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Research paper

Performance of the Simple Clinical Score (SCS) and the Rapid Emergency Medicine Score (REMS) to predict severity level and mortality rate among patients with sepsis in the emergency department

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ABSTRACT

Nurses play a key role as the first line of service for patients with medical conditions and injuries in the emergency department (ED), which includes assessing patients for sepsis. The researchers evaluated tools to examine the performance of the Simple Clinical Score (SCS) and the Rapid Emergency Medicine Score (REMS) to predict sepsis severity and mortality among sepsis patients in the ED. A retrospective survey was performed, selecting participants by using a purposive sampling method, and including the medical records of all patients diagnosed with sepsis admitted to the ED at Singburi Hospital, Thailand. Data were analysed using the ROC curve and the Area Under Curve (AUC) to calculate the accuracy of each patient's mortality prediction. A total of 225 patients diagnosed with sepsis was identified, with a mortality rate of 59.11% after admission to the medical service and intensive care unit. The AUC analysis showed that the accuracy of the model generated from the REMS (88.6%) was higher than that of the SCS (76.7%). The authors also recommend that key variables identified in this research should be used to develop screening and assessment tools for sepsis in the context of the ED.

Introduction

Sepsis is a bloodstream infection that includes septic shock, traditionally considered to result from a patient's systemic inflammatory response syndrome (SIRS), leading to infection (Sepsis 2) [1–5]. Since 2016, however, the Third International Consensus Definitions of Sepsis and Septic Shock (Sepsis-3) has redefined the contemporary classification of sepsis, defining it as 'life-threatening organ dysfunction caused by a dysregulated host response to infection' (p. 805) [1]. Diagnosis of sepsis uses traditional microbiological methods of biomarker examination and the introduction of molecular diagnostics and automation [1–4]. Sepsis causes complications after infection, resulting in organ dysfunction [1–4]. Sepsis screening tools are used to predict the severity and mortality of patients diagnosed with sepsis and to allow doctors and nurses to provide prompt medical treatment [5–7]. Prompt sepsis identification and treatment typically results in a positive response to antibiotic therapy and reduces treatment cost and the duration of a patient's hospital stay [5–7]. Global studies have shown that antibiotic-resistant infections and antibiotic-susceptible infections increase treatment costs [5–11]. At the same time, morbidity and mortality rates have also increased [5–7]. Multiple tools can be used for assessing patients diagnosed with sepsis [6,12–22]. However, these patients can present with different signs and symptoms based on the location or cause of the infection and depending on the severity of an organ's loss of function, resulting in sepsis or septic shock [1–5].

Accordingly, there is a need to find an appropriate tool within each context to rapidly assess the severity of the infection and allow for accurate diagnosis and timely and appropriate treatment. Five tools are typically used and have several similarities and differences, as follows: (1) the Simple Clinical Score (SCS) consists of 14 indicators, including age, systolic blood pressure (SBP), pulse rate (PR), temperature (Temp), respiratory rate (RR), oxygen saturation (O2 Sat), breathless on presentation, abnormal electrocardiogram (ECG), diabetes, coma without intoxication or overdose, altered mental status without coma or intoxication or overdose, new stroke on presentation or unable to stand unaided, nursing home resident, and, prior to the current illness, spending some part of the daytime

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in bed [13,14]; (2) the Rapid Emergency Medicine Score (REMS), which consists of six indicators: age, mean arterial pressure (MAP), heart rate (HR), RR, O2 Sat, Glasgow coma scale (GCS) score [15]; (3) SIRS (Systemic Inflammatory Response Syndrome), consisting of four indicators: Temp, HR, RR or PaCO2, and white blood cell (WBC) count; (4) SOS score (Search Out Severity), which consists of six indicators: Temp, SBP, HR, RR, mental status (GCS score), and urine output [6,19]; and lastly, (5) the quick Sequential (sepsis-related) Organ Failure Assessment (qSOFA), which consists of 3 indicators: RR, mental status (GCS), and SBP [17,18]. The sepsis scores determined by these tools show varying precisions in the prediction of hospital mortality in patients diagnosed with sepsis in different hospital departments and across countries. In Thailand, the Emergency Severity Rating (ESI) is carried out on a five-level triage scale; along with body temperature, blood pressure, respiratory rate, heart rate, peripheral oxygen saturation, level of consciousness, and laboratory results (white blood cell count, lactate values). The serious consequences of sepsis mean it is important to assess patients accurately and rapidly with potential sepsis at the earliest opportunity [20,21]. However, the aim of these national strategies is to first consider predicting the signs of sepsis and to systematically assess patients in the ED to facilitate early diagnosis [18,20,21]. While the sepsis screening tools focus on calculating SCS and REMS scores to predict which patients might develop sepsis, using such tools in the management of patients diagnosed with sepsis has not yet been studied [12–15]. Therefore, there may be systematic gaps in sepsis screening within nursing practices with respect to the under-detection and under-treatment of sepsis in many patients [18,21].

Thus, our study aimed to examine the performance of SCS and REMS scores in predicting sepsis severity and mortality among patients diagnosed with sepsis in the ED in Thailand. Additionally, evidence of the accuracy of the different tools used in the same population will be useful for the further development of a unified sepsis assessment. This was therefore the second aim of the study.

Materials and methods

A retrospective analysis study design, using a retrospective case note review method, was adopted. The study was conducted at a public tertiary hospital with 310 beds in Singburi Province, Thailand. The emergency service is available 24 h a day, with an average of 1109 clients a day, and is responsible for the population of 56,657 people in the Muang Singburi neighbourhood. Medical staff include two physicians and 15 nurses on each shift, as well as 5 Intermediate Emergency Medical Technicians (EMT-I), to care for this number of patients. The study's population comprised the medical records of patients diagnosed with sepsis who had been treated at the ED of Singburi Hospital from November 2018 to November 2019.

Study sample

A purposive sampling method was selected, based on the following inclusion criteria: (1) medical records of patients aged 15 years or older, both female and male, and (2) entering the ED and being diagnosed with sepsis, severe sepsis, or septic shock, using the Sepsis-2 criteria based on the new definitions of the Third International Consensus Definitions [1,2]. An estimated 400 cases of sepsis, severe sepsis or septic shock per year were diagnosed. Using a 95% confidence interval (α = 0.05), the 5% precision sample size [23] indicated a sample size of 201 patients.

Data collection

The data collection phase involved reviewing the ED's medical records (hand-written medical records) and the daily list of ED admissions to identify those patients with a diagnosis, according to the inclusion criteria. All data were reviewed and collected by the first author (MC), who has previous experience of working with ED nurses, and a research assistant, who was an infection control nurse at the study hospital.

Table 1
Scoring table for the Simple Clinical Score (SCS) [13,14] and the Rapid Emergency Medicine Score (REMS) [15].

Simple Clinical Score (SCS)	Points	Rapid Emergency Medicine Score (REMS)	Points
Age (years)	0	Age (years)	0
<50 for men or <55 for women	2	<45	+2
≥50 for men and ≥55 for	4	45–54	+3
women but ≤75 for either		55–64	+5
>75 for both men and women		65–74	+6
		>74	
Systolic blood pressure (mmHg)	0	MAP (mmHg)	0
>100	2	70–109	+2
>80 and ≤100	3	110–129 or 50–69	+3
≥70 and ≤80	4	130–159	+4
<70		>159 or ≤49	
Pulse rate >systolic blood pressure	2	Heart rate (bpm)	0
		70–109	+2
		110–139 or 55–69	+3
		140–179 or 40–54	+4
		>179 or ≤39	
Temperature <35 °C or ≥39 °C	2		
Respiratory rate (per min)	0	RR (breaths/min)	0
≤20	1	12–24	+1
>20 and ≤30	2	25–34 or 10–11	+2
>30		6–9	+3
		35–49	+4
		>49 or ≤5	
Oxygen saturation (%)	0	Oxygen saturation	0
≥95%	1	(%)	+1
≥90% and <95%	2	>89	+3
<90%		86–89	+4
		75–85	
		<75	
Breathless on presentation	1	Glasgow Coma	0
Abnormal ECG	2	Scale (GCS)	+1
Diabetes (type I or II)	1	14 or 15	+2
Coma without intoxication or	4	11–13	+3
overdose		8–10	+4
Altered mental status without	2	5–7	
coma, intoxication, or		3 or 4	
overdose, and aged ≥50 years			
New stroke on presentation	3		
Unable to stand unaided, or a	2		
nursing home resident			
Prior to current illness, spent some	2		
part of daytime in bed			
Total	33	Total	26

Definitions

The REMS score consists of six clinical variables: age, MAP, heart rate, RR, and O2 Sat [15]. The score ranges from 0 to 6 for age value, and five variables are each assigned a score from 0 to 4 (Table 1). REMS is the sum of these values with a maximum composite score of 26, with a higher value indicating a poor prognosis. The SCS score consists of 14 indicators: age, SBP, PR, Temp, RR, O2 Sat, breathless on presentation, abnormal ECG, diabetes, coma without intoxication or overdose, altered mental status without coma or intoxication or overdose, new stroke on presentation or unable to stand unaided, nursing home resident, and prior to the current illness, spent some part of daytime in bed [13,14], and the SCS consists of summed scores in five mortality risk categories. These values include very low risk (0–3 points), low risk (4–5 points), medium risk (6–7 points), high risk (8–11 points), and very high risk (> 11 points) (Table 1).

Table 2
Major factors affecting increased mortality of patients diagnosed with sepsis from an analysis of the importance of SCS and REMS assessment in the ED.

SCS	Estimate	Std. Error	z value (importance)	REMS	Estimate	Std. Error	Z value (importance)
Oxygen saturation	1.57	0.42	3.78	Glasgow Coma Scale (GCS)	0.99	0.26	3.87
<90%				3–4			
≥90% and <95%				5–7			
≥95%				8–10			
				11–13			
				14–15			
Prior to current illness, spent some part of daytime in bed	0.87	0.29	2.94	Respiratory rate	1.22	0.39	3.15
				12–24			
				25–34 or 10–11			
				6–9			
				35–49			
				>49 and ≤5			
Coma without intoxication or overdose	0.45	0.16	2.79	Oxygen saturation	1.05	0.49	2.13
				<75%			
				75–85%			
				86–89%			
				>89%			
Pulse rate > systolic blood pressure	0.52	0.27	1.93				
Respiratory rate	1.14	0.44	2.58				
≤20							
>20 and ≤30							
>30							
Abnormal ECG	0.58	0.33	1.76				

Ethical considerations

The human research ethics committee of Singburi Hospital approved the study (document 03204.2/80). The researchers informed medical records personnel regarding the objectives of the research and the use of medical records. The ED clinicians were also informed.

Statistical analysis

Demographic data were analysed with descriptive statistics based on frequency, percent, mean and standard deviation. *R statistical software* [24] was used to test logistical regression models for the SCS and REMS assessments using the same training data. Mortality data were predicted from the test data and evaluated for accuracy using the same models. The results are displayed as a linear graph showing the area under the curve (AUC), using the ROC.

Results

Participant data

The sample included 225 patients diagnosed with sepsis. The participants' ages ranged between 18 and 96 years (mean age = 67.6 years, *SD* = 17.0). Among the 225 patients, 132 were female (58.7%). Severe sepsis was diagnosed in 92 patients (40.9%) and sepsis in 89 (39.5%). Of the sepsis cases investigated, 148 (65.8%) involved pneumonia, while 53 (23.6%) were located in the urinary tract system, 13 (5.8%) in the gastrointestinal system, and 11 (4.9%) in the cardiovascular system. Comorbidities included 210 (93.3%) cases of cardiovascular diseases, as well as dyspnoea, orthopnea, paroxysmal nocturnal dyspnoea (PND), syncope, cardiac arrest, and arrhythmia. Risk factors for sepsis were present across all patient groups. A total of 210 (93.3%) of the patients had previously been treated for diabetes and high blood pressure together, and 13 (5.8%) were treated for risk-taking behaviours, such as smoking or obesity. The length of stay in the ED ranged from 20 min to 4 h (average = 1.1 h, SD = 0.58), whereas the time from diagnosis to administering the first antibiotics ranged from 0.3 min to 23.5 h (mean = 12.5 min, SD = 4.3). The length of hospitalisation varied from 0 to 198 days with a median of 5 days, and the interquartile range (IQR) was 2–9 days. Patient outcomes included 133 (59.1%) deaths, while 85 (37.8%) were discharged to home, and, due to the escalation of their condition, 7 (3.1%) were referred to other hospitals for haemodialysis.

Predictive effectiveness of SCS and REMS

A total of 225 patients diagnosed with sepsis and treated at the ED were scored using the SCS and REMS. These scores were used to calculate the predicted mortality rate based on the assessed severity of sepsis. The SCS contains five mortality risk categories. The SCS assessment results showed that the majority of the patients received high and extremely high scores, with 38 (16.9%) and 168 (74.7%) deaths per category, respectively, while the REMS assessment determined a maximum score of 26. The scores were classified into nine categories of risk-mortality rates as follows: 0.3% (0–2 score), 2% (3–5 score), 6.7% (6–9 score), 20.3% (10–11 score), 32.9% (12–13

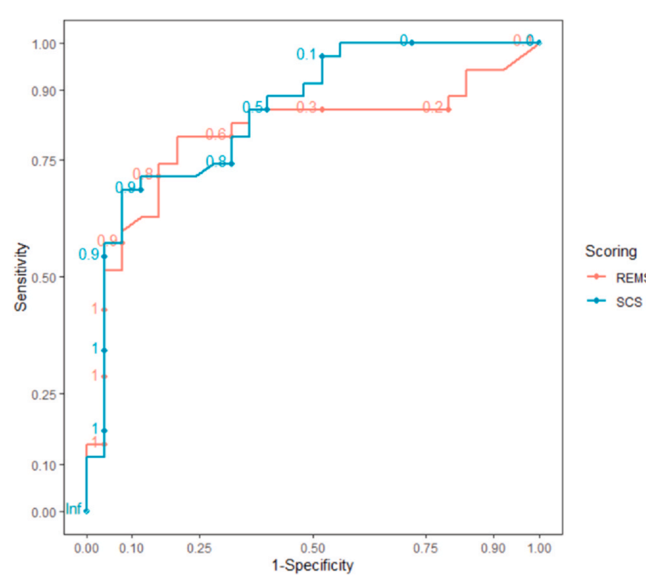

Fig. 1. Receiver Operator Characteristic (ROC) curve of the logistic regression models based on SCS and REMS scoring.

Table 3
Performance of SCS and REMS for predicting mortality in patients with sepsis.

Tools	AUC (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	LR+ (95% CI)	LR- (95% CI)
SCS	0.767 (0.657–0.876)	0.818 (0.597–0.948)	0.743 (0.567–0.875)	3.182 (1.752–5.778)	0.245 (0.099–0.607)
REMS	0.886 (0.800–0.973)	0.910 (0.708–1.00)	0.886 (0.733–0.968)	7.955 (3.133–20.195)	0.103 (0.027–0.387)

score), 45% (14–15 score), 80.5% (16–19 score), 92.9% (20–21 score), and 100% (22–26 score). Our results showed that the majority of the patients were classified into four levels. A total of 42 patients (18.7%) were categorised as having a 0.3% risk-mortality rate, 173 patients (76.9%) as a 2% risk-mortality rate, nine patients (4.0%) as a 6.7% risk-mortality rate, and one patient (0.40%) as a 32.9% risk-mortality rate.

The second objective of the study was to evaluate and compare the accuracy of the mortality prediction between the SCS and REMS. The researchers analysed the logistic regression coefficients for each parameter in the SCS and REMS assessments and their impact on mortality. Firstly, the researchers prepared two datasets from the same patient data; one assessed with the SCS, and the other with the REMS. Each dataset was randomly split into training and test data. The training data consisted of 75% of the dataset (167 patient records) and the test data consisted of the remaining 25% of the dataset (58 patient records). Two logistic regression models were created, based on these two datasets and using the patient status "dead" as an outcome (i.e., mortality of patient), with the components of the SCS and REMS assessments as independent predictors. Using these models, the researchers analysed the importance of various predictors and summarised the main factors that influenced the outcome of each patient's mortality. Table 2 shows the factors identified as being important for predicting the patient's mortality using the SCS and REMS assessments.

The analysis of the SCS data showed six main factors that increased the mortality rates of sepsis patients (see Table 2): (1) oxygen saturation (importance = 3.78); (2) prior to current illness, spent some part of daytime in bed (importance = 2.94); (3) coma without intoxication or overdose (importance = 2.79); (4) Pulse rate > systolic blood pressure (importance = 1.93); (5) respiratory rate (importance = 2.58); and (6) abnormal ECG (importance = 1.76). The researchers measured the performance of our logistic regression model using the sensitivity and specificity analysis and found a sensitivity of 81.82% and specificity of 74.29% for the importance of SCS in predicting mortality. The analysis of the REMS assessment also showed three main factors that contributed to an increase in mortality in sepsis patients: (1) Glasgow coma scale (importance = 3.87); (2) oxygen saturation (importance = 3.15); and (3) respiratory rate (importance = 2.13). Next, the researchers tested this model by comparing it with the training data. The performance of the logistic regression model based on REMS has a sensitivity of 90.91% and a specificity of 88.57%. The results are plotted as the Receiver Operator Characteristic (ROC) curve in Fig. 1.

The researchers also calculated a 95% confidence interval for the Area Under Curve of ROC and found values of 0.767 for the SCS and 0.886 for the REMS, indicating that the predictive accuracy was good (Table 3).

Discussion

The results showed that the majority of patients diagnosed with sepsis were over the age of 60 (70.22%), with a mean age of 67.59 years. Within the sample, 40.89% were diagnosed with severe sepsis and 39.55% were with sepsis. These results are consistent with those obtained by Gotts and Matthay [3], who collected data from 500 hospitals in the U.S.A. and found that nearly 65% of patients over the age of 65 were possibly developing sepsis. Older patients with comorbidities were twice as likely to be at high risk of sepsis, and two-to-three times as likely to die. This study also found that all included patients presented with risk factors for sepsis. A history of diabetes and high blood pressure (together) was found in 210 patients (93.33%), while 13 (5.78%) had risk factors such as smoking and obesity. The most frequent systemic infections were identified as pneumonia (148 patients, 65.77%), urinary system (53 patients, 23.56%), gastrointestinal system (13 patients, 5.78%), and cardiovascular system (11 patients, 4.89%). Certain groups with chronic diseases or compromised immune systems were found to be more susceptible to developing sepsis, such as patients diagnosed with HIV/AIDS, a low level of neutrophils, or cancer [1–5].

The results of the SCS and REMS assessments were analysed using the ROC curve (AUC) to determine the reliability of the mortality prediction in patients diagnosed with. The REMS were not statistically significantly different from the SCS, with REMS having an AUC value of 88.6% (95% CI 80.0–97.3%) compared to the SCS AUC of 76.7% (95% CI 65.7–87.6%). Based on this research, both the SCS and REMS assessments can be used in the ED to predict mortality. There is no significant difference between the SCS and REMS scores, so, selecting the most appropriate rating depends on the ease of applying the rating in the ED setting. However, our results differ from those of a study by Ghanem-Zoubi et al. [6] on the SCS and REMS assessments, which used a cohort of 1072 patients diagnosed with infections in the general medicine department. The mortality prediction for patients diagnosed with sepsis was similar between the two instruments, in which the SCS was found to have 81.82% sensitivity and 74.29% specificity, and the REMS with 90.91% sensitivity and 88.57% specificity. The REMS assessment was recommended as a statistically significant predictor of mortality in patients diagnosed with sepsis in mainstream services. As our results indicate, what makes the REM more important than the SCS assessment is having a critical patient triage ED system for assessing sepsis in the appropriate setting. The ED-triage tools consider a variety of factors, such as blood pressure, oxygen saturation, RR, and GCS, which improve the efficiency of the triage process, thereby appropriately routing patients [12,16].

In addition, our results showed an antibiotic reception time of between 0.3 min and 23.5 h. As part of our study, we gathered information on the limitations of sepsis screening and the time taken by nurses to perform these measurements and found that their performance may have led to the inappropriate or delayed diagnosis and treatment. Tromp and colleagues [25] recommend that the role of nurses is important in the implementation of early screening for sepsis. It has also been suggested that a primarily nurse-focused sepsis protocol, based on a suite of care designed to improve the quality of care for patients diagnosed with sepsis patients [15,18,21], could lead to better outcomes for an enormous number of patients who are predicted of having sepsis through positive REMS scores.

Conclusion

Regarding nursing practice, the establishment of an emergency screening system is recommended. The five predominant assessment tools were shown to share some variables, including (1) use of the Glasgow Coma Scale or other assessment of consciousness/coma, (2) respiratory rate, (3) blood oxygen concentration, (4) abnormal

ECG, and (5) a portion of time spent in bed prior to current illness. Our results indicated great variability between the SCS and REMS assessments, and also identified and ranked parameters that are important for the detection of sepsis. The REMS calculation is an important mortality predictor in patients with sepsis. These variables could be developed as a tool for screening patients diagnosed with sepsis among the Thai population. Promptly and effectively assessing the severity of sepsis is crucial to saving these patients' lives.

Authors' contribution

All authors gave an equal contribution to this project. The final manuscript was read and accepted by all authors.

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Conflict of interest

No conflict of interests to be declared.

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