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ORIGINAL ARTICLE

MICROBIOLOGICAL PROFILES AND CLINICAL OUTCOMES OF BLOODSTREAM INFECTIONS IN GERIATRIC PATIENTS ADMITTED TO INTENSIVE CARE UNITS: A SINGLE-CENTER EXPERIENCE

Abstract

Introduction: Bloodstream infections are associated with high mortality in older adults due to immunosenescence and comorbidities. This study aimed to investigate pathogen distribution, antimicrobial resistance patterns, and predictors of early and late mortality in intensive care unit patients aged ≥65 years.

Materials and Method: Between September 2022 and September 2024, blood culture results of intensive care unitpatients aged ≥65 years at Fırat University Hospital were evaluated. The first clinically significant isolates were analyzed; identification and susceptibility were performed by automated systems and confirmed by conventional methods when necessary. Statistical analyses were conducted.

Results: Among 469 patients, the most frequent pathogens were *Klebsiella spp.* (18.6%), *Enterococcus spp.* (16.8%), and Escherichia coli(12.6%). Extended-spectrum β-lactamase positivity was 77.0% in *Klebsiella spp.* 50.8% in *Escherichia coli*. In *Klebsiella spp.*, imipenem and meropenem susceptibilities were 37.3% and 35.3%, respectively, and amikacin susceptibility was 84.9%. *Acinetobacter spp.* showed 94.7% susceptibility to colistin, while Staphylococcus aureus was 100% susceptible to vancomycin. Approximately 40–50% of *Candida* isolates demonstrated azole resistance. Secondary bloodstream infections occurred in 62.5%, with higher C-reactive protein levels (p=0.034). In multivariable analysis, only serum albumin was independently associated with early mortality.

Conclusion: In geriatric intensive care unit patients, bloodstream infections were mostly secondary, predominantly caused by Klebsiellaspeciesand Escherichia coli.High Extended-spectrum β-lactamase rates and marked carbapenem resistance complicate treatment.Low serum albumin independently predicted early mortality. Our findings highlight the need for close monitoring of infection burden and resistance patterns.

Keywords: Aged; Intensive Care Units; Sepsis; Bacteremia; Drug Resistance.

INTRODUCTION

Bloodstream infections (BSIs), ranging from bacteremia to sepsis and septic shock, are serious clinical conditions that result in high morbidity and mortality among older adults. Advanced age, immunosenescence, and the presence of multiple comorbidities increase susceptibility to infections and contribute to a more severe and rapid disease course. In addition, BSIs in the elderly often present with atypical symptoms, leading to diagnostic and therapeutic delays that are recognized as major contributors to mortality (1,2). Previous studies have reported that individuals aged ≥65 years are significantly more likely to be diagnosed with sepsis compared to younger adults, imposing a growing burden on healthcare systems (3,4).

BSIs are particularly frequent among geriatric patients admitted to intensive care units (ICUs), where they often require urgent management. Knowledge of the clinical course and antimicrobial resistance patterns of BSIs in this population is therefore critical for guiding appropriate therapeutic decisions (3).

Colonization with multidrug-resistant organisms is more common in older adults who require long-term care, complicating treatment and adversely affecting quality of life. Gram-negative bacteria account for 40–60% of BSIs in this age group and are associated with higher rates of antimicrobial resistance (5,6).

Population-based studies indicate a rising incidence of BSIs in the elderly. However, data regarding pathogen distribution, resistance patterns, and clinical predictors of mortality in this vulnerable group remain limited (7).

This study aimed to evaluate the distribution of microorganisms and antimicrobial resistance patterns isolated from blood cultures of patients aged ≥65 years admitted to Level I, Level II, and Level III intensive care units (ICUs), and to investigate the association of clinical and laboratory parameters with early (≤7 days) and late (7–30 days) mortality.

MATERIALS AND METHOD

Study Design, Setting, and Participants

Between September 2022 and September 2024, blood culture results of patients aged ≥65 years admitted to intensive care units of Fırat University Hospital were retrospectively evaluated. Based on their clinical capabilities and available organ-support modalities, ICUs were categorized into Level I, Level II, and Level III. Internal Medicine, Anesthesiology, Infectious Diseases, and Nephrology ICUs were classified as Level III; Gastroenterology, Surgical, Oncology, Hematology, and mixed ICUs as Level II; and the Cardiology ICU as Level I. The first clinically significant isolates were included in the analysis. A clinically significant isolate was defined as the first microorganism considered a true pathogen based on compatible clinical features, growth in ≥1 blood culture set, presence of systemic inflammatory response, and confirmation by an infectious diseases specialist. Identification and antimicrobial susceptibility testing were performed by automated systems and confirmed with conventional methods when necessary. Patients were classified as primary and secondary BSIs; in addition to clinical findings, key laboratory parameters such as C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), procalcitonin, creatinine, and albumin were analyzed in relation to pathogen distribution and resistance patterns; independent risk factors for mortality were determined using multivariable analyses. Associations with early (≤7 days) and late (7–30 days) mortality were also evaluated.

Inclusion and Exclusion Criteria

Only bloodstream infections that occurred after ICU admission were included; patients with pre-existing infections or positive cultures before ICU admission were excluded. Among multiple blood culture samples from the same patient, only the first clinically significant isolate was included. Isolates considered to be contaminants and repeated growths within 10 days were excluded.

Definitions

Bloodstream Infection (BSI): Defined as the detection of a viable microorganism in a blood culture.

Blood Culture Contamination: Growth of one or more microorganisms belonging to the skin flora in only a single blood culture set (e.g., in one or more bottles of a single set, or in only one of two or three sets) without clinical or microbiological evidence supporting true infection with that organism (8).

This group typically includes organisms such as coagulase-negative *Staphylococci*, *Corynebacterium spp.*, *Bacillus spp.* (non-anthracis), and *Micrococcus spp.*

Primary BSI: Infections originating directly from endovascular sources (e.g., infective endocarditis) (8).

Secondary BSI: Infections resulting from hematogenous spread from a secondary focus such as the urinary tract, lungs, or catheters (8).

Lung-derived Secondary BSI: Secondary bloodstream infection of pulmonary origin was defined when radiologically confirmed pneumonia was present, a pathogenic microorganism was isolated from a lower respiratory tract sample (endotracheal aspirate or bronchoalveolar lavage), and the same microorganism with identical species identification was isolated from the blood culture within the same infectious episode.

Data Collection and Clinical Assessment

Electronic records obtained from hospital and laboratory information systems were retrospectively reviewed. Recorded data included demographic and clinical characteristics such as age, sex, and comorbidities; ward of admission, source of infection, recent antibiotic use (within the last three months), and prior hospitalization history. In addition, isolated micro organisms and their anti microbial susceptibility profiles from blood cultures were documented. Patients were classified under two main groups based on the infection source: primary BSIs and secondary BSIs. Laboratory parameters, including CRP, ESR, procalcitonin, leukocyte count, neutrophil and lymphocyte percentages, lactate, AST, ALT, urea, creatinine, total protein, and albumin, were evaluated. Differences between early (≤7 days) and late (7–30 days) mortality were also analyzed. Due to missing data in some laboratory parameters, analyses were performed on the available subsample for each parameter.All biochemical and hematological measurements were taken from blood samples drawn at the time of blood culture collection.

Microbiological Studies

Blood cultures were incubated using an automated system (BD BACTEC™, USA). For cultures yielding growth signals, subcultures were performed after Gram staining onto 5% sheep blood agar and EMB media. Identification and antimicrobial susceptibility testing were carried out using a semi-automated system (BD Phoenix™, Becton, Dickinson and Company, Sparks, MD, USA), disk diffusion (Bioanalyse, Ankara, Türkiye), and broth microdilution (Sensititre™, Thermo Fisher Scientific Inc., Waltham, MA, USA). Potential contaminants were excluded from the analysis. Antimicrobial susceptibility results were interpreted according to the criteria of the European Committee on Antimicrobial Susceptibility Testing (EUCAST v2023) and the recommendations of the Turkish Society of Microbiology ADTS (Standardization of Antimicrobial Susceptibility Testing) working group.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics v22.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Shapiro–Wilk test. For normally distributed variables, the independent samples t-test was applied, while the Mann–Whitney U test was used for non-normally distributed variables.

Categorical variables were presented as counts and percentages, and continuous variables as mean ± standard deviation or median (min–max). Associations between variables were examined using Spearman correlation analysis. Multivariable logistic regression was applied to identify predictors of early and late mortality among patients with known outcomes. Variables included in the multivariable logistic regression model were age, sex, infection source (primary/secondary), ICU level, major comorbidities, initial vital signs (temperature, systolic and diastolic blood pressure, heart rate, respiratory rate), inflammatory markers (CRP, ESR, procalcitonin), WBC, neutrophil and lymphocyte percentages, lactate, renal and liver function tests (urea, creatinine, AST, ALT), total protein, and albumin levels.A p-value <0.05 was considered statistically significant.

Ethics approval

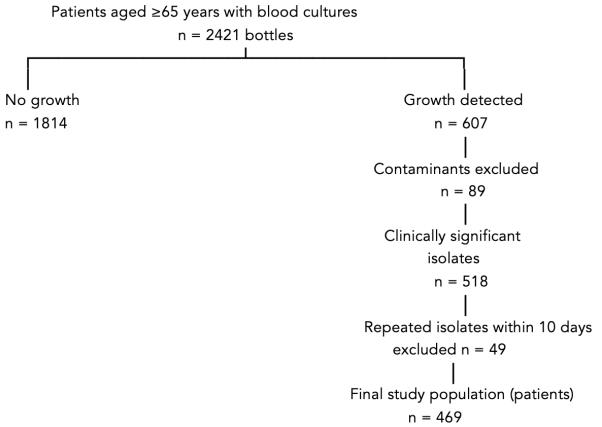
The study was conducted in accordance with the Declaration of Helsinki and approved by the Fırat University Non-Interventional Research Ethics Committee (Approval No: 2025/03-35, Date: 19.02.2025). Informed consent was waived due to the retrospective design.Data extraction and analyses were performed after ethics approval had been obtained.

RESULTS

Cohort flow and baseline characteristics

During the study period, a total of 2421 blood culture bottles from patients aged ≥65 years were screened through the hospital information system. Among these, 1814 bottles (74.9%) showed no growth, while 607 bottles (25.1%) yielded microbial growth. All reported results are based on the 469 patients included in the final analysis.

Of the 607 positive blood culture samples obtained during the study period, 89 (14.7%) were considered contaminants and excluded from the analysis. Only the first clinically significant isolate from each patient was included, resulting in a total of 469 geriatric patients (200 women, 42.6%; 269 men, 57.4%) analyzed.



Due to missing data in some laboratory parameters, comparisons were performed on the available subsamples. The mean age was 75.4 ± 7.9 years for women and 76.9 ± 8.5 years for men. In accordance with standard clinical practice, at least two blood culture sets were obtained from each patient during the diagnostic evaluation. In most cases, 2 to 3 sets (4–6 bottles) were collected.

Among the 469 geriatric ICU patients included in the study, multimorbidity was highly prevalent. The median number of chronic comorbidities per patient was 3 (IQR: 2–5), and 74% of the cohort had three or more chronic conditions. The most common comorbidities were hypertension (63.5%), diabetes mellitus (51.5%), ischemic heart disease (38.0%), chronic kidney disease (26.0%), heart failure (24.0%), and chronic obstructive pulmonary disease (19.4%). Cerebrovascular disease was present in 14.3% of patients, while 13–14% had an active malignancy (solid or hematologic). In addition, neurological disorders such as dementia, Parkinson's disease, and a history of stroke were frequent, contributing to reduced airway protection and increased aspiration risk. Overall, the patient population exhibited substantial frailty and physiologic vulnerability consistent with advanced age and multiple chronic diseases.

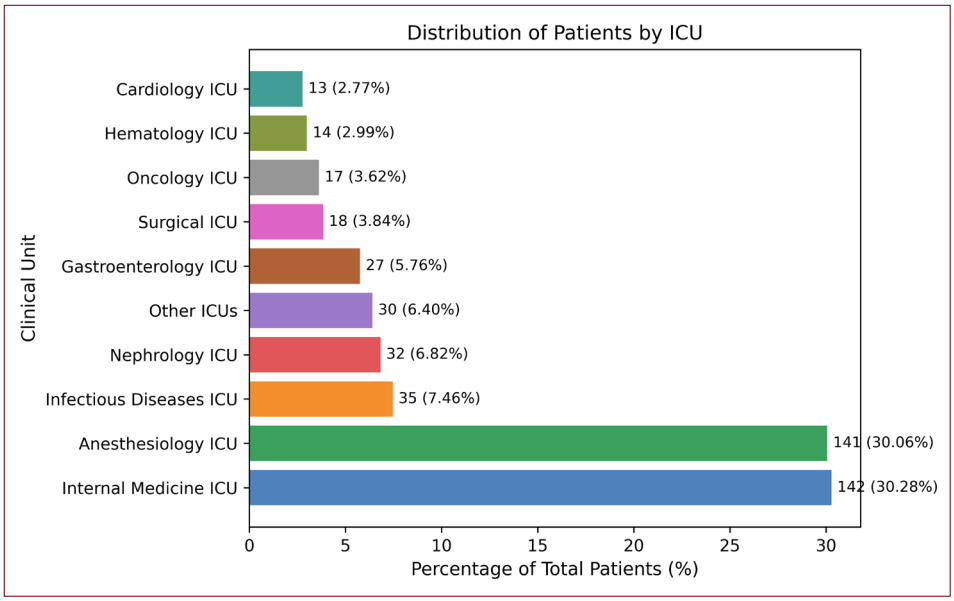


Figure 1. Distribution of geriatric patients with bloodstream infections by intensive care unit (n=469).

The most frequent admissions were to the Internal Medicine ICU (n=142, 30.3%) and the Anesthesiology ICU (n=141, 30.1%) (Figure 1). Among 469 patients with BSI, 350 (74.6%) were monitored in Level III ICUs, 106 (22.6%) in Level II ICUs, and 13 (2.8%) in Level I ICUs. The mean time from ICU admission to the first BSI episode was 6.4 ± 4.7 days.

Distribution of pathogens

Among the microorganisms isolated from blood cultures, *Klebsiella spp.* was the most frequent (n=87, 18.6%), followed by *Enterococcus spp.* (n=79, 16.8%), *Escherichia coli (E. coli)* (n=59, 12.6%), *Acinetobacter spp.* (n=57, 12.1%), and *Staphylococcus aureus* (n=51, 10.9%). Other isolates included *Pseudomonas spp.* (n=28, 6.0%), *Stenotrophomonas maltophilia* (n=20, 4.3%), and *Streptococcus spp.* (n=12, 2.6%). In addition, of 41 isolates (8.7%), 34 (7.2%) were other *Enterobacterales* (e.g., *Enterobacter aerogenes, Morganella morganii, Proteus mirabilis*), and 7 (1.5%) were other Gram-negative bacteria (e.g., *Achromobacter spp., Moraxella spp.*).

Fungal pathogens were isolated in 7.5% (n=35) of positive cultures, including 20 *Candida albicans* isolates (4.3%) and 15 *non-albicans Candida* species (3.2%) such as *C. glabrata, C. parapsilosis, C. tropicalis, C. kefyr, C. dubliniensis,* and *C. haemulonii*

Antimicrobial and antifungal susceptibility patterns

Extended-Spectrum Beta-Lactamase (ESBL) production was detected in 59.9% of Enterobacterales isolates. ESBL positivity was 77.0% in *Klebsiella spp.*, 50.8% in *E. coli,* and 23.1% in other *Enterobacterales.*

Carbapenem resistance was high in Klebsiella spp. (imipenem 60.2%, meropenem 64.7%, ertapenem 68.2%) and Acinetobacter spp. (88.9% for both imipenem and meropenem). In contrast, E. coli showed markedly lower resistance (imipenem 5.3%, meropenem 7.1%, ertapenem 26.4%). Pseudomonas spp. exhibited moderate resistance (16–25%), while other Enterobacterales demonstrated heterogeneous resistance ranging from 25% to 50%.

Table 1 summarizes the susceptibility profiles of *Klebsiella spp.*, *Escherichia coli*, and other *Enterobacteriaceae* isolates. Table 2 presents the susceptibility distributions of non-fermentative

Table 1. Susceptibility profiles of Klebsiella spp.,Escherichia coli, and other Enterobacteriaceae isolates to commonly used antibiotics.

	Enterobacteriaceae											
	Klebsiella				***Escherichia coli***				**Other *Enterobacteriaceae***			
Antibiotic	**S (n, %)**	**I (n, %)**	**R (n, %)**	**Total**	**S (n, %)**	**I (n, %)**	**R (n, %)**	**Total**	**S (n, %)**	**I (n, %)**	**R (n, %)**	**Total**
Ampicillin	–	–	86, 100%	86	11, 20.0%	–	44, 80.0%	55	–	–	–	–
Amoxicillin–Clavulanate	15, 18.3%	–	67, 81.7%	82	19, 40.4%	–	28, 59.6%	47	5, 14.3%	–	30, 85.7%	35
Ampicillin–Sulbactam	16, 22.2%	–	56, 77.8%	72	19, 40.4%	–	28, 59.6%	47	–	–	–	–
Ceftazidime	15, 17.7%	1, 1.2%	69, 81.2%	85	22, 38.6%	3, 5.3%	32, 56.1%	57	10, 32.3%	–	21, 67.7%	31
Cefazolin	–	11, 12.9%	74, 87.1%	85	–	16, 28.6%	40, 71.4%	56	–	–	–	–
Ceftazidime–Avibactam	38, 82.6%	–	8, 17.4%	46	9, 81.8%	–	2, 18.2%	11	5, 41.7%	–	7, 58.3%	12
Ceftriaxone	17, 19.4%	–	70, 80.5%	87	23, 39.0%	–	36, 61.0%	59	12, 36.4%	–	21, 63.6%	33
Cefepime	17, 20.2%	–	67, 79.8%	84	27, 49.1%	–	28, 50.9%	55	10, 29.4%	3, 8.8%	21, 61.8%	34
Cefuroxime	–	10, 11.9%	74, 88.1%	84	–	19, 34.5%	36, 65.5%	55	–	2, 15.4%	11, 84.6%	13
Imipenem	31, 37.4%	2, 2.4%	50, 60.2%	83	51, 91.1%	2, 3.6%	3, 5.4%	56	18, 64.3%	3, 10.7%	7, 25.0%	28
Meropenem	30, 35.3%	–	55, 64.7%	85	52, 92.9%	–	4, 7.1%	56	21, 70.0%	–	9, 30.0%	30
Ertapenem	27, 31.8%	–	58, 68.4%	85	39, 73.6%	–	14, 26.4%	53	14, 50.0%	–	14, 50.0%	28
Gentamicin	69, 79.3%	–	18, 20.7%	87	47, 79.7%	–	12, 20.3%	59	17, 50.0%	–	17, 50.0%	34
Amikacin	73, 84.9%	2, 2.3%	12, 13.9%	86	55, 96.5%	–	2, 3.5%	57	25, 64.1%	–	14, 35.9%	39
Ciprofloxacin	19, 21.8%	1, 1.2%	67, 77.0%	87	24, 40.7%	3, 5.1%	32, 54.2%	59	17, 41.5%	3, 7.3%	21, 51.2%	41
Levofloxacin	18, 20.9%	1, 1.2%	67, 77.9%	86	24, 42.1%	1, 1.8%	32, 56.1%	57	19, 48.7%	4, 10.3%)	16, 41.0%	39
Piperacillin–Tazobactam	24, 27.9%	–	62, 72.1%	86	42, 72.4%	–	16, 27.6%	58	20, 54.1%	2, 5.4%	15, 40.5%	37
Trimethoprim–Sulfamethoxazole	39, 44.8%	1, 1.2%	47, 54.0%	87	26, 44.1%	–	33, 55.9%	59	24, 68.6%	–	11, 31.4%	35
Colistin	15, 34.1%	–	29, 65.9%	44	21, 100%	–	–	21	4, 26.7%	–	11, 73.3%	15

Results are expressed as the number and percentage of isolates classified as susceptible (S), intermediate (I), or resistant (R) according to EUCAST breakpoints

Table 2. Susceptibility profiles of *Acinetobacter spp.* and *Pseudomonas spp.* isolates to commonly used antibiotics.

	Non-fermentative Bacteria							
	Acinetobacter				***Pseudomonas spp.***			
Antibiotic	**S (n, %)**	**I (n, %)**	**R (n, %)**	**Total**	**S (n, %)**	**I (n, %)**	**R (n, %)**	**Total**
Ceftazidime	–	–	–	–	–	21, 77.8%	6, 22.2%	27
Ceftazidime–Avibactam	–	–	–	–	11, 78.6%	–	3, 21.4%	14
Cefepime	–	–	–	–	–	21, 84.0%	4, 16.0%	25
Imipenem	6, 11.1%	–	48, 88.9%	54	–	21, 75.0%	7, 25.0%	28
Meropenem	5, 9.3%	1, 1.9%	48, 88.9%	54	19, 76.0%	2, 8.0%	4, 16.0%	25
Gentamicin	7, 12.5%	–	49, 87.5%	56		–	–	–
Amikacin	7, 12.7%	–	48, 87.3%	55	26, 92.9%	–	2, 7.1%	28
Ciprofloxacin	–	6, 10.7%	50, 89.3%	56	–	21, 80.8%	5, 19.2%	26
Levofloxacin	6, 11.1%		48, 88.9%	54	–	23, 82.1%	5, 17.9%	28
Piperacillin–Tazobactam	–	–	–	–	–	24, 85.7%	4, 14.3%	28
Trimethoprim–Sulfamethoxazole	14, 26.4%	1, 1.9%	38, 71.7%	53	–	–	–	–
Colistin	18, 94.7%	–	1, 5.3%	19	–	–	–	–

Results are expressed as the number and percentage of isolates classified as susceptible (S), intermediate (I), or resistant (R) according to EUCAST breakpoints.

Gram-negative bacilli (*Acinetobacter spp.* and *Pseudomonas spp.*). Table 3 displays susceptibility results for Gram-positive organisms, including *Staphylococcus aureus*, *Streptococcus spp.*,*Enterococcus faecalis*, and *Enterococcus faecium*. Table 4 shows antifungal susceptibility patterns for *Candida albicans* and non-albicans Candida species.

Primary versus secondary BSIs and mortality

Among the 469 geriatric patients included, 176 (37.5%) had primary BSIs and 293 (62.5%) had secondary BSIs. Chi-square analysis showed that secondary BSIs were significantly more frequent in males compared to females ($\chi^2 = 6.37$, $p = 0.012$). The most common source of secondary infection was the lungs (n = 117, 39.9%), followed by the urinary

Table 3. Susceptibility profiles of Gram-positive bacteria, including *Staphylococcus aureus*, *Streptococcus spp.*, *Enterococcus faecalis*, and *Enterococcus faecium*.

	Gram-positive Bacteria							
	Staphylococcus aureus				***Streptococcus spp.***			
Antibiyotic	**S (n, %)**	**I (n, %)**	**R (n, %)**	**Total**	**S (n, %)**	**I (n, %)**	**R (n, %)**	**Total**
Penicillin G	5, 10.9%	–	41, 89.1%	46	7, 58.3%	5, 41.7%	–	12
Cefoxitin	11, 47.8%	–	12, 52.2%	23	–	–	–	–
Erythromycin	39, 76.5%	–	12, 23.5%	51	–	–	–	–
Clindamycin	36, 75.0%	1, 2.1%	11, 22.9%	48	–	–	–	–
Cefuroxime	–	–	–	–	5, 71.4%	–	2, 28.6%	7
Cefotaxime/Ceftriaxone	–	–	–	–	6, 85.7%	–	1, 14.3%	7
Cefepime	–	–	–	–	4, 57.1%	–	3, 42.9%	7
Trimethoprim–Sulfamethoxazole	47, 92.2%	2, 3.9%	2, 3.9%	51	–	–	–	–
	38, 77.6%	–	11, 22.4%	49	–	–	–	–
Levofloxacin	0, 0%	44, 88.0%	6, 12.0%	50	–	–	–	–
Gentamicin	50, 98.0%	–	1, 2.0%	51	9, 100%	–	0, 0%	9
Fusidic Acid	41, 82.0%	–	9, 18.0%	50	–	–	–	–
Teicoplanin	46, 100%	–	0, 0%	46	–	–	–	–
Vancomycin	46, 100%	–	0, 0%	46	11, 91.7%	–	1, 8.3%	12
Linezolid	46, 95.8%	2, 4.2%	–	48	–	–	–	–
Meropenem	–	–	–	–	7, 100%	–	–	7
	E. fecalis				***E. faecium***			
	S (n, %)	**I (n, %)**	**R (n, %)**	**Total**	**S (n, %)**	**I (n, %)**	**R (n, %)**	**Total**
Ampicillin	34, 91.9%	1, 2.7%	2, 5.4%	37	6, 15.8%	1, 2.6%	31, 81.6%	38
Streptomycin-Syn	22, 59.5%	–	15, 40.5%	37	6, 16.2%	–	31, 83.8%	37
Gentamicin	28, 75.7%	–	9, 24.3%	37	12, 32.4%	–	25, 67.6%	37
Teicoplanin	34, 94.4%	–	2, 5.6%	36	30, 81.1%	–	7, 18.9%	37
Vancomycin	36, 97.3%	–	1, 2.7%	37	32, 86.5%	–	5, 13.5%	37
Linezolid	34, 97.1%	–	1, 2.9%	35	36, 97.3%	–	1, 2.7%	37

Results are presented as the number and percentage of isolates classified as susceptible (S), intermediate (I), or resistant (R) according to EUCAST clinical breakpoints

Table 4. Antifungal susceptibility profiles of *Candida albicans* and *non-albicans Candida* isolates. Non-albicans species (3.2%) included *C. glabrata*, *C. parapsilosis*, *C. tropicalis*, *C. kefyr*, *C. dubliniensis*, and *C. haemulonii*.

	Candida albicans				***non-albicans Candida***			
Antibiyotic	**S (n, %)**	**I (n, %)**	**R (n, %)**	**Total**	**S (n, %)**	**I (n, %)**	**R (n, %)**	**Total**
Amfoterisin B	16, 84.2%	–	3, 15.8%	19	12, 75.0%	–	4, 25.0%	16
Anidulafungin	14, 73.7%	–	5, 26.3%	19	5, 100%	–	–	5
Fluconazol	11, 57.9%	–	8, 42.1%	19	8, 50.0%	4, 25.0%	4, 25.0%	16
Vorikonazol	8, 47.1%	3, 17.6%	6, 35.3%	17	8, 80.0%	–	2, 20.0%	10
Itrakanazol	8, 50.0%	–	8, 50.0%	16	–	–	–	–
Posakanazol	10, 58.8%	–	7, 41.2%	17	–	–	–	–
Mikofungin	17, 89.5%	–	2, 10.5%	19	10, 71.4%	–	4, 28.6%	14

Results are presented as the number and percentage of isolates classified as susceptible (S), intermediate (I), or resistant (R) according to EUCAST clinical breakpoints.

Table 5. Comparison of biochemical parameters between primary (n=176) and secondary (n=293) bloodstream infection groups.

Parameter	**Primary BSI (n=176)**	**Secondary BSI (n=293)**	**p-value**
CRP (mg/L)	84 (41.5–163.9)	111 (53.3–164.3)	0.034
ESR (mm/h)	62 (31–94.5)	64 (36.5–98.0)	0.399
Procalcitonin (ng/mL)	0.9 (0.3–3.2)	0.85 (0.3–4.7)	0.050
Leukocytes ($\times 10^3/\mu L$)	12.170 (9.100–17.100)	11.430 (8.500–14.400)	0.275
Neutrophils (%)	82 (70.5–90.0)	82 (73.0–89.0)	0.901
Lymphocytes (%)	11 (6–15)	7 (4–14)	0.267
Lactate (mmol/L)	1.8 (1.1–2.7)	2.3 (1.3–3.9)	0.205
AST (U/L)	38 (26–66.5)	37.5 (24–64)	0.958
ALT (U/L)	30 (18–60.5)	21 (14–41.8)	0.243
Urea (mg/dL)	95 (58–138)	90.5 (60–112)	0.331
Creatinine (mg/dL)	1.2 (0.9–2.2)	1.3 (0.9–2.1)	0.201
Total protein (g/dL)	5.8 (5.2–6.5)	5.95 (5.1–6.4)	0.861
Albumin (g/dL)	3.07 ± 0.62	3.09 ± 0.69	0.773

(Note: The n values for each parameter represent available data; therefore, effective sample size varies by parameter).

tract (n = 92, 31.4%) and catheter-related infections (n = 30, 10.2%). Other sources included wound, intra-abdominal, biliary, and joint fluid infections (n = 54, 18.4%). Regarding mortality, in the primary BSI group, early mortality (≤7 days) was 16.5% (n = 29) and late mortality (7–30 days) was 18.8% (n = 33); while in the secondary BSI group, early mortality was 17.1% (n = 50) and late mortality 21.2% (n = 62). The difference between groups was not statistically significant ($p = 0.853$). When biochemical parameters were compared, CRP levels were significantly higher in the secondary BSI group ($p = 0.034$). Procalcitonin levels were also higher in the secondary group, but only showed borderline significance ($p = 0.050$). No other parameters differed significantly between groups (all $p > 0.05$) (Table 5).

Multivariable analysis

In multivariable logistic regression analysis, only serum albumin level was independently associated with early mortality (OR = 0.57, 95% CI: 0.38–0.85, p = 0.009). Each 1 g/dL increase in albumin was associated with an approximately 43% reduction in the risk of early mortality. Model fit was confirmed by the Hosmer–Lemeshow test (p = 0.395). The explanatory power was moderate (Cox & Snell R^2 = 0.098, Nagelkerke R^2 = 0.131), and the model correctly classified 63.6% of cases.

DISCUSSION

In our cohort of elderly ICU patients, bloodstream infections were associated with substantial comorbidity burden and high mortality, consistent with previous studies reporting increased susceptibility in geriatric populations (1). This makes BSIs one of the leading causes of morbidity and mortality in this population. Previous studies have reported an increasing frequency of BSIs in geriatric patients, with Gram-negative bacteria as the predominant pathogens and widespread ESBL production among *Enterobacterales* (9–11). These resistance patterns highlight the growing antimicrobial resistance burden in the elderly and further complicate appropriate therapeutic choices in life-threatening conditions such as sepsis. Inappropriate empirical therapy has been shown to markedly reduce survival in septic shock (12).

In older adults, urinary tract infections, pneumonia, and catheter-related bacteremias have been reported as the most common secondary sources. Chandroulis et al. reported that secondary BSIs significantly increased mortality, while Rodriguez-Mañas emphasized that urinary infections are particularly prominent as causes of geriatric sepsis (10, 13). In an epidemiological study by Sante et al., the incidence of secondary BSIs in ICU settings was found to be substantial; 69% of patients had central venous catheters, 68% had urinary catheters, and overall mortality was reported at approximately 29% (14). In our study, the rate of secondary BSIs in geriatric patients was 62.5%, which is consistent with previous reports. Furthermore, unlike some other studies, our findings identified the lungs, urinary tract, catheters, and other sources (wound, intra-abdominal, biliary, joint fluid, etc.) as the leading foci of secondary infections in descending order. Although Gram-negative bacteria frequently colonize the gastrointestinal and urinary tracts in elderly individuals, respiratory tract infections are a leading source of secondary bacteremia in ICU settings. Advanced age, impaired swallowing reflexes, and high aspiration risk contribute to the development of pneumonia. In addition, mechanical ventilation, prolonged intubation, tracheostomy, and impaired airway clearance significantly increase the incidence of ventilator-associated and hospital-acquired pneumonia. Therefore, the predominance of lung-derived secondary BSIs in our cohort is consistent with the pathophysiology of critical illness and aligns with previous studies reporting the respiratory tract as a major origin of secondary bacteremia in ICU patients.

The higher rate of secondary BSIs observed in male patients suggests that sex may represent an independent risk factor for infection development in the geriatric population. Previous studies have indicated that male sex, particularly in combination with advanced age, may increase susceptibility to urinary and catheter-related infections (10). Consistently, chi-square analysis in our study also demonstrated that secondary BSIs were significantly more frequent in males than in females.

In bacteriological analysis, the majority of isolates were Gram-negative bacteria, with *Klebsiella spp.* and *E. coli* being the most frequently detected pathogens. This finding parallels previous studies reporting that gastrointestinal and urinary tract-related secondary bacteremias are common in the elderly, and that Gram-negative pathogens play a dominant role in geriatric sepsis (5, 6, 9).

Klebsiella spp., E. coli, and *Acinetobacter spp.* isolates exhibited high resistance rates to β-lactam antibiotics, with particularly low susceptibility to ampicillin, cephalosporins, and fluoroquinolones. Moreover, the high prevalence of ESBL production among our isolates is consistent with the findings of Ilmavirta et al., who highlighted increasing ESBL rates in *E. coli* bacteremias in recent years (11). Carbapenems showed limited activity against Klebsiella and *E. coli*, while *Acinetobacter spp.* isolates demonstrated marked resistance to carbapenems; in such cases, only colistin retained significant effectiveness. In Pseudomonas spp. isolates, the aminoglycoside antibiotic amikacin showed the highest activity. Similarly, previous studies have emphasized the widespread prevalence of ESBL-positive *Enterobacterales* and the rising rates of carbapenem resistance in elderly ICU patients (11). These findings underscore the necessity of tailoring empirical antibiotic choices to local resistance patterns in elderly ICU patients and highlight the increasing challenges in selecting appropriate therapy.

Among Gram-positive isolates, *S. aureus* and *Enterococcus spp.* were predominant, showing particularly high resistance rates to penicillin G. In contrast, glycopeptide and oxazolidinone antibiotics such as vancomycin, teicoplanin, and linezolid exhibited high levels of susceptibility across all isolates. *E. faecium* isolates showed very low susceptibility to ampicillin and limited activity against agents such as gentamicin and streptomycin. In *Streptococcus spp.* isolates, moderate susceptibility to β-lactams was maintained. These findings indicate that classical β-lactam agents may be insufficient against Gram-positive BSI pathogens, while glycopeptides continue to play a crucial role in empirical therapy. Furthermore, the presence of resistant species such as *E. faecium* has been linked to increased prolonged hospital stays in the geriatric population (15, 16).

The *Candida* species identified in our study also stand out as important causes of sepsis in geriatric patients. Approximately 7.5% of isolates were *Candida albicans* and *non-albicans Candida,* indicating that invasive candidemia represents a considerable pathogen burden in elderly ICU patients. The literature clearly describes risk factors for candidemia in advanced age, including immune senescence, prolonged broad-spectrum antibiotic therapy, central venous catheterization, and extended ICU stays (17). The increasing proportion of *non-albicansCandida* species necessitates careful consideration of changing antifungal resistance profiles (18). This finding underscores the importance of revising antifungal treatment protocols in the elderly population. The antifungal susceptibility profiles of *Candida albicans* and *non-albicans* isolates highlight the need for careful consideration in the treatment of candidemia in elderly patients. In *Candida albicans* isolates, echinocandins and polyenes such as micafungin, amphotericin B, and anidulafungin demonstrated high efficacy, whereas azole antifungals, particularly voriconazole and itraconazole, showed low susceptibility rates. In *non-albicans Candida* species, fluconazole susceptibility remained around 50%, whereas anidulafungin was effective in all tested isolates. This finding supports the growing trend of azole resistance in geriatric patients. The literature has reported a strong association between invasive candidemia and mortality in elderly individuals, recommending echinocandins as the preferred therapy due to increasing azole resistance (18, 19). Our findings emphasize the importance of carefully planning empirical antifungal therapy and integrating antifungal susceptibility testing into treatment strategies for elderly ICU patients.

In this study, CRP and procalcitonin levels were higher in the secondary BSI group, but they did not show an independent association with mortality in multivariable analysis. Similarly, no significant

association was observed for neutrophil-to-lymphocyte ratio. In contrast, only serum albumin level was independently associated with early mortality. The literature has emphasized the role of CRP and procalcitonin in the diagnosis and prognosis of sepsis, reporting their association with mortality particularly in elderly patients (15, 16, 20). Our findings suggest that these biomarkers should be carefully interpreted in elderly patients and highlight the importance of establishing age-specific cutoff values.

Low serum albumin levels may reflect conditions such as malnutrition, high comorbidity burden, and immune deficiency in geriatric patients, and can therefore be associated with poor prognosis. The literature has also demonstrated that hypoalbuminemia increases the risk of mortality in sepsis and critical illness (21, 22). In our multivariable logistic regression analysis, only serum albumin level was independently associated with early mortality within the first 7 days. This finding supports the prognostic importance of albumin and indicates that it may serve as a clinically valuable biomarker. Our results are consistent with the literature reporting early and late mortality rates in elderly patients with sepsis (23). Therefore, individualized supportive treatments based on albumin levels and the implementation of early, multidisciplinary approaches are recommended in geriatric patients.

Strengths and Limitations

The major strength of this study is the analysis of resistance profiles using a large microbiological and clinical dataset in patients aged ≥65 years followed in Level I, Level II, and Level III ICUs. With these features, it represents one of the few comprehensive studies focusing on BSIs in geriatric patients in the literature. On the other hand, its single-center, retrospective design and the presence of missing data for some laboratory parameters limited the analytical power of the study.

Summary of Findings and Clinical Significance

The findings of this study demonstrate that BSIs in elderly ICU patients are largely secondary in origin and predominantly caused by Gram-negative bacteria. The high rates of ESBL production observed particularly in *Klebsiella spp.* and *E. coli* highlight the growing burden of antimicrobial resistance in the geriatric population. In addition, the marked carbapenem resistance observed especially in *Acinetobacter spp.* and some *Enterobacterales* isolates further complicates appropriate treatment planning. Our results are consistent with numerous studies reporting increased infection rates, shifting pathogen distributions, and progressively resistant antimicrobial patterns in elderly individuals (9–11).

Pathophysiological Reasons and Future Recommendations

Immunosenescence associated with aging and the high burden of comorbidities increase susceptibility to infections. Therefore, consideration of local resistance patterns, the use of biomarkers (CRP, procalcitonin, albumin, etc.) as prognostic indicators, and the application of early, appropriate empirical therapy combined with aggressive supportive strategies are crucial. Multicenter, prospective studies evaluating long-term outcomes are needed.

CONCLUSION

Bloodstream infections in geriatric ICU patients are predominantly secondary in origin and largely caused by Gram-negative organisms, particularly *Klebsiella spp.* and *Escherichia coli,* with high rates of ESBL production and substantial carbapenem resistance. Low serum albumin was the only independent predictor of early mortality. These findings highlight the importance of early recognition, appropriate empirical therapy, and close clinical monitoring in elderly ICU populations. Given that pathogen distribution and antimicrobial resistance profiles vary widely across institutions, it

is essential for each center to regularly monitor its own epidemiological and resistance data to guide empirical treatment strategies and strengthen infection control practices.

In addition, strict hand hygiene, meticulous catheter care, regular decubitus pressure–injury monitoring, and early respiratory rehabilitation are essential components of infection prevention bundles in geriatric ICU patients and should be systematically implemented.

Limitations

Patient-level linkage of susceptibility results was not available, which limited pathogen-specific mortality analysis. Because only patients with confirmed BSI were included and ICU-level denominators (total number of patients monitored in each ICU type) were not available, true incidence rates by ICU level could not be calculated and comparisons across ICU types were not possible.

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