Original Article

Survival Outcomes in Patients with Catheter-Related Bloodstream Infection

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Abstract

Background: **Catheter-related bloodstream infection (CRBSI) is one of the most serious complications related to central venous catheter use and is associated with substantial morbidity and mortality. This retrospective cohort study aimed to identify prognostic factors associated with 90-day mortality among patients with CRBSI at Hospital Pakar Universiti Sains Malaysia (HPUSM).**

Methods: **This retrospective cohort study included 181 patients diagnosed with CRBSI at HPUSM between 2018 and 2022. Time zero was defined as the date of CRBSI diagnosis, while the event of interest was all-cause mortality within 90 days of diagnosis. Cox proportional hazards regression analysis was used to identify factors associated with 90-day mortality.**

Results: **Of the 181 included patients, 64 (35.4%) died within 90 days of CRBSI diagnosis, while 117 (64.6%) were censored. Factors independently associated with higher mortality risk were sepsis or septic shock (adjusted hazard ratio [aHR] 5.95; 95% confidence interval [CI]: 2.88, 12.28), mechanical ventilation (aHR 5.94; 95% CI: 3.29, 10.71), shorter length of hospital stay (aHR 1.13; 95% CI: 1.10, 1.17), and female sex (aHR 2.71; 95% CI: 1.60, 4.58). Infection caused by Gram-negative organisms was associated with lower mortality risk (aHR 0.31; 95% CI: 0.18, 0.55).**

Conclusion: **Several clinical and microbiological factors were independently associated with 90-day mortality among patients with CRBSI. These findings may be useful for risk stratification and clinical management of patients with CRBSI.**

Keywords: *catheter-related bloodstream infection, CRBSI, survival, prognostic factors, Cox proportional hazards regression, Malaysia*

Introduction

Each year, millions of patients worldwide are affected by healthcare-associated infections, including catheter-related bloodstream infections (CRBSIs). CRBSI is the third most common healthcare-associated infection (HCAI), after ventilator-associated pneumonia and catheter-associated urinary tract infection (CAUTI) (1). CRBSI is associated with prolonged hospital stays, increased healthcare costs and financial burdens and higher morbidity and mortality rates (2–5).

CRBSI diagnosis is based on epidemiological, clinical and laboratory criteria (6). CRBSI is diagnosed in patients with a central venous catheter (CVC) *in situ,* or that was removed within the 48 h prior to diagnosis, who develop clinical symptoms and have the same microorganism isolated from both peripheral blood culture and catheter tip culture (7). Differential time to positivity, in which microbial growth is detected in blood samples drawn from the catheter hub at least 2 h earlier than in blood samples obtained from a peripheral vein, is the preferred diagnostic criterion for CRBSI (8).

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Compared with other medical devices, CVCs are associated with the highest risk of device-related infections (9). The estimated incidence rate of CRBSI ranges from 0.5 to 5 infections per 1,000 catheter-days (10). Previous studies have reported several prognostic factors associated with increased mortality or case-fatality rates among patients with CRBSI in both intensive care unit (ICU) and non-ICU settings, including older age, insertion of a new catheter, high Acute Physiology and Chronic Health Evaluation II (APACHE II) scores, high sequential organ failure assessment scores, high Charlson comorbidity index scores and infections caused by *Staphylococcus aureus* or *Candida* spp. (11, 12).

Identification of mortality-associated prognostic factors among patients with CRBSI is important for risk stratification, clinical decision-making and optimisation of patient management. Early recognition of high-risk patients may assist clinicians in determining appropriate monitoring strategies and therapeutic interventions. Furthermore, understanding prognostic factors within the local population may improve care delivery and resource allocation for patients with CRBSI. Therefore, this study aimed to identify prognostic factors associated with mortality among patients with CRBSI at Hospital Pakar Universiti Sains Malaysia (HPUSM).

Methods

Study Design and Setting

This study was conducted at HPUSM, Kubang Kerian, Kelantan, a tertiary teaching hospital located on the east coast of Peninsular Malaysia. A retrospective cohort study design was employed, whereby data were extracted through a review of the medical records of patients diagnosed with CRBSI at HPUSM from January 2018 to December 2022. Patients diagnosed with CRBSI more than 48 h after CVC insertion were included, and those with community-acquired infections were excluded.

Sample Size Calculation

The sample size was calculated using the PS: Power and Sample Size Calculation software version 3.1.6 (Dupont & Plummer, 1990). The significance level was set at $\alpha = 0.05$ with 80% statistical power. The detectable hazard ratio (R) of appropriateness of antimicrobial therapy was 1.59 (13), the accrual time was 1,825 days, and the additional follow-up period (F) was 90 days. The final sample size was 183 cases, including a 20% dropout rate. Because the number of eligible cases available during the study period was approximately equal to the calculated sample size, all eligible patients fulfilling the study criteria were included.

Data Collection

All relevant information was extracted and recorded in a data collection form by a single researcher. The collected variables included patient-related, catheter-related, clinical and organism-related factors. Survival outcomes within 90 days after CRBSI diagnosis and censored observations were recorded. The vital status of patients was obtained from the Medical Record Unit of HPUSM and the Sector for Biostatistics and Data Repository, National Institutes of Health, Ministry of Health Malaysia. Ethical approval for this study was obtained from the Human Research Ethics Committee of Universiti Sains Malaysia.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics, version 27 (IBM Corp., 2020) for descriptive analysis and Stata Statistical Software (StataCorp, 2015) for survival analysis. Time-to-event data were measured in days. Time zero was defined as the date of CRBSI diagnosis, and the event of interest was all-cause mortality within 90 days after diagnosis. Censored observations included those of patients who remained alive or died more than 90 days after CRBSI diagnosis or were lost to follow-up.

Cox proportional hazards regression analysis was performed to identify mortality-associated prognostic factors. All variables were considered clinically and biologically relevant and were therefore included in the development

of the multivariable Cox regression model. Variable selection was performed using the forward stepwise likelihood ratio (LR), backward stepwise LR and enter methods. Model fit was compared using the Bayesian information criterion, and the model with the best fit was selected as the final model.

Continuous variables were assessed for linearity assumptions, and those that violated the linearity assumption were further examined using multivariable fractional polynomial modelling. The final Cox regression model was presented using crude hazard ratios (HRs), adjusted hazard ratios (aHRs), 95% confidence intervals (CIs), Wald statistics and *P*-values. Statistical significance was set at $P < 0.05$.

Results

A total of 195 patients diagnosed with CRBSI between 2018 and 2022 at HPUSM were identified, and medical records for 188 patients were successfully retrieved from the Medical Record Unit. After screening according to the inclusion and exclusion criteria, 181 patients were eligible for analysis. In terms of 90-day all-cause mortality, 64 patients (35.4%) died from all causes, while 117 patients (64.6%) were censored. The baseline characteristics of the study population are presented in Table 1.

Table 1. Baseline characteristics of patients diagnosed with CRBSI at HPUSM (n = 181).

Variables	Patient's status		
	Died *n* (%)	Censored *n* (%)	Total *n* (%)
Patient-related factors			
Age category			
< 60 years	33 (51.6)	88 (75.2)	121 (66.9)
≥ 60 years	31 (48.4)	29 (24.8)	60 (33.2)
Gender			
Male	32 (50.0)	73 (62.4)	105 (58.0)
Female	32 (50.0)	44 (37.6)	76 (42.0)
Race			
Malay	61 (95.3)	116 (99.2)	177 (97.8)
Non-Malay	3 (4.7)	1 (0.9)	4 (2.2)
Length of hospital stay[a] (days)	13.5 (17.0)	15.0 (10.0)	14.0 (13.0)
Types of wards			
Medical ward	42 (65.6)	65 (55.6)	107 (59.1)
Non-medical ward	22 (34.4)	52 (44.4)	74 (40.9)
≥ 3 comorbidities			
No	25 (39.1)	69 (59.0)	94 (51.9)
Yes	39 (60.9)	48 (41.0)	87 (48.1)
Underlying disease			
Hypertension	43 (67.2)	63 (53.9)	106 (58.6)
Chronic kidney disease	32 (50.0)	52 (44.4)	84 (46.4)
Diabetes mellitus	36 (56.3)	43 (36.8)	79 (43.7)
Malignancy	14 (21.9)	42 (35.9)	56 (30.9)
Cardiovascular disease	31 (48.4)	25 (21.4)	56 (30.9)
Lung disease	10 (15.6)	9 (7.7)	19 (10.5)

(*continued on next page*)

Table 1. (*continued*)

Variables	Patient's status		
	Died *n* (%)	Censored *n* (%)	Total *n* (%)
Stroke	11 (17.2)	9 (7.7)	20 (11.1)
Liver disease	5 (7.8)	6 (5.1)	11 (6.1)
Catheter-related factors			
Types of catheter use			
Non-tunnelled	58 (90.6)	80 (68.4)	138 (76.2)
Others	6 (9.4)	37 (31.6)	43 (23.8)
Site of insertion			
Femoral vein	37 (57.8)	48 (41.0)	85 (47.0)
Others	27 (42.2)	69 (59.0)	96 (53.0)
Number of lumens			
≤ 2 lumens	37 (57.8)	89 (76.1)	126 (69.6)
> 2 lumens	27 (42.2)	28 (23.9)	55 (30.4)
Reinsertion of new catheter/exchange or recannulation before onset			
No	54 (84.4)	105 (89.7)	159 (87.9)
Yes	10 (15.6)	12 (10.3)	22 (12.2)
Duration of catheterization[a] (days)	19.5 (24.0)	23.0 (111.0)	21.0 (47.0)
Period from CVC insertion until CRBSI onset[a] (days)	14.5 (19.0)	16.0 (95.0)	16.0 (42.0)
Antibiotic lock therapy			
No	60 (93.8)	93 (79.5)	153 (84.5)
Yes	4 (6.3)	24 (20.5)	28 (15.5)
Delayed removal of CVC without antibiotic lock (> 3 days after onset)			
No	34 (53.1)	65 (55.6)	99 (54.7)
Yes	30 (46.9)	52 (44.4)	82 (45.3)
Clinical-related factors			
Haemodialysis			
No	23 (35.9)	62 (53.0)	85 (47.0)
Yes	41 (64.1)	55 (47.0)	96 (53.0)
Sepsis/septic shock			
No	10 (15.6)	66 (56.4)	76 (42.0)
Yes	54 (84.4)	51 (43.6)	105 (58.0)
Immunosuppressive therapy			
No	44 (68.8)	76 (65.0)	120 (66.3)
Yes	20 (31.3)	41 (35.0)	61 (33.7)
Chemotherapy			
No	54 (84.4)	78 (66.7)	132 (72.9)
Yes	10 (15.6)	39 (33.3)	49 (27.1)

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Table 1. (*continued*)

Variables	Patient's status		
	Died *n* (%)	Censored *n* (%)	Total *n* (%)
Mechanical ventilation			
No	28 (43.8)	95 (81.2)	123 (68.0)
Yes	36 (56.3)	22 (18.8)	58 (32.0)
Nasogastric tube			
No	22 (34.4)	82 (70.1)	104 (57.5)
Yes	42 (65.6)	35 (29.9)	77 (42.5)
TPN			
No	54 (84.4)	106 (90.6)	160 (88.4)
Yes	10 (15.6)	11 (9.4)	21 (11.6)
Blood transfusion			
No	11 (17.2)	30 (25.6)	41 (22.7)
Yes	53 (82.8)	87 (74.4)	140 (77.4)
Appropriate antimicrobial therapy			
No	20 (31.3)	30 (25.6)	50 (27.6)
Yes	44 (68.8)	87 (74.4)	131 (72.4)
Organism-related factors			
Gram-positive only			
No	36 (56.3)	61 (52.1)	97 (53.6)
Yes	28 (43.8)	56 (47.9)	84 (46.4)
Gram-negative only			
No	39 (60.9)	64 (54.7)	103 (56.9)
Yes	25 (39.1)	53 (45.3)	78 (43.1)
Fungal only			
No	57 (89.1)	109 (93.2)	166 (91.7)
Yes	7 (10.9)	8 (6.8)	15 (8.3)
Multiple organisms isolated			
No	56 (87.5)	110 (94.0)	166 (91.7)
Yes	8 (12.5)	7 (6.0)	15 (8.3)
Presence of MDRO			
No	43 (67.2)	99 (84.6)	142 (78.5)
Yes	21 (32.8)	18 (15.4)	39 (21.6)
Types of MDRO			
None	43 (67.2)	99 (84.6)	142 (78.5)
CRE	9 (14.1)	6 (5.1)	15 (8.3)
ESBL	2 (3.1)	5 (4.3)	7 (3.9)
MDR	2 (3.1)	2 (1.7)	4 (2.2)
MRSA	3 (4.7)	3 (2.6)	6 (3.3)
XDR	5 (7.8)	2 (1.7)	7 (3.9)

[a] Median (IQR); CRE = Carbapenem-resistant *Enterobacterales*; ESBL = extended-spectrum β-lactamase; MDR = multidrug-resistant organism; MRSA = methicillin-resistant *Staphylococcus aureus*; XDR = extensively drug-resistant organism: MDRO = multiple drug-resistant organism

Univariable Cox proportional hazards regression analysis was initially performed to assess the association between candidate prognostic factors and 90-day all-cause mortality (Table 2). Variables considered clinically and biologically relevant were subsequently included in the multivariable Cox regression analysis. The final multivariable Cox regression model identified five factors that were independently associated with 90-day all-cause mortality among patients with CRBSI at HPUSM: sepsis or septic shock, mechanical ventilation, shorter length of hospital stay, female sex, and Gram-negative organism infection (Table 3).

Table 2. Prognostic factors of 90-day all-cause mortality among patients with CRBSI at HPUSM using simple Cox proportional hazards regression based on patient-related factors (n = 181).

Variables	*n*	Regression coefficient (β)	Crude HR (95% CI)	Wald statistic	*P*-value
Age category					
< 60 years	121		1		
≥ 60 years	60	0.85 (0.25)	2.34 (1.43, 3.83)	11.54 (1)	0.001
Gender					
Male	105		1		
Female	76	0.41 (0.25)	1.50 (0.92, 2.45)	2.67 (1)	0.102
Race					
Malay	177		1		
Non-Malay	4	0.78 (0.59)	2.18 (0.68, 6.97)	1.74 (1)	0.187
*Length of hospital stay (days)	181	−0.01 (0.01)	0.99 (0.98, 1.01)	0.63 (1)	0.426
Types of wards					
Medical ward	107		1		
Non-medical ward	74	−0.39 (0.26)	0.68 (0.41, 1.14)	2.14 (1)	0.144
≥ 3 comorbidities					
No	94		1		
Yes	87	0.65 (0.26)	1.92 (1.16, 3.17)	6.45 (1)	0.011
Types of catheter use					
Non-tunnelled	138		1		
Others	43	−1.31 (0.43)	0.27 (0.12, 0.63)	9.27 (1)	0.002
Site of insertion					
Femoral vein	85		1		
Others	96	−0.54 (0.25)	0.58 (0.35, 0.95)	4.62 (1)	0.032
Number of lumens					
≤ 2 lumens	126	0	1		
> 2 lumens	55	0.62 (0.25)	1.87 (1.14, 3.07)	6.08 (1)	0.014
Reinsertion of new catheter/exchange or recannulation before onset					
No	159	0	1		
Yes	22	0.30 (0.34)	1.34 (0.68, 2.64)	0.74 (1)	0.391

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Table 2. (*continued*)

Variables	*n*	Regression coefficient (*β*)	Crude HR (95% CI)	Wald statistic	*P*-value
Period from CVC insertion until CRBSI onset (days)	181	−0.002 (0.001)	0.998 (0.996, 1.000)	3.05 (1)	0.081
Antibiotic lock therapy					
No	153		1		
Yes	28	−1.22 (0.52)	0.30 (0.11, 0.82)	5.54 (1)	0.019
Delayed removal of CVC without antibiotic lock (> 3 days after onset)					
No	99		1		
Yes	82	−0.02 (0.25)	0.98 (0.60, 1.60)	0.01 (1)	0.932
Sepsis/septic shock					
No	76	0	1		
Yes	105	1.65 (0.34)	5.19 (2.64, 10.20)	22.77 (1)	< 0.00
Mechanical ventilation					
No	123	0	1		
Yes	58	1.32 (0.25)	3.74 (2.28, 6.13)	27.15 (1)	< 0.001
Gram-positive					
No	93		1		
Yes	88	0.07 (0.25)	1.08 (0.66, 1.76)	0.09 (1)	0.764
Gram-negative					
No	100		1		
Yes	81	−0.04 (0.25)	0.96 (0.59, 1.58)	0.02 (1)	0.877

HR = hazard ratio; CI = confidence interval; *Inverse-transformed using multivariable fractional polynomial modelling.

Table 3. Prognostic factors of 90-day all-cause mortality among patients with CRBSI at HPUSM (*n* = 181).

Variables	Regression coefficient (*β*)	Adjusted HR (95% CI)	Wald statistic	*P*-value
Sepsis/septic shock				
No	0	1		
Yes	1.78	5.95 (2.88, 12.28)	23.33	< 0.001
Mechanical ventilation				
No	0	1		
Yes	1.78	5.94 (3.29, 10.71)	35.16	< 0.001
*Length of hospital stay (days)	0.12	1.13 (1.10, 1.17)	54.61	< 0.001
Gender				
Male	0	1		
Female	1.00	2.71 (1.60, 4.58)	13.76	< 0.001

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Table 3. (*continued*)

Variables	Regression coefficient (β)	Adjusted HR (95% CI)	Wald statistic	*P*-value
Gram-negative only				
No	0	1		
Yes	−1.16	0.31 (0.18, 0.55)	16.48	< 0.001

HR = hazard ratio; CI = confidence interval. *Inverse-transformed using multivariable fractional polynomial modelling.

Forward stepwise was applied. Two-way interaction and multicollinearity were not detected. Log-minus-log plots, hazard function plots, Schoenfeld partial residual plots, scaled Schoenfeld and global tests, and C-statistics were applied and checked for the proportional hazards assumption of the model. Cox-Snell residual, martingale residual, deviance residual, and influential analysis were performed to assess model fitness, functional form, and determine possible outliers or influential observations.

After adjusting for other variables, patients with sepsis or septic shock had a significantly higher risk of death compared with those without sepsis or septic shock (aHR = 5.95; 95% CI: 2.88, 12.28; $P < 0.001$). Patients who required mechanical ventilation also had a higher risk of death than those who did not (aHR = 5.94; 95% CI: 3.29–10.71; $P < 0.001$).

Length of hospital stay was analysed using inverse transformation within the multivariable fractional polynomial framework to account for non-linearity. Shorter hospital stay remained independently associated with higher mortality after modelling the non-linear relationship (aHR = 1.13; 95% CI: 1.10, 1.17; $P < 0.001$).

Female patients had a 2.71-fold higher risk of death compared with male patients (aHR = 2.71; 95% CI: 1.60, 4.58; $P < 0.001$). In contrast, patients with CRBSI caused solely by Gram-negative organisms had a lower risk of death compared with patients infected with other organisms (aHR = 0.31; 95% CI: 0.18, 0.55; $P < 0.001$).

Discussion

In the present study, mortality-associated factors among patients with CRBSI were categorised as patient-related, catheter-related, clinical and organism-related. Based on the Cox proportional hazards regression analysis, significant prognostic factors associated with 90-day all-cause mortality were sepsis or septic shock, mechanical ventilation, shorter length of hospital stay, female sex, and Gram-negative organism infection.

Patients who developed sepsis or septic shock had an almost sixfold higher risk of death compared with patients without either condition. This finding is consistent with previous studies that also identified sepsis or septic shock as an important mortality-associated prognostic factor (14, 15). The association between sepsis and increased mortality may be explained by the systemic inflammatory response and subsequent organ dysfunction commonly observed in severe sepsis and septic shock (16).

Mechanical ventilation was also identified as a significant prognostic factor for mortality in this study. Patients who required mechanical ventilation had a substantially higher risk of death than those who did not; similar findings have been reported in previous studies (15, 17). The need for mechanical ventilation in patients with CRBSI may reflect greater illness severity, respiratory compromise or multi-organ dysfunction, which are commonly associated with poorer clinical outcomes. In addition, Ismaeil et al. (18) reported that survival among mechanically ventilated patients may vary according to patient age and the underlying indication for ventilation.

In this study, length of hospital stay was inversely transformed within the multivariable fractional polynomial framework to account for non-linear effects. Shorter hospital stays were associated with a higher hazard of death after adjusting for other variables, which may reflect early mortality among critically ill patients who died shortly after CRBSI diagnosis, resulting in shorter recorded hospital stays. Differences in statistical methodology, particularly the application of variable

transformation techniques, may also contribute to variations in findings across studies. In contrast, Han et al. (19) reported that prolonged hospital stays were associated with increased mortality risk, particularly among patients with complications or more severe illness. However, prolonged hospitalisation may reflect underlying disease severity rather than a direct effect on mortality.

Female sex was independently associated with higher mortality risk in the present study. Female patients had a 2.71-fold higher risk of death compared with male patients. Similar findings were reported in a study conducted in Turkey (20), although inconsistent results were reported for studies from Thailand and Spain (11, 21). Given the observational nature of this study, residual confounding should be carefully considered when interpreting this association. Unmeasured factors, such as differences in comorbidities, illness severity, healthcare utilisation or treatment patterns, may have influenced the observed relationship. Although biological and immunological differences between sexes have been proposed in previous literature (22), these mechanisms were not specifically evaluated in the present study.

Patients infected with Gram-negative organisms had a lower risk of death compared with those infected with other microorganisms. This finding is consistent with previous studies that reported higher mortality among patients infected with Gram-positive organisms, particularly *Staphylococcus aureus*, which has been associated with biofilm formation and poorer clinical outcomes (11, 23). However, greater mortality associated with Gram-negative infections has been reported in certain populations, such as patients with neutropenic onco-haematological conditions (24). Variations in patient characteristics, underlying diseases, antimicrobial resistance patterns, and pathogen virulence may contribute to these differing findings.

Contrary to previous studies (1, 12, 25), age and multiple drug-resistant organisms (MDROs) were not identified as significant prognostic factors in the present study. Differences in ward settings, patient characteristics, age categorisation methods, healthcare systems and outcome definitions may partly explain these discrepancies. In addition, the relatively low prevalence of MDROs in this study population may have limited the ability to detect a significant association. Nevertheless, the potential impact of MDROs on CRBSI outcomes remains clinically important and warrants continued surveillance and appropriate infection control measures.

A major strength of this study was the use of Cox proportional hazards regression analysis to evaluate prognostic factors associated with mortality among patients with CRBSI, an approach that has been reported infrequently in related studies. Furthermore, this study assessed prognostic factors in the overall CRBSI population, which may enhance the clinical relevance of the findings compared with studies limited to specific patient groups, healthcare settings or microorganism types. However, several limitations should be acknowledged. First, the retrospective study design relied on existing medical records, which may have been incomplete or missing data. Second, the calculated sample size was not fully reached because some medical records could not be retrieved. Finally, because this study was conducted in a single tertiary care centre, the findings may have limited generalisability to other healthcare settings or the broader Malaysian population.

Conclusion

Significant prognostic factors associated with 90-day mortality among patients with CRBSI included sepsis or septic shock, mechanical ventilation, shorter length of hospital stay, female sex and infection with Gram-negative organisms (which was associated with a lower risk of death). These findings contribute to the understanding of factors associated with CRBSI outcomes and may assist clinicians in risk stratification and patient management.

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Ethics of Study

Ethical approval to conduct this study was granted on 18 January 2024 with reference number USM/JEPeM/KK23110856.

Conflict of Interest

None.

Funds

None.

Authors' Contributions

Conception and design: NAH, SA, SSMN
Analysis and interpretation of the data: NAH, SA, SSMN
Drafting of the article: NAH
Critical revision of the article for important intellectual content: NAH, SA, SSMN
Final approval of the article: NAH, SA, SSMN
Provision of study materials or patients: NAH, SSMN
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References

1. İnce N, Yekenkurul D, Çalişkan E, Gürbüz AR, Yener S. Investigation of the factors associated with mortality in catheter-related bloodstream infections: five-year observation. *Duzce Med J*. 2020;**22(3)**:149–153. https://doi.org/10.18678/dtfd.746887

2. Chaves F, Garnacho-Montero J, Del Pozo JL, Bouza E, Capdevila JA, de Cueto M, et al. Diagnosis and treatment of catheter-related bloodstream infection: clinical guidelines of the Spanish Society of Infectious Diseases and Clinical Microbiology (SEIMC) and the Spanish Society of Intensive and Critical Care Medicine and Coronary Units (SEMICYUC). *Med Intensiva*. 2018;**42(1)**:5–36. https://doi.org/10.1016/j.medin.2017.09.012

3. Turken M, Kilinc Toker A, Zincirlioglu C, Kose S. Risk factors and incidence of catheter-related bloodstream infections in a tertiary hospital ICU. *EJMI*. 2019;**3(1)**:32–36. https://doi.org/10.14744/ejmi.2018.0001

4. Shahar S, Mustafar R, Kamaruzaman L, Periyasamy P, Pau KB, Ramli R. Catheter-related bloodstream infections and catheter colonization among haemodialysis patients: prevalence, risk factors, and outcomes. *Int J Nephrol*. 2021;**2021(1)**:5562690. https://doi.org/10.1155/2021/5562690

5. Inan Sarıkaya R, Karaşahin O. Prognostic factors for mortality in catheter-related bloodstream infections among hemodialysis patients: a prospective single-center study. *Medicina*. 2025;**61(12)**:2205. https://doi.org/10.3390/medicina61122205

6. Calderwood MS. Intravascular non-hemodialysis catheter-related infection: clinical manifestations and diagnosis. [Internet]. Waltham (MA): UpToDate; 2023. [Retrieved 2023 Oct 06]. Available at: https://www.uptodate.com/contents/intravascular-non-hemodialysis-catheter-related-infection-clinical-manifestations-and-diagnosis

7. Zhang Y, Wang Y, Sheng Z, Wang Q, Shi D, Xu S, et al. Incidence rate, pathogens and economic burden of catheter-related bloodstream infection: a single-center, retrospective case-control study. *Infect Drug Resist*. 2023;**16**:3551–3560. https://doi.org/10.2147/IDR.S406681

8. Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 update by the Infectious Diseases Society of America. *Clin Infect Dis*. 2009;**49(1)**:1–45. https://doi.org/10.1086/599376

9. Gahlot R, Nigam C, Kumar V, Yadav G, Anupurba S. Catheter-related bloodstream infections. *Int J Crit Illn Inj Sci*. 2014;**4(2)**:162–167. https://doi.org/10.4103/2229-5151.134184

10. Ngo Bell EC, Chapon V, Bessede E, Meriglier E, Issa N, Domblides C, et al. Central venous catheter-related bloodstream infections: epidemiology and risk factors for hematogenous complications. *Infect Dis Now*. 2024;**54(3)**:104859. https://doi.org/10.1016/j.idnow.2024.104859

11. Saliba P, Hornero A, Cuervo G, Grau I, Jimenez E, García D, et al. Mortality risk factors among non-ICU patients with nosocomial vascular catheter-related bloodstream infections: a prospective cohort study. *J Hosp Infect*. 2018;**99(1)**:48–54. https://doi.org/10.1016/j.jhin.2017.11.002

12. Zhong Y, Zhou L, Liu X, Deng L, Wu R, Xia Z, et al. Incidence, risk factors, and attributable mortality of catheter-related bloodstream infections in the intensive care unit after suspected catheters infection: a retrospective 10-year cohort study. *Infect Dis Ther*. 2021;**10(2)**:985–999. https://doi.org/10.1007/s40121-021-00429-3

13. Su TY, Ye JJ, Hsu PC, Wu HF, Chia JH, Lee MH. Clinical characteristics and risk factors for mortality in cefepime-resistant *Pseudomonas aeruginosa* bacteremia. *J Microbiol Immunol Infect*. 2015;**48(2)**:175–182. https://doi.org/10.1016/j.jmii.2013.07.009

14. Calo F, Retamar P, Perez-Crespo PMM, Lanz-Garcia J, Sousa A, Goikoetxea J, et al. Catheter-related bloodstream infections: predictive factors for Gram-negative bacteria aetiology and 30-day mortality in a multicentre prospective cohort. *J Antimicrob Chemother*. 2020;**75(10)**:3056–3061. https://doi.org/10.1093/jac/dkaa262

15. Lee Y, Lee YT, Wang YC, Chen CT, Sun JR, Liu CP, et al. Risk of mortality of catheter-related bloodstream infections caused by *Acinetobacter* species: is early removal of the catheters associated with a better survival outcome? *J Intensive Care Med*. 2018;**33(6)**:361–369. https://doi.org/10.1177/0885066616677710

16. Kalil A, Bailey KL. Septic shock. [Internet]. Newark (NJ): Medscape; 2025. [Retrieved 2025 May 26]. Available at: https://emedicine.medscape.com/article/168402-overview#a3

17. Rosenthal VD, Yin R, Lu Y, Rodrigues C, Myatra SN, Kharbanda M, et al. The impact of healthcare-associated infections on mortality in ICU: a prospective study in Asia, Africa, Eastern Europe, Latin America, and the Middle East. *Am J Infect Control*. 2023;**51(6)**:675–682. https://doi.org/10.1016/j.ajic.2022.08.024

18. Ismaeil T, Almutairi J, Alshaikh R, Althobaiti Z, Ismaiel Y, Othman F. Survival of mechanically ventilated patients admitted to intensive care units: results from a tertiary care center between 2016–2018. *Saudi Med J*. 2019;**40(8)**:781–788. https://doi.org/10.15537/smj.2019.8.24447

19. Han TS, Murray P, Robin J, Wilkinson P, Fluck D, Fry CH. Evaluation of the association of length of stay in hospital and outcomes. *Int J Qual Health Care*. 2022;**34(2)**:mzab160. https://doi.org/10.1093/intqhc/mzab160

20. Çepni Kütahya E, Ugur O, Tomruk M, Demirel S, Demirel F, Balasar B, et al. The effect of risk factors on mortality in central line associated bloodstream infections developing in the intensive care unit. *Chron Precis Med Res*. 2024;**5(2)**:84–88. https://doi.org/10.5281/zenodo.12805654

21. Cheewinmethasiri J, Chittawatanarat K, Chandacham K, Jirapongchareonlap T, Chotirosniramit N. Microbiology, risk factors and mortality of patients with intravenous catheter related blood stream infections in the surgical intensive care unit: a five-year, concurrent, case-controlled study. *J Med Assoc Thai*. 2014;**97(Suppl 1)**:S93–S101.

22. Shields CA, Wang X, Cornelius DC. Sex differences in cardiovascular response to sepsis. *Am J Physiol Cell Physiol*. 2022;**324(2)**:C458–C466. https://doi.org/10.1152/ajpcell.00134.2022

23. Oliva A, Stefani S, Venditti M, Di Domenico EG. Biofilm-related infections in Gram-positive bacteria and the potential role of the long-acting agent dalbavancin. *Front Microbiol*. 2021;**12**:749685. https://doi.org/10.3389/fmicb.2021.749685

24. Lendak D, Puerta-Alcalde P, Moreno-García E, Chumbita M, García-Pouton N, Cardozo C, et al. Changing epidemiology of catheter-related bloodstream infections in neutropenic oncohematological patients. *PLoS One*. 2021;**16(4)**:e0251010. https://doi.org/10.1371/journal.pone.0251010

25. Badia-Cebada L, Peñafiel J, López-Contreras J, Pomar V, Martínez JA, Santana G, et al. Decreased mortality among patients with catheter-related bloodstream infections at Catalan hospitals (2010–2019). *J Hosp Infect*. 2022;**126**:70–77. https://doi.org/10.1016/j.jhin.2022.05.009