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RESEARCH ARTICLE

Does Age Change the Risks Leading to Bloodstream Infections in the Intensive Care Unit?

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ABSTRACT

Objectives: A significant correlation exists between bloodstream infections (BSI) in intensive care units (ICU) and morbidity, mortality, and healthcare costs. The objective of our study was to investigate risk analysis as a means of preventing BSI.

Methods: A total of 183 (1.57%) patients diagnosed with BSI were included in the study. Risk analysis was performed by comparing patients over 65 years of age with patients under 65 years of age. Epidemiological data, Glasgow Coma Scales, APACHI-II, expected mortality rates, number of days of hospitalization, C-reactive protein (c-RP), procalcitonin (PRC), microorganism strains, mean days of infection, and mean days of mortality were distributed to both groups. Significant differences facilitating the occurrence of infection were searched. A p-value<0.05 was considered significant.

Results: A total of 232 microorganisms were isolated. There were 79 (43.2%) female patients. 102 (55.7%) patients were over 65 years of age. The most common diagnoses among patients were sepsis (14.7%), aspiration pneumonia (13.1%), and COVID-19 (4.9%). The most common comorbidities were diabetes mellitus, hypertension, and cerebrovascular diseases. The expected mortality was 64.53±21.31 in the group under 65 years of age and 64.01±19.57 in the group over 65 years of age. The most commonly isolated microorganisms are *A.baumannii* (16.38%), *Enterococci* (14.22%), *C.albicans* (12.5%), and K.pneumonia (12.07%). Days to infection and mortality were also analyzed between the groups.

Conclusion: No risk factors were identified for BSI. The risk can be reduced by a well-functioning surveillance network, continuous education, and compliance with standard isolation precautions.

Keywords: Bloodstream infections, intensive care unit, risk analysis

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Introduction

BSIs were defined as the growth of a clinically significant pathogen in at least one blood culture bottle. Potential contaminants, including coagulase-negative Staphylococci, Corynebacterium species, Bacillus species, Diphtheroid, Aerococcus, and Propionibacterium species (sp.), were identified in accordance with the National Surveillance Guidelines for Healthcare-Associated Infections (Ankara-2024) and were not considered to be BSI.[1–3]

The prevalence of BSIs is approximately twice as high in ICUs compared to other hospitalized patients.[4] There is a significant correlation between BSIs in ICU and morbidity, mortality, and healthcare costs.[5,6] No studies have been found that estimate the risk of BSI in critically ill patients based on ICU admission criteria. In our study, we aimed to determine the risk analysis for BSI.

Methods

A total of 14,372 patients over the age of 18, who were admitted to the adult ICUs of our hospital between September 2016 and August 2023, were screened. Patients who were hospitalized in the ICU for less than 48 hours and 23 isolates detected within the first 48 hours after admission

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were excluded from the study. A total of 11,648 patients were included in our study. The study was approved by The Kartal Dr. Lütfi Kırdar City Hospital Clinical Research Ethics Committee (no: 2023/514/262/18, date: 29/11/2023), and our study was conducted in accordance with the Declaration of Helsinki. All central catheter-associated and laboratory-confirmed BSIs of the patients were screened. There were 162 central catheter-associated BSIs and 21 laboratory-confirmed BSIs. Only one isolate was considered in cases with multiple isolates of the same microorganism. After excluding potential contaminants and missing data, 232 microorganisms were isolated from 183 patients with positive blood cultures. The rate of positive blood cultures was 1.57%. BSIs were diagnosed in accordance with the national guidelines.[3]

The patients were divided into two groups as those above 65 years of age and those below 65, and these groups were compared. On the day of ICU admission, the patients' gender, blood types, comorbidities, Glasgow Coma Scales, APACHE-II scores, expected mortality rates, length of stay in the ICU, C-reactive protein (c-RP) and procalcitonin (PCT) levels on the day of blood culture sampling, isolated microorganisms, average time to the onset of infection, and average days to mortality were distributed equally across both groups. Significant differences affecting the occurrence of infections were investigated.

Statistical Analysis

The distribution of variables was analyzed using the one-sample Kolmogorov-Smirnov test. Qualitative data were presented as numbers and percentages, while quantitative data were expressed as means and standard deviations. Group comparisons were performed using the Mann-Whitney U test, and categorical data were compared using the Chi-square test. All analyses were conducted using the Statistical Package for Social Sciences version 20 software (SPSS Inc., Chi, IL). Statistical significance was set at $p<0.05$ for all comparisons.

Results

Over the 7-year period, 11,648 ICU patients were monitored for more than 48 hours. A total of 183 patients diagnosed with BSI were included in the study, of which 79 (43.2%) were female and 104 (56.8%) were male. Eighty-one (44.3%) patients were under the age of 65, and 102 (55.7%) were over the age of 65. The mean age was 64.38±17.84 years. There was no significant difference in gender between the groups ($p>0.05$). The most common blood type was A Rh(+). No significant difference in blood types was observed between the age groups (Table 1).

The most common diagnoses at the time of admission were sepsis (14.7%), aspiration pneumonia (13.1%), COVID-19 (4.9%), and subarachnoid hemorrhage (3.8%). Our study also encompasses the period of the COVID-19 pandemic. The most common comorbidities were hypertension, diabetes mellitus, cerebrovascular diseases, Alzheimer's disease, and chronic renal failure. No significant differences were found in the distribution of comorbidities between the groups ($p>0.05$; Table 2).

Following the distribution of parameters, including the Glasgow Coma Scale (GCS), APACHE-II, length of ICU stay, microbial growth day, C-reactive protein (c-RP), and procalcitonin (PCT), no significant difference was observed between the two groups ($p>0.05$; Table 3).

The most frequently isolated microorganism was *A.baumannii* (15.7%), followed by Enterococci (13.6%) and *C.albicans* (12%). When all Candida species were considered, the rate of candidemia was 28.45%. There were no significant differences in the types of isolated microorganisms between the groups ($p>0.05$; Table 4).

Laboratory-confirmed BSIs and central venous catheter-associated BSIs were distributed between the two groups, and no significant differences were observed ($p>0.05$; Table 5). The overall mortality rate was 67.2%, and no significant difference was found between the groups in terms of mortality rate ($p=0.078$; Table 5).

Discussion

The duration of application of catheters used for the monitoring and treatment of patients in the ICU is associated with infection rates.[7] BSIs are a significant cause of healthcare-associated infections in the ICU, leading to prolonged hospital stays, increased costs, and high mortality rates.[8] Preventing these infections should be one of the primary strategies of infection control committees in hospitals. For this, a robust surveillance network should be established, and the behavior of staff should be monitored 24/7. Patients should be admitted to their beds only after proper room and bed cleaning, and contact isolation must be rigorously maintained until the patient leaves the unit. Preventing BSIs requires effort, time, education, professional staff, and a high standard of healthcare delivery. The primary goal in addressing BSIs should be focused on prevention. In our study, we aimed to identify risk factors before BSI development by examining multifaceted parameters related to patients, with the ultimate goal of preventing their occurrence.

Immunosuppressed patients with advanced age, hematological malignancies, the use of new drugs in the treatment of cancer and autoimmune diseases, sepsis, trauma, and major surgical interventions expand the spectrum of ICU

Table 1. Demographic characteristics and distribution of blood types

	<65 years		>65 years		p
	n	%	n	%	
Gender					
Female	40	49.4	39	38.2	0.130
O Rh (+)	19	23.5	25	24.5	NA
A Rh (+)	28	34.6	42	41.2	
B Rh (+)	13	16	19	18.6	
O Rh (-)	3	3.7	2	2	
A Rh (-)	8	9.9	4	3.9	
AB Rh (+)	7	8.6	4	3.9	
B Rh (-)	3	3.7	4	3.9	
AB Rh (-)	–	–	2	2	

Chi-square test. NA: Not applicable.

patients.[9] We divided the 183 patients included in the study into two groups: those over 65 and those under 65 years of age. This was based on the fact that immune problems are more commonly seen in patients over 65.

Of the patients who developed BSI, 43.2% were female, and there was no significant difference in gender distribution between the two groups; the same was observed for the male patients (p>0.05; Table 1). The role of patients' blood types in the occurrence of BSI was also examined, but no correlation was found. The distribution of blood types in both groups was similar to that of the general population, with A Rh(+) being the most frequently identified blood type (Table 1).

As stated in the review article by Silamlak, it was noted that blood group B increased the incidence of *Streptococcus pneumoniae, E.coli*, and Salmonella sp., and blood group AB increased the incidence of *E.coli* and Salmonella sp.[10] Since hospital-acquired bacteremia isolates were included in our study, we believe that there is no statistically significant difference between blood groups.

The distribution of comorbidities was analyzed in both groups, and no significant difference was found (p>0.05; Table 2). The most common comorbidities were diabetes mellitus (DM), hypertension (HT), chronic renal failure, Alzheimer's disease, coronary artery disease, cerebrovascular diseases, and COVID-19, as our study also covered the pandemic period (Table 2). Although some of these conditions cause immunosuppression, no predisposing factor to BSI was found (p>0.05).

Table 2. The distribution of comorbidities

		<65 years		>65 years		p
		n	%	n	%	
DM	Presence	26	32.1	32	31.4	0.916
HT	Presence	41	50.6	39	38.2	0.093
CVD	Presence	9	11.1	18	17.6	0.216
CRF	Presence	14	17.3	9	8.8	0.086
COPD	Presence	8	9.9	9	8.8	0.807
Alz Dis	Presence	12	14.8	14	13.7	0.834
Seizure	Presence	4	4.9	11	10.8	0.152
Park Dis	Presence	2	2.5	3	2.9	0.846
AF	Presence	5	6.2	4	3.9	0.484
CAD	Presence	7	8.6	12	11.8	0.492
CHF	Presence	7	8.6	4	3.9	0.182
Pulmonary HT	Presence	1	1.2	1	1	0.870
Obesity	Presence	2	2.5	3	2.9	0.846
Hyperthyroidism	Presence	4	4.9	–	–	NA
Asthma	Presence	2	2.5	–	–	NA
BPH	Presence	1	1.2	2	2	0.701
Hydrocephaly	Presence	2	2.5	–	–	NA
HVR	Presence	1	1.2	1	1	0.870
SAS	Presence	1	1.2	1	1	0.870
COVID-19	Presence	3	3.7	6	5.9	0.498

Chi-square test. DM: Diabetes mellitus; HT: Hypertension; CVD: Cerebrovascular disease; CRF: Chronic renal failure; COPD: Chronic obstructive pulmonary disease; Alz Dis: Alzheimer's disease; Park Dis: Parkinson's disease; AF: Atrial fibrillation; CAD: Coronary artery disease; CHF: Chronic heart failure; BPH: Benign prostate hypertrophy; HVR: Heart valve replacement; SAS: Sleep apnea syndrome; COVID-19: Coronavirus disease; NA: Not applicable.

Table 3. Hospital parameters

	<65 years Mean±SD	>65 years Mean±SD	p
GCS	7.87±4.53	7.22±4.05	0.485
APACHE-II	29.18±7.37	28.93±7.39	0.507
Expected mortality	64.53±21.31	64.01±19.57	0.669
Hospital stay (days)	68.11±48.42	88.89±104.9	0.295
Day of Microbial growth	37.08±35.09	37.81±28.96	0.419
c-RP	166.01±78.6	177.79±85.58	0.424
PCT	9.21±20.98	11.67±24.28	0.751

Mann-Whitney U test. SD: Standard deviation; GCS: Glasgow coma scale; APACHE: Acute physiology and chronic health evaluation; c-RP: C-reactive protein; PCT: Procalcitonin.

Table 4. The distribution of microbial growth

	<65 years		>65 years		p
	n	%	n	%	
Acinetobacter baumannii	15	18.5	23	22.5	0.504
Acinetobacter lwoffii	–	–	1	1	NA
Klebsiella pneumonia	9	11.1	19	18.6	0.161
Klebsiella oxytoca	1	1.2	1	1	0.870
Pseudomonas aeruginosa	6	7.4	8	7.8	0.912
Burkholderia sp.	–	–	1	1	NA
Escherichia coli	6	7.4	7	6.9	0.887
KNS	3	3.7	4	3.9	0.939
Enterococcus fecalis	9	11.1	9	8.8	0.606
Enterococcus faecium	8	9.9	7	6.9	0.460
Enterobacter cloacae	1	1.2	4	3.9	0.268
Staphylococcus aureus	4	4.9	1	1	0.103
Stenotrophomonas maltophilia	3	3.7	3	2.9	0.774
Serratia arcescens	2	2.5	3	2.9	0.846
Enterobacter aerogenes	1	1.2	3	2.9	0.433
Proteus mirabilis	–	–	2	2	0.205
Citrobacter sp.	–	–	2	2	0.205
Candida albicans	17	21	12	11.8	0.09
Candida parapsilosis	9	11	13	12.7	0.736
Candida glabrata	3	3.7	3	2.9	0.774
Candida tropicalis	–	–	4	3.9	0.072
Candida krusei	2	2.5	–	–	NA
Candida kefyr	1	1.2	–	–	NA
Candida dubliniensis	–	–	1	1	NA

Chi-square test. KNS: Coagulase negative staphylococcus; NA: Not applicable.

When the Glasgow Coma Scales, APACHE-II scores, and expected mortality rates were calculated for the patients upon ICU admission and distributed between the two groups, no significance was found to explain the risk of BSI development (p>0.05; Table 3). The length of ICU stay was 68.11±48.42 days for patients under 65 years of age and 88.89±104.9 days for those over 65. There was no significant relationship between the length of stay and BSI occurrence in either group (p=0.295; Table 3).[11]

The duration of microorganism growth was 37.08±35.09 days for patients under 65 years of age and 37.81±28.96 days for those over 65. No significant relationship was found between the duration of microorganism growth and the occurrence of BSI (p=0.419; Table 3).

Although blood culture is the gold standard for diagnosing bloodstream infections, identifying microorganisms typically takes 1–5 days, and the positivity rate of blood cultures is between 10–20%.[11] When the c-RP and PCT

Table 5. Cause of infection and mortality rate

	<65 years		>65 years		p
	n	%	n	%	
Source of infection					
Laboratory	7	8.6	14	13.7	0.284
CVC	74	91.4	88	86.3	
Mortality	60	74.1	63	61.8	0.078

Chi-square test. CVC: Central venous catheter.

values, measured on the day of blood culture, were distributed between the two groups, no correlation was found between these values and the occurrence of BSI (p=0.424 and p=0.751, respectively; Table 3). Considering that CRP monitoring is useful also in the older population, it is not surprising that markers of inflammation (leukocytes, CRP, and procalcitonin) at presentation were similar between the groups, and likewise the index of severity.[11]

The strains of microorganisms isolated in both groups were also evaluated. *A.baumannii* (15.7%), *K.pneumoniae* (11.2%), *P.aeruginosa* (5.8%), and *E.coli* (5.4%) were the most frequently isolated Gram-negative pathogens. Enterococci (13.6%) were the most frequently isolated gram-positive pathogens, and no significant difference was observed between the groups (p>0.05; Table 4).

The leading causes of candidemia include the use of broad-spectrum antibiotics, central venous catheters, parenteral nutrition, corticosteroid use, H2 receptor antagonist use, and insufficient adherence to infection control measures.[12] *C.albicans* (12%) was the most common cause of candidemia, followed by *C.parapsilosis* (9%) (Table 4). The total rate of isolated Candida species was 28.45%. No microorganism was found to significantly cause BSI in both groups (p>0.05; Table 4). Our findings were seen to be compatible with many studies in the literature.

The overall mortality rate was 67.2%, and no significant difference was found between the groups in terms of mortality rate (p=0.078; Table 5). Of the 333 ICUs from 52 countries comprising the EUROBACT-2 cohort, 219 ICUs from 43 countries reported on at least one older adult (≥75 years old). Accordingly, a total of 2111 individuals hospitalized in ICU and diagnosed with HA-BSI were included in the current study.[13] In this multicenter study, the mortality rate was found to be 51%.

There is no well-established definition for older adults. We classified our cohort using the age cutoff of 65, assuming it had the best discriminatory ability. However, a different age cut-off would likely have yielded slightly different results.

We had an expectation of finding differences in the presence of comorbidities such as chronic renal failure and diabetes mellitus, which are associated with immunosuppression, as well as in the Glasgow Coma Scale and APACHE-II scores calculated upon the patients' admission to the ICU. However, none of the parameters examined were indicative of the BSI risk between the groups.

Early identification of patients at high risk for BSI, obtaining targeted blood cultures, and initiating effective antibiotics are crucial. Delayed effective treatment is associated with poor outcomes.[14] Although the isolation rate of pathogens in blood cultures is typically 10–20%, the blood culture positivity rate in our study was 1.57%. This suggests that the actual number of BSIs may be higher than detected.[14] In patients with clinical signs of infection, a negative blood culture does not rule out the diagnosis and still necessitates treatment.

The primary aim should be to prevent the occurrence of BSI. With this, morbidity, mortality, and healthcare costs can be reduced.[15,16] One of the most effective practices in preventing infections is establishing a strong hand hygiene culture, which can significantly reduce infection rates.[17] Implementing standard isolation precautions during patient interventions, monitoring staff behavior within the unit, restricting unnecessary entries and exits, avoiding unnecessary catheterization, ensuring proper catheter care, and timely removal of catheters all contribute to reducing the prevalence of BSI.[18,19]

Conclusion

In our study, which aimed to predict the risk of BSI based on patient-related parameters, we did not reach a significant conclusion. This, in fact, suggests that BSIs are closely associated with healthcare practices. Continuous education and the establishment of an effective surveillance network place significant responsibilities on healthcare personnel in the unit and infection control committees.

Disclosures

Ethics Committee Approval: The study was approved by The Kartal Dr. Lütfü Kırdar City Hospital Clinical Research Ethics Committee (no: 2023/514/262/18, date: 29/11/2023).

Authorship Contributions: Concept – B.K., S.Ş., E.B., S.D.T.; Design – B.K., S.Ş., E.B., S.D.T.; Supervision – B.K., S.Ş., E.B., S.D.T.; Fundings – B.K., S.Ş., E.B., S.D.T.; Materials – B.K., S.Ş., E.B., S.D.T.; Data collection &/or processing – B.K., S.Ş., E.B., S.D.T.; Analysis and/or interpretation – B.K., S.Ş., E.B., S.D.T.; Literature search – B.K., S.Ş., E.B., S.D.T.; Writing – B.K., S.Ş., E.B., S.D.T.; Critical review – B.K., S.Ş., E.B., S.D.T.

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