Comparison of the Value of SOFA and Pitt Bacteremia Scores in the Prognostic Evaluation of Patients With Hospital-acquired *Klebsiella Pneumoniae* Bloodstream Infection

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Research

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Abstract

This clinical research studied the value of SOFA score and Pitt bacteremia score in the prognosis assessment of patients with hospital-acquired *Klebsiella pneumonia* bloodstream infection. We conducted a retrospective analysis of 40 patients with hospital-acquired *Klebsiella pneumoniae* bloodstream infection in a tertiary hospital from January 2016 to December 2020. For these patients, the SOFA score and Pitt bacteremia score were used to evaluate the prognosis. Logistic regression was performed with the known prognosis results to obtain the best cut-off value, sensitivity, and specificity. Pitt bacteremia score [3 (3-4) points to 6 (5.5-7) points] and SOFA score [7 (6-10) points to 17 (13-17.5) points] in the survival group were lower than those in the death group (P<0.05). The SOFA score predicts the death of hospital-acquired *Klebsiella pneumoniae* bloodstream infection patients with a sensitivity of 80%, a specificity of 84%, and the area under curve(AUC) of SOFA score is 0.8960 (95% CI 0.7951-0.9969); Pitt bacteremia score predicts the hospital-acquired *Klebsiella pneumoniae* blood infection with a sensitivity of 86.67%, a specificity of 80%, and AUC of Pitt bacteremia score is 0.9413 (95% CI 0.8700-1.000). Both the SOFA score and the Pitt bacteremia score have predictive value for the prognosis of patients with HAI (hospital acquired infection) *Klebsiella pneumonia* blood infection. However, the difference shows that the SOFA score has obvious accuracy and specificity in the prognosis of patients with HAI *Klebsiella pneumoniae* bloodstream infection, it is better than the Pitt bacteremia score and has greater application prospects in prognostic evaluation.

1. Introduction

As the Centers for Disease Control and Prevention (CDC) identified, complications or infections secondary to device implantation or surgery are called HAI[1].Tens of thousands of people are infected worldwide every year [2, 3]. According to statistics data, about 2 million patients suffer from HAI each year in the United States with 99,000 total deaths, which costs 33 billion dollars each year[4, 5]. In European, the number of people who die directly from HAI each year is about 37,000, and the total length of hospital stay increases by 1,600 Million[6]. Bloodstream infection is one of the important infection types in HAI. Musicha P et al[7] showed that the mortality rate of bloodstream infection in HAI is higher, and the incidence of *Klebsiella pneumoniae* bloodstream infection in Enterobacteriaceae is in the forefront. CHINET(China Antimicrobial Surveillance Network) shows the isolation rate of *Klebsiella pneumoniae* bloodstream infection is 16.51%, which is the second place among bloodstream infection bacteria [8]. What's worse is that the resistance rate of *Klebsiella pneumoniae* is increasing every year. According to calculations, 426,277 cases of HAI caused by antimicrobial drug-resistant microorganisms occur in the EU every year, and the number of deaths due to drug-resistant microorganisms in the EU is 33,110 each year[9]. Therefore, the early assessment for the condition of patients with *Klebsiella pneumoniae* infection can effectively guide the selection of clinical treatment and the intensity of care levels, as to minimize the mortality rate and improve the prognosis. Then the criteria for evaluating the prognosis of the disease are particularly important. After continuous clinical practice, many scholars have formed a scoring system

used in a variety of different scenarios. The Pitt bacteremia score and the SOFA score are currently two widely used clinical scoring system.

The Pitt bacteremia score was first proposed by Rasmussen HH et al[10] in 1985. Its scoring items include temperature, blood pressure, mechanical ventilation, cardiopulmonary resuscitation, and mental status. The total score is 18 points. The higher the score, the worse the prognosis. Recently, many studies confirmed that the Pitt bacteremia score has great significance for the prognosis assessment of acute and critical illness[11, 12], and many studies have shown that Pitt bacteremia score>4 can be used as a risk factor for death[13, 14], so it is widely recognized by domestic and foreign researchers and clinicians to evaluate the prognosis of critical patients. The SOFA score was first proposed in 1994 by the European Society of Intensive Care Medicine[15], and its purpose is to describe the occurrence, development and incidence of MODS. It includes the assessment of the respiratory system, coagulation system, liver, circulatory system, nervous system and kidneys. The total score is 40 points. The higher the score, the worse the prognosis. A number of studies have shown that SOFA scores can be used to evaluate the prognosis of critically ill patients[16, 17], so it is widely used in clinical evaluation of the prognosis of critically ill patients. However, there are still no relevant studies on the evaluation of the Pitt bacteremia score and SOFA score in the prognosis of patients with bloodborne infections.

This study retrospectively analyzed the prognostic evaluation of SOFA score and Pitt bacteremia score in 40 patients with hospital acquired *Klebsiella pneumoniae* bloodstream infection. The objective has explored the application value and advantages and disadvantages of SOFA score and Pitt bacteremia score in the prognosis evaluation of HAI patients with *Klebsiella pneumoniae* bloodstream infection.

2. Research Object, Clinical Diagnosis And Methods

2.1 Research object

A retrospective analysis of HAI(hospital acquired infection) cases was conducted in a tertiary hospital which has a total 1000 beds in Beijing, China. From January 2016 to December 2020, a total of 1879 cases of HAI were reported, including 225 cases of bloodstream infection, 54 cases of *Klebsiella pneumoniae* blood infection, except for 14 patients with incomplete case data. A total of 40 cases of HAI Klebsiella pneumoniae blood infection were included in this study. In this study, a special CRF table was designed, and Pitt bacteremia score and SOFA score were calculated on these 40 patients based on medical records, examination and test results.

Inclusion criteria: (1) According to the definition, it was identified as a HAI patient with complete medical records, examination and test results, and clear prognostic information; (2) Strain isolation and culture of clinical specimens according to the National Clinical Laboratory Procedures"[18], The Mérieux Vitek-2 Compact automatic microbial system was used to identify the bacterial species, and the blood culture microbiological examination and drug sensitivity test indicated that it was *Klebsiella pneumoniae* infection; (3) There were at least 2 blood culture results.

Exclusion criteria: (1) Patients with incomplete clinical data such as medical records, examinations, and tests; (2) Suspected blood samples are contaminated, and common skin colonization bacteria isolated from a single bottle of blood culture are inconsistent with clinical symptoms and signs, and can be other Reasons explained; (3) Only one blood culture result.

2.2 Clinical diagnosis

1. HAI Klebsiella pneumoniae infection: During the hospitalization period, complete blood culture examinations and drug susceptibility tests are confirmed to be *Klebsiella pneumoniae*, except that the sample may be contaminated, and the HAI *Klebsiella pneumonia* infection can be diagnosed.
2. Blood infection: There are related manifestations of blood infection: chills, high fever, tachycardia, shortness of breath, skin rash, mental and mental changes, etc.
3. Etiology: There are relevant etiology and bacterial culture evidence to verify.

2.3 Methods

Graphpad Prism8 statistical software was used for data analysis. 1. Count variables are represented by median and interquartile range. 2. As a grade variables, the results of Pitt bacteremia score and SOFA score were convert to dichotomous variables by Logistic regression. (1) Perform Logistic regression on the scores of the 40 groups and the prognosis to obtain the best cut-off value, and use the Youden Index (a method to evaluate the authenticity of the screening test, which is the sum of sensitivity and specificity minus 1) to verify the cut-off value accuracy, and then perform ROC curve analysis separately with the prognostic quantitative variables, and evaluate the prognosis of the two scores by comparing the area under the curve; (2) The cut-off value was used to determine the positive and negative predictive results. The sensitivity, specificity, positive predictive value and negative predictive value of the two groups were compared to evaluate the predictive effect of the two scores on the prognosis. (3) Retrospectively analyze the predicted survival time and actual survival time of 40 patients, and draw a survival curve. Comparing with the known prognosis results, it is more intuitive to reflect the accuracy of the two scores in evaluating the prognosis of such patients.

3. Results

3.1 Analysis of the mortality of the study population

The brief information of all the included cases is shown below:

Table 1
Basic information of the enrolled cases

Serial number	Age	Gender	Pitt bacteremia score	SOFA score	Gastric tube	Urinary tube	Mechanical ventilation	Survival situation
1	59	Female	4	7	No	Yes	Yes	Died
2	54	Female	3	9	Yes	Yes	Yes	Survived
3	68	Male	4	10	Yes	Yes	Yes	Survived
4	77	Male	4	18	Yes	Yes	Yes	Died
5	52	Male	6	21	Yes	Yes	Yes	Died
6	35	Male	2	6	Yes	Yes	Yes	Survived
7	1	Female	7	15	Yes	Yes	Yes	Died
8	54	Male	7	17	Yes	Yes	Yes	Died
9	70	Male	5	17	Yes	Yes	Yes	Died
10	82	Male	6	14	Yes	Yes	Yes	Died
11	50	Female	3	5	Yes	Yes	Yes	Survived
12	67	Male	4	7	Yes	Yes	Yes	Survived
13	36	Male	6	14	Yes	Yes	Yes	Survived
14	52	Male	6	13	Yes	Yes	Yes	Survived
15	60	Male	5	13	Yes	Yes	Yes	Survived
16	60	Male	5	13	Yes	Yes	Yes	Survived
17	77	Female	7	12	Yes	Yes	Yes	Survived
18	78	Female	6	12	Yes	Yes	Yes	Survived
19	35	Male	4	12	Yes	Yes	Yes	Survived
20	65	Male	4	12	Yes	Yes	Yes	Died
21	61	Male	4	10	Yes	Yes	Yes	Died
22	47	Male	5	9	Yes	Yes	Yes	Survived
23	41	Female	3	9	Yes	Yes	Yes	Survived
24	85	Female	3	9	Yes	Yes	Yes	Survived
25	83	Female	3	9	Yes	Yes	No	Survived

(Both of these two scores were obtained at the time of diagnosis)

Serial number	Age	Gender	Pitt bacteremia score	SOFA score	Gastric tube	Urinary tube	Mechanical ventilation	Survival situation
26	51	Male	4	8	Yes	Yes	No	Survived
27	56	Male	5	7	Yes	Yes	Yes	Survived
28	85	Male	5	7	Yes	Yes	Yes	Died
29	43	Female	4	7	Yes	Yes	Yes	Died
30	65	Male	4	7	Yes	Yes	Yes	Died
31	75	Male	4	7	Yes	Yes	Yes	Died
32	70	Male	4	7	Yes	Yes	No	Survived
33	17	Male	3	7	Yes	Yes	No	Survived
34	34	Male	2	6	Yes	Yes	No	Survived
35	84	Male	2	6	Yes	Yes	Yes	Died
36	30	Female	3	5	Yes	Yes	Yes	Survived
37	38	Female	3	4	Yes	Yes	No	Survived
38	19	Male	3	4	Yes	No	No	Survived
39	73	Female	2	4	Yes	Yes	Yes	Died
40	51	Male	3	2	Yes	Yes	Yes	Survived
(Both of these two scores were obtained at the time of diagnosis)								

Table 2
Statistical description of enrollment

Characteristic	Survived(Median [IQR] or n%) n=25	Died (Median [IQR] or n%) n=15	Total (Median [IQR] or n%) n=40
Age	51 (36-67)	65 (56.5-76)	57.5 (42.5-70.75)
Male	18 (72)	10 (66.67)	28 (70)
Pitt score	3 (3-4)	6 (5.5-7)	4 (3-6)
SOFA score	7 (6-10)	17 (13-17.5)	11 (7-15)

In all 40 cases of *Klebsiella pneumoniae* hematological infections, the median age was 57.5 years (interquartile range 42.5-70.75), of which 51 (36-67) in the survival group and the death group was 65

(56.5-76) (Table 1). The overall mortality rate of these hospitalized patients was 37.5%. The Pitt bacteremia score of the survival group was 3 (3-4), the death group was 6 (5.5-7); the SOFA score of the survival group was 7 (6-10), and the death group was 17 (13-17.5).

3.2 Selection and analysis of the best cut-off value

The 40 groups of Pitt bacteremia score results and prognostic results (0 means survival, 1 means death) are used for Logistic regression, and the best cut-off value is 4 points. By calculation, when the cut-off value is 4 points, the Youden Index also reaches its maximum. Under the best cut-off value, the Pitt bacteremia score is calculated to have a sensitivity of 86.67%, a specificity of 80%, and a total prediction accuracy of 82.5% (Table 2) for predicting the death of patients with HAI *Klebsiella pneumoniae* infection. The negative predictive value was 90.91%, and the positive predictive value was 72.22%.

In the same way, using Logistic regression to analysis the obtained 40 groups of SOFA score results and prognostic results (0 means survival, 1 means death), the best cut-off value is 13 points. By calculation, when the cut-off value is 13 points, the Youden index also reached the maximum. Under the best cut-off value, the SOFA score has a sensitivity of 66.67%, a specificity of 88%, a total prediction accuracy of 80% (Table 3), the negative predictive value is 81.48%, and the positive predictive value was 76.92%.

Table 3
Predictive comparison of Pitt bacteremia score and SOFA score

		Survived	Died	Total	% Correctly classified
Pitt bacteremia score	Survived	20	5	25	80
	Died	2	13	15	86.67
	Total	22	18	40	82.5
SOFA score	Survived	22	3	25	88
	Died	5	10	15	66.67
	Total	27	13	40	80

3.3 The ratio of Pitt bacteremia score and SOFA score to the prediction of prognosis

According to the best cut-off value obtained, the Pitt bacteremia score and SOFA score were made into ROC curves to be compared (Figure 3). According to the results of ROC analysis, the AUC of the Pitt bacteremia score was 0.9413 (95% CI 0.8700- 1.000), and the AUC of the SOFA score was 0.8960 (95% CI 0.7951- 0.9969).

4. Discussion And Conclusion

A number of studies have shown that HAI could cause the mortality, morbidity, length of stay (LOS) and economic burden of hospitalized patients to be too high(4, 19-22). The total hospitalization cost and length of stay of HAI patients are significantly longer than General patients[19, 21, 22]. In Chinese mainland, *Klebsiella pneumoniae* is the second common Gram-negative pathogen causing hospital bloodstream infection after E.coli[23–26]. In recent years, with the use of broad-spectrum antibiotics in medical settings more and more common, drug-resistant *Klebsiella pneumoniae* has emerged and spread quickly, which has caused many problems for clinical practice. For this reason, the World Health Organization issued a global action plan for antimicrobial resistance in 2015, and take antibiotic management as the core pillar of this plan [27]. Therefore, it is important to predict the outcome of nosocomial infection early and correctly. The SOFA score mainly predicts the occurrence or development of critical illness by observing the dynamic changes of organ function, so as to accurately judge the condition; the Pitt bacteremia score quickly judges the development process of the patient's condition based on the patient's general condition.

In this study, both the Pitt bacteremia score and SOFA score were calculated respectively, the prognosis obtained from these two scores were compared with actual prognosis. Through epidemiological analysis (Table 2), it is found that the age of the survival group is slightly smaller than that of the death group; the Pitt bacteremia score and SOFA score of the survival group are significantly lower than those of the death group, which preliminarily shows that there was a certain correlation between these two scores and prognosis. On this basis, the best cut-off value was found through Logistic regression and found that Pitt bacteremia score> 4 points and SOFA score> 13 points are good predictors for the prognosis of patients with HAI *Klebsiella pneumoniae* bloodstream infection. The fit is relatively high. The Pitt bacteremia score (86.67%) is slightly more sensitive to prognostic evaluation than the SOFA score (66.67%), but the specificity of the SOFA score (88%) is better than the Pitt bacteremia score (80%), The negative predictive value of Pitt bacteremia score was higher (90.91%), and there may be the possibility of aggravating clinical condition. From the perspective of the survival curve (Figure 2), the SOFA score has better performance than the Pitt bacteremia score in evaluating the survival days of patients; from the perspective of the ROC curve (Figure 3), the fit of the Pitt bacteremia score for the prognostic evaluation is slightly better than the SOFA score. Overall, the SOFA score and Pitt bacteremia score both have good performance in the prognosis evaluation of patients with HAI *Klebsiella pneumoniae* bloodstream infection, but the accuracy and specificity of SOFA score is significantly better than Pitt bacteremia score, and it has greater prospects in prognostic evaluation.

In this retrospective study, we innovatively compared the Pitt bacteremia score and SOFA score for the prognosis of hospital acquired bloodstream infection caused by *Klebsiella pneumoniae* for the first time. The scientificity of the clinical application of Pitt bacteremia score and SOFA score is verified, and some references are provided for such research. At the same time, all patients in this study received the same medical resources, excluding the prognostic infection caused by the interference of the external environment, which improved the credibility of the results. However, since this study is a single-center retrospective study, the sample size is limited, and the available data are only medical records,

examinations and test results kept in the hospital, and it may not be possible to objectively evaluate the patient's condition at time. Therefore, it is expected that studies with more complete designs and larger sample sizes will provide more accurate comparative data.

Declarations

This manuscript has been reviewed by the ethics committee of our hospital, and there is no potential ethical risk.

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Disclosure statement

The authors declare no conflict of interest regarding the publication of this paper.

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Figures

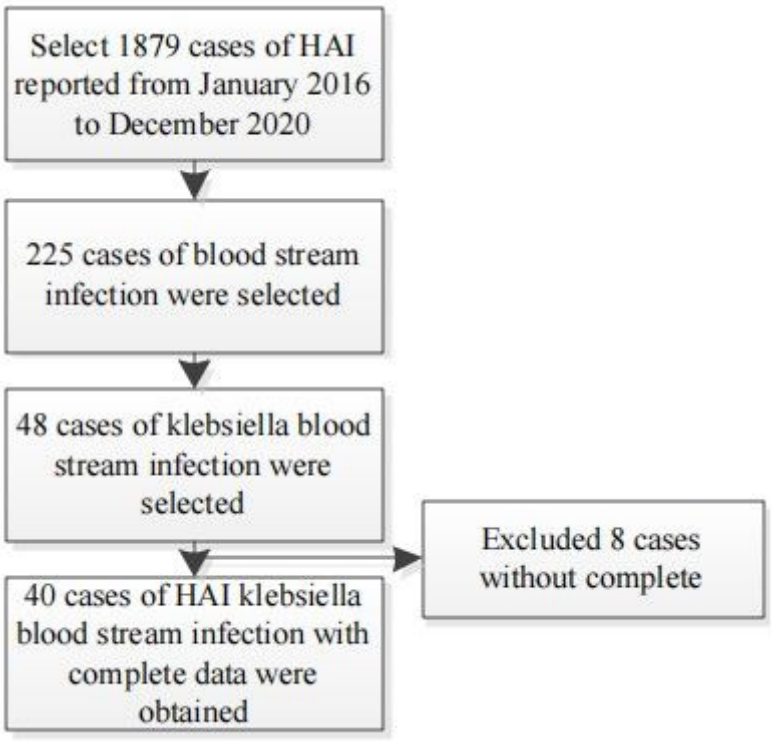

Figure 1

Selection of study

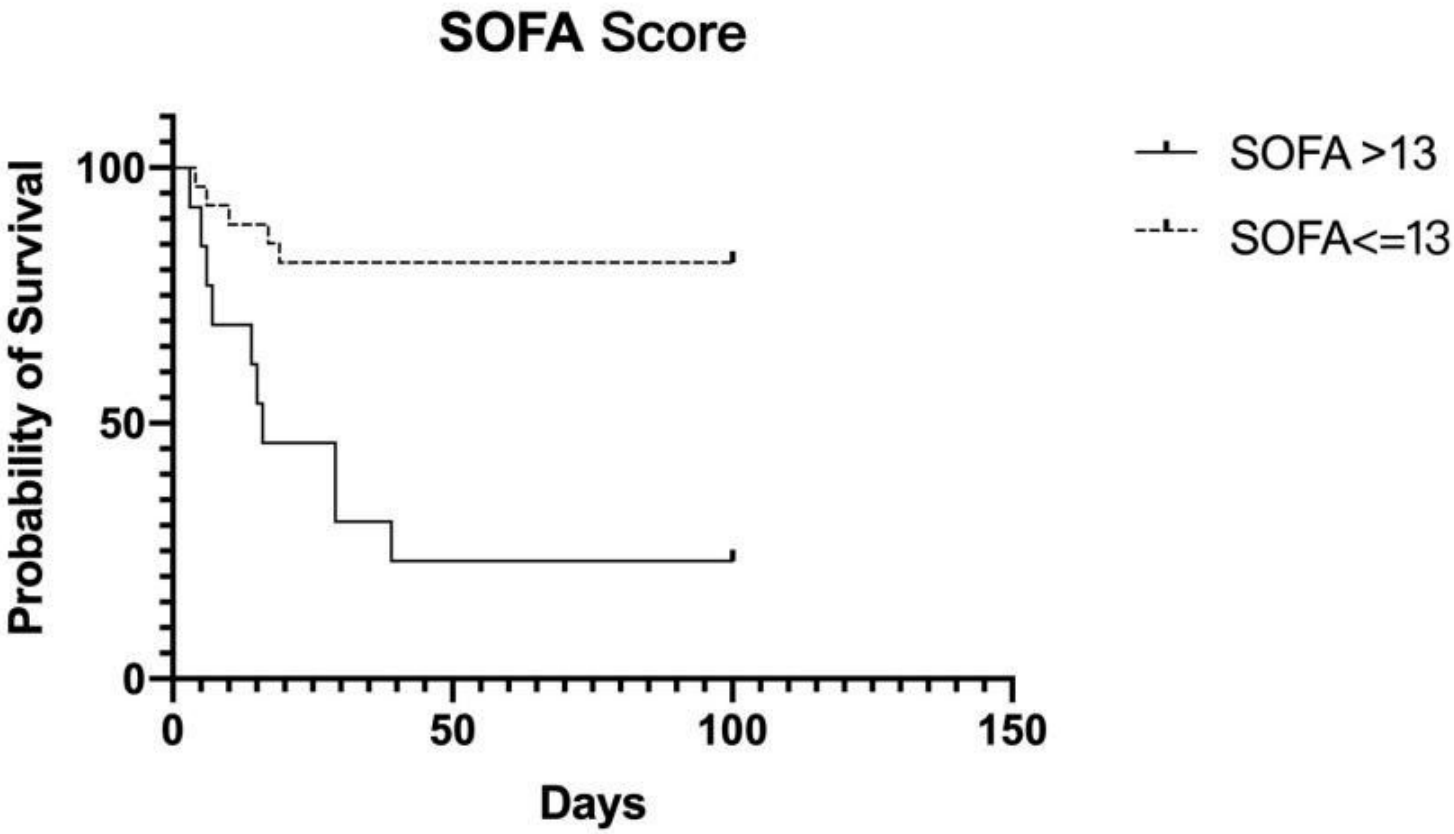

Figure 2

Survival rate curve of SOFA score

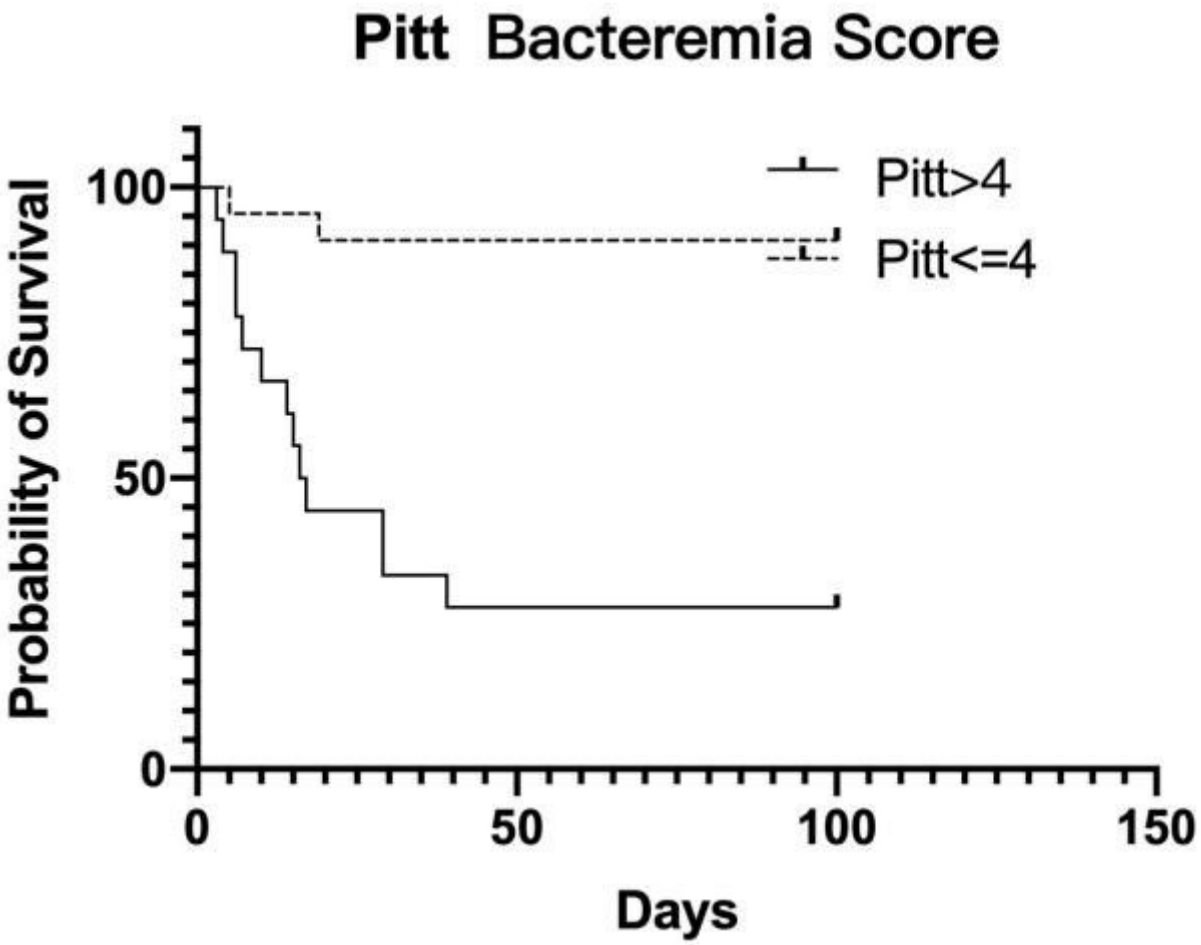

Figure 3

Survival rate curve of Pitt bacteremia score

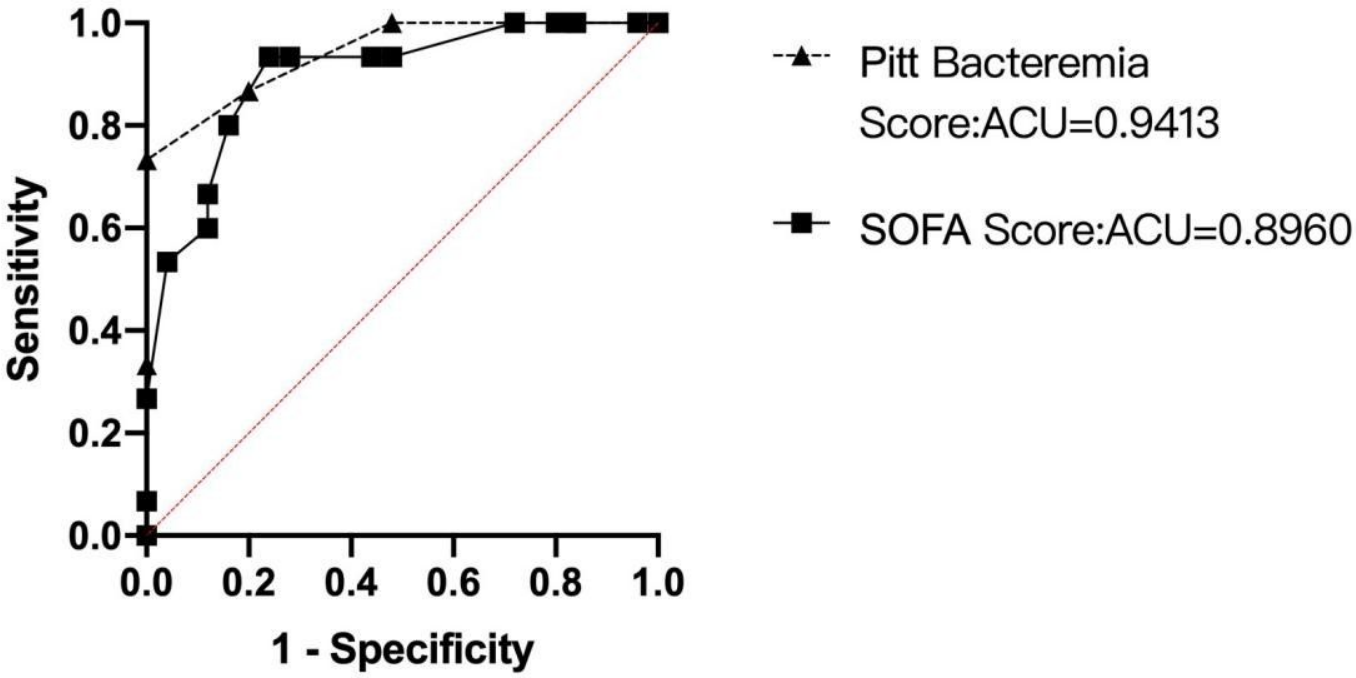

Figure 4

Comparison of Pitt bacteremia score and SOFA score