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Original Article

Bloodstream infections in older cancer patients: epidemiology and risk factors for mortality

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Abstract

Introduction: Both aging and malignancy are associated with an increased risk of infections, including bloodstream infections. Despite their clinical significance, research concentrating on the epidemiology, outcomes, and risk factors influencing mortality in older cancer patients is still limited. This study aims to examine the epidemiology of bloodstream infections and factors contributing to mortality among older cancer patients.

Methodology: This retrospective cohort study was conducted at Etlik City Hospital from January to December 2023. The subjects included cancer patients aged 65 years and older who had experienced bloodstream infections and received a minimum of 48 hours of antimicrobial therapy. Data, including demographics, clinical features, microbiological findings, and antimicrobial therapy, were collected. Bloodstream infections were categorized as either hospital-acquired or community-acquired infections and further classified by their source.

Results: Among 160 bloodstream infection episodes observed, 68.8% of them occurred in patients with solid tumors, while 31.3% were found in those with hematological malignancies. Hospital-acquired infections comprised 78.8% of the total cases. Mortality was significantly associated with inappropriate initial antimicrobial therapy, carbapenem resistance, and multidrug resistance. Additionally, patients who presented with septic shock and fungal infections had higher mortality rates.

Conclusion: The findings underscore the urgent need for early implementation of appropriate antimicrobial therapy and effective infection control measures. The persistence of multidrug resistance and hospital-acquired infections presents critical challenges in reducing mortality rates among older cancer patients. The development of tailored infection management strategies and robust antimicrobial stewardship programs is essential for enhancing outcomes in cancer patients.

Key words: Bloodstream infections; older cancer patients; antimicrobial resistance; mortality risk factors.

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Introduction

The increasing prevalence of cancer diagnoses among the aging global population has led to a heightened risk of infections, particularly bloodstream infections (BSIs). The combination of age-related immune dysfunction, increased frailty, numerous comorbid conditions, and immune dysfunction associated with cancer and chemotherapy contributes to the vulnerability of elderly cancer patients to infections. BSIs represent significant complications, resulting in considerable morbidity and mortality among cancer patients [1]. Inadequate management of these infections can lead to devastating outcomes, including septic shock and multiple organ failure, ultimately elevating mortality rates. Both hospital-acquired pathogens and endogenous microorganisms are potential causes of BSIs. This is especially prevalent in patients undergoing extended hospital stays or those subjected to invasive procedures.

The mortality rate associated with BSIs in elderly cancer patients is critically high, ranging from 30% to 50% in severe cases [2]. The emergence of infections caused by multidrug-resistant (MDR) bacteria severely limits treatment alternatives, ultimately leading to increased mortality. Consequently, it is important to understand the epidemiology and resistance patterns of pathogens responsible for BSIs in elderly cancer patients to develop effective treatment strategies, improve survival rates, and formulate specific infection prevention measures [2,3].

Despite the clinical importance, research focusing on the epidemiology, risk factors, and outcomes of

infections in older cancer patients remains limited. Thus, this study investigates the epidemiological aspects of BSIs in cancer patients and analyzes the risk factors associated with mortality. In this setting, the microbial agents responsible for BSIs were identified, alongside an assessment of the demographic and clinical factors influencing infection-related mortality. This study aims to enhance infection management and prevention strategies for this high-risk population.

Methodology

Study Design

This retrospective cohort study was conducted at the Oncology Tower of Etlik City Hospital. The patients were monitored by infectious disease specialists with expertise in managing infections in immunocompromised individuals. The research included cancer patients aged 65 years and older who developed BSIs during one year, from January 1 to December 31, 2023. Only those who received antimicrobial therapy for at least 48 hours were included in the study. Ethical approval was granted by the Ethics Committee of AESH (Approval Number: AESH-BADEK-2024-605, Approval Date: July 10, 2024).

Data Collection

Data were gathered from the hospital's electronic medical records. Information collected included demographic and clinical variables such as age, gender, type of malignancy, stage of malignancy, administration of chemotherapy and/or steroids, existing comorbidities, hospital ward, necessity for intensive care unit (ICU) admission, and the requirement for mechanical ventilation. Additionally, data regarding prior hospitalizations and exposure to broad-spectrum antibiotics were also assessed

BSIs were defined as the isolation of at least one Gram-negative or Gram-positive bacterium from blood cultures that was confirmed by the hospital laboratory. The criteria for significant growth in blood cultures varied depending on the type of bacteria. For coagulase-negative staphylococci, *Streptomyces spp., Granulicatella spp., Lactobacillus spp., Micrococcus spp*., and diphtheroid bacilli—considered potential skin contaminants—significant growth required isolation in at least two blood cultures. For other pathogens, the isolation of a single bacterium in one blood culture was regarded as significant. In case of multiple isolates of the same organism, only the first isolate was included in the analysis.

Catheter-Related Bloodstream Infection (CRBSI) was defined by the presence of systemic signs of infection—such as fever, chills, and/or hypotension—along with a time to positivity in blood cultures obtained from the catheter that was at least two hours earlier than those drawn peripherally, assuming no alternative source of infection was identified. BSIs were classified as hospital-acquired if symptoms arose and blood cultures were obtained after the first 48 hours of hospitalization. Infections were classified as community-acquired if symptoms were present before hospitalization or within the first 48 hours of admission.

Furthermore, BSIs were categorized into primary, catheter-related, and secondary based on their source of infection. Primary BSIs were documented as neutropenia-associated if the presence of neutropenia was noted, while secondary BSIs were attributed to infections originating from respiratory, intra-abdominal, urinary, or other systems. The documentation also included whether any necessary source control interventions were performed. Isolated pathogens were grouped into categories of Gram-positive, Gram-negative, polymicrobial, and fungal organisms. Polymicrobial bacteremia was defined as the growth of two or more different microorganisms within the same blood culture or the isolation of two or more distinct pathogens from separate blood cultures obtained from the same patient within a time frame of less than 72 hours.

Laboratory findings on the day of blood culture collection included measurements of C-reactive protein (CRP), procalcitonin, albumin, and creatinine levels. The initial antimicrobial therapy given to patients was recorded, as well as an evaluation of the appropriateness of this treatment. The therapy was presumed appropriate if at least one administered antimicrobial was effective against the isolated microorganism. Conversely, it was considered inappropriate if none of the antimicrobials were effective. Additionally, the date on which appropriate therapy was initiated was documented.

Analysis

Patients were categorized into two groups: survivors and non-survivors. An analysis of independent risk factors for mortality was conducted among these groups. Additionally, antimicrobial resistance patterns were evaluated, focusing on various factors, including methicillin resistance in staphylococci, vancomycin resistance in enterococci, extended-spectrum beta-lactamase (ESBL) production, and carbapenem resistance in Gram-negative bacilli. Multidrug resistance was defined as resistance to three

or more classes of antibiotics commonly used in the treatment of the specific organism.

Results

A total of 160 BSIs were included in the study. The mean age of the patients was 72.44 years (standard deviation = 6.53), with 53 patients (33.1%) identified as female and 107 patients (66.9%) as male. Concerning underlying conditions, 50 patients (31.3%) had hematologic malignancies, whereas 110 patients (68.8%) were diagnosed with solid tumors. Among those with hematologic malignancies, acute leukemias were the most prevalent subtype (19 patients, 11.9%), followed by lymphomas (16 patients, 10.0%), multiple myelomas (9 patients, 5.6%), and other hematologic malignancies (6 patients, 3.8%). In terms of solid tumors, cancers of the gastrointestinal system were most common (39 patients, 24.4%), followed by genitourinary cancers (31 patients, 19.4%), lung cancers (10 patients, 6.3%), hepatobiliary cancers (6 patients, 3.8%), and head and neck tumors (6 patients, 3.8%).

Hospital-acquired infections (HAIs) constituted the majority of cases, accounting for 126 patients (78.8%). The most frequently observed type of infection was primary bacteremia, reported in 115 patients (71.9%), followed by catheter-associated infections (32 patients, 20.0%) and secondary bacteremia (13 patients, 8.1%). Thirty (26%) of the primary bacteremia were neutropenia-related. Appropriate initial antibiotic therapy was administered to 79 patients (49.4%). Comorbid conditions were prevalent within the cohort, with hypertension being the most common (55 patients, 34.4%), followed by diabetes mellitus (45 patients, 28.1%), chronic kidney disease (32 patients, 20.0%), and chronic obstructive pulmonary disease (COPD) (24 patients, 15.0%). Demographic data and clinical variables associated with the BSI periods are presented in Table 1.

The presence of solid tumors was strongly correlated with higher mortality, as 75.8% of non-survivors had solid tumors compared to 59.4% of survivors ($\chi^2 = 4.915$, $p = 0.027$). HAIs were significantly more prevalent in non-survivors, occurring in 87.9% of cases compared to 66.7% among survivors ($\chi^2 = 10.585$, $p = 0.001$). Resistance patterns also influenced mortality outcomes. Carbapenem-resistant pathogens were identified in 33.0% of non-survivors, in contrast to 10.1% of survivors ($\chi^2 = 11.498$, $p = 0.001$). MDR organisms were more frequently found among non-survivors (27.5%) compared to survivors (7.2%) ($\chi^2 = 10.538$, $p = 0.001$).

Fungal infections, another significant factor, were observed in 18.7% of non-survivors, compared to 5.8% of survivors ($\chi^2 = 5.713$, $p = 0.017$). The appropriateness of initial antibiotic therapy emerged as a determinant of survival. Appropriate therapy was administered to 73.9% of survivors, whereas only 30.8% of non-survivors received appropriate treatment ($\chi^2 = 29.224$, $p < 0.001$). Furthermore, the presence of sepsis and septic shock was significantly associated with mortality. Sepsis was present in 89.0% of non-survivors compared to 34.8% of survivors ($\chi^2 = 51.158$, $p < 0.001$), while septic shock occurred in 63.7% of non-survivors compared to only 10.1% of survivors ($\chi^2 = 46.726$, $p < 0.001$). The use of invasive devices, such as central and urinary catheters, was significantly more prevalent among non-survivors. Central catheter usage was documented in 69.2% of non-survivors compared to 47.8% of survivors ($\chi^2 = 7.492$, $p = 0.006$), while

Table 1. Clinical variables.

Characteristics	Number of bloodstream infections n (%), n = 160
Age, mean (SD)	72.44 (6.53)
Gender, n (%)	
Female	53 (33.1%)
Male	107 (66.9%)
Underlying Disease, n (%)	
Hematological Malignancy	50 (31.3%)
Solid Tumor	110 (68.8%)
Malignity Subtypes, n (%)	
Acute Leukemias	19 (11.9%)
Lymphomas	16 (10.0%)
Multiple Myelomas	9 (5.6%)
Other Hematological Mal.	6 (3.8%)
Lung cancer	10 (6.3%)
Gastrointestinal Tract Tumor	39 (24.4%)
Hepatobiliary tumor	6 (3.8%)
Head-Neck tumor	6 (3.8%)
Cerebral Tumor	5 (3.1%)
Genitourinary ca	31 (19.4%)
Pancreas Cancer	6 (3.8%)
Breast Cancer	4 (2.5%)
Other Solid mal.	3 (1.9%)
Hospital-Acquired Infection, n (%)	126 (78.8%)
Type of Infection, n (%)	
Primary Bacteremia	115 (71.9%)
Catheter-Associated Infection	32 (20.0%)
Secondary Bacteremia	13 (8.1%)
Appropriate Initial Antibiotic Therapy, n (%)	79 (49.4%)
Initial Antibiotic Therapy, n (%)	
Ceftriaxone	17 (10.63%)
Piperacillin/Tazobactam	90 (56.3%)
Carbapenem	32 (20.0%)
Piperacillin/Tazobactam + Glycopeptide	2 (1.3%)
Carbapenem + Glycopeptide	12 (7.5%)
Other	7 (4.4%)
Comorbidities, n (%)	
Chronic Kidney Disease	32 (20.0%)
Diabetes mellitus	45 (28.1%)
Chronic Obstructive Pulmonary Disease	24 (15.0%)
Hypertension	55 (34.4%)
Coronary Artery Disease	15 (9.4%)
Other	68 (42.5%)

urinary catheter use was reported in 73.6% of non-survivors versus 42.0% of survivors ($\chi^2 = 16.325$, $p < 0.001$). Patients who received chemotherapy within the previous month were less likely to experience mortality, with 31.9% of non-survivors and 49.3% of survivors having received recent chemotherapy ($\chi^2 = 4.981$, $p = 0.026$). Finally, the need for source control was greater among non-survivors, occurring in 28.6% of cases compared to 11.6% of survivors ($\chi^2 = 6.759$, $p = 0.009$). However, among patients requiring source control, the effectiveness of such interventions did not significantly differ between the groups ($p = 0.317$). Clinical variables between groups are summarized in Table 2.

Laboratory findings demonstrated significant differences between the non-survivors and survivors. Procalcitonin levels were considerably higher in non-survivors (148.31 ± 224.75 ng/mL) compared to survivors (107.35 ± 181.21 ng/mL), with this difference being statistically significant (U = 2520.5, Z = -2.133, $p = 0.033$). Albumin levels were also significantly lower in non-survivors (36.81 ± 50.21 g/L) than in survivors (43.74 ± 67.12 g/L) (U = 1826.5, Z = -4.531, $p < 0.001$). In contrast, no statistically significant differences were found in C-reactive protein (CRP) ($p = 0.085$) and creatinine levels ($p = 0.677$) between the two groups (Laboratory Parameters Between Groups are summarized in Table 3).

In terms of microbiological findings, significant differences were noted in the types of microorganisms isolated ($\chi^2 = 10.766$, $p = 0.019$). Gram-negative bacteria were more frequently isolated from survivors (66.7%) compared to non-survivors (46.2%). Fungal infections were significantly more prevalent among non-survivors (19.8%) than among survivors (5.8%) (χ^2

Table 2. Clinical variables between groups.

Characteristics	Non- Survivors (N = 91)	Survivors (N = 69)	Test Statistic (U/Z or χ^2)	*p*
Age, mean (SD)	73.16 (6.80)	71.49 (6.07)	2702.5 / -1.510[1]	0.131
Gender, n (%)			0.084[2]	0.772
Female	31 (34.1%)	22 (31.9%)		
Male	60 (65.9%)	47 (68.1%)		
Underlying Disease, n (%)			4.915[2]	0.027
Hematological Malignancy	22 (24.2%)	28 (40.6%)		
Solid Tumor	69 (75.8%)	41 (59.4%)		
Hospital-Acquired Infection, n (%)	80 (87.9%)	46 (66.7%)	10.585[2]	0.001
Type of Infection, n (%)			5.584[2]	0.061
Primary Bacteremia	61 (67.0%)	54 (78.3%)		
Catheter-Associated Infection	24 (26.4%)	8 (11.6%)		
Secondary Bacteremia	6 (6.6%)	7 (10.1%)		
Resistant Pathogens, n (%)				
MRSA	2 (2.2%)	-[3]	-	0.506
MDR CoNS	9 (9.9%)	5 (7.2%)	0.344[2]	0.558
VRE	-	-	-	-
ESBL	23 (25.3%)	22 (31.9%)	0.848[2]	0.357
Carbapenem Resistance (CR)	30 (33.0%)	7 (10.1%)	11.498[2]	0.001
Multidrug Resistance (MDR)	40 (44.0%)	11 (16.0%)	14.183[2]	< 0.001
Fungal Infection, n (%)	17 (18.7%)	4 (5.8%)	5.713[2]	0.017
Appropriate Initial Antibiotic Therapy, n (%)	28 (30.8%)	51 (73.9%)	29.224[2]	< 0.001
Sepsis, n (%)	81 (89.0%)	24 (34.8%)	51.158[2]	< 0.001
Septic Shock, n (%)	58 (63.7%)	7 (10.1%)	46.726[2]	< 0.001
Central Catheter, n (%)	63 (69.2%)	33 (47.8%)	7.492[2]	0.006
Urinary Catheter, n (%)	67 (73.6%)	29 (42.0%)	16.325[2]	< 0.001
Febrile Neutropenia, n (%)	22 (24.2%)	21 (30.4%)	0.782[2]	0.376
Blood Transfusion in the Last Week, n (%)	24 (26.4%)	10 (14.5%)	3.310[2]	0.069
Chemotherapy in the Last Month, n (%)	29 (31.9%)	34 (49.3%)	4.981[2]	0.026
Steroid Use in the Last Month, n (%)	27 (29.7%)	13 (18.8%)	2.455[2]	0.117
Hospitalization in the Last 3 Months, n (%)	68 (74.7%)	49 (71.0%)	0.275[2]	0.600
ICU Stay in the Last 3 Months, n (%)	28 (30.8%)	14 (20.3%)	2.226[2]	0.136
Antibiotic Use in the Last 3 Months, n (%)	41 (45.1%)	29 (42.0%)	0.146[2]	0.702
TPN, n (%)	7 (7.7%)	1 (1.4%)	-[3]	0.139
Chronic Kidney Disease, n (%)	19 (20.9%)	13 (18.8%)	0.102[2]	0.750
Diabetes mellitus, n (%)	25 (27.5%)	20 (29.0%)	0.044[2]	0.833
Chronic Obstructive Pulmonary Disease, n (%)	15 (16.5%)	9 (13.0%)	0.364[2]	0.546
Hypertension, n (%)	37 (40.7%)	18 (26.1%)	3.694[2]	0.055
Coronary Artery Disease, n (%)	8 (8.8%)	7 (10.1%)	0.852[2]	0.771
Other Comorbidities, n (%)	42 (46.2%)	26 (37.7%)	1.153[2]	0.283
Mechanical Ventilation During Infection, n (%)	38 (41.8%)	7 (10.1%)	19.402[2]	< 0.001
Source Control Needed, n (%)	26 (28.6%)	8 (11.6%)	6.759[2]	0.009
Source Control Performed, n (%)	26 (63.4%) (N = 41)	10 (50.0%) (N = 20)	1.000[2]	0.317

*[1]Mann Whitney U Test; [2]Pearson Chi-Square; [3]Fisher Exact Test.

Table 3. Laboratory parameters between groups.

Laboratory Parameter, mean (SD)	Non-Survivors (N = 91)	Survivors (N = 69)	Test Statistic (U/Z or χ^2)	*p*
CRP (mg/L)	176.01 (98.84)	148.94 (94.10)	2639.0 / -1.724	0.085
Procalcitonin (ng/mL)	148.31 (224.75)	107.35 (181.21)	2520.5 / -2.133	**0.033**
Albumin (g/L)	36.81 (50.21)	43.74 (67.12)	1826.5 / -4.531	**< 0.001**
Creatinine (mg/dL)	83.20 (99.18)	83.49 (111.28)	3018.5 / -0.417	0.677

*[1]Mann Whitney U Test.

Table 4. Microorganism differences between groups.

	Non-Survivors Group (N = 91)	Survivors (N = 69)	Test Statistic (χ^2)	*p*
Isolated Microorganisms, n (%)			10.766[1]	**0.019**
Gram-positive bacteria	23 (25.3%)	17 (24.6%)		
Gram-negative bacteria	42 (46.2%)	46 (66.7%)		
Polymicrobial	13 (14.3%)	3 (4.3%)		
Fungi	12 (13.2%)	3 (4.3%)		
Anaerobes	1 (1.1%)	-		

*[1]Fisher Freeman Halton Test.

= 6.470, p = 0.011). Additionally, polymicrobial infections were observed more frequently in non-survivors (14.3%) than in survivors (4.3%). Table 4 summarizes microorganism differences between groups.

Among the subtypes of malignancies and disease status, remission was significantly more common in survivors (11.6%) compared to non-survivors (1.1%) (p = 0.005). No other statistically significant differences were noted regarding variables such as the type of hematologic malignancy or solid tumors (p = 0.060). Similarly, metastatic disease, new diagnoses, refractory conditions, relapsed cases, and localized conditions did not show statistically significant differences between the non-survivor and survivor groups. Malignancy subtypes and disease status between groups are summarized in Table 5.

Binary logistic regression analysis identified independent risk factors for in-hospital mortality. The analysis indicated several factors influencing mortality among patients. The type of malignancy served as a significant predictor, with patients having hematologic malignancies demonstrating a reduced odds of mortality (odds ratio = 0.111, 95% confidence interval: 0.014–0.885, p = 0.038) compared to those with solid tumors. HAIs did not significantly influence mortality (p = 0.643), and the odds ratio indicated minimal change (odds ratio = 1.440, 95% CI: 0.307–6.747). Similarly, factors such as carbapenem resistance (odds ratio = 2.598, p = 0.548), multidrug resistance (odds ratio = 0.797, p = 0.892), and fungal infections (odds ratio = 0.136, p = 0.241) were not statistically significant predictors of mortality.

Table 5. Malignancy subtypes and disease status between groups.

Malignite Subtypes, n (%)	Non-Survivors (N = 91)	Survivors (N = 69)	Test Statistic (χ^2)	*p*
Acute Leukemias	7 (7.7%)	12 (17.4%)	3.528[1]	0.060
Lymphomas	8 (8.8%)	8 (11.6%)	0.343[1]	0.558
Multiple Myelomas	5 (5.5%)	4 (5.8%)	-[2]	1.000
Other Hematological Malignity	2 (2.2%)	4 (5.8%)	-[2]	0.404
Lung cancer	7 (7.7%)	3 (4.3%)	-[2]	0.517
Gastrointestinal Tract Tumor	22 (24.2%)	17 (24.6%)	0.005[1]	0.946
Hepatobiliary cancer	5 (5.5%)	1 (1.4%)	-[2]	0.237
Head-Neck tumor	4 (4.4%)	2 (2.9%)	-[2]	0.700
Cerebral Tumor	5 (5.5%)	-	-[2]	0.070
Genitourinary cancer	17 (18.7%)	14 (20.3%)	0.065[1]	0.799
Pancreas cancer	5 (5.5%)	1 (1.4%)	-[2]	0.237
Breast cancer	2 (2.2%)	2 (2.9%)	-[2]	1.000
Other Solid Tumor.	2 (2.2%)	1 (1.4%)	-[2]	1.000
Disease Status, n (%)				
New Diagnosis	26 (28.6%)	14 (20.3%)	1.435[1]	0.231
Remission	1 (1.1%)	8 (11.6%)	-[2]	**0.005**
Refractory	4 (4.4%)	4 (5.8%)	-[2]	0.727
Relapse	5 (5.5%)	3 (4.3%)	-[2]	1.000
Local	7 (7.7%)	8 (11.6%)	0.703[1]	0.402
Locally Advanced	6 (6.6%)	6 (8.7%)	0.250[1]	0.617
Metastatic	39 (42.9%)	22 (31.9%)	2.003[1]	0.157
Other/Unknown	3 (3.3%)	4 (5.8%)	-[2]	0.466

*[1]Pearson Chi-Square; [2]Fisher Exact Test.

Patients who did not receive appropriate initial antibiotic therapy had a significantly higher risk of mortality (odds ratio = 5.390, 95% CI: 1.528–19.015, p = 0.009). Additionally, sepsis was another important factor; patients experiencing sepsis had higher odds of mortality (odds ratio = 5.264, 95% CI: 1.061–26.123, p = 0.042). Furthermore, septic shock dramatically increased the risk of mortality (odds ratio = 20.472, 95% CI: 3.782–110.820, $p < 0.001$).

The presence of central and urinary catheters did not show significant associations with mortality, with p values of 0.764 and 0.621, respectively. Patients receiving chemotherapy within the last month exhibited a slight reduction in mortality risk, though not significant (odds ratio = 0.336, p = 0.092). Other factors, such as mechanical ventilation during infection, the need for source control, procalcitonin levels, and albumin levels, did not significantly predict mortality. The odds ratios for these variables displayed wide confidence intervals and non-significant p values. Finally, the presence of various isolated microorganisms (Gram-positive bacteria, Gram-negative bacteria, polymicrobial organisms, and fungi) yielded no significant results, all having p values of 1.000. Likewise, the disease status indicating remission did not demonstrate a statistically significant association with mortality (p = 0.564).

The model exhibited good fit, demonstrated by a non-significant Hosmer and Lemeshow test (p = 0.797), and explained 79.7% of the variance in in-hospital mortality (Nagelkerke R^2 = 0.722). Additionally, the model accurately predicted mortality in 87.5% of cases, underscoring its robustness in identifying critical predictors of mortality among hospitalized patients (Table 6 summarizes Risk Factors Predicting Mortality).

Table 6. Risk factors predicting mortality.

Variable	Category	B	S.E.	*p*	Odds Ratio (ExpB)	95% CI Lower	95% CI Upper
Constant		12.990	40193.373	1.000	438006.992		
Malignancy Type	Solid Organ Tumor			(Reference)			
	Hematological Malignancy	-2.197	1.059	**.038**	.111	.014	.885
Hospital-Acquired Infection	Absent			(Reference)			
	Present	.365	.788	.643	1.440	.307	6.747
Carbapenem Resistance	Absent			(Reference)			
	Present	.955	1.590	.548	2.598	.115	58.628
Multidrug Resistance	Absent			(Reference)			
	Present	-.227	1.669	.892	.797	.030	21.004
Fungal Infection	Absent			(Reference)			
	Present	-1.994	1.701	.241	.136	.005	3.820
Appropriate Initial Antibiotic Therapy	Yes			(Reference)			
	No	1.684	.643	**.009**	5.390	1.528	19.015
Sepsis	Absent			(Reference)			
	Present	1.661	.817	**.042**	5.264	1.061	26.123
Septic Shock	Absent			(Reference)			
	Present	3.019	.862	**.000**	20.472	3.782	110.820
Central Catheter	Absent			(Reference)			
	Present	-.218	.726	.764	.804	.194	3.336
Urinary Catheter	Absent			(Reference)			
	Present	.316	.639	.621	1.372	.392	4.800
Chemotherapy in the Last Month	Yes			(Reference)			
	No	-1.090	.647	.092	.336	.095	1.196
Mechanical Ventilation During Infection	Yes			(Reference)			
	No	.919	.725	.205	2.507	.605	10.385
Source Control Needed	Yes			(Reference)			
	No	.733	.793	.356	2.081	.440	9.848
Procalcitonin (ng/mL)		.002	.002	.287	1.002	.999	1.005
Albumin (g/L)		.010	.007	.186	1.010	.995	1.025
Isolated Microorganisms, Gram-positive bacteria	Absent			(Reference)			
	Present	-16.501	40193.373	1.000	.000	.000	.
Isolated Microorganisms, Gram-negative bacteria	Absent			(Reference)			
	Present	-17.923	40193.373	1.000	.000	.000	.
Isolated Microorganisms, Polymicrobial	Absent			(Reference)			
	Present	-16.157	40193.373	1.000	.000	.000	.
Isolated Microorganisms, Fungi	Absent			(Reference)			
	Present	-15.342	40193.373	1.000	.000	.000	.
Disease Status, Remission	Absent			(Reference)			
	Present	-1.056	1.830	.564	.348	.010	12.573

Binary logistic regression analysis was used to examine the independent variables predicting mortality. All variables with significant differences between groups were included in the analysis.

Discussion

The present study concludes significant findings regarding BSIs in geriatric cancer patients aged 65 years and older. The cohort, with a mean age of 72.44 years, was primarily composed of patients with solid tumors (68.8%), while a smaller percentage had hematological malignancies (31.3%). The predominance of male patients (66.9%) correlates with previous research indicating a greater susceptibility to infections among older males, likely attributable to differing comorbidities and immunological responses [4,5]

A notable finding is the high prevalence of HAIs (78.8%) and primary bacteremia (71.9%), which emerged as the most common type of infection. This aligns with existing literature that emphasizes the heightened vulnerability of hospitalized geriatric cancer patients to nosocomial infections [6-8]. Furthermore, CRBSIs (20.0%) and secondary bacteremia (8.1%) highlight the crucial importance of infection control practices, especially in older adults who may experience prolonged hospitalizations or require invasive interventions. Alarmingly, only 49.4% of patients received appropriate initial antibiotic therapy, raising significant concerns regarding antimicrobial stewardship within this high-risk group. The relatively low rate of suitable therapy indicates a need for enhanced diagnostic accuracy and timely pathogen identification [9].

The distribution of comorbid conditions within the study cohort—hypertension (34.4%), diabetes mellitus (28.1%), and chronic kidney disease (20.0%)—illustrates the complexity involved in managing BSIs among the geriatric population. These comorbidities may hinder the body's capacity to mount an effective immune response and complicate therapeutic interventions, as similarly observed in studies exploring infection-related mortality in older adults with cancer [10-12]. Among the underlying malignancies, solid tumors, especially cancers of the gastrointestinal (24.4%) and genitourinary systems (19.4%), were most prevalent, consistent with their high incidence in older populations [13]. In the context of hematological cancers, acute leukemias (11.9%) were the most frequently observed, reflecting the aggressive nature of these diseases and their considerable impact on immune competence in elderly individuals.

The findings reveal that solid tumors were significantly associated with higher mortality (75.8% vs. 59.4%), while hematological malignancies were more common among survivors. Patients with hematological malignancies often undergo closer monitoring and aggressive infection management, which may contribute to improved survival rates [9].

Moreover, the increased prevalence of HAIs among non-survivors (87.9% vs. 66.7%) underscores the profound impact of nosocomial pathogens on mortality rates in geriatric patients. This observation resonates with existing studies that demonstrate that HAIs can lead to longer hospital stays, extended antibiotic treatment, and elevated healthcare costs in elderly populations [14].

The prevalence of carbapenem-resistant organisms (33.0% vs. 10.1%) and MDR organisms (44.0% vs. 16.0%) in non-survivors further highlights the adverse effects of antimicrobial resistance on survival outcomes. Infections caused by MDR organisms are linked to higher morbidity and mortality rates as well as prolonged hospitalization [15]. Antimicrobial resistance constitutes a formidable challenge to achieving successful treatment outcomes in cancer patients. A systematic review has indicated that infections with resistant pathogens increase mortality rates and complicate the management of cancer patients, emphasizing the critical need for tailored antimicrobial stewardship programs in geriatric oncology. The implementation of such programs is vital to mitigating the spread of resistant pathogens and improving patient outcomes [16,17]. Additionally, comprehensive and effective infection control practices are essential to reduce cancer patients' exposure to antimicrobial-resistant pathogens. The high prevalence of HAIs and antimicrobial-resistant organisms among non-survivors emphasizes the urgent necessity for targeted interventions, including antimicrobial stewardship and comprehensive infection control practices, aimed at enhancing survival outcomes in geriatric oncology patients.

Fungal infections were found to be significantly associated with mortality, occurring in 18.7% of non-survivors compared to 5.8% of survivors. This observation supports previous studies that indicate a correlation between fungal pathogens and poor prognoses in immunocompromised individuals [18,19].

Furthermore, the appropriateness of initial antibiotic therapy was identified as a critical determinant of survival [20,21]. Only 30.8% of non-survivors received appropriate initial therapy, in stark contrast to 73.9% of survivors. The strong association between sepsis (89.0% vs. 34.8%) and septic shock (63.7% vs. 10.1%) with mortality further underscores the necessity for early recognition and aggressive management of these complications [22].

Moreover, the observed higher utilization of

invasive devices, such as central venous and urinary catheters, among non-survivors is consistent with existing literature indicating that the use of invasive devices is associated with an increased risk of complications, including infections, which can adversely impact patient outcomes [23]. Conversely, the association between recent chemotherapy and improved survival may reflect the advantages of closer monitoring and comprehensive supportive care provided to patients actively undergoing cancer treatment. Studies have demonstrated that patients receiving chemotherapy typically undergo more frequent medical evaluations, which can facilitate the early detection and management of complications, potentially enhancing survival rates [24]. The increased frequency of source control procedures among non-survivors suggests that these patients likely experienced more severe or advanced infections that necessitated such interventions. However, the lack of significant differences in the effectiveness of these procedures between groups indicates that while source control is essential, other factors, such as the patient's overall health status and the timeliness of the intervention, play a critical role in determining outcomes [25]. These findings highlight the importance of judicious use of invasive devices, vigilant monitoring of patients undergoing chemotherapy, and prompt, effective source control measures to improve survival outcomes in hospitalized cancer patients.

Laboratory findings indicated significantly higher procalcitonin levels in non-survivors compared to survivors, underscoring its potential role as a biomarker for the severity of sepsis and associated poor outcomes [26-28]. In contrast, albumin levels were markedly lower in non-survivors than in survivors. Hypoalbuminemia is a well-recognized predictor of adverse outcomes, often indicative of malnutrition, systemic inflammation, or compromised hepatic function [29,30].

The absence of significant differences in C-reactive protein (CRP) and creatinine levels between non-survivors and survivors may be attributed to several factors. CRP, a non-specific biomarker of systemic inflammation, may lose its prognostic value in older adults due to the high prevalence of "inflammaging," a condition characterized by chronic low-grade inflammation associated with aging [31]. This baseline elevation of CRP in the elderly potentially obscures its ability to distinguish acute inflammatory responses. Additionally, reduced muscle mass in older individuals, a phenomenon known as sarcopenia, can result in lower baseline serum creatinine levels, even when significant renal dysfunction is present. This condition, referred to as "creatinine blindness," limits the reliability of serum creatinine as a marker of kidney function in older adults [32].

Moreover, mortality among elderly patients is influenced by a complex interplay of comorbidities, frailty, and physiological reserve, which often overshadows the impact of individual biomarkers like CRP and creatinine [31,32]. Research has indicated the importance of dynamic changes in these biomarkers, such as acute fluctuations in CRP or creatinine levels during hospitalization, as they may be more predictive of outcomes than static measurements [33]. Therefore, incorporating additional biomarkers, such as procalcitonin for indicating infection severity or cystatin C for assessing renal function, alongside clinical scoring systems, could provide a more comprehensive evaluation of mortality risk in this population.

The microbiological findings reveal a higher prevalence of gram-negative bacteria among survivors and an increased incidence of fungal and polymicrobial infections in non-survivors. These results are consistent with recent studies investigating pathogen-specific outcomes in sepsis. Research indicates that gram-negative bacteria are common causative agents in sepsis. One study assessed the prognostic differences between sepsis caused by gram-negative and gram-positive bacteria, finding that while both types are associated with significant morbidity, mortality rates may vary depending on the specific pathogen involved [34].

Fungal infections, particularly those caused by *Candida spp.,* are linked to higher mortality in septic patients. An article underscored that invasive Candida infections can result in sepsis with a markedly high mortality rate, highlighting the urgency of initiating prompt antifungal therapy in high-risk patients. [35]. Polymicrobial infections have been associated with poorer outcomes in sepsis. One study examined the risk factors and pathogenic significance of severe sepsis and septic shock, highlighting that the presence of multiple pathogens can complicate treatment and elevate the risk of mortality [36]. These findings align with earlier observations regarding the links between specific pathogens and patient outcomes in sepsis, emphasizing the necessity for targeted antimicrobial therapy and comprehensive management strategies to enhance survival rates.

Additionally, logistic regression analysis identified key predictors of mortality, including the type of malignancy, the severity of sepsis, the presence of

septic shock, and the lack of effective antibiotic therapy in the initial treatment regimen. The recognition of these critical mortality predictors in geriatric oncology patients with BSIs underscores the urgent need for early, tailored interventions and multidisciplinary care to improve patient outcomes.

The finding that hematological malignancies are associated with significantly lower odds of mortality contrasts with some studies that suggest higher mortality rates in these patients due to severe immunosuppression. However, outcomes can vary depending on factors such as the specific type of hematologic malignancy, treatment regimens, and supportive care measures. One study reported elevated mortality rates among patients with hematologic malignancies experiencing septic shock, underscoring the necessity for specialized care within this population [37].

Furthermore, the nearly tenfold increase in mortality risk associated with septic shock is consistent with existing literature. Septic shock, which is characterized by profound circulatory, cellular, and metabolic abnormalities, poses a greater risk of mortality compared to sepsis alone. A narrative review emphasizes the increased susceptibility to sepsis and the heightened mortality risk in older patients, highlighting the critical importance of early recognition and aggressive management to improve outcomes [38].

The absence of effective initial antibiotic therapy as a predictor of mortality underscores the critical importance of prompt and appropriate antimicrobial treatment. Delays or inadequacies in therapy can facilitate the rapid progression of infection and elevate the risk of mortality. One study identified key predictors of mortality in cancer patients with septic shock, emphasizing the significance of timely and effective antimicrobial therapy in improving patient outcomes [39].

There are some limitations to this study. Firstly, it is a retrospective single-center study, which results in a limited number of patients being included. Additionally, because the data were collected retrospectively from the hospital system, certain severity scores, such as APACHE-II, which are crucial for assessing the severity of the disease, were not specified.

Conclusions

This study offers valuable insights into the management of BSIs in geriatric cancer patients, highlighting their vulnerability due to nosocomial infections, antimicrobial resistance, and complex comorbidities. Notably, solid tumors were associated with higher mortality rates compared to hematological malignancies, suggesting that patients with solid tumors may require more aggressive monitoring and supportive care.

The high prevalence of HAIs and MDR organisms underscores the urgent need for tailored infection control measures and effective antimicrobial stewardship programs. Additionally, fungal and polymicrobial infections were significantly linked to poor outcomes, reflecting the complexities involved in managing infections within this demographic.

The findings emphasize the critical importance of early and effective antimicrobial therapy, as well as comprehensive sepsis management, given the robust associations between sepsis, septic shock, and mortality. Notably, elevated procalcitonin levels and hypoalbuminemia were identified as key laboratory markers associated with adverse outcomes, reinforcing the necessity for timely interventions and nutritional support. Furthermore, the logistic regression model identified malignancy type, sepsis severity, and the appropriateness of initial therapy as independent predictors of mortality, providing actionable targets for clinical intervention. A multidisciplinary approach that integrates infection control, nutritional support, and individualized care is essential to optimize survival outcomes for geriatric cancer patients affected by BSIs.

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Conflict of interests

No conflict of interest is declared.

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