmHg	1.298	0.224	33.498	<0.001	3.661	2.359–5.681
GCS <15	2.210	0.707	9.776	0.002	9.117	2.281–36.434
Tachycardia	0.608	0.255	5.670	0.017	1.837	1.114–3.030
$S_1Q_3T_3$	1.037	0.169	37.883	<0.001	2.822	2.028–3.926
RBBB	1.651	0.213	60.124	<0.001	5.211	3.433–7.909
TWI	1.646	0.166	97.707	<0.001	5.184	3.741–7.184

1 mmHg = 0.133 kPa. RR: Respiratory rate; SBP: Systolic blood pressure; GCS: Glasgow Coma Scale; SE: Standard error; *OR*: Odds ratio; *CI*: Confidence interval; $S_1Q_3T_3$: McGinn-White sign; RBBB: Right bundle branch block; TWI: T-wave inversion of leads V_1–V_3; PE: Pulmonary embolism.

Table 3: Predictive performance of qSOFA score, ECG score, and qSOFA-ECG score for patients with acute PE

Predictors	AUC	95% *CI*	Cutoff value	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	+LR	-LR
qSOFA	0.681	0.643–0.719	≥1	66.8	62.3	31.4	87.9	1.77	0.53
ECG	0.786	0.756–0.815	≥1	91.9	51.0	32.7	96.0	1.88	0.16
qSOFA-ECG	0.820	0.791–0.848	≥2	81.5	72.3	43.2	93.8	2.94	0.26

PPV: Positive predictive value; NPV: Negative predictive value; LR: Likelihood ratio; AUC: Area under the ROC curve; ROC: Receiver operating characteristic; qSOFA: Quick Sequential Organ Failure Assessment; ECG: Electrocardiography; *CI*: Confidence interval; PE: Pulmonary embolism.

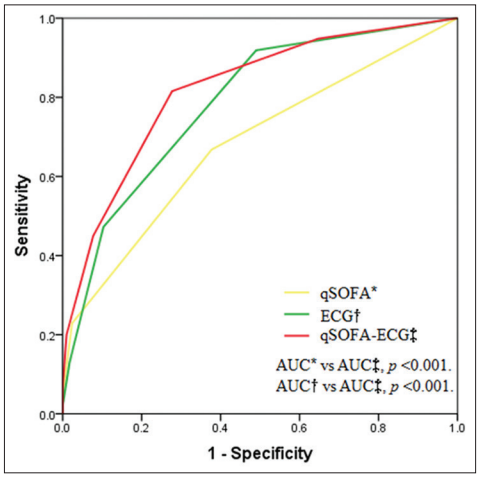

Figure 2: Receiver operating characteristic curve of qSOFA score, ECG score, and qSOFA-ECG score. qSOFA: Quick Sequential Organ Failure Assessment; ECG: Electrocardiography.

PESI ≥ Class III, and 65 (68%) had a simplified PESI ≥1. The ratio of patients who accepted reperfusion therapy was higher in the patients with qSOFA-ECG ≥2 than it was in patients with PESI ≥ Class III ($P < 0.001$) and simplified PESI ≥1 ($P < 0.001$).

Discussion

As our study showed, the qSOFA score is superior to any isolated index from it for predicting high-risk stratification in acute PE patients, since each of the three indicators has a contribution to it in a certain degree. Blood pressure is considered as a crucial index to determine initiation of reperfusion therapy for those acute PE patients appearing clinical signs of hemodynamic decompensation.[11] However, blood pressure cannot identify which patients are at risk of hemodynamic collapse and need close monitoring. The qSOFA score includes systolic blood pressure and raises the threshold to 100 mmHg, and it also contains respiration and consciousness evaluations. Hence, the qSOFA score can identify additional patients at risk of hemodynamic collapse and early adverse outcome. In our cohort, of the total nine deaths, only one showed hypotension at the ED arrival, but all of the nine met the criterion of qSOFA ≥2. This identification is vitally important because timely recognition and appropriate, effective treatment substantially improves survival.

The qSOFA score is used to assess sequential organ dysfunction/failure secondary to local lesions; the more the organs involved, the worse the prognosis was. If qSOFA = 1, it indicates that only one organ has dysfunction and predicts high-risk stratification with a moderate sensitivity (66.8%) and specificity (62.3%). Data analysis displayed that 433/489 (88.5%) patients had a source of a respiratory rate ≥22 and 56/489 (11.5%) patients had a source of systolic pressure ≤100 mmHg. These findings provide evidence that accelerated respiratory rate was the main source of qSOFA = 1. This suggests that PE-induced sequential organ failure begins in the respiratory system itself. With the increase of the qSOFA score, it indicates the aggravation of the disease, which is consistent with our previous research in pneumonia patients.[13] If qSOFA ≥2, it forebodes that multiple organs may have experienced dysfunction or even failure and that acute PE patients at risk of early death probably need multiple organ support and potential rescue reperfusion therapy. For predicting high-risk stratification, it possesses poor sensitivity (22.9%) and high specificity (97.6%). In our cohort, all dead patients met the criterion of qSOFA ≥2. These findings were in accordance with the characteristics of qSOFA for assessing septic patients, which showed that the hospital mortality was 3% for patients with qSOFA <2 and 24% for qSOFA ≥2.[14]

ECG parameter changes are not inherently better or worse than the qSOFA score for identifying patients at risk of hemodynamic collapse and early mortality. Tachycardia, $S_1Q_3T_3$, RBBB, and TWI on the ECG are classic signs indicating PE-induced RV strain.[15] Previous studies demonstrated that inhospital mortality of patients with acute PE was associated with $S_1Q_3T_3$ and TWI and noted that these ECG parameters are useful in predicting myocardial injury and assessing prognosis in patients with acute PE.[16,17] Other studies proved that RBBB was associated with RV overload, cardiac injury, and cardiogenic shock in patients with acute PE.[18,19] Kukla *et al.*[20] showed that mortality rates were significantly higher in the group with TWI than they were in the group without TWI; thus, this may be a useful measure for risk-stratifying patients with acute PE. In this study, all of the four ECG parameters contribute to risk stratification of patients with acute PE, and these results are consistent with the abovementioned publications. To facilitate clinical application, we defined the accumulation of four variables as ECG score. As the score increases, it is significant for risk stratification as high risk but more narrowly limits the target population, and this occurs with a trade-off of identifying fewer patients. As a result, some high-risk patients with acute PE may be missed. Therefore, single or multiple ECG parameters each embrace different predictive outcomes, one targeting a sensitive approach suited for early care and allowing fewer missed cases of progression and another focusing on specific identification of the higher strata of illness that can aid in later care decisions and pool cohorts with a narrow but high risk of death.

To improve the accuracy and reliability, we have created an alternative bedside-usable assessment algorithm, named qSOFA-ECG, by combining the qSOFA score with the ECG score. The qSOFA-ECG is more powerful than the isolated use of each of the original variables based on an AUC comparison that showed a significant difference. The assignment of the qSOFA-ECG score ranges from 0 to 7, and the optimal cutoff value was 2 points, where we obtained a balanced sensitivity (81.5%) and specificity (72.3%). If qSOFA-ECG equals or exceeds the cutoff point, which is defined as positive, the reliability in stratifying a high risk of acute PE obviously increased. If qSOFA-ECG is below the cutoff point, which is defined as negative, the reliability in excluding a high risk of acute PE also increased. When comparing against the PESI and simplified PESI, the qSOFA-ECG showed advantages in predicting potentially life-threatening hemodynamic decompensation or collapse that need monitoring, urgent or bedside echocardiography, and reperfusion therapy at the ED arrival. On the other hand, the qSOFA-ECG is equally effective as PESI and simplified PESI in identifying acute PE patients at low risk of inhospital mortality.

In the current study, the intermediate-high-risk acute PE patients were affiliated to the high-risk group, and the intermediate-low-risk acute PE patients were affiliated to the low-risk group. This algorithm is a emergent preliminary assessment for patients with acute PE at the ED arrival and possesses an important clinical significance that is to identify those acute PE patients who are at risk of hemodynamic collapse (intermediate to high risk) and monitor them closely for potential rescue reperfusion therapy until results of echocardiography and cardiac biomarker were obtained; the rest (low or intermediate to low risk) patients do not need monitoring would access a routine procedure.

There are several limitations in this study. First, as a retrospective study, the ECGs before the onset of acute PE as control are unavailable, and we cannot determine whether the patients' ECG changes are new or old. To address this problem, we have excluded those patients with a potential risk of right cardiac overload to eliminate as many patients with the possible past expressions of the ECG changes as possible but not all. Our results are subject to interference from those patients not yet excluded from the study cohort, and our conclusions cannot be applied to those patients who have a history of right heart overload. Second, although qSOFA-ECG improves the accuracy of clinical prediction, it only provides a rough clinical estimate and cannot replace a detailed clinical evaluation process. If this program is used to an unconfirmed case and the final diagnostics for acute PE are negative, this would lead to improper management. Thus, careful attention should be paid to weighing the risks and benefits when dealing with serious cases where acute PE is highly clinically suspected. Third, the mortality rate of the cohort was only 0.7%, which was related to the inclusion criteria. Moreover, there were still some critically ill cases with no chance to complete diagnostic tests or hospitalization. For these cases, qSOFA-ECG may be an alternative assessment method for empirical management in the ED.

In conclusion, the qSOFA score contributes effectively to identify acute PE patients with potentially life-threatening hemodynamic decompensation or collapse that need close monitoring and possible rescue reperfusion therapy at the ED arrival when used in combination with tachycardia, $S_1Q_3T_3$, RBBB, and TWI from ECG parameters.

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Conflicts of interest

There are no conflicts of interest.

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qSOFA评分联合心电图有助于急性肺栓塞患者危险分层

摘要

背景：快速序贯器官功能衰竭评估（qSOFA）评分最近广泛应用，我们探讨其与心电图（ECG）联合在急性肺栓塞危险分层中的作用。

方法：从2008年到2018年在首都医科大学附属北京朝阳医院诊断的急性肺栓塞患者被纳入回顾性研究，通过影像学和生物标记分为高危和低危组。ECG评分包括心动过速，McGinn-White征（$S_1Q_3T_3$）、右束支传导阻滞（RBBB）、胸前导联V_1-V_3 T波倒置（TWI）。使用logistic回归建立一个由qSOFA评分和ECG评分组成的联合评分预测急性肺栓塞患者高危危险分层，由受试者操作特征曲线对其预测效能进行评价。

结果：共计1318例患者入选，高危组271人，低危组1047人。一个联合评分系统被命名为qSOFA-ECG，qSOFA-ECG=qSOFA评分+ECG评分。最佳截点值是2，灵敏度、特异度、阳性预测值和阴性预测值分别为81.5%、72.3%、43.2%和93.8%。qSOFA-ECG在预测高危危险分层和再灌注治疗方面优于肺栓塞严重指数及其简化版。

结论：当qSOFA评分与ECG评分在急诊联合使用时，有助于识别有潜在血液动力学失代偿风险的急性肺栓塞患者，以备给予监测和可能的再灌注治疗。