Original Article

Epidemiology of bloodstream infections and surface swab cultures in burn patients

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Aim: For infection control in burn patients, it is essential to understand the epidemiology of bloodstream infection (BSI) and the local microbiological situation. There are few studies on blood and swab culture results among burn patients in Japan. The purpose of this study was to investigate the epidemiology of BSI and swab cultures in burn patients.

Methods: Data from 355 burn patients over 13 years from 2008 were analyzed retrospectively. Bloodstream infection was defined as the isolation of bacteria or fungi from two or more blood cultures. The characteristics of burn patients and microorganisms detected from various cultures were analyzed.

Results: The mortality rate among burn patients with BSI was 37.8%, which was more than twice that among burn patients without BSI. The univariate analysis showed that inhalation injury, total burn surface area (TBSA), and mortality were associated with BSI. The multivariate logistic analysis indicated that TBSA was an independent risk factor for BSI. The most frequently isolated organism from blood and swab cultures were Candida species and Pseudomonas aeruginosa, respectively. Seventy-five percent of the microorganisms isolated from blood were detected previously in swab cultures performed within 1 week from blood cultures.

Conclusions: The prognosis of burn patients with BSI was poor, and TBSA was an independent risk factor for BSI. The predominant organisms isolated from blood and swab cultures were Candida species and P. aeruginosa, respectively. Surveillance wound swab cultures could be utilized for monitoring the local microbiological situation in burn patients.

Key words: Burn injury, Candida species, infection control, microbiology, mortality

INTRODUCTION

PAST STUDIES REPORTED that most of deaths among burn victims were attributed to infections.[1–3] Thus, infection control is integral to improving outcomes in burn patients.

In burn patients, bloodstream infection (BSI) is one of the most important and serious complications.[4] Burn patients are at a high risk of BSI because of multiple surgeries, the use of medical devices, and prolonged hospitalization.[5] Moreover, previous reports indicated that BSI was an indicator of a poor outcome.[3,6] It is essential to understand the epidemiology of BSI in burn patients; therefore, the first aim of this study was to investigate the epidemiology of BSI.

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Received 7 Feb, 2022; accepted 20 Apr, 2022

Funding information

No funding information provided.

As the microorganisms colonizing burn patients and their microbial susceptibility are thought to change during hospitalization,[7] clinicians need to pay attention to the local microbiological situation and antimicrobial susceptibility during treatment.

Various practices have been used for the monitoring of organisms in burn patients. Surface swab culture is a convenient and effective method involving the routine collection of multiple superficial wound samples,[8] but this technique is not suitable for prediction of the presence or progression of BSI.[9] Although it was reported that the routine swab cultures were valuable for the detection of methicillin-resistant *Staphylococcus aureus* (MRSA),[10] there are few studies regarding the epidemiology of swab cultures among burn patients in Japan. The second aim of this study was to clarify the epidemiology of surface swab culture results in burn patients.

METHODS

THIS STUDY WAS carried out according to local guidelines and with the approval of the Ethics Committee of

Kyorin University (Tokyo, Japan). The requirement for informed consent was waived because of the anonymous nature of the data.

The medical records of burn patients admitted to the burn center at Kyorin University Hospital from January 2008 to December 2020 were investigated retrospectively. At our facility, burn patients are treated in a mixed ward with other critical patients, such as trauma and sepsis patients. The exclusion criteria were cardiac arrest on arrival and inhalation injury without cutaneous burn.

The data collected were age, sex, the percentage of total burn surface area (TBSA), the percentage of partial-thickness burn area, the percentage of full-thickness burn area, the presence of inhalation injury with clinical signs and evidence on bronchoscopy, and the presence of BSI. Bloodstream infection was defined as the isolation of bacteria or fungi from two or more blood cultures. If patients had more than one blood culture positive for the same microorganisms during the same hospitalization event, only the first episode of BSI was included. The microorganisms detected from the various cultures were recorded, and the consistency between the microorganisms isolated from the blood cultures and those from various cultures performed less than 1 week before blood cultures was estimated.

Blood samples were basically collected from the peripheral vein prior to the change in microbial agents, and the samples were incubated both aerobically and anaerobically.

Treatment strategies for infection control, such as the management of intravenous catheters and patient isolation, were largely consistent throughout the study. Approaches to antimicrobial therapy were also consistent in terms of empiric or targeted therapy based on previous microbiological results.

Continuous variables are expressed as the medians (interquartile ranges), and dichotomous variables are expressed as numbers with percentages. Continuous variables were compared using Student's *t*-test or the Mann–Whitney *U*-test. Categorical data were compared using the χ^2-test or Fisher's exact test. Univariate analysis and logistic regression analysis were used to estimate the associations with the presence of BSI. Statistical analyses were undertaken with GraphPad Prism (MDF Co. Ltd., Tokyo, Japan).

RESULTS

DURING THE 13-year study period, 355 burn patients were admitted to the Kyorin University Hospital Burn Center. After the inclusion and exclusion criteria were applied, 235 burn patients were included in this study (Fig. 1).

Table 1 shows the characteristics of the burn patients. The BSI group included 37 patients, and the non-BSI group included 198 patients. The mortality rate among burn patients with BSI was 37.8%, which was more than twice that among burn patients without BSI. The univariate analysis showed that inhalation injury, TBSA, and mortality rate were associated with BSI.

Table 2 shows the results of the multivariate logistic analysis. Total burn surface area was an independent risk factor associated with BSI.

There were 64 isolates from 37 patients with the BSI. A total of 17 patients (45.9%) had more than two positive blood cultures, so the number of cultures was higher than the number of patients.

Table 3 shows the microorganisms identified in the blood cultures. The most frequently isolated causative organism was *Candida* species (28.1%), followed by *Enterobacter* species (23.4%), *Pseudomonas aeruginosa* (18.8%), and MRSA (17.1%). Among the *P. aeruginosa* isolates, one isolate (8.3%) was identified as multidrug-resistant. Overall, Gram-negative bacteria were more common than Gram-positive bacteria. *Candida albicans* accounted for 61.1% and non-*albicans Candida* accounted for 38.8% of all the *Candida* isolates. There were no significant differences in the characteristics of the microorganisms isolated from blood cultures between nonsurviving and surviving BSI patients. However, the mortality rate in burn patients with *P. aeruginosa* and *Candida* species infections was 42.9%, which was more than twice that in burn patients with MRSA infection.

Figure 2 shows the time from the burn incident to BSI onset. A total of 84.4% of the BSI episodes occurred at 2 or more weeks after the burn incident. The median time from the burn incident to BSI onset was 32 (interquartile range [IQR], 19–76) days. The median times for positive blood cultures results for *P. aeruginosa*, *Candida* species, *Enterobacter* species, and MRSA were 28 (IQR, 19–38) days, 28 (IQR, 19–72) days, 34 (IQR, 20–78) days, and 75 (IQR, 46–81) days, respectively.

Table 4 shows the microorganisms identified in the surface swab cultures. There were 158 isolates collected from the surface swabs in 37 patients with BSI. The most frequently isolated causative organism was *P. aeruginosa* (23.4%). This was followed by *Enterobacter* species (21.5%), *Candida* species (20.3%), and MRSA (12.6%). A total of 35.1% of the *P. aeruginosa* isolates were multidrug-resistant. Overall, Gram-negative bacteria were more common than Gram-positive bacteria. *Candida albicans* accounted for 44.8% and non-*albicans Candida* accounted for 55.2% of all *Candida* species. The median times for positive surface swab culture results for *Enterobacter* species,

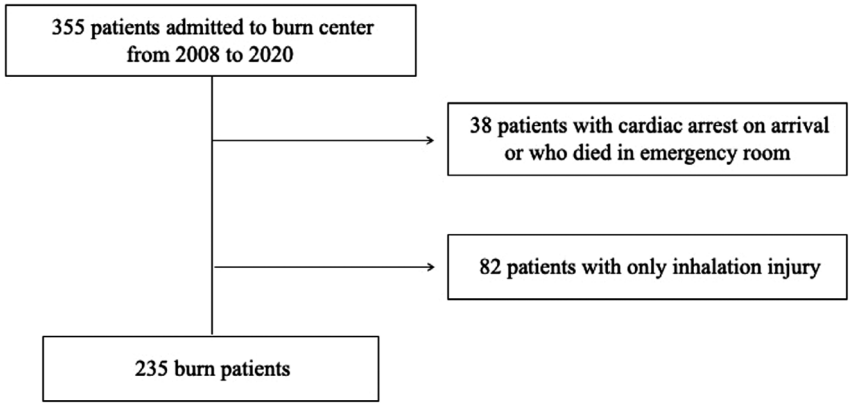

Fig. 1. . Patient selection for this study investigating the epidemiology of bloodstream infection and swab cultures in burn patients.

Table 1. . Characteristics of 235 burn patients

Variable	All cases (n = 235)	BSI+ (n = 37)	BSI− (n = 198)	P value
Male gender, *n* (%)	102 (43.4)	17 (45.9)	85 (45.2)	0.9999
Inhalation injury, *n* (%)	95 (40.4)	23 (62.2)	72 (36.4)	0.0056
Age (years)	53 (34–74)	54 (38–70)	53 (31–74)	0.5200
TBSA (%)	15 (8–35.5)	52 (30–64)	14 (7–27)	<0.0001
PTBA (%)	9 (4–16.5)	16 (6–37)	8 (4–14)	0.0021
FTBA (%)	6 (0–15)	15 (0–42)	0 (0–9.8)	<0.0001
Mortality, *n* (%)	38 (16.6)	14 (37.8)	26 (13.8)	0.0140

BSI, bloodstream infection; FTBA, full thickness burn surface area; PTBA, partial thickness burn surface area; TBSA, total burn surface area.

Table 2. . Logistic regression analysis for the presence of blood stream infection in 235 burn patients

Variable	Coefficient	Standard error	Wald value	P value
Age	0.0004	0.0081	0.0056	0.9553
Sex	0.5216	0.4093	1.274	0.2026
TBSA	0.0323	0.0068	4.773	<0.0001
Presence of inhalation injury	0.6609	0.4236	1.560	0.1187

TBSA, total burn surface area.

Table 3. . Pathogens identified in blood cultures from 235 burn patients

Pathogen	*n* (%)
Candida species	18 (28.1)
Enterobacter species	15 (23.4)
Pseudomonas aeruginosa	12 (18.8)
MRSA	11 (17.1)
Stenotrophomonas maltophilia	4 (6.3)
Other GPC	4 (6.9)

GPC, Gram-positive cocci; MRSA, methicillin-resistant *Staphylococcus aureus*.

P. aeruginosa, Candida species, MRSA, and multidrug-resistant *P. aeruginosa* were 8 (IQR, 4–16) days, 9 (IQR, 6–30) days, 10 (IQR, 6–11) days, 11 (IQR, 9–40) days, and 60 (IQR, 38–114) days, respectively. There were no significant differences in the characteristics of cultured microorganisms from surface swabs between the nonsurviving and surviving BSI patients. However, the filamentous fungi were isolated more frequently from nonsurviving than surviving BSI patients.

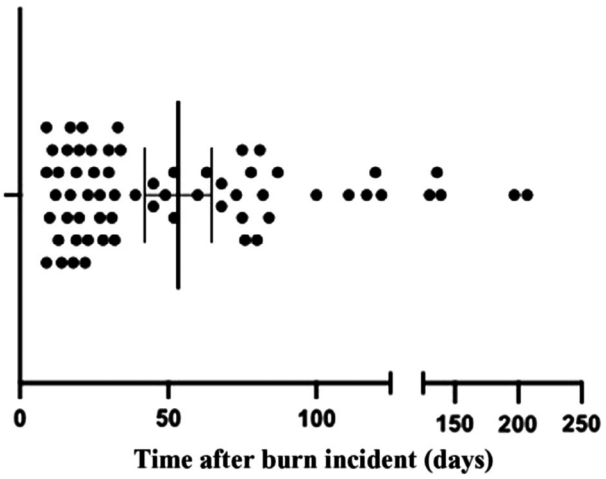

Fig. 2. . Time from burn incident to episodes of bloodstream infection among 235 burn patients. The median time from burn to bloodstream infection was 32 (interquartile range, 19–76) days.

Table 4. . Pathogens identified in the surface swab cultures of 235 burn patients

Pathogen	*n* (%)
Pseudomonas aeruginosa	37 (23.4)
Enterobacter species	34 (21.5)
Candida species	32 (20.3)
MRSA	20 (12.6)
Other GPC	18 (11.4)
Stenotrophomonas maltophilia	10 (6.3)
Filamentous fungi	7 (4.4)

GPC, Gram-positive cocci; MRSA, methicillin-resistant *Staphylococcus aureus*.

Regarding the consistency between blood cultures and swab cultures undertaken within 1 week from the blood culture, 48 isolates (75%) of the microorganisms cultured from blood were detected previously in cultures of swab samples, and six isolates (9.4%) cultured from blood were different from those cultured from swab samples. Surveillance swab cultures were not performed in 10 cases (15.6%).

Among the 48 cases for which the microorganisms cultured from the blood were isolated in previous cultures, microbial detection in 22 cases (45.8%) was positive on swab cultures but negative on sputum or urine culture. However, among the cases in which microorganisms cultured in the blood were not detected in previous swab cultures, isolates from four cases (66.6%) were detected on sputum culture, and isolates from two cases (33.3%) were detected on urine culture.

DISCUSSION

IN THE CURRENT study, we evaluated the epidemiology of BSI and swab culture results in a Japanese tertiary referral burn center.

The overall mortality rate among patients with BSI was 37.8% in this study, which was more than twice that among burn patients without BSI. This poor prognosis of BSI in burn patients was in accordance with past reports.[4,6,11] As the mortality rate in the BSI group in our study was higher than that in previous studies, more stringent infection control in burn patients might be needed in our center.

Our study showed that TBSA was an independent risk factor for BSI. These findings were consistent with the results of previous similar reports.[12] Thus, we should be cognizant of poor BSI outcomes, and that the risk of BSI increases with higher TBSA in burn patients.

Our study found that the median time from the burn incident to BSI onset was 32 days and that 84.4% of BSIs occurred after 2 weeks. This finding was different from past studies that reported that the median time from the burn incident to BSI onset was 7 days[4] or 8 days,[12] probably because early aggressive excision of the eschar was performed in our burn center within 2 weeks after the burn. Excising the eschar and covering the wound as early as possible is crucial for infection control in burn patients,[13] and total debridement should be completed within 2 weeks at the latest in our burn center.

In our study, *Candida* species were the most frequently isolated microorganisms from blood cultures. Some studies reported that Gram-positive organisms were more commonly associated with BSI than Gram-negative organisms.[5,14] Other studies showed the predominance of Gram-negative organisms. Soleymanzadeh-Moghadam *et al*. and Strachinaru *et al*. indicated that *P. aeruginosa* was the most prevalent isolated species in blood cultures.[15,16] Hu *et al*. and Chim *et al*. found that *Acinetobacter baumannii* was the most frequently detected organism in blood culture from burn patients.[12,17] These variations in the prevalence of microorganisms might be due to the differences in countries and facilities. Furthermore, not only the causative organism but also its microbial susceptibility could change during hospitalization. Thus, the local microbiological situation should be monitored in each patient at each burn center.

The predominant microorganism isolated from the swab cultures in the current study was *P. aeruginosa*, and 35.1% of the isolates were multidrug-resistant. Multidrug-resistant organisms are one of the biggest challenges in infection

control, and multidrug-resistant organisms were associated with a severe status burn patients.[18]

To monitor changes in causative pathogens and their microbial susceptibility, various practices have been applied for burn patients. Although surface swab culture of routinely collected multiple wound samples is a convenient and effective method, there are few studies on the epidemiology of surveillance culture results of burn injuries. As it was reported that surveillance swab cultures were useful for the detection of MRSA,[10] swab cultures might be valuable for the early detection of multidrug-resistant organisms. Moreover, 75% of the microorganisms cultured from blood were detected previously in swab cultures, and 45.8% of them were isolated from only swab cultures in this study. The results of swab cultures could lead to prediction of the causative pathogens of BSI in burn patients.

An important issue regarding swab cultures is the compliance rate. In this report, the surveillance swab cultures were not performed in 15.6% of cases. The low compliance rate of wound-site swabs has been noted in past reports.[18] We need to carry out surveillance cultures properly to achieve infection control in burn patients.

LIMITATIONS

SEVERAL LIMITATIONS OF our study should be noted. First, this was a retrospective study undertaken at a single center. Second, we could not exclude confounding factors associated with BSI mortality in burn patients. Finally, the incidence of BSI might be underestimated because we defined BSI as the isolation of bacteria or fungi from two or more blood cultures.

CONCLUSIONS

THE PROGNOSIS OF burn patients with BSI was poor, and TBSA was an independent risk factor for BSI. The predominant organisms isolated from blood and swab cultures were *Candida* species and *P. aeruginosa,* respectively. Surveillance wound swab cultures could be utilized for monitoring the local microbiological situation in burn patients.

DISCLOSURE

APPROVAL OF THE research protocol with approval no. and committee name: This study was conducted according to the guidelines and with the approval of the Ethics Committee of Kyorin University.

Informed consent: Requirement for informed consent was waived because of the anonymous nature of the data.

Registry and registration no. of the study/trial: N/A.

Animal studies: N/A.

Conflict of interest: None.

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