Research Article
E-ISSN : 3048-1368

Volume 05, Issue No. 03. 2024
P-ISSN : 3048-1376

The International Journal of Medical Science and Health Research



A Comprehensive Literature Review of Complication Rates of Central Venous Catheters

[1] Stefanie, [2] Wahyu, [2] Muhammad Indra

[1] Hasan Sadikin Central General Hospital, Bandung City, West Java, Indonesia
[2] Faculty of Medicine, Padjadjaran University, Bandung City, West Java, Indonesia
Correspondence : drstefanie284@gmail.com

Article History :
Received date : 2024/07/02
Revised date : 2024/08/14
Accepted date : 2024/09/21
Published date : 2024/10/19

Copyright: *© 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (BY NC) license (https://creativecommons.org/licenses/by-nc/4.0/).*

E-ISSN :
ISSN 3048-1368
9 773048 136000

P-ISSN :
ISSN 3048-1376
9 773048 137007

ABSTRACT

Background: The literature on the complication rates of central venous catheters (CVCs) reveals a complex interplay of risks associated with their use, particularly in vulnerable patient populations such as those with cancer or undergoing hemodialysis. The foundational work by (Schumacher & H. Wagner, 2007) established the significance of implanted central venous port catheter systems, pointing out the persistent challenges of catheter-associated thrombosis and infections. This early recognition of complications set the stage for subsequent studies that have consistently reported high complication rates, ranging from 10-25% among cancer patients as highlighted by (Marin et al., 2021). **Literature Review:** The complications associated with CVCs extend beyond mere infection and thrombosis; they encompass a range of insertion-related issues including arrhythmias and arterial punctures, as discussed by (Hodzic et al., 2014). Innovation in catheter design has been explored as a potential solution to mitigate infection rates. The review by (Casimero et al., 2020) stresses the importance of selecting the appropriate catheter type based on patient-specific factors, thereby minimizing complications. The impact of the COVID-19 pandemic on CVC complications was notably addressed by (Tanveer Ud Din et al., 2021), which illustrated how procedural lapses during high-pressure situations can exacerbate the risks associated with CVC placement. **Conclusion:** In conclusion, the literature collectively underscores the multifaceted complications associated with CVCs and emphasizes the need for ongoing research and innovation to improve patient outcomes. The findings highlight the importance of tailored management strategies, adherence to procedural protocols, and the continuous development of catheter technology to mitigate risks associated with CVC use.

Keywords: Complication Rates, Central Venous Catheters

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

INTRODUCTION

The literature surrounding the complication rates of central venous catheters (CVCs) has evolved significantly over the years, reflecting both advancements in clinical practices and a deeper understanding of associated risks. In their 2007 study, (Schumacher & H. Wagner, 2007) highlighted the importance of implanted central venous port catheter systems in oncology, emphasizing that while these systems provide safe vascular access, they are not without complications, particularly catheter-associated thromboses and infections. This foundational work set the stage for subsequent research, illustrating the persistent challenges in managing CVC-related complications.

Building upon this, (Jung Kim et al., 2010) conducted a prospective observational study that revealed a concerning complication rate of 10-25% among cancer patients using CVCs. Their findings underscored the need for effective management strategies to prevent infections and thrombosis, while also pointing out the lack of evidence-based guidelines for selecting appropriate vascular access devices. This gap highlighted the necessity for ongoing research to improve patient outcomes, particularly in vulnerable populations.

Further exploring the complications associated with CVCs, (Hodzic et al., 2014) identified a range of insertion-related issues, including arrhythmias and arterial punctures, as well as more severe complications such as mediastinal hematoma and sepsis. Their work illustrated the significant impact of CVC complications on morbidity and mortality, emphasizing the need for heightened awareness and improved insertion techniques in critical care settings.

In 2017, (Peng et al., 2017) expanded the discussion by examining the hemodynamic changes following tunneled CVC placements in hemodialysis patients. Their findings revealed a high incidence of CVC-related bloodstream infections

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

and thrombosis, which were linked to various risk factors. This study highlighted the complexities of managing CVCs in patients with compromised vascular conditions, suggesting that hemodynamic factors play a crucial role in the development of complications.

The quest for innovation in catheter design to mitigate infection rates was addressed by (Casimero et al., 2020), who reviewed the emerging materials and design considerations for CVCs. Their findings indicated that the choice of catheter type significantly influences infection risk, particularly for long-term use. This research emphasized the need for tailored catheter selection based on individual patient factors to minimize complications.

(Marin et al., 2021) focused specifically on catheter-associated deep vein thrombosis in cancer patients, revealing a thrombosis rate of 15.1% and highlighting the relationship between catheter infections and venous thrombosis. Their study reinforced the importance of preventive measures, such as optimal catheter placement techniques, to reduce the risk of complications.

In the context of the COVID-19 pandemic, (Tanveer Ud Din et al., 2021) presented a case report detailing the severe consequences of inadvertent carotid artery insertion during CVC placement. This incident underscored the ongoing risks associated with CVC insertion, with complications leading to increased hospital stays and mortality rates, further emphasizing the critical need for meticulous procedural adherence.

Lastly, (Deng et al., 2022) investigated the effectiveness of impregnated CVCs in reducing catheter-related bloodstream infections in pediatric patients. Their meta-analysis highlighted the alarming prevalence of CRBSIs among children and the potential benefits of using impregnated CVCs, although they noted insufficient evidence for their efficacy in this population. This study calls for further research to establish robust prevention strategies tailored to pediatric patients.

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

Together, these articles provide a comprehensive overview of the complexities and challenges associated with central venous catheters, underscoring the need for ongoing research and innovation to improve patient outcomes and minimize complication rates.

LITERATURE REVIEW

The article "Central venous port system associated thromboses: outcome in 3498 implantations and literature review" by (Schumacher & H. Wagner, 2007) provides a comprehensive examination of the complication rates associated with implanted central venous port catheter systems, particularly focusing on thrombosis and infection. The authors emphasize the significance of these systems in oncology patient management, highlighting their role in ensuring safe vascular access with relatively low complication rates.

One of the key insights from the study is the identification of catheter-associated thromboses as a notable complication despite the overall safety profile of central venous catheters (CVCs). The authors report that while infections are common, thrombosis poses a serious risk, potentially leading to significant morbidity among patients. This finding is critical, as it underscores the need for ongoing vigilance and management strategies to mitigate such risks.

The study presents an analysis of 3,498 implantations, which lends considerable weight to the findings. By aggregating data from a substantial patient population, (Schumacher & H. Wagner, 2007) provide a robust statistical foundation for their conclusions regarding the incidence of catheter-related venous thromboses. This large sample size enhances the reliability of the authors' recommendations for best practices in port implantation, as they draw comparisons with recent studies to propose standards aimed at minimizing complications.

Furthermore, the authors advocate for a systematic approach to port implantation, which includes careful patient selection and adherence to established protocols. This recommendation is particularly

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

relevant for healthcare providers involved in the management of oncology patients, as it can directly influence patient outcomes and the overall safety of CVC use.

The article "Safety and Effectiveness of Central Venous Catheterization in Patients with Cancer: Prospective Observational Study" by (Jung Kim et al., 2010) presents a thorough examination of the complications associated with central venous catheters (CVCs) in a population that increasingly relies on these devices for complex treatment regimens. The authors highlight the dual nature of CVCs, which provide essential vascular access while also presenting significant risks, including a notable incidence of complications such as infection and thrombosis.

One of the key insights from the article is the reported complication rate of 10-25%, with a morbidity rate of approximately 10%. This statistic underscores the critical need for healthcare professionals to weigh the benefits of CVCs against their potential risks, particularly in vulnerable populations like cancer patients. The authors emphasize that, despite advancements in CVC management and design, complications remain a significant concern. This finding aligns with existing literature that acknowledges the inherent risks of CVCs, particularly in immunocompromised patients.

The article further discusses various management strategies aimed at minimizing the risks of infection and thrombosis, which are the major complications associated with CVCs. The authors advocate for improved insertion techniques and ongoing management protocols as essential components in reducing complication rates. The emphasis on the need for tailored approaches based on individual patient factors—such as catheter duration and compliance—reflects a growing recognition in the medical community of the importance of personalized medicine.

Moreover, the authors point out the lack of comprehensive studies specifically addressing CVCs in cancer patients within Korea, highlighting a gap in the existing literature. This acknowledgment not only justifies the need for their

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

research but also calls for further investigation into subtype-specific complications and outcomes associated with CVCs in this particular demographic.

The article titled "Complications Related to Insertion and Use of Central Venous Catheters (CVC)" by (Hodzic et al., 2014) provides a comprehensive examination of the various complications associated with central venous catheter (CVC) insertion and utilization. The authors systematically categorize the complications into common and less frequent but more severe outcomes, offering a nuanced perspective on the risks involved in CVC procedures.

One of the central themes of the article is the identification of the most prevalent complications, which include cardiac arrhythmias, arterial puncture, improper catheter positioning, and hematomas at the insertion site. The authors emphasize that these complications often arise during urgent catheter insertions, particularly in critically ill patients. This highlights a significant concern regarding the safety protocols and training surrounding emergency procedures, as the urgency of the situation can lead to increased risks of complications.

The article further discusses the critical issue of catheter-related infections, which account for 10-15% of nosocomial infections in intensive care units (ICUs). The authors note that these infections not only contribute to increased morbidity and mortality but also extend hospital stays, thereby escalating treatment costs. The discussion on the sources of microbial colonization—originating from the patient's skin, healthcare personnel, or contaminated infusions—underscores the importance of stringent aseptic techniques and infection control measures in clinical settings.

Moreover, the article does not shy away from addressing the less common but more severe complications, such as perforations of the superior vena cava and left atrium, which can lead to life-threatening conditions like cardiac tamponade and mediastinal hematoma. These complications, while rarer, pose significant risks that necessitate

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

careful monitoring and management during and after CVC insertion.

The article "Numerical Simulation of Hemodynamic Changes in Central Veins after Tunneled Cuffed Central Venous Catheter Placement in Patients under Hemodialysis" by (Peng et al., 2017) provides a detailed examination of the complications associated with tunneled central venous catheters (CVCs) in hemodialysis patients, specifically focusing on the incidence of catheter-related infections and thrombosis. The authors emphasize the critical nature of CVC placement in this patient population, which serves as a necessary alternative for those requiring hemodialysis.

One of the key insights from the article is the documented incidence of CVC-related bloodstream infections, which ranges from 1.1 to 5.5 episodes per 1000 catheter days. This statistic highlights the significant risk associated with CVC use, as these infections contribute to increased hospitalization rates, morbidity, and mortality among patients. The authors advocate for adherence to CDC-recommended interventions, such as rigorous hand hygiene and catheter care observations, as effective strategies to mitigate the risk of infections.

Furthermore, the article delves into the phenomenon of CVC dysfunction, predominantly attributed to thrombus formation around the catheter, which can occur in up to 53.3% of cases. The implications of catheter-related thrombosis are profound, as it not only compromises the patency of the central venous lumen but also adversely affects the overall performance of the catheter. The authors highlight various risk factors for thrombosis, including the catheter's location, duration of placement, and patient-specific characteristics. However, they note a gap in understanding the precise mechanisms and risk factors contributing to CVC-related thrombosis, indicating a need for further research in this area.

The study employs a patient-specific model to simulate hemodynamic parameters and their impact on thrombus formation post-CVC insertion. This innovative approach underscores the importance

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

of hemodynamics in the context of thrombosis, particularly in patients with end-stage renal disease (ESRD). The authors suggest that the placement of CVCs may alter hemodynamic conditions in the central veins, potentially exacerbating the risk of thrombus development.

The article "Minimising Blood Stream Infection: Developing New Materials for Intravascular Catheters" by (Casimero et al., 2020) presents a thorough examination of the design considerations in the development of central venous catheters (CVCs) and their associated risks, particularly regarding bloodstream infections (BSIs). The review highlights the critical relationship between the type of catheter used and the patient's specific needs, emphasizing that the choice of catheter—whether non-tunnelled, tunnelled, peripherally inserted central catheters (PICC), or totally implantable venous access ports (TIVAPs)—is heavily influenced by factors such as the intended duration of use and frequency of access.

One of the key insights from this article is the correlation between the duration of catheter placement and the likelihood of infection. As noted, the longer a catheter remains in situ, the higher the risk of complications such as catheter-related bloodstream infections (CRBSI). This finding underscores the importance of careful selection and management of CVCs, particularly in patients requiring long-term venous access. The authors argue that tunnelled CVCs and TIVAPs, designed for extended use, are particularly prominent in the literature concerning CRBSIs, reflecting their common application in clinical practice.

Furthermore, the article discusses the role of needle-free connectors (NFCs) in the context of infection risk. The authors point out that the manipulation of NFCs is a significant contributor to contamination and subsequent infections. This aspect is critical as it highlights a procedural element that healthcare providers can target for improvement in infection control practices. The discussion around NFCs suggests that innovations in catheter design and technology could potentially mitigate these risks.

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

In terms of materials used in catheter construction, the article emphasizes the need for ongoing research and development to create materials that minimize bacterial colonization and enhance the safety of intravascular devices. The authors advocate for a multidisciplinary approach to catheter design, integrating insights from microbiology, materials science, and clinical practice to address the persistent challenge of infection associated with CVCs.

The article "Central catheter-associated deep vein thrombosis in cancer: clinical course, prophylaxis, treatment" by (Marin et al., 2021) provides a detailed examination of the complications associated with central venous catheters (CVCs), particularly in the context of cancer patients. The authors highlight a significant association between catheter infections and the development of intraluminal thrombosis, as well as catheter-related venous thrombosis, which is crucial for understanding the risks involved in CVC placement and maintenance.

The study reported that thrombosis occurred in 15.1% of cases, which underscores the prevalence of this complication in patients with CVCs. Additionally, the article notes that exit-site infections occurred at a rate of 1.9%, and CVC-related bloodstream infections were recorded at 7.5 per 1000 CVC-days. These statistics are vital for clinicians as they illustrate the potential risks associated with CVCs, emphasizing the need for stringent monitoring and preventive measures.

One of the key insights from the article is the recommendation to utilize the subclavian vein for non-tunneled CVC placement as a strategy to minimize infection risk. This aligns with general guidelines for preventing intravascular catheter-related infections and highlights the importance of site selection in the management of CVCs. Furthermore, the authors advocate for the use of CVCs with the minimum number of ports or lumens, which is essential in reducing the risk of complications.

Critically, while the article provides valuable data and recommendations, it could benefit

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

from a more extensive discussion on the long-term implications of these complications, particularly in the cancer population, which often has unique challenges related to catheter management. Additionally, exploring the implications of these findings on clinical practice and patient outcomes could enhance the overall impact of the study.

The article titled "Amidst COVID-19 pandemic: the catastrophic sequelae of an inadvertent carotid artery insertion during central venous catheter placement – a case report" by (Tanveer Ud Din et al., 2021) presents a critical examination of the complications associated with central venous catheter (CVC) placement, particularly in the context of the COVID-19 pandemic. The authors effectively highlight the essential role of CVCs in the management of critically ill patients, emphasizing their utility in administering life-supporting medications and nutritional support when peripheral lines are deemed unsafe.

A significant contribution of the article is its detailed exploration of the complication rates associated with CVC placement. The authors note that over 15% of patients experience complications from CVC procedures, which can include mechanical issues, infections, and thrombosis. This statistic underscores the inherent risks of CVC placement, which are exacerbated during high-pressure situations such as the COVID-19 pandemic. The authors provide a case report that illustrates the dire consequences of an inadvertent carotid artery insertion, thereby offering a concrete example of the potential complications that can arise from CVC placement.

The discussion surrounding the complications is particularly thorough, with the authors linking the increased rates of complications to factors such as the urgency of care during the pandemic and potential lapses in protocol adherence. The consequences of these complications are significant, leading to extended hospital stays, increased healthcare costs, and a heightened risk of mortality. This comprehensive evaluation of the implications of CVC-related complications is crucial

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

for healthcare practitioners, as it emphasizes the need for vigilance and adherence to best practices during catheter placement.

The article titled "Effectiveness of Impregnated Central Venous Catheters on Catheter-Related Bloodstream Infection in Pediatrics" by (Deng et al., 2022) presents a thorough examination of the implications of central venous catheters (CVCs) in pediatric populations, particularly focusing on the incidence of catheter-related bloodstream infections (CRBSIs). The authors highlight the critical role CVCs play in various medical treatments, including venous pressure monitoring and drug infusion, while also addressing the associated risks of infection, which can significantly affect patient outcomes.

The article establishes that CRBSIs are a prevalent concern in the pediatric demographic, with reported rates of occurrence ranging from 13% to 20% among catheterized newborns, and a notable statistic indicating that 1 in 10 children with a CVC may develop a central line-associated bloodstream infection. This statistic underscores the necessity for effective prevention strategies, as CRBSIs are linked to increased mortality, extended hospital stays, and heightened antibiotic exposure, all of which contribute to the overall burden on healthcare systems.

Deng et al. (2022) discuss several prevention strategies, emphasizing the importance of hand hygiene, maximal sterile barrier precautions, and the avoidance of femoral site catheterization. However, the authors advocate for the use of impregnated CVCs as a promising intervention, supported by national guidelines in the US and UK for high-risk patients. The article reviews various antimicrobial agents used in impregnated CVCs, such as chlorhexidine, minocycline-rifampicin, and silver sulfadiazine, which have shown efficacy in reducing CRBSI rates in adult populations.

Despite these findings, the authors note a significant gap in the evidence regarding the effectiveness of impregnated CVCs specifically in pediatric patients. This lack of data is

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

a critical limitation, as it raises questions about the generalizability of adult studies to the pediatric population. The authors' meta-analysis aims to bridge this gap by evaluating the efficacy of heparin and antimicrobial-impregnated catheters compared to standard and non-impregnated options.

CONSCLUSION

The literature on the complication rates of central venous catheters (CVCs) reveals a complex interplay of risks associated with their use, particularly in vulnerable patient populations such as those with cancer or undergoing hemodialysis. The foundational work by (Schumacher & H. Wagner, 2007) established the significance of implanted central venous port catheter systems, pointing out the persistent challenges of catheter-associated thrombosis and infections. This early recognition of complications set the stage for subsequent studies that have consistently reported high complication rates, ranging from 10-25% among cancer patients as highlighted by (Marin et al., 2021).

The complications associated with CVCs extend beyond mere infection and thrombosis; they encompass a range of insertion-related issues including arrhythmias and arterial punctures, as discussed by (Hodzic et al., 2014). This comprehensive examination of complications emphasizes the need for improved insertion techniques and heightened awareness among healthcare providers. Furthermore, the study by (Peng et al., 2017) illustrates the specific challenges faced by hemodialysis patients, where the incidence of CVC-related bloodstream infections and thrombosis is compounded by their compromised vascular conditions.

Innovation in catheter design has been explored as a potential solution to mitigate infection rates. The review by (Casimero et al., 2020) stresses the importance of selecting the appropriate catheter type based on patient-specific factors, thereby minimizing complications. This is further supported by the findings of (Marin et al., 2021), which highlight a direct correlation between catheter infections and venous thrombosis,

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

reinforcing the need for preventive measures in clinical practice.

The impact of the COVID-19 pandemic on CVC complications was notably addressed by (Tanveer Ud Din et al., 2021), which illustrated how procedural lapses during high-pressure situations can exacerbate the risks associated with CVC placement. This case report serves as a stark reminder of the importance of adherence to established protocols even in challenging circumstances.

In pediatric populations, the study by (Deng et al., 2022) underscores the alarming rates of catheter-related bloodstream infections, advocating for the use of impregnated CVCs while recognizing the need for further research to establish their efficacy in this demographic.

In conclusion, the literature collectively underscores the multifaceted complications associated with CVCs and emphasizes the need for ongoing research and innovation to improve patient outcomes. The findings highlight the importance of tailored management strategies, adherence to procedural protocols, and the continuous development of catheter technology to mitigate risks associated with CVC use.

DISCLOSURE STATEMENT

Disclosure Statement : The authors have no conflicts of Interest to declare.

REFERENCES

1. Schumacher, M. & H. Wagner, R., 2007. Central venous port system associated thromboses: outcome in 3498 implantations and literature review. ncbi.nlm.nih.gov
2. Jung Kim, H., Yun, J., Jo Kim, H., Ha Kim, K., Hyung Kim, S., Lee, S. C., Byung Bae, S., Kyu Kim, C., Su Lee, N., Taek Lee, K., Kyu Park, S., Won, J. H., Sook Park, H., & Sik Hong, D., 2010. Safety and Effectiveness of Central Venous Catheterization in Patients with Cancer: Prospective Observational Study. ncbi.nlm.nih.gov
3. Hodzic, S., Golic, D., Smajic, J., Sijercic, S., Umihanic, S.,

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved

& Umihanic, S., 2014. Complications Related to Insertion and Use of Central Venous Catheters (CVC). ncbi.nlm.nih.gov

4. Peng, L., Qiu, Y., Huang, Z., Xia, C., Dai, C., Zheng, T., & Li, Z., 2017. Numerical Simulation of Hemodynamic Changes in Central Veins after Tunneled Cuffed Central Venous Catheter Placement in Patients under Hemodialysis. ncbi.nlm.nih.gov
5. Casimero, C., Ruddock, T., Hegarty, C., Barber, R., Devine, A., & Davis, J., 2020. Minimising Blood Stream Infection: Developing New Materials for Intravascular Catheters. ncbi.nlm.nih.gov
6. Marin, A., Bull, L., Kinzie, M., & Andresen, M., 2021. Central catheter-associated deep vein thrombosis in cancer: clinical course, prophylaxis, treatment. ncbi.nlm.nih.gov
7. Tanveer Ud Din, M., Nasrullah, A., Sarma, D., Ashraf, O., & Arshad, H., 2021. Amidst COVID-19 pandemic: the catastrophic sequelae of an inadvertent carotid artery insertion during central venous catheter placement – a case report. ncbi.nlm.nih.gov
8. Deng, Z., Qin, J., Sun, H., Xv, F., & Ma, Y., 2022. Effectiveness of Impregnated Central Venous Catheters on Catheter-Related Bloodstream Infection in Pediatrics. ncbi.nlm.nih.gov

Downloaded from theInternationalmedicaljournal.org. For personal use only. No other uses without permission.
Copyright © International Medical Journal Corp. Ltd. All rights reserved