The Clinical Value of Satellite Blood Culture in the Early Diagnosis of Sepsis

Ziqi Guo
  Henan Provincial People's Hospital

Bo Guo
  Henan Provincial People's Hospital

Shanmei Wang
  Henan Provincial People's Hospital

Huifeng Zhang
  Henan Provincial People's Hospital

Wenxiao Zhang
  Henan Provincial People's Hospital

Bingyu Qin
  Henan Provincial People's Hospital

Huanzhang Shao (✉ 1181342588@qq.com)
  Henan Provincial People's Hospital

Abstract

Background: Early antibiotic treatment is a key component of therapy for sepsis. However, current blood culture can't fulfill it. The aim of this study was to assess whether satellite blood cultures (immediate incubation of blood cultures in the ICU) can improve turnaround times, antibiotic switching and patient prognosis.

Methods: This a observational single-center study, satellite blood culture and medical microbiology laboratory blood culture were performed separately in two groups. septic patients are collected from department of critical care medicine, Henan Provincial People`s Hospital from February 5,2018, to January 19, 2019.All septic patients are older than 18 and diagnosed sepsis according sepsis-3 criteria, who have been stayed hospital stay longer than 48 hour admitted to ICU.

Results: In total, we analyzed 299 blood culture sets from 73 ICU patients, including:149 from the medical microbiology laboratory blood culture group and 150 from the satellite blood culture group. There is no significant difference between the two group in positive rate. Comparing to laboratory blood culture group, the median time from specimen collection until incubation as reduced by 3.02h in satellite blood culture group (P < 0.001); the median time from specimen collection to notify blood culture positivity to the clinicians was reduced by 9.76h in satellite blood culture group(P <0.001).The median time was 54.05h in medical microbiology laboratory blood culture group and 30.97h in satellite blood culture group until the first change of antibiotic therapy regimen (P = 0.056).There was no difference in duration of ICU stay、duration of hospital stay、medical cost between the two group.

Conclusion: We have found that satellite blood culture may reduced turnaround times and it may speed up antibiotic switching and benefit on patients outcomes.

Introduction

Sepsis is life-threatening organ dysfunction caused by a dysregulated host response to infection[1],which is the leading cause of death worldwide[1 – 4]. It is important for improving the outcome of patients with sepsis by early detection and timely treatment[5]. Each hour of delay in antimicrobial administration was associated with an average decrease in survival of 7.6%[6]. Antibiotic treatment is a key component of therapy for sepsis. Early targeted therapy relays on the identification of the underlying pathogen. Blood culture and susceptibility are needed to guide antibiotic treatment. However, current culture-based pathogen detection – the current gold standard diagnostic method – is impaired by a delayed time to result[7]. An earlier time to positivity likely to be achieved by satellite blood culture(SBC), which is a blood culture system set up in a clinical department outside the hospital microbiology laboratory to meet the requirement for timely specimen submission. A method to increase the speed of blood culture detection. Satellite blood culture is able to significantly reduces time to obtain test results and speeds up antibiotic adjustment[8, 9]. It is useful for the early diagnosis and treatment of sepsis.

Based on this, this study retrospectively collected patients with sepsis February 5,2018, to January 19, 2019 and compared them with medical microbiology laboratory blood culture(LBC) to explore our hypothesis that satellite blood culture could shorten the turnround time and accelerated antibiotic switching, and might improve patient prognosis. With this goal, we assessed the effect of satellite blood culture on turnaround times: time to blood culture incubation, time to knowledge of positivity, time to antibiotic change; and duration of ICU stay、duration of hospital stay、medical cost are included.

Materials And Methods

Setting

This study was performed in department of Critical Care Medicine, Henan Provincial People`s Hospital, China. Enrollment commenced on February 5,2018, and concluded on January 19, 2019.

Inclusion Criteria

Patients are older than 18 with confirmed sepsis admitted to the ICUs during the study period were included in the analysis. Beside, hospital stay longer than 48 hour.

Study Design

This is a retrospective single-centre study, ICU patients with sepsis were analyzed to study the impact of satellite blood culture compared to medical microbiology laboratory blood culture at the following time intervals:

TI: time from specimen collection until begain to incubation,

TK: time from specimen collection until notify clinicians of blood culture positivity.

TA: time from specimen collection until adjust antibiotics.

Additionally, The comparison of prognosis of the patients with sepsis in two different groups: duration of ICU stay、duration of hospital stay、medical cost are included.

Statistical Analysis

Data are presented as mean and SD, or median and interquartile range (IQR) based on the distribution of the quantitative variables. Means for continuous variables were compared using independent group T tests when the data were normally distributed; otherwise, the Mann-Whitney test was used. Proportions for categorical variables were compared using the χ2 test, although the Fisher exact test was used when the data were limited.

Result

According to the inclusion criteria, the patients from February 5 2018 to July 30 2018 were collected as medical microbiology laboratory blood culture group,the patients from August 1, 2018 to January 19, 2019 collected as the satellite blood culture group. In total, 299 blood culture sets from 73 sepsis patients (35 in the medical microbiology laboratory blood culture group, 38 in the satellite blood culture group) were processed: 149 sets in the medical microbiology laboratory blood culture group and 150 sets in the satellite blood culture group.

Patient Characteristics

summarizes the baseline demographic and clinical characteristics of each group. There were no significant differences between the two groups at baseline except the age and gender.(Table 1)

Adjustment Of Antibiotics And Patient Outcomes

In medical microbiology laboratory blood culture group, 66 (44.3%) of 149 blood culture sets are positive, while in the satellite blood culture group, 78 (52%) of 150 blood culture sets are positive, but there was no significant difference in positivity rate between two groups.(Table 3)

Compared with the medical microbiology laboratory blood culture group, TI(4.48 vs 1.46)and TK (27.83 vs 18.07) is significantly shorten in satellite blood culture group, there was a statistical difference in TI and TK between the two groups(P < 0.001).However, although TA was reduced by 23.08 h in satellite blood culture group, we found no significant difference in TA between the two group(P = 0.056).(Table 2)

In the study, antibiotics were adjusted according to the blood culture results in part of patients, but there was no significant differences in the rate of antibiotics adjustment between the two groups(P = 0.09).(Table 4) Furthermore, we compared the duration of ICU stay、duration of hospital stay and medical cost of patients between these two groups, the length of ICU stay(15vs12)and the length of hospital stay(23vs15) was shorter as well as medical cost was less in satellite blood culture group, but there was no significant difference between the two groups, which is related to the small sample size.

Table 1
Baseline characteristics of sepsis patients

No. of patient	LBC group(n = 35)	SBC group(n = 38)	P value
Age,median (IQR), y	46(36,61)	60(49.25,73.5)	< 0.001
Sex	24(68.6%)	32(84.2%)	< 0.001
male	11(31.4%)	6(15.8%)	
female			
White Blood cell count, 10^9/L	14.16 ± 9.13	10.82 ± 5.46	0.066
PCT,ng/ml	5.22(0.75,22.42)	4.98(1.03,11.11)	0.392
CRP,mg/L	150(58.20,200)	169.60 (120.18,200)	0.430
Temperature	37.2(36.5,38)	36.95 (36.50,37.85)	0.929
Acute Physiology and Chronic Health Evaluation II score	17(12,21)	17.00(15.00,23.00)	0.239
Infection site	18(51.4%)	17(44.7%)	0.754
Pneumonia	9(25.7%)	9(23.7%)	
Abdominal	8(22.9%)	12(31.6%)	
Other			
Data are mean (SD), median (interquartile range), or n (%).			

Table 2
Time intervals between blood culture incubation, positive,
antibiotics change

Time	LBC group	SBC group	P value
TI	4.48(1.71,8.77)	1.46(0.85,3.23)	< 0.001
TK	27.83(21.72,46.04)	18.07(15.82,26.28)	< 0.001
TA	54.05(41.35,67.325)	30.97(22.33,45.78)	0.056
Data are median (interquartile range).			

Table 3
The outcome of Blood culture in different group

Blood culture	LBC group	Satellite BC group	P value
Positive	66(44.3%)	78(52%)	0.182
Negative	83(56.7%)	72(48%)	
Data are n (%)			

Table 4
The adjustment of antibiotics after blood culture positivity

No. of patient	LBC group(n = 35)	SBC group(n = 38)	P value
adjustment	9(25.7%)	17(44.7%)	0.09
Non adjustment	26(74.3%)	21(55.3%)	
Data are n (%)			

Table 5
Length of stay in ICU、length of hospital stay、and hospitalization costs

No.of patient	LBC group(n = 35)	SBC group(n = 38)	P value
ICU stay	15(5,27)	12(5,22.5)	0.388
Hospital stay	23(10,43)	15(8.75,28.25)	0.129
cost	181152.89(87663.81,316593.6)	146814.14(50518.29,211007.5)	0.122
Data are median (interquartile range).			

Discussion

Our research suggested that satellite blood culture significantly reduces turnaround time including TI and TK(P < 0.001), which is similar with the previous studies[8, 9]. In our study, compared with medical microbiology laboratory blood culture group, TI was reduced by 3.02 h and TK was reduced by 9.76 h in satellite blood culture group. It indicated that when TI was only 3 hours earlier, TK was roughly 10 hours earlier, which is related to workflow in the lab[10].Schwarzenbacher et al. controled the incubation time within 1 h in satellite blood culture group, even if in the medical microbiology laboratory blood culture group, the incubation time were not more than 8h[9].which is better than our data. Maybe it because we didn't train the staffs to get blood culture incubated as soon as possible. A study shown that after improving awareness of sepsis in the staff associated with improving pre-analytical phase procedures in blood culture collection,the isolation of bacteria by blood culture increased 3.25-fold[11]. Which might explain our results and lead us to make improvements in future research. Janapatla.et al proved that there is no difference in the time to positive detection of pathogens which was observed in bottles

processed during the day and after overnight delay[12]. It's the opposite of what we thought it was and deserve more research to explore.

In Schwarzenbacher's study, the time to know positive was more length than ours, which might owe to the staffs 24 h on duty in our hospital so that we can learn about the positive outcome quickly. However, when it comes to TA, the study didn't demonstrate that satellite blood culture is better than medical microbiology laboratory blood culture (p = 0.056),although the median time from specimen collection to adjust antibiotic was reduced by 23.08 h in satellite blood culture group. It is contrary to Schwarzenbacher's findings[9]. Small sample size maybe the main reason for it.

Besides, because lack of staff during off-hours, there is an increased risk of death among patients hospitalized during off-duty[13].Timely intervention for positive blood culture results during weekends,the duration of hospital stay with the hospital-acquired bacteremia patients was significantly reduced during after controlling for confounders [14].

The probability of cultures positive result decreased of 16% while the laboratory was closed. Further, the positive rate of blood culture may decrease by 0.3% for every one hour delay from blood sample collection to incubation[10]. We found that although the positive rate is increased in satellite blood culture group, there is no significant difference between the two groups, which is opposite of the Schwarzenbacher's study[9].Small scale of patients maybe account for it. Further to analysis, we indicated that the percentage of antibiotic regimen adjustment is rising in satellite blood culture group, but there is no significant difference between the two groups. Which is correspond with results published by Kerremans et al[8].In addition, a study showed that blood cultures collected during 24 hours after admission yielded more positive results than those collected later[15]. Lambregts et al reported that if blood culture had remained negative for 24 hours, The probability of bacteremia was 1.8% which may contribute to decisions on antimicrobial therapy[16].when the time of culture incubation is more than 48 hours, few true bloodstream infection could be detected[17]. Evaluation of the blood volume can also improve the rate of blood culture positivity[18, 19]. So clinicians may adjust empirical antibiotic coverage at this time with little risk for subsequent bacterial pathogen detection.

Procop have shown that shorten process time (specimen collection to positive blood culture detection)could decrease hospital stays and mortality rates[20].However, we found that there is no significant differences in duration of ICU stay、duration of hospital stay and medical cost between the two groups, while the three factors is lower in satellite blood culture group. But these findings are consistent with research of Kerremans et al[8].One possible explanation is the higher proportion of old patients in satellite blood culture group. Another explanation might be the flaw of design of our study. Beside our sample size was too small. Therefore, it need to do further research to explore the impact of shorten process time on hospital stays, mortality rates, and medical cost.

Otherwise, most studies also have focused on rapid diagnostics through new technologies including Multiplex PCR、matrix-assisted laser desorption ionization-time of flight mass spectrometry、Next-Generation Sequencing、Metagenomic Sequencing[21−24].

The limitation of our study is that this was a non-randomized controlled study and the baseline was not perfectly balanced, so we cannot exclude an analytical bias. and in addition, The sample size is too small for the adjustment of antibiotic regimen，length of hospital stay and medical costs. In the future, we will design a randomized controlled study and increase the sample size to provide more robust evidence for satellite blood cultures.

Conclusion

In conclusion, satellite blood culture may significantly reduced turnaround times, which could result in earlier change s in antibiotic therapy and benefit on patients outcomes.

Declarations

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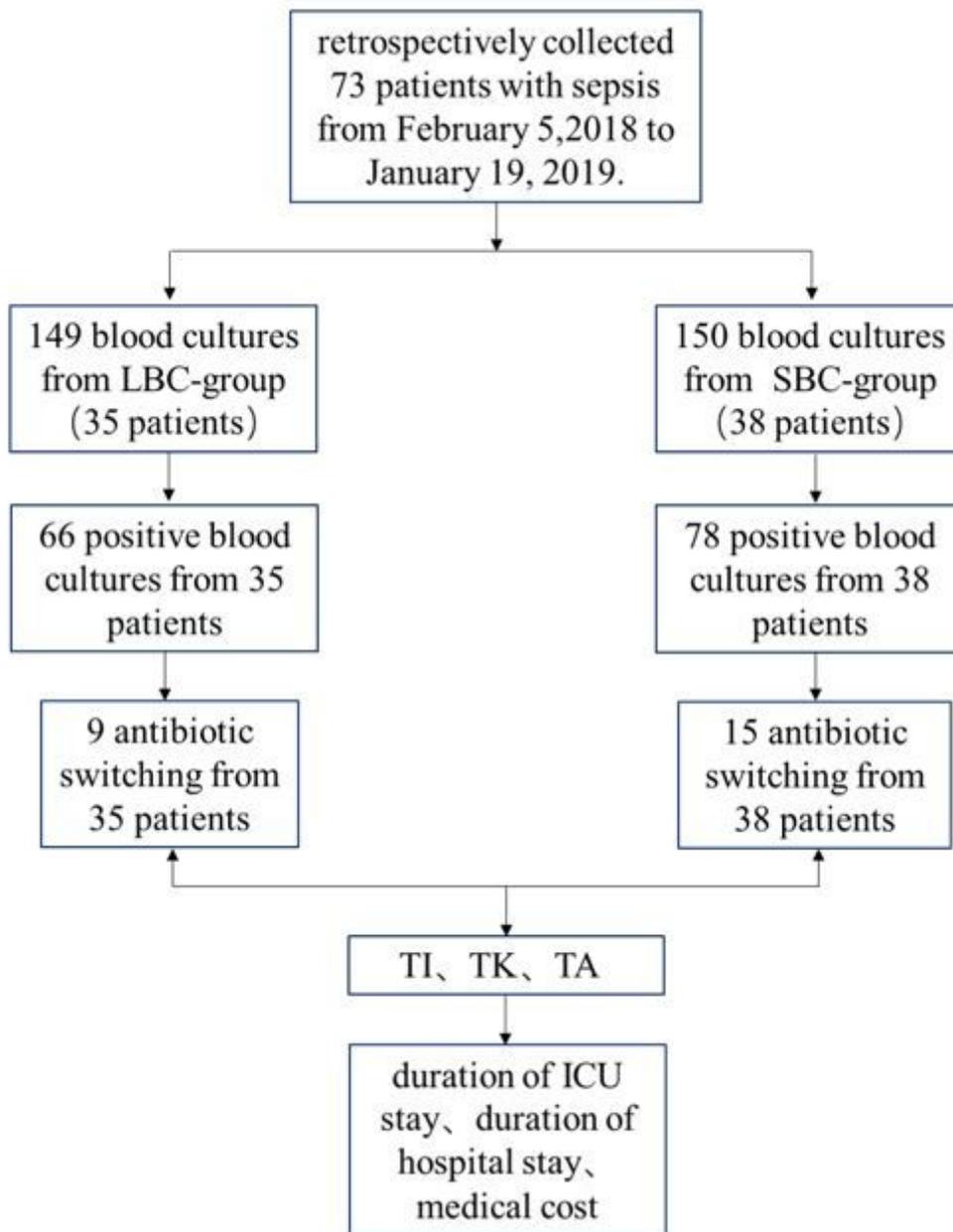
Figures

Figure 1

Flow chart of study design