

# CUIDADO É FUNDAMENTAL

Escola de Enfermagem Alfredo Pinto – UNIRIO

INTEGRATIVE REVIEW OF LITERATURE

DOI: 10.9789/2175-5361.rpcf.v17.13785

## BIOFILM ON CATHETERS ASSOCIATED WITH BLOODSTREAM INFECTIONS IN THE INTENSIVE CARE UNIT

*Biofilme em cateteres associados a infecções de corrente sanguínea na unidade de terapia intensiva**Biofilme em catéteres asociados a infecciones de corriente sanguínea en la unidad de terapia intensiva***Victor Daniel Ribeiro Pereira**<sup>1</sup> **Karol Fireman de Farias**<sup>2</sup> **Ana Caroline Melo dos Santos**<sup>3</sup> 

### RESUMO

**Objetivo:** avaliar a prevalência de microrganismos em infecções da corrente sanguínea relacionadas ao uso de cateteres venosos centrais em pacientes adultos de UTI, destacando os patógenos mais prevalentes, os fatores de risco e as medidas preventivas. **Método:** revisão integrativa da literatura, com busca em bases de dados eletrônicas como Science Direct, PubMed, SciELO, CAPES e Biblioteca Virtual em Saúde (BVS), abrangendo o período de 2020 a 2024. **Resultados:** 1.364 artigos foram identificados, sendo 14 incluídos para análise. *Staphylococcus epidermidis*, *Klebsiella pneumoniae* e *Acinetobacter baumannii* foram os patógenos mais prevalentes em biofilmes de cateteres. O uso prolongado de CVCs, especialmente por mais de 15 dias, foi associado a uma maior incidência de infecções. A resistência antimicrobiana, especialmente entre patógenos Gram-negativos, foi significativa, complicando o tratamento dessas infecções. **Conclusão:** a formação de biofilmes em CVCs está associada a infecções graves em pacientes de UTI, com predominância de microrganismos resistentes a múltiplos fármacos.

**DESCRITORES:** Infecções hospitalares; Infecção da corrente sanguínea; Biofilme microbiano; Unidades de Terapia Intensiva.

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Accepted: 20/02/2025

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**Received:** 2025/02/07. **Accepted:** 2025/02/12

**How to cite this article:** Pereira VDR, Farias KF, Santos ACM. Biofilm on catheters associated with bloodstream infections in the intensive care unit. R Pesq Cuid Fundam. 2025 [cited year month day];17:13785. Available from: <https://doi.org/10.9789/2175-5361.rpcf.v17.13785>



## ABSTRACT

**Objective:** to evaluate the prevalence of microorganisms in bloodstream infections related to the use of central venous catheters in adult ICU patients, highlighting the most prevalent pathogens, risk factors and preventive measures. **Method:** integrative literature review, searching electronic databases such as Science Direct, PubMed, SciELO, CAPES and Virtual Health Library (BVS), spanning the period from 2020 to 2024. **Results:** 1,364 foram articles identified, with 14 included for analysis. *Staphylococcus epidermidis*, *Klebsiella pneumoniae* and *Acinetobacter baumannii* are the most prevalent pathogens in catheter biofilms. Prolonged use of CVCs, especially for more than 15 days, was associated with a higher incidence of infections. Antimicrobial resistance, especially among Gram-negative pathogens, was significant, complicating the treatment of these infections. **Conclusion:** the formation of biofilms in CVCs is associated with severe infections in ICU patients, with a predominance of microorganisms resistant to multiple drugs.

**DESCRIPTORS:** Hospital infections; Bloodstream infection; Microbial biofilm; Intensive Care Units.

## RESUMEN

**Objetivo:** evaluar la prevalencia de microorganismos em infecciones de corriente sanguínea relacionadas con el uso de catéteres venosos centrales en pacientes adultos de ITU, destacando los patógenos más prevalentes, los factores de riesgo y las medidas preventivas. **Método:** revisión integrativa de la literatura, con busca em bases de datos electrónicos como Science Direct, PubMed, SciELO, CAPES e Biblioteca Virtual en Salud (BVS), abriendo el período de 2020 a 2024. **Resultados:** 1.364 artículos foram identificados, siendo 14 incluidos para análisis. *Staphylococcus epidermidis*, *Klebsiella pneumoniae* y *Acinetobacter baumannii* forman los patógenos más prevalentes en biopelículas de catéteres. El uso prolongado de CVC, especialmente durante más de 15 días, está asociado a una mayor incidencia de infecciones. La resistencia antimicrobiana, especialmente entre patógenos Gram-negativos, complica significativamente el tratamiento de estas infecciones. **Conclusión:** la formación de biopelículas en CVC está asociada a infecciones graves en pacientes de ITU, con predominio de microorganismos resistentes a múltiples fármacos.

**DESCRIPTORES:** Infecciones hospitalarias; Infección de la corriente sanguínea; Biofilm microbiano; Unidades de Cuidados Intensivos.

## INTRODUCTION

The prevalence of biofilms on central venous catheters (CVCs) and their association with bloodstream infections (BSIs) in Intensive Care Unit (ICU) patients has become a global public health issue, given the seriousness of these complications.<sup>1</sup> The use of venous catheters is common in critically ill patients, as it facilitates the administration of essential drugs and fluids.<sup>2</sup> However, these devices also pose a considerable risk of infection, mainly due to the formation of microbial biofilms on the catheter surface.<sup>3</sup>

Biofilms are structured aggregates of microorganisms that adhere to surfaces, forming a protective layer against the action of antimicrobials and the immune system.<sup>4</sup> This results in persistent infections that are difficult to treat, increasing mortality rates and prolonging hospital stays.<sup>5</sup> Catheter-associated BSIs are one of the main causes of sepsis in ICUs, and controlling these infections represents a significant challenge for healthcare teams.<sup>6</sup> In addition, catheter-associated bloodstream infections (CSBIs) are responsible for a significant increase in hospital costs and prolonged hospital stays, as well as being associated with serious complications such as septic thrombophlebitis, endocarditis and metastatic infections.<sup>1,7,8</sup>

The devices also represent a significant entry point for infections due to the formation of biofilms, which increase the adherence of microorganisms to the catheter surface.<sup>3</sup> Biofilm formation is one of the main virulence factors, since it hinders the action of antimicrobials and the immune system's defenses, and can result in serious complications, such as sepsis.<sup>9</sup> Sepsis often progresses to multiple organ dysfunction, and is responsible for the majority of ICU deaths.<sup>5,8,10</sup>

Among the pathogens most commonly found in CVC-related infections are *Staphylococcus aureus* and coagulase-negative *Staphylococcus*, followed by Gram-negative bacteria such as *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and *Acinetobacter baumannii*.<sup>1,9,11</sup> These microorganisms are particularly prevalent in intensive care settings and represent a significant challenge to treatment due to their ability to form resistant biofilms and the presence of strains that are multidrug-resistant.<sup>11,12</sup>

Several studies point to the predominance of Gram-negative bacteria in bloodstream infections associated with the use of CVCs, with *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* standing out.<sup>13,14</sup> In addition, coagulase-negative *Staphylococcus* remains one of the main agents in catheter biofilms, responsible for bloodstream infections in approximately 55% of cases.<sup>15,16</sup>

Given the growing concern about the formation of biofilms on central venous catheters and the increase in antimicrobial resistance, as well as the limitations in the treatment of bloodstream infections, this study sought to evaluate, based on scientific literature, the prevalence of biofilms on catheters associated with bloodstream infections in patients in Intensive Care Units.

## **MATERIAL AND METHODS**

This is an integrative review study. The first stage of this integrative review consisted of formulating a guiding question, which was fundamental in guiding the entire data search and analysis process. The central question guiding this research was: what is the evidence in the literature about the prevalence of microorganisms in bloodstream infections associated with the use of catheters in patients admitted to the Intensive Care Unit (ICU)? The literature search was carried out by consulting

various electronic databases, such as Science Direct, PubMed, SciELO, CAPeS and the Virtual Health Library (VHL). Specific descriptors were used in both English and Portuguese to optimize the results, such as: “sepsis”, “biofilms”, “central venous catheters” and “Intensive Care Unit”.

The criteria established for the inclusion of the articles were: a) articles with full free text available; b) studies published in the last 5 years (2020 - 2024); c) studies that dealt directly with the prevalence of microorganisms in bloodstream infections related to the use of catheters in the ICU; d) publications in English and Portuguese; e) articles focused on the thematic area of microbiology and immunology. The exclusion criteria considered were: a) articles without free access to the full text; b) articles published more than 5 years ago; c) articles that did not focus on the central theme of the review; d) studies published in languages other than English and Portuguese; e) studies carried out on animals. The article selection process is described in Flowchart 1.



After full analysis of the articles, 55 studies were excluded because they dealt with COVID-19 patients in the ICU (n = 29), studies carried out on animals or in vitro (n = 8), articles not directly related to bloodstream infections (n = 4), lack of specific data on the subject (n = 6) and studies that did not report the length of time the catheter remained in the patient (n = 8). There were 14 articles, with the following characteristics: published in English and Portuguese between 2020 and 2024, thematic area focused on microbiology and immunology, with

the majority of studies coming from Brazil (n = 7), followed by publications in Turkey (n = 1), Egypt (n = 1), France (n = 1), Taiwan (n = 1), Japan (n = 1), the United States of America (n = 1) and Greece (n = 1).

Table 1 shows a descriptive article on *Staphylococcus epidermidis* as the most prevalent microorganism, responsible for 76.93% of central venous catheter-associated bloodstream infections (CVBIs), while *Staphylococcus aureus* was responsible for 23.07% of cases.

**Table 1.** Characteristics of descriptive and observational studies on bloodstream infections associated with pathogens prevalent in central venous catheter biofilm, involving adults hospitalized in the Intensive Care Unit.

Author	Goal	Country	Method	Outcome
Nahla et al. (2020)	To identify central catheter-related bloodstream infections and their microbiological characteristics.	Egypt	A descriptive exploratory study of 120 ICU patients, with blood cultures collected 7 days after the insertion of a central venous catheter.	10.83% of patients developed an infection, with a predominance of <i>Staphylococcus epidermidis</i> (76.93%) and <i>Staphylococcus aureus</i> (23.07%).
Almeida et al. (2022)	To characterize the profile of hospitalized patients and the trend in mortality due to sepsis in the Unified Health System (SUS) between 2010 and 2019 in Brazil and its regions.	Brazil	Observational, analytical and retrospective study using secondary data from the SUS Hospital Information System, analyzing hospitalizations and deaths from sepsis.	463,000 deaths from sepsis between 2010 and 2019, with an upward trend in mortality. Average coefficient of 22.8 deaths per 100,000 inhabitants. The highest rates occurred in the elderly and in the Southeast region.
Moriyama et al. (2022)	To analyze the factors associated with catheter-related bloodstream infections (CLABSI) in a university hospital ICU.	Japan	Retrospective observational study analyzing 1,472 patients with a central venous catheter inserted over 5 years (2013-2018).	The risk factors most associated with CLABSI were: longer ICU stay, longer catheter use and higher APACHE II score.

Table 2 shows five retrospective studies highlighting the prevalence of *Escherichia coli*, *Staphylococcus*

*aureus* and coagulase-negative staphylococci (CNS) and *Klebsiella pneumoniae*.

**Table 2.** Characteristics of retrospective studies on the prevalence of microorganisms involved in catheter-associated bloodstream infections.

Author	Goal	Country	Method	Outcome
Cekin et al. (2023)	To identify the risk factors associated with bloodstream infection (BSI) caused by multidrug-resistant bacteria.	Turkey	Retrospective study of 222 patients with BSI, microbiological analysis of isolated pathogens and antimicrobial resistance.	Predominant pathogens: <i>Escherichia coli</i> (22.8%), <i>Staphylococcus aureus</i> (15.1%), <i>Klebsiella pneumoniae</i> (11.2%). Mortality rates were high in patients with sepsis.
Pitiriga et al. (2020)	To compare the rates of catheter-associated bloodstream infection (CLABSI) and colonization between insertion sites (subclavian, internal jugular and femoral), and to analyze the distribution of multidrug-resistant pathogens.	Greece	Retrospective study carried out in a tertiary hospital, analyzing 1414 catheters and 13,054 days of central venous catheter use between 2016 and 2018.	The femoral site had the highest rate of infection (6.93/1000 days) and colonization (22.91/1000 days). There was a predominance of multidrug-resistant gram-negative pathogens, particularly <i>Acinetobacter baumannii</i> .
Silva et al. (2021)	To analyze the temporal trend of central venous catheter-associated bloodstream infections (CLABSI) in adult ICUs in Brazil, including antimicrobial resistance patterns.	Brazil	Retrospective ecological study carried out in 42 adult ICUs in Goiânia, Brazil, with data from 2012 to 2016, analyzing CLABSI notifications and microbial resistance.	The incidence of CLABSI was high and stationary during the period (2.3 to 3.2 per 1,000 catheter days). The most common pathogens were coagulase-negative <i>Staphylococcus</i> , <i>Klebsiella pneumoniae</i> and <i>Acinetobacter</i> spp.
Liao et al. (2021)	To evaluate the epidemiology and prognosis of nosocomial bloodstream infections in a tertiary center in Taiwan.	Taiwan	Retrospective study in a tertiary hospital with 584 patients between 2016 and 2017, analyzing microbiological characteristics and risk factors for mortality.	<i>Klebsiella</i> spp. and <i>Escherichia coli</i> were the most common pathogens. Patients with severe comorbidities had higher mortality.
Bell et al. (2024)	To investigate the hematogenous complications associated with central venous catheter-related bloodstream infections (CRBIs).	France	A 2-year retrospective study in a single center, including 254 patients with CRBIs, analyzing patient characteristics and catheter types.	CRBIs caused by <i>Staphylococcus aureus</i> (SA) had a higher risk of hematogenous complications, such as suppurative thrombophlebitis and endocarditis. Hemodialysis and persistent bacteremia increased the risk of complications.

Table 4 highlights two articles in the retrospective cohort study model. Júnior et al. (2022) addresses the costs and clinical impacts of ICU patients with bloodstream infections caused by

multidrug-resistant microorganisms, and Gouel-Cheron et al. (2022) analyzed the epidemiology of bloodstream infections acquired in the Intensive Care Unit.

**Table 3.** Characteristics of retrospective cohort studies on costs and impacts of ICU patients and prevalence of ICU-acquired bloodstream infections.

Author	Goal	Country	Method	Outcome
Júnior et al. (2022)	Avaliar o impacto econômico das infecções primárias da corrente sanguínea associadas a cateter central causadas por microrganismos multirresistentes (MMRs).	Brazil	Retrospective cohort study of 5,326 patients admitted to the ICU between 2016 and 2020 using CVCs. Comparison between patients with infections caused by MMRs and nMMRs.	Patients with infections caused by MMRs had higher hospital costs and higher hospital mortality. Total costs per patient with MMRs were significantly higher.
Gouel-Cheron et al. (2022)	Determinar a prevalência de infecções da corrente sanguínea adquiridas em UTI, perfil de patógenos e fatores de risco associados.	United States of America	Retrospective cohort study based on data from 150,948 patients in 85 US hospitals between 2009 and 2015.	1,306 patients (0.9%) acquired BSI in the ICU, with the most common pathogens being <i>Pseudomonas</i> , <i>Acinetobacter</i> , <i>Enterococcus</i> and <i>Candida</i> , and high associated mortality (37.9%).
Faria et al. (2021)	Identificar fatores de risco associados ao desenvolvimento de infecções de corrente sanguínea relacionadas a cateter venoso central (ICSRC)	Brazil	Retrospective study with a quantitative approach. The sample consisted of 24 patients admitted to the ICU between 2015 and 2019.	A prevalence of 1.2% of CRPSI was observed in the patients studied, with a sepsis-related mortality rate of 37.5%. Adherence to preventive practices (bundles) is recommended.

Table 4 shows three cross-sectional articles, with coagulase-negative *Staphylococcus* isolated as the most prevalent microorganism among sepsis patients admitted to the ICU, responsible for 55% of infection cases.

**Table 4.** Characteristics of cross-sectional studies on the prevalence of pathogens and ICU-acquired bloodstream infections.

Author	Goal	Country	Method	Outcome
Reiner et al. (2020)	Identificar os desfechos clínicos e os fatores associados ao óbito em pacientes com sepse internados em UTI.	Brazil	To identify the clinical outcomes and factors associated with death in ICU patients with sepsis.	The prevalence of sepsis was 18.4%, with a mortality rate of 37.4%. The main infectious focus was pulmonary (39.4%), and the main pathogen was coagulase-negative <i>Staphylococcus</i> (55%).
Pires et al. (2020)	Investigar as características clínicas, microbiológicas e epidemiológicas de pacientes com sepse em UTI.	Brazil	To investigate the clinical, microbiological and epidemiological characteristics of ICU patients with sepsis.	Mortality was 58.03%. Main pathogens: <i>Pseudomonas</i> spp. (6.17%), <i>Klebsiella</i> spp. (3.70%), <i>Staphylococcus aureus</i> (2.47%). Main foci: respiratory, abdominal, urinary.

Author	Goal	Country	Method	Outcome
Inácio et al. (2024)	Descrever o perfil microbiológico de contaminação das pontas de cateter venoso central de pacientes internados em UTI e analisar a resistência bacteriana aos antibióticos.	Brazil	This cross-sectional study analyzed the medical records of 149 patients admitted to the ICU between January 2022 and June 2023. The samples were analyzed by microbiological culture and antibiogram.	Of the 149 catheters analyzed, 45 were contaminated. The main microorganisms found were <i>Staphylococcus epidermidis</i> , <i>Klebsiella pneumoniae</i> and <i>Proteus mirabilis</i> .

## DISCUSSION

In the selected studies, males had the highest percentage of cases of infections related to central venous catheters (CVC), with prevalence variations between 52.4% and 64.4%. Among these studies, 52.4% of bloodstream infection cases were associated with males,<sup>17</sup> while another study found a prevalence of 54.2%.<sup>13</sup> Similarly, Reiner et al. (2020) found that 64.4% of patients with sepsis in the Intensive Care Unit were male. Despite this predominance, the studies did not present specific hypotheses or explanations for this trend.

The age range of patients who developed infections related to the use of a central venous catheter varied considerably between the studies analyzed. According to Cekin et al. (2023), the majority of patients with infections caused by multidrug-resistant microorganisms, including *Escherichia coli* and *Staphylococcus aureus*, had a mean age of 58 years, and were predominantly in the Intensive Care Unit (ICU), which indicated a relationship between serious comorbidities and prolonged catheter use. In addition, Bell et al. (2024) observed that the prevalence of serious bacterial infections, mainly by *Staphylococcus aureus* and *Klebsiella pneumoniae*, was higher in patients who had persistent bacteremia after three days of hospitalization, with a high rate of hematogenous complications associated with these microorganisms.

Similarly, in the study by Pitiriga et al. (2020), they found that patients with CVC infections inserted in the femoral region had a higher rate of colonization by multidrug-resistant pathogens, such as *Acinetobacter baumannii*, when compared to those with catheters inserted in other sites, such as the internal jugular. This reinforces the importance of the catheter insertion site as a risk factor for serious infections. In the study by Reiner et al. (2020), it was found that 64.4% of patients with sepsis in ICUs used central venous catheters, and infections were strongly associated with the development of serious complications, such as multiple organ failure.

In addition, Liao et al. (2021) indicated that in patients with nosocomial infections related to CVCs, *Klebsiella pneumoniae* and *Escherichia coli* were the most common pathogens, with an incidence of 14% in both cases. These pathogens were more prevalent in patients with significant comorbidities, such as diabetes and chronic renal failure, which can aggravate the evolution of infections. The importance of additional risk factors, such as prolonged CVC use and length of mechanical ventilation, which significantly increase the risk of infections in critically ill patients, with an associated mortality rate of up to 37.9% in cases of ICU-onset bloodstream infections.<sup>18</sup>

The incidence and mortality rate related to bloodstream infections associated with the use of a central venous catheter (CVC) vary significantly according to various factors, such as the length of time the catheter is in place, the presence of comorbidities, the type of pathogen involved and the therapeutic measures adopted.<sup>13,19</sup> Patients admitted to the Intensive Care Unit (ICU) are especially vulnerable due to the combination of invasive procedures and fragile health conditions. In addition, the formation of microbial biofilms on CVCs is a common complication, which can aggravate the evolution of infections and increase mortality rates.<sup>19</sup>

According to Cekin et al. (2023), the presence of comorbidities such as diabetes, chronic renal failure and heart disease is widely associated with an increased incidence of infections related to the use of central venous catheters. These conditions compromise patients' immune response, making them more susceptible to invasion by multidrug-resistant pathogens.<sup>18</sup> In this sense, Faria et al. (2021) showed that patients with comorbidities had a significantly higher rate of infections in catheters that remained in place for more than 14 days. These data reinforce the need for careful monitoring and preventive interventions in high-risk patients.

The formation of biofilms on the surfaces of central venous catheters is an additional factor that aggravates bloodstream infections, especially in patients with chronic diseases. Biofilms provide a protective layer for microorganisms, hindering the

action of antimicrobials and prolonging the infection.<sup>9</sup> Also according to Cekin et al. (2023), *Staphylococcus aureus* and *Klebsiella pneumoniae* are among the pathogens most frequently isolated in infections associated with biofilm formation on central venous catheters. In these cases, antimicrobial resistance is particularly high, which contributes to the persistence of infections and increases the risk of serious complications such as bacteremia and sepsis.

The literature showed that 13.8% of patients developed hematogenous complications, such as endocarditis (2.8%), metastatic infections (6.3%) and suppurative thrombophlebitis (5.9%), 13 frequently observed in patients with CVC-related infections. These cases are particularly critical in patients with persistent bacteremia and serious underlying diseases, such as renal failure and diabetes.

In summary, the mortality associated with these infections depends significantly on factors such as the length of time the CVC is used, the antimicrobial resistance of the pathogens involved and the timeliness of therapeutic interventions. Reiner et al. (2020) reported that patients with prolonged use of CVCs, combined with comorbidities, have mortality rates of over 30%, especially when the infection progresses to sepsis. Therefore, strategies such as periodic catheter replacement and the use of antimicrobial-impregnated devices become essential to prevent serious complications and reduce mortality in these vulnerable patients.

The implementation of rigorous preventive measures is fundamental to reducing the risk of infections. Strategies include the periodic replacement of catheters, the use of catheters impregnated with antimicrobials and the adoption of strict hygiene protocols, including the proper disinfection of hubs and the sterile handling of devices. In addition, the use of checklists during CVC insertion and maintenance has shown a significant reduction in the incidence of infections, promoting greater safety for patients in intensive care settings.

Prolonged use of a central venous catheter (CVC) is directly related to an increased risk of bloodstream infections, especially in patients in the Intensive Care Unit (ICU).<sup>11</sup> Catheters kept for more than 15 days have a higher incidence of infections, due to the prolonged exposure of patients to hospital microorganisms and the formation of microbial biofilms on the internal surface of the device.<sup>9</sup> The study by Faria et al. (2021), indicated that the average length of stay of catheters was 11.5 days, with a higher frequency of infections in devices that remained for more than 14 days. The formation of biofilms on CVCs significantly increases the risk of persistent infections and serious complications such as bacteremia and septic shock.<sup>3</sup>

The prolonged stay of central venous catheters is therefore a key factor in the increase in bloodstream infection rates in ICUs. Pitiriga et al. (2020) pointed out that biofilms formed on CVCs kept for prolonged periods are often composed of

multidrug-resistant pathogens, such as *Staphylococcus aureus* and *Klebsiella pneumoniae*, which increases the risk of serious infections.<sup>11</sup> The need for continuous surveillance and strict control of bacterial colonization, especially in catheters kept for more than 15 days, where the prevalence of infections is significantly higher.<sup>9</sup> Preventive measures, such as the use of catheters impregnated with antimicrobial substances and the early removal of devices, are fundamental to reducing the incidence of serious complications.<sup>1,7</sup>

As noted, the resistance of gram-negative microorganisms to antimicrobials has become a growing concern in the episode of infections associated with the central venous catheter, especially in the Intensive Care Unit.<sup>15</sup> According to the results presented in the study, *Acinetobacter* spp. maintained high rates of resistance to carbapenems in 89.3% and *Klebsiella pneumoniae* resisted third and fourth generation cephalosporins in 48.1% of cases. And among Gram-positive microorganisms, an increase was described in the resistance of coagulase-negative *Staphylococcus* to oxacillin of up to 91.8% in 2016.

Despite the high rates of antimicrobial resistance, some therapeutic options still proved effective in fighting infections. The pathogens showed high sensitivity to vancomycin, ampicillin and levofloxacin, suggesting that these antibiotics may be viable alternatives in the treatment of serious infections, particularly in scenarios of increasing resistance.<sup>6</sup> However, significant resistance was observed to other widely used antibiotics, such as amoxicillin, meropenem, clindamycin, ceftriaxone and gentamicin, which reinforces the complexity of managing these infections and the need for studies with new compounds with antimicrobial properties in clinical practice.<sup>20</sup>

The problem of antimicrobial resistance was even more pronounced in the study by Liao et al. (2021), which identified alarming levels in several bacterial strains. *Klebsiella* spp., *Escherichia coli* and *Serratia marcescens* showed a 100% resistance rate to ampicillin, which significantly limits therapeutic options. In addition, 56.7% of *Enterococcus* strains showed resistance to vancomycin, a last-line antibiotic, indicating a high risk in the treatment of serious infections. However, *Staphylococcus aureus* proved to be sensitive to vancomycin, linezolid and teicoplanin, highlighting that, for this specific pathogen, these antimicrobial agents are still effective.

The study by Inácio et al. (2024) adds to concerns about antimicrobial resistance, particularly in relation to *Klebsiella pneumoniae*, which has shown high resistance to several classes of antibiotics, such as ampicillin, cefepime and ceftazidime, limiting the therapeutic options for treating these infections. In contrast, *Proteus mirabilis* and *Pseudomonas aeruginosa* showed lower rates of resistance, suggesting that some antibiotics may still be effective in managing infections caused by these

bacteria. Gram-positive pathogens, such as *Staphylococcus epidermidis* and *Staphylococcus aureus*, showed significant resistance to lincosamides and quinolones, highlighting the ongoing challenge of controlling the spread of resistant strains in hospital environments.

The study by Gouel-Cheron et al. (2022) identified that the pathogens most frequently associated with Intensive Care Unit (ICU)-acquired bloodstream infections (ICU-onset BSIs) were *Pseudomonas*, *Acinetobacter*, *Enterococcus*, *Candida* species and coagulase-negative staphylococci. In contrast, bloodstream infections associated with the presence of an ICU catheter but with onset in the community (ICU-BSIPOA) were more often caused by *Staphylococcus aureus*, *Escherichia coli* and streptococci. In terms of antimicrobial resistance, ICU-acquired infections had more cases of methicillin-resistant staphylococci (MRSA), vancomycin-resistant enterococci (VRE), ceftriaxone-resistant Enterobacterales and carbapenem-resistant *Acinetobacter*.<sup>18</sup>

The highest resistance rates were observed in *Acinetobacter baumannii*, reaching 82.3%, followed by coagulase-negative staphylococci with 64.5%, *Escherichia coli* with 60.3% and *Klebsiella pneumoniae* with 50%. These findings reinforce the growing trend of resistance among critical pathogens, making effective treatment of nosocomial infections even more difficult.<sup>9</sup>

The relationship between the insertion site of central venous catheters (CVC) and the incidence of catheter-associated bloodstream infections (CICSI) is widely discussed in the literature, with clear evidence that the choice of site can directly influence infection rates. Insertion of the catheter in the femoral vein is associated with higher rates of colonization and infections (6.93/1,000 days), while the subclavian artery tends to have lower rates of CICSI (5.1/1,000 days), followed by the internal jugular (3.73/1,000).<sup>11</sup>

The greater bacterial colonization of the femoral region, close to the perineal area, contributes to this high risk, while the subclavian vein, being less exposed, has a lower chance of contamination. The femoral vein, due to its proximity to areas of high bacterial colonization, such as the inguinal region, has a higher colonization rate (22.91/1,000 days), compared to the subclavian vein (13.39/1,000 days) and the internal jugular vein (7.34/1,000 days).<sup>11</sup>

Silva et al. (2021) complement these findings by pointing out that, although the rate of use of CVCs in Brazilian ICUs is high (56.9%), adherence to preventive practices, such as correct disinfection of the insertion site and hand hygiene, combined with proper catheter management, can significantly contribute to controlling the incidence of these infections. These studies reinforce the importance of a careful choice of CVC insertion site, coupled with rigorous maintenance practices, continuous monitoring and early removal of the catheter, as fundamental strategies for reducing the incidence of CICSI.

## CONCLUSION

This study allowed us to understand the prevalence of microorganisms involved in infections and episodes of sepsis related to the use of central venous catheters in adult patients admitted to Intensive Care Units (ICUs). It was observed that the organisms causing these infections vary according to the condition of the patients and the region where the catheters are inserted, with *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Acinetobacter baumannii* being the most frequent. The formation of biofilms on these devices has been identified as a relevant risk factor for the development of serious infections and sepsis, especially in immunocompromised patients.

Thus, this study reinforces the need for strict protocols for the control and management of catheters in ICUs, with the aim of ensuring patient safety and reducing the morbidity and mortality associated with infections related to the use of central venous catheters. It also points to the need for future research focused on new strategies to combat the formation of biofilms and the advance of antimicrobial resistance. Continued research into bacterial resistance and the evolution of biofilms is crucial to optimizing treatment and preventing infections in ICU environments.

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