Original Article

Comparison of Systemic Inflammatory Response Syndrome and quick Sequential Organ Failure Assessment scores in predicting bacteremia in the emergency department

Katsuyuki Furuta,[1] Hiroaki Akamatsu,[1] Ryuichi Sada,[2] Kyohei Miyamoto,[3] Shunsuke Teraoka,[1] Atsushi Hayata,[1] Yuichi Ozawa,[1] Masanori Nakanishi,[1] Yasuhiro Koh,[1] and Nobuyuki Yamamoto[1]

[1]Internal Medicine III, Wakayama Medical University, Wakayama, Japan, [2]Department of General Internal Medicine, Tenri Hospital, Tenri, Japan, and [3]Department of Emergency and Critical Care Medicine, Wakayama Medical University, Wakayama, Japan

Aim: The emergency department requires simple and useful clinical indicators to identify bacteremia. This retrospective study explored the Systemic Inflammatory Response Syndrome (SIRS) and quick Sequential Organ Failure Assessment (qSOFA) scores for predicting bacteremia.

Methods: Between April and September 2017, we assessed blood cultures of 307 patients in our emergency department. We calculated the SIRS and qSOFA scores for these patients and evaluated their correlation with bacteremia.

Results: Of 307 patients, 66 (21.5%) had bacteremia, 237 (77.2%) were SIRS-positive, and 123 (40.0%) were qSOFA-positive. The sensitivity and specificity of the SIRS score for predicting bacteremia were 87.9% and 25.7%, respectively. The sensitivity and specificity of the qSOFA score were 47.0% and 61.8%, respectively. Multivariate analysis revealed that body temperature (odds ratio, 2.16; 95% confidence interval, 1.22–3.84; $P = 0.009$) and blood pressure (odds ratio, 2.72; 95% confidence interval, 1.39–5.35; $P = 0.004$) significantly associated with bacteremia.

Conclusions: The SIRS score was a more sensitive indicator than the qSOFA score for predicting bacteremia.

Key words: Sepsis/multiple organ failure, Systemic Inflammatory Response Syndrome, quick Sequential Organ Failure Assessment

INTRODUCTION

IN EMERGENCY MEDICINE, bacteremia is common and often fatal. Its reported mortality is high, between 14% and 37%.[1–5] Although the importance of blood culture has been emphasized, it is positive only approximately 10% of the time.[6–7] Currently, blood culture is taken at the physician's discretion, which is inaccurate. Therefore, it is clinically important to establish a highly sensitive model to predict bacteremia. Previous studies have advocated various clinical indicators and formulas,[8–10] but most are complex and cannot be easily applied in daily practice.

The Systemic Inflammatory Response Syndrome (SIRS) and quick Sequential Organ Failure Assessment (qSOFA) scores are well-known and easily assessable clinical scores in patients with infectious diseases.[11,12] The SIRS score was initially introduced for assessing the severity of infectious diseases and is a useful tool to predict bacteremia. However, previous reports showed a wide range of sensitivities (80–96%).[13,14] For example, Jones and Lowes (1996) reported high sensitivity, but they mostly diagnosed patients with bacteremia using a single set of blood cultures. The qSOFA score, which predicts the prognosis of patients with sepsis,[15,16] has not been well investigated as a tool to predict bacteremia. Here, we investigated the utility of SIRS and qSOFA scores in predicting bacteremia in the emergency department.

METHODS

BETWEEN APRIL 2017 and September 2017, we included Japanese patients aged ≥18 years who visited the emergency department of Wakayama Medical

Corresponding: Hiroaki Akamatsu, MD, PhD, Internal Medicine III, Wakayama Medical University, 811-1 Kimiidera, Wakayama City, Wakayama, Japan. E-mail: h-akamat@wakayama-med.ac.jp.
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University Hospital (Wakayama, Japan) and those who had blood cultures carried out for suspected bacteremia. We excluded patients from whom only one set of blood culture was taken or whose vital signs were not described in the medical records. Blood cultures were collected during the patients' stay at the emergency department in accordance with the Cumitech blood culture guidelines.[17] The blood culture was defined as positive when one or more blood cultures were positive within 5 days, using BACTEC FX (Becton Dickinson, Franklin Lakes, NJ, USA). Additionally, at least two infectious disease specialists (A.H. and K.F.) distinguished contaminated cases from true positive cases in accordance with the Cumitech blood culture guidelines.[17,18]

We retrospectively collected patients' clinical information, such as age, sex, concurrent diseases, vital signs, concomitant drug use, and blood culture results, from electronic medical records of the hospital. The Pitt bacteremia score was calculated to assess the severity of infection.[19] The SIRS score was considered positive when the patient had at least two of the following clinical criteria: (i) body temperature <36°C or >38°C, (ii) respiratory rate >20/min or $PaCO_2$ <32 mmHg, (iii) pulse rate >90/min, (iv) white blood cell count <4,000/mm^3 or >12,000/mm^3. The qSOFA score was considered positive if the patient had at least two of the following clinical criteria: (i) systolic blood pressure <100 mmHg, (ii) respiratory rate >22/min, (iii) Glasgow Coma Scale score ≤14.[12,20] To calculate these scores, we used the first-measured vital signs recorded in the emergency department. The correlation between the blood culture-positive rate and these indicators was investigated. We then calculated the sensitivity and specificity of SIRS and qSOFA scores for bacteremia. Next, we analyzed the variables of SIRS and qSOFA scores that influenced bacteremia using univariate and multivariate logistic regression analyses. We analyzed the receiver operating characteristic curves and calculated the area under the curve of SIRS and qSOFA for bacteremia (Fig. S1).

Statistical analysis was undertaken using the χ^2-test or Fisher's exact test. Differences were considered statistically significant when the *P*-value was <0.05. Analyses were carried out using JMP Pro 14 (SAS Institute, Cary, NC, USA). The present study was carried out in accordance with the provisions of the Declaration of Helsinki and was approved by the Wakayama Medical University Hospital Institutional Review Board (IRB number: 2426).

RESULTS

Characteristics of patients

BETWEEN APRIL AND September 2017, we obtained blood cultures from 360 patients. Of these, we excluded patients who lacked two sets of blood cultures or with missing data on vital signs in their medical records that are required to evaluate SIRS or qSOFA scores. Finally, we analyzed data from 307 patients (Fig. 1).

Table 1 describes the characteristics of included patients. The median age was 76 years (range, 19–98 years), and 55.7% were men. Of 307 patients, 191 (62.2%) had a

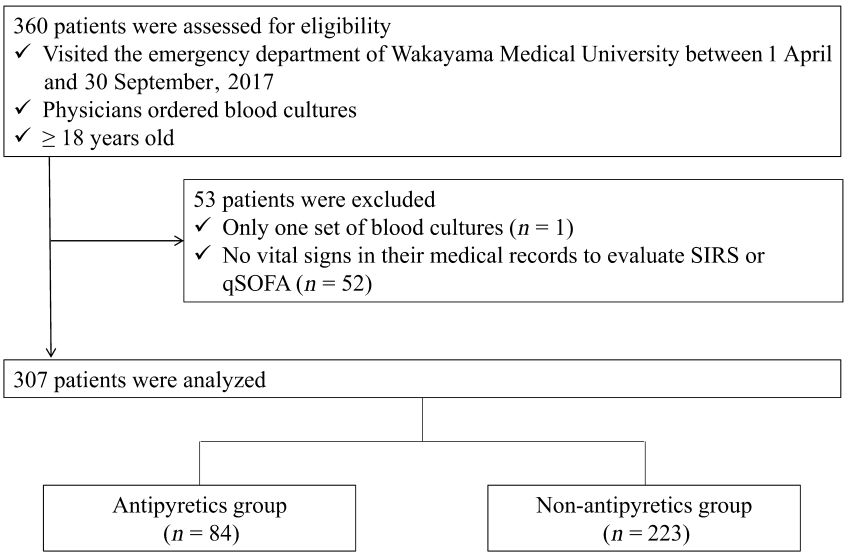

Fig. 1. Patient selection process. qSOFA, quick Sequential Organ Failure Assessment; SIRS, Systemic Inflammatory Response Syndrome.

Table 1. Characteristics of 307 patients who visited the emergency department

Parameters	All patients (n = 307)	Blood culture results		P-value
		Positive (n = 66)	Negative (n = 241)	
Age, years				
Median (range)	76 (19–98)	80 (30–93)	76 (19–98)	0.0660
Sex, n (%)				
Male	171 (55.7)	36 (54.5)	135 (56.0)	0.8900
Female	136 (44.3)	30 (45.5)	106 (44.0)	
Antibiotics administration after ED visit, n (%)				
Yes	274 (89.3)	65 (98.5)	209 (86.7)	0.0030
Origin of infection, n (%)				
Lung	98 (31.9)	11 (16.7)	87 (36.1)	
Urinary tract	40 (13.0)	16 (24.2)	24 (10.0)	
Biliary tract	28 (9.1)	11 (16.7)	17 (7.1)	
Skin and soft tissue	13 (4.2)	5 (7.6)	8 (3.3)	
Unknown focus	50 (16.3)	2 (3.0)	48 (19.9)	
Others	78 (25.4)	21 (31.8)	57 (23.7)	
Antipyretics before ED visit, n (%)				
Yes	84 (27.4)	30 (45.5)	54 (22.4)	0.0005
Concurrent disease, n (%)				
Malignancy	73 (23.8)	16 (24.2)	57 (23.7)	>0.9900
Diabetes	86 (28.0)	22 (33.3)	64 (26.6)	0.2800
Chronic liver failure	16 (5.2)	3 (4.5)	13 (5.4)	>0.9900
Chronic kidney disease	54 (17.6)	14 (21.2)	40 (16.6)	0.3700
Chronic heart failure	46 (15.0)	11 (16.7)	35 (14.5)	0.7000
Chronic obstructive pulmonary disease	29 (9.4)	5 (7.6)	24 (10.0)	0.6400
Pitt bacteremia score				
Median (IQR)	1 (0–2)	1 (0–3)	1 (0–2)	0.0011
SIRS score, n (%)				
<2	70 (22.8)	8 (12.1)	62 (25.7)	0.0200
≥2	237 (77.2)	58 (87.9)	179 (74.3)	
qSOFA score, n (%)				
<2	184 (60.0)	35 (53.0)	149 (61.8)	0.2000
≥2	123 (40.0)	31 (47.0)	92 (38.2)	

ED, emergency department; IQR, interquartile range; qSOFA, quick Sequential Organ Failure Assessment; SIRS, Systemic Inflammatory Response Syndrome.

concurrent disease such as malignancy, diabetes, chronic kidney disease, chronic obstructive pulmonary disease, chronic heart failure, or chronic liver disease. The most common site of infection was lung (98 patients, 31.9%), followed by urinary tract (40 patients, 13.0%). Infection sites could not be identified in 50 patients (16.3%). Two hundred and sixty-six patients (86.7%) were admitted to our hospital and 23 (7.5%) died during hospitalization.

Eighty-five patients were positive for at least one blood culture, and 66 cases were considered as true positive (21.5%; 95% confidence interval [CI], 16.9–26.1), after referral to infectious disease specialists. Details of the 19 contaminated blood cultures are shown in Table S1. Among true positive cases, *Escherichia coli* was detected most frequently (23 patients), and *Staphylococcus aureus* was the second most common bacteria (eight patients) (Table S2). Urinary tract infection was the most common cause of bacteremia. The Pitt bacteremia score was significantly higher in the blood culture-positive group (interquartile range, 0–3 versus 0–2; P = 0.001).

Distribution of SIRS and qSOFA scores

Of 307 patients, 237 (77.2%) were SIRS-positive (SIRS (+)) and 123 (40.0%) were qSOFA-positive (qSOFA (+)). The median SIRS and qSOFA scores were 2 and 1, respectively.

The SIRS scores were 0, 1, 2, 3, and 4 in 24 (7.8%), 46 (15.0%), 78 (25.4%), 114 (37.1%), and 45 (14.7%) patients, respectively. Eighty-three (27.0%), 101 (32.9%), 102 (33.2%), and 21 (6.8%) patients had qSOFA scores of 0, 1, 2, and 3, respectively.

Sensitivity and specificity of SIRS and qSOFA scores for bacteremia

Of 237 SIRS (+) patients, 58 (24.5%) had bacteremia (95% CI, 19.0–29.9), whereas eight (11.4%) SIRS (−) patients had bacteremia (95% CI, 3.7–19.2); this difference was significant (P = 0.02; Fig. 2). Of 123 qSOFA (+) patients, 31 (25.2%) had bacteremia (95% CI, 17.6 − 32.8), whereas 35 (19%) of qSOFA (−) patients had bacteremia (95% CI, 13.3 − 24.7; P = 0.20; Fig. 2). The sensitivity and specificity of the SIRS score for bacteremia were 87.9% and 25.7%, respectively, and those of the qSOFA score were 47.0% and 61.8%, respectively. The area under the receiver operating characteristic curves of SIRS and qSOFA was 0.61 and 0.58, respectively.

Univariate and multivariate analyses of factors predicting bacteremia

Of the variables included in the SIRS and qSOFA scores, respiratory rate >20/min or $PaCO_2$ <32 mmHg, body temperature <36°C or >38°C, and systolic blood pressure <100 mmHg were associated with the blood culture results in the univariate analysis. Multivariate analysis showed that body temperature (odds ratio, 2.16; 95% CI, 1.22–3.84; P = 0.009) and blood pressure (odds ratio, 2.72; 95% CI, 1.39–5.35; P = 0.004) were significantly correlated with bacteremia (Table 2).

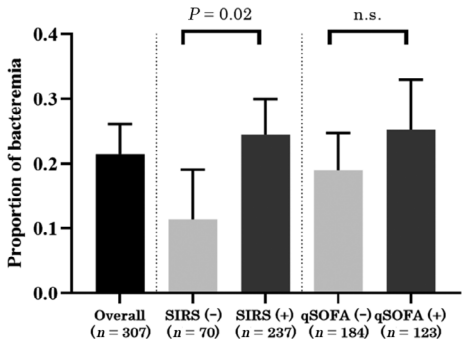

Fig. 2. Incidence of bacteremia among 307 patients in the emergency department. n.s., not significant, qSOFA, quick Sequential Organ Failure Assessment; qSOFA (−), qSOFA-negative; qSOFA (+), qSOFA-positive; SIRS, Systemic Inflammatory Response Syndrome, SIRS (−), SIRS-negative, SIRS (+), SIRS-positive.

Antipyretics detrimentally affected sensitivity of SIRS score in predicting bacteremia

These results suggested that body temperature was one of the most valuable variables among four SIRS criteria for predicting bacteremia. To assess its impact specifically, we obtained the history of use of antipyretics from the onset of symptoms to the emergency department visit and divided patients into antipyretics (n = 84) and non-antipyretics (n = 223) groups. Table 3 summarizes their clinical backgrounds. Although body temperature and SIRS score were not different between the groups, the proportion of patients with bacteremia was significantly higher in the antipyretics group than in the non-antipyretics group (35.7% versus 16.1%; P = 0.0005; Fig. 3).

The sensitivity of SIRS score for bacteremia was worse in the antipyretics group than in the non-antipyretics group (83.3% versus 91.7%), although the specificity was similar (27.8% versus 25.1%). Figure 3 shows the blood culture-positive rates in each group. Although no significant differences were observed between the two groups, the sensitivity of SIRS in predicting bacteremia tended to be lower in the antipyretics group than in the non-antipyretics group (Fig. 3). Only three SIRS (−) patients in the non-antipyretics group had bacteremia, and all patients were older than 85 years and had underlying malignant disease or diabetes mellitus.

DISCUSSION

TO DATE, OURS is the first cohort study to investigate the utility of the SIRS and qSOFA scores for predicting bacteremia. As we analyzed only patients who underwent two sets of blood cultures, our result is more robust than those reported previously.[13,14] The SIRS score had 87.9% sensitivity for predicting bacteremia, which increased to more than 90% for patients who did not receive antipyretics. In contrast, the qSOFA score was not useful in predicting bacteremia; it had a sensitivity of only 47.0%. A recent meta-analysis in an outpatient setting reported low sensitivity of the qSOFA score in predicting sepsis.[21] One possible explanation is that the variables for evaluating the SIRS score are more sensitive for capturing early changes in bacteremia.[22] In the current study, the median Pitt bacteremia score indicated that most cases were not fatal (7.5% of mortality). As the qSOFA score was originally developed to detect fatal organ failure, our result suggested that qSOFA is not a useful tool to predict bacteremia in the ED setting.

It has not been clarified which of the SIRS criteria are most valuable for predicting bacteremia. Our univariate and

Table 2. Univariate and multivariate analyses of variables significantly associated with bacteremia in patients in the emergency department

Variables	Odds ratio (95% CI)	*P*-value
Univariate analysis		
SIRS		
WBC > 12,000 or < 4,000/mL	1.35 (0.77–2.37)	0.290
Respiratory rate >20/min or $PaCO_2$ <32 mmHg	2.26 (1.12–4.56)	0.020
Pulse rate >90/min	1.25 (0.69–2.27)	0.460
Temperature >38°C or <36°C	2.12 (1.22–3.69)	0.007
qSOFA		
Blood pressure <100 mmHg	2.64 (1.38–5.06)	0.003
Change of consciousness (GCS ≤ 14)	1.10 (0.63–1.92)	0.730
Respiratory rate ≥22/min	1.78 (0.97–3.27)	0.060
Multivariate analysis		
Respiratory rate >20/min or $PaCO_2$ <32 mmHg (SIRS)	1.81 (0.88–3.74)	0.110
Temperature >38°C or <36°C (SIRS)	2.16 (1.22–3.84)	0.009
Blood pressure (qSOFA)	2.72 (1.39–5.35)	0.004

CI, confidence interval; GCS, Glasgow Coma Scale; SIRS, Systemic Inflammatory Response Syndrome; qSOFA, quick Sequential Organ Failure Assessment; WBC, white blood cell.

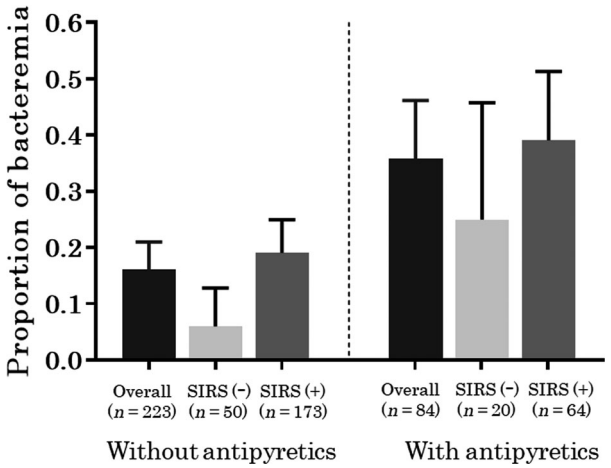

Fig. 3. Incidence of bacteremia among 307 patients in the emergency department who did or did not receive antipyretics (non-steroidal anti-inflammatory drugs + acetaminophen). SIRS, Systemic Inflammatory Response Syndrome; SIRS (−), SIRS-negative; SIRS (+), SIRS-positive.

multivariate analyses revealed that both body temperature and blood pressure were the most important factors. In addition, our subset analysis showed that the sensitivity of SIRS in predicting bacteremia tended to be lower in the antipyretics group than in the non-antipyretics group, although no significant differences were observed. Even though some studies have reported that antipyretics do not alter the prognosis in patients with sepsis,[23,24] we should consider the possibility that antipyretics could delay the diagnosis of bacteremia when deciding to undertake a blood culture test based on the SIRS score.

We observed three blood culture-positive cases among SIRS (−) patients in the non-antipyretics group. These patients were older than 85 years and had underlying diseases, such as diabetes and malignancy. Studies have reported that older adults have a lower basal body temperature, and that even in the case of bacteremia, the body temperature does not readily increase.[25,26] Additionally, such patients are usually recognized as being at high risk of bacteremia but are less likely to have symptoms.[1] We must be careful to judge the necessity of blood culture in immunocompromised patients, even if their SIRS scores are negative. In summary, we determined the utility of SIRS in predicting bacteremia in the ED. In particular, negative SIRS score could efficiently exclude those who do not need a blood culture. However, we should pay attention to those who are immunocompromised or receive antipyretics prior to visiting the ED. The qSOFA score was not useful.

Limitations

This study has several limitations. This was a single-center analysis undertaken in a university hospital, although the

Table 3. Baseline characteristics of patients who did or did not receive antipyretics (non-steroidal anti-inflammatory drugs and acetaminophen) before hospital visit

Parameters	Non-antipyretics group *n* = 223	Antipyretics group *n* = 84	*P*-value
Age, years			
Median (range)	76 (22–98)	75 (19–94)	0.09
Sex, *n* (%)			
Male	126 (56.5)	45 (53.6)	0.70
Female	97 (43.5)	39 (46.4)	
Antibiotics treatment after ED visit, *n* (%)			
Yes	199 (89.2)	75 (89.3)	>0.99
Origin of infection, *n* (%)			
Pneumonia	75 (33.6)	23 (27.4)	
Urinary tract	27 (12.1)	13 (15.5)	
Biliary tract	23 (10.3)	5 (6.0)	
Skin and soft tissue	7 (3.1)	6 (7.1)	
Unknown focus	37 (16.6)	13 (15.5)	
Others	54 (24.2)	24 (28.6)	
Concurrent disease, *n* (%)			
Malignancy	50 (22.4)	23 (27.4)	0.37
Diabetes	62 (27.8)	24 (28.6)	0.89
Chronic liver failure	10 (4.5)	6 (7.1)	0.39
Chronic kidney disease	38 (17.0)	16 (19.0)	0.74
Chronic heart failure	34 (15.2)	12 (14.3)	1.00
Chronic obstructive pulmonary disease	20 (9.0)	9 (10.7)	0.66
Body temperature (°C)			
Median (range)	37.6 (33.8–40.8)	37.5 (35.6–40.5)	0.88
Pitt bacteremia score,			
Median (IQR)	1 (0–2)	1 (0–2)	0.93
SIRS score, *n* (%)			
<2	50 (22.4)	20 (23.8)	0.88
≥2	173 (77.6)	64 (76.2)	
qSOFA score, *n* (%)			
<2	132 (59.2)	52 (61.9)	0.70
≥2	91 (40.8)	32 (38.1)	

ED, emergency department; IQR, interquartile range; qSOFA, quick Sequential Organ Failure Assessment; SIRS, Systemic Inflammatory Response Syndrome.

patients' clinical backgrounds were similar to those in previous reports. The rate of blood culture positivity in this study cohort is relatively higher than in previous studies,[6,7] probably because our facility has more patients with complications or comorbidities. Because of the retrospective nature of this study, information such as medications that could affect blood pressure and pulse rate was not fully extracted; therefore, information is lacking to link these extraneous factors affecting blood pressure with the blood culture results. No specific information was available on the time interval between the use of antipyretics and the measurement of vital signs and collection of blood. Additionally, due to the retrospective nature of our study, we could not analyze the parameters missing in the medical records. However, clinical outcomes (admission rates and mortality) of the patients included or excluded in this analysis did not differ. Thus, this exclusion might not contribute to generating a bias. Finally, although blood cultures were taken in accordance with the guidelines, a doctor judged the necessity for it. Therefore, we could have missed some cases of bacteremia. Nevertheless, our results indicate that we might be able to omit blood cultures in SIRS (−) patients. A well-designed prospective study is needed to validate this finding.

CONCLUSIONS

OUR STUDY INDICATES that in an ED, the SIRS score is a more reliable tool to predict bacteremia than the qSOFA score. Further prospective studies are warranted.

DISCLOSURE

Approval of the research protocol: The protocol for this research project was approved by a suitably constituted Ethics Committee of the institution and it conforms to the provisions of the Declaration of Helsinki. Wakayama Medical University Hospital Institutional Review Board (IRB number: 2426).
Registry and the registration no. of the study/trial: N/A.
Informed consent: Informed consent was obtained in the form of opt-out on the Wakayama Medical University Hospital website.
Animal studies: N/A.
Conflicts of interest: None.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Fig. S1. Receiver operating characteristic curves of Systemic Inflammatory Response Syndrome (SIRS) (A) and quick Sequential Organ Failure Assessment (qSOFA) (B) for bacteremia.

Table S1. Isolated bacteria in cases with contamination.

Table S2. Isolated bacteria in cases with true positive.