

Factors associated with central venous catheter infection in critically ill patients

Abstract

Introduction: The study was conducted by analyzing 8 articles related to Central Venous Catheter Infections in critically ill patients in the Intensive Care Unit to analyze the factors associated with central venous catheter infection in critically ill patients.

Objectives: The main objective is to determine the incidence of central venous catheter infection and related factors by these routes in patients treated in the Intensive Care Unit.

Methodology: This systematic review was applied with Holly, it was carried out according to the eligibility criteria by means of the PIO question and with PRISMA methodology. Results. It was found that 70% of the results of the analysis of the studies refer to the proper use of the central venous catheter being related to insertion and maintenance and that the incidence of central venous catheter infection is based on prolonged ICU stay. **Conclusion:** The follow-up of general and specific protocols, with the introduction of verification routines that minimize the risk of error in a highly complex environment, must have the participation of all health personnel, including management bodies.

Recommendations: Show commitment from the management, administrative, and quality areas, to adequately monitor the processes and procedures for patient safety in the central venous catheter. Avoid unnecessarily prolonging catheter life and clearly define catheter insertion indications. Among the various factors that produce infection, the environment has to do with it, maintaining an adequate temperature inside the patient's cubicle or room to reduce the proliferation of organisms.

Keywords: central venous catheter, critical area nursing and critical patient, intensive care unit.

Volume 10 Issue 3 - 2024

Claudia Gabriela Esquivel Franco,¹ Cynthia Margarita Gonzalez Delgadillo,² Karla Nallely García Siller,³ Hermelinda Guzman Daniel,¹ Efrain Rios Sanchez,⁴ Javier Moran Martínez¹

¹Autonomous University of Coahuila, Mexico

²Mexican Social Security Institute, Mexico

³Institute of Social Security and Service for State Workers

⁴Ministry of Health, Mexico

Correspondence: Renata Adriana Labanca, Associate Professor, Faculty of Pharmacy (Department of Food), Federal University of Minas Gerais (UFMG), Brazil, Tel +5531991056145, Email Renatalabanca@ufmg.br

Received: September 01, 2024 | **Published:** September 16, 2024

Introduction

According to García Carranza,¹ central venous catheters (CVC) are devices with direct access to the bloodstream, so their improper handling is often the main cause of infection; since nursing staff is responsible for handling, it is necessary to implement strategies that allow improving nursing care, as well as the Pan American Health Organization (PAHO) mentions the adoption of scientifically based nursing interventions that guarantee the safety of the subject and care; Likewise, it states that the practice of nursing is a valuable resource for health, and for this resource to reach full development, nursing care must offer a competent and useful service for people who require it.¹ The World Health Organization's (WHO) Global Alliance for Patient Safety (GAPS) has established strategies to achieve safer healthcare² establishes compliance with specific measures to reduce the risk of associated infections during the insertion, maintenance and monitoring of CVCs; based on the fact that in 2008 alone it reached a prevalence of 4.8%, and is currently the cause of 10 to 15% of nosocomial infections.^{3,4} refers that The Joint Commission International believes that healthcare is facing a major challenge, as patients suffer some form of harm every day around the world. It therefore announces that solutions include avoiding errors in the connection of catheters and tubes, and invites the interprofessional health team to take preventive and corrective measures.⁴

By mutual agreement, The Centers for Disease Control, The Nurses Society and The Oncology Nursing Society, mention that one in five patients has a high risk of morbidity and mortality associated with

CVC infection,⁵ which is alarming and requires the implementation of interventions that guarantee quality care by the interprofessional health team, considering the risks to which patients are exposed and the need to achieve improvements, as well as the adoption of evidence-based measures.¹ According to data from the PAHO, Bacteremia Zero (BRC) is an important cause of morbidity and mortality, even though the burden of disease caused by these infections is unknown, since the data obtained are from specific studies, which only reflect specific situations. Experience shows that, in Latin America, only some countries have implemented adequate epidemiological surveillance, however, there is no database of updated records. The case of other countries is unfavorable, since they still do not have structured surveillance, which prevents them from integrating epidemiological surveillance with CVC care.⁶ Specifically in Mexico, the General Directorate of Epidemiology, through the Hospital Epidemiological Surveillance Network (RHOVE), reports an incidence of BRC of 7.9 and 6.5 episodes/1000 days/catheter in 2018 and 2019, respectively; the incidence is presented in relation to the effectiveness of nosocomial infection control programs, as reported by the National Cancer Institute (INCAN), with an incidence of less than two episodes/1000 days/catheter, and less than one episode/1000 days/catheter at the National Institute of Medical Sciences and Nutrition (INCMNSZ), permanently for more than 10 years.

At the Mexican Social Security Institute (IMSS) in the High Specialty Medical Unit (UMAE) within the epidemiological surveillance division, 3 cases of BRC are recorded from 2017 to 2019; an incidence of 3.5 to 2.9 is shown from 2017 to 2019

case/1000 days/catheter, there is a tendency towards a decrease through improvement in various elements of surveillance, prevention, and control of nosocomial infections in patients with central venous catheters.⁷ In accordance with the above, the General Health Council in conjunction with the Permanent Nursing Commission (CPE) have developed a series of initiatives that demonstrate the interest of nursing management staff in improving the safety of care offered to patients related to the insertion and care of CVC; these institutions incorporated the checklist indicator at a national level, which public, private and social health institutions measure and use to improve this practice.

Problem definition

Central venous catheter-associated infection is one of the top five causes of nosocomial infection with an incidence of 4.9-11.9 cases per thousand catheters inserted in the United States.⁸⁻¹²

Knowing the factors associated with central venous catheters is essential for nursing; they may be related to the type of catheter, the insertion site, and the experience of the professional who performs the insertion. Nursing is the health personnel who manipulates the catheter, monitors the catheter's permanence, administration of medications, and its characteristics. For this reason, it is important to carry out the incidence of infections related to central venous catheters, because more than 50% of cases with bacteremia are lethal and caused by various microorganisms that affect the health of critical patients in the ICU.

Research question

What are the factors associated with central venous catheter infection in critically ill patients in the Intensive Care Unit?

The main objective is to determine the incidence of central venous catheter infection and the factors related to these routes in patients treated in the Intensive Care Unit. The secondary objectives are to identify the factors associated with central venous catheter infection in critically ill patients in the Intensive Care Unit. To calculate the incidence of infection associated with central venous catheter management. To describe the epidemiological profile of the population with infection related to central venous catheter management.¹³

Frame theorist

Benner's model was used: the training theory. Benner was one of the first nurses to specialize in intensive care, and she also brought nursing into the field of care, clinical wisdom and ethics in nursing practice. The training theory is described as a process that nurses go through from the time they graduate until they specialize in a certain area. During this process, a series of changes and behaviors arise and skills are acquired that are part of professional performance, which is increasingly of better quality.¹⁴⁻¹⁷

Benner model has 5 levels

The first level refers to the beginner, referring to the person facing a new situation. This level applies to the inexperienced nurse in an unknown area or situation.

The second level refers to the beginner-advanced nurse who, after having acquired certain experiences, can develop more performance capabilities.

The third level is the competent nurse capable of imitating what is indicated or performing certain activities based on her experience.

The fourth level refers to the efficient nurse capable of perceiving a situation and safely performing activities based on her knowledge and skills involved with the critical patient.

The fifth level refers to the expert nurse, who has a complete command that generates the ability to identify a problem without wasting time in carrying out appropriate interventions for the immediate care of a critical patient, providing care with quality and care. There are difficulties in differentiating between the relevant and irrelevant aspects of a situation, for example the different factors that a central venous catheter infection presents; in this case it is applied to novice nurses in a certain area such as the Intensive Care Unit, who must face a situation or an area that is unknown to them. Nurses at this level follow certain rules and are guided by the tasks they must perform, having problems in mastering the current situation of the patient from a broader perspective.

Benner's theory states that nursing is a relationship of care during the process of interaction that occurs in an environment where it is reciprocal to help and be helped, this is based on morality and ethics. Nursing seeks the history of patients and in this way investigates their background. The person is a being who, during his or her life, develops different personality characteristics that are given by lived experiences; the body and the mind are independent, in such a way that the nurse focuses his or her care on the body. Health is defined as what can be perceived, while being healthy is the human experience of health or integrity. It refers to a situation, which is the environment in which the body is found at a given time or situation and is the interaction that occurs with the environment and with customs. Benner model is important for this systematic review, due to the nursing experience in the area of an Intensive Care Unit, that is, it is essential that care is provided by an expert nurse, because she has the appropriate experience and knowledge to carry out the function, and also identifies the situation in which a critical patient is found and carries out the appropriate treatment based on scientific knowledge. The expert nurse knows how to identify when a CVC presents some type of complication or infection and in turn must implement optimal care and management of the CVC in order to avoid these complications, this is based on her experience and empirical knowledge, recognizing the situation that a critical patient presents so that his health does not worsen.

Methodology

Research methodology involves systematization, that is, the organization of the steps through which scientific research will be carried out. The type of study carried out, the strategy for searching for scientific information (search databases, terms used in the search (thesauri), limiters, use of Boolean operators, inclusion and exclusion criteria for studies, use of tools for critical evaluation of scientific evidence) are detailed.

Study design

The type of study is a Systematic Review of studies focused on central venous catheter infection in the intensive care unit. It will be carried out according to the six steps of Holly, Salmond and Saimbert,¹⁸ which are appropriate for nursing practice and consists of:

- 1) formulate a question,
- 2) establish inclusion and exclusion criteria,
- 3) develop search strategies,
- 4) select articles to be included in the review,
- 5) extract data and
- 6) synthesize the data.

Eligibility criteria

This systematic review is based on a structured question PIO (Problem, Intervention, and Outcomes), where original articles of any study design were included, from 2017 to 2022, in English and Spanish, full text and open access, that address Central Venous Catheter Infections in critically ill patients in the Intensive Care Unit. Practice guidelines, case studies, narrative reviews, anecdotal reviews, and editorials were excluded.

Sources of information

The search was performed in the databases Redalyc, Scielo, Cuiden Plus, Medline, PubMed and Google Scholar where the terms used to search for different sources of information were: Central Venous Catheter, Related Infections, Risk Factors, Knowledge and Skills, respecting the established selection criteria; leaving a total of 8 articles as a sample for the present review.

Search strategy

A bibliographic search strategy was developed and carried out from January to May 2022, to obtain the best evidence the DeCSy descriptors were included MeSH CATHETERS AND CRITICAL CARE AND INFECTIONS. Using English and Spanish in all possible combinations, as well as Boolean operators: AND and OR, respecting the established selection criteria.

Selection of studies

The selection of studies was carried out according to the eligibility criteria, for which the bibliographic manager MENDELEY was used to organize the articles found, eliminate duplicates and articles that do not meet the established criteria. In addition, the PRISMA flow diagram was used to discriminate the articles found.

Data collection procedure

The information collection was prepared from the bibliographic review of national and international articles, whose essential content was Central Venous Catheter infections in critically ill patients in the Intensive Care Unit. Of all the academic works located, those of greatest importance will be included according to the level of evidence and those not relevant will be discarded.

PRISM

A bibliographic manager was used to discriminate the studies according to the prism flow diagram, where first the number of studies found with the search strategy in each of the databases and additional studies was counted, then the articles were eliminated by duplicates, then by titles and abstracts, resulting in the number of studies to be read in full text and to perform a critical reading.

Glossary of terms

Central venous access: Used to administer intravenous fluids, blood transfusions, chemotherapy, and other medications.

In: Nosocomial infections.

Antiseptic: Use of a chemical agent on the skin or other living tissue for the purpose of inhibiting or destroying microorganisms.

Antiseptic: Antimicrobial substance that opposes sepsis or putrefaction of living tissues.

Transparent Dressing: The sterile, adherent polyurethane film used to cover the catheter insertion site, allowing visibility and gas exchange.

Asepsis: Condition free of microorganisms that cause diseases or infections.

Catheter Asepsis: Procedure to keep the area or vascular access device (VAD) where the catheter is installed clean and free of contamination.

Bacteremia: The presence of viable bacteria in the blood.

Sterile: Condition that ensures a state free of microorganisms.

Term used to designate the thickness of long catheters and is expressed as (Fr).

Infection: The most frequent and important complication generated by the application of devices that interrupt the skin barrier and allow microorganisms to enter the bloodstream, acting as foreign agents.

Obstruction: disappearance of the lumen of the intraluminal catheter channel due to adhesions in its wall.

Catheter Perforation: Loss of continuity of the catheter causing the fluid to be infused to leak out.

Sterile Technique: Contamination-free procedure for installing a catheter.

Results

Selection of studies

1. Central venous catheter and its complications.

Shows the complications of central venous catheter installation, both ultrasound-installed and anatomically installed.

2. Bloodstream infection in patients with central venous catheter in intensive care units.

It shows that the hospitalization time of a patient with a central venous catheter and the incidence of bloodstream infection is different in relation to the use of antiseptics.

3. Current trends in infections associated with the use of central venous catheters.

It shows that the infection associated with the bloodstream is due to the handling and care of health personnel, in addition to the increased length of stay with said device.

4. Device-associated infection in intensive care unit.

Shows the comparison of infection rates of different invasive methods.

5. Prevalence of healthcare-associated infection in patients hospitalized in intensive care units.

It shows the prevalence rate of the epidemiological profile that affects patients in the intensive care unit, as well as the resistance to different antimicrobials.

6. Septic vasculitis as a manifestation of central venous catheter-associated bacteremia.

It shows the clinical case of the dermatological manifestations of bacteremia and the use of cephalosporins for its treatment.

7. Central venous catheter insertion and maintenance: evidence-based clinical recommendations.

It shows the processes of insertion and maintenance of the central venous catheter for the prevention of infections.

8. Demographic and technical factors and characteristics associated with bacteremia in patients with central venous catheter in the intensive care unit of the San Vicente Foundation University Hospital.

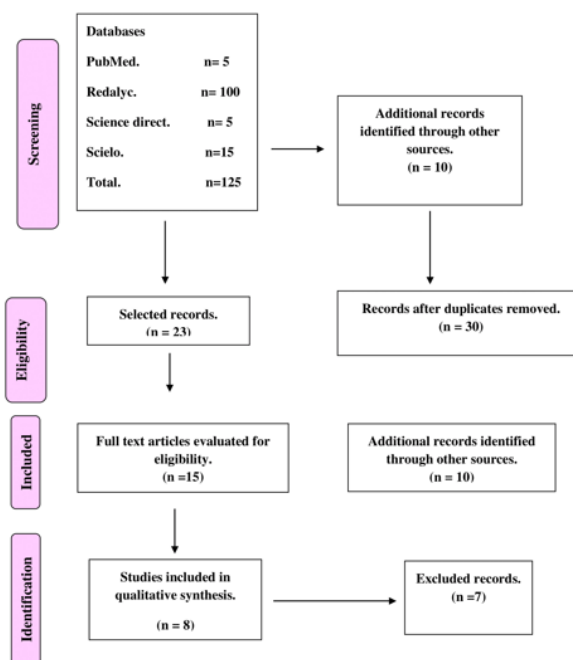
It shows the bacteremia associated with the central venous catheter according to its insertion location, most frequent age and most recurrent sex.

Summary of results

The study was conducted by analyzing 8 articles related to Central Venous Catheter Infections in critically ill patients in the Intensive Care Unit. Among the selected articles were found: 70% of the results of the analysis of the studies indicate that the proper use of the central venous catheter is related to insertion and maintenance. While 30% indicate that the most common CVC is the subclavian, but the one with the highest risk of infection is the one with its insertion site in the femoral area, followed by the jugular area lastly and with less incidence in the subclavian area. 70% of the incidence of central venous catheter infection is based on prolonged stay in the ICU. While 30% shows that bacteremia can be treated with antibiotic therapy. 20% of the articles mention that the epidemiological profile found in CVC is *Staphylococcus*, *klebsiella* and *Pseudomona*.

Discussion

The central venous catheter is an invasive method that goes directly into the bloodstream, according to what says, infections occur due to local infection at the insertion point, in addition to the placement axis. Compared to what mentions, complications between insertion by anatomical reference and ultrasound are more prevalent, complications and infections by anatomical placement than by ultrasound.¹⁹ refers to the epidemiological profile within the intensive care unit, which found gram-negative pathogens that cause infection, such as *klebsiella* and *Pseudomona*. While mentions that the pathogen found in the catheter shaft refers to *Staphylococcus*. It is important to mention that in order to try to combat these pathogens, the administration of certain medications is necessary, as mentioned by²⁰ which shows the use of vancomycin and cephalosporin to combat the infection, while shows that certain carbapenems, in addition to cephalosporins, help combat certain pathogenic groups, but a comparison is also made to the resistance to these medications.



Appendix A flowchart of systematic review of factors associated with central venous catheter infection in critically ill patients.

Conclusion

The present literature review allows us to identify the main risk factors, as well as the most common ones and their predisposing characteristics for infections associated with extravascular devices that can be grouped into extrinsic and intrinsic. Considering that nosocomial infections are preventable errors and knowing their incidence are essential requirements for their eradication. Infection prevention should be based on education and preparation for the practice and safety of healthcare personnel, and should ensure a team-based working environment in which interventions with the greatest evidence and the lowest implementation difficulty and cost are applied. The monitoring of general and specific protocols, with the introduction of verification routines that minimize the risk of error in a highly complex environment, should involve the participation of all healthcare personnel, including management bodies.

Recommendations

Demonstrate commitment from management, administrative and quality areas to adequately monitor processes and procedures for patient safety with central venous catheters. Carry out work in synergy, as part of an interdisciplinary team, basing the processes in direct relation to the patient in the management of the central venous catheter. Consider a specific area, specifically in the emergency area, for invasive procedures, such as the installation of a central venous catheter. It is recommended to perform selective and non-urgent catheter insertion, that is, to do it in a scheduled and supervised manner. Although the authors do not recommend specific measures to be implemented in case the catheter must necessarily be inserted urgently, as nursing professionals this would be a factor to take into

account within the follow-up and care of vascular access, especially from the point of view of the daily evaluation of the catheter indication, to be removed when the indication that motivated the installation ceases, it is a measure that has been seen to be implemented for all intravascular catheters, it is analyzed that it would be a point of greater relevance in these cases. The frequency of dressing changes should be carried out within a range of three to seven days, with no significant statistical evidence showing a lower risk of infection if performed on the third or seventh day, so compliance with this range is an adequate strategy, although it should always be adjusted to the patient's needs. It is recommended that the indication for inserting the catheter be periodically analyzed so that it can be removed when the indication ceases. Avoid unnecessarily prolonging the duration of catheters and clearly define the indications for their insertion. There are several factors that cause infection, including the environment and maintaining an adequate temperature inside the patient's cubicle or room to reduce the proliferation of organisms.

Perform proper asepsis of the insertion site each time dressing is performed.

Understand the characteristics of the catheter, make good use of each lumen, regarding its use (administration of medications, parenteral nutrition, number of blood draws, medical devices, hemodialysis). When installing the catheter, avoid applying organic solvents (acetone) or during the healing of the catheter. Use transparent dressings with chlorhexidine at each dressing to cover the insertion point and avoid moisture to reduce the risk of microorganism proliferation. Replace the dressing if it is wet, dirty, bloody, or peeling off. Do not use topical antibiotics at insertion sites due to the possibility of promoting antibiotic resistance and fungal infections. It is recommended that the equipment used for the administration of TPN (parenteral nutrition) should be changed within 24 hours following the start of the infusion. Monitor the closure of lumens when not in use.

Acknowledgments

None.

Conflicts of interest

The author declares that there are no conflicts of interest.

References

- García, GE Payá, CR Olivares, et al. Diagnosis of infections associated with central vascular catheters. 2017.
- Secretary of Health. Prevention, diagnosis and treatment of infections related to vascular lines. Mexico City: CENETEC. 2013.
- Service galician health. Bacteremia zero. Madrid Spain: Ministry of health and consumer affairs. 2018.
- Pan American health organization. Nursing services to combat the achievement of equity, access, quality and sustainability of health services. Medium term plan. 2011–2003. Washington; PAHO. 2010
- Pan American health organization. Health surveillance. Washington, DC. 2012
- World Health Organization. Foreword to solutions for patient safety. Geneva, Switzerland: WHO Press. 2007.
- Orozco KE, Cruz FC, Castillo DL, et al. Insertion and maintenance of central venous catheter: evidence-based clinical recommendations. *Colombia J Obstetric Gynecol.* 2020;71(2):115–162.
- Center for disease control. Department of Health and Human Services. USA. Guidelines for the prevention of intravascular catheter-related infections. 2018.
- Nursing practice. Report of an WHO expert committee. *World Health Organ Tech Rep Ser.* 1996;860:1–33.
- Pan American Health Organization. *Epidemiological surveillance of infections associated with health care in the puerperium. Module V.* 2015.
- World Health Organization. Cleaner care is safer care. Geneva, Switzerland: WHO. 2015.
- Undersecretariat for health prevention. Manual of standardized procedures for epidemiological surveillance. 2018.
- Mexican social security Institute. Prevention, diagnosis and treatment of infections related to vascular lines. Mexico City, Mexico; IMSS. 2018.
- Imigo F, et al. Central venous access. *Cir.* 2018;11(25):52– 58.
- Moher D, Altman DG Liberati A, et al. Statement PRISMA. *Epidemiology.* 2011;22(1):128.
- Stetler CB, Morsi D, Rucki S, et al. Utilization-focused integrative reviews in a nursing service. *Appl Nurs Res.* 1998;11(4):195–206.
- Jiménez RR, Arias AV, Guanache Garcell H, et al. Device-associated infection in an intensive care unit. Western Qatar. *Havana J Med Sci Med.* 2019;18(2):231–240.
- Holly C, Salmond S, Saimbert M. *Comprehensive systematic review for advanced nursing practice.* Springer publishing company. 2016.
- Araújo L, Mendonça PO, et al. Prevalence of healthcare-associated infection in patients hospitalized in intensive care units. *Global Nursing.* 2018;17(52):278–290.
- Velarde EC, Canales WC. Septic vasculitis as a manifestation of bacteremia associated with central venous catheter. *J Nephrol Dialysis Transplant.* 2022;42(3):257–259.