

Adherence to central venous catheter maintenance bundle and analysis of primary bloodstream infection rates in an intensive care unit in Southern Brazil

Adesão ao *bundle* de manutenção de cateteres venosos centrais e análise das taxas de infecção primária de corrente sanguínea em uma unidade de terapia intensiva no Sul do Brasil

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ABSTRACT

Introduction: Central Line-Associated Bloodstream Infection (CLABSI) are associated with unfavorable health outcomes, particularly in critically ill patients. These events can be preventable through adequate maintenance of devices by a multidisciplinary team. The closed infusion system integrates the venous catheter (CVC) maintenance bundle recently adopted in the Intensive Care Unit (ICU) to reduce complications related to central venous catheters, especially infections. **Objective:** To evaluate adherence to the CVC maintenance bundle measures in the ICU and relate it to PBSI rates. **Method:** Quantitative cross-sectional study, carried out in an ICU of a public hospital in Southern Brazil. Seven bundle adherence practices were observed in September and October/2022. To assess compliance with practices, the Carter Positivity Index was used. **Results:** 322 CVC evaluations were performed. The practice with the greatest compliance was valid CVC dressing (97%); 78% of observations showed $\geq 80\%$ adherence to the bundle, indicating safe assistance. The CRBSI rate decreased from 7.0/1000 catheter/day from 2019 to 2020 to 6.7/1000 catheter/day in 2021 and 2022, without statistical significance ($p=0.351$). Compared with the post-implantation period, there was a tendency for CRBSI rates to decrease $[-0.1$ (95% CI $-0.42 - 0.21$)] ($p=0.522$). **Conclusion:** The results made it possible to evaluate adherence to measures relating to the CVC maintenance bundle and, thus, the quality of nursing care and weaknesses to be addressed with the teams. Adequate adherence to the bundle positively impacts care and will serve as one of the pillars for reducing CRBSI in ICUs.

KEYWORDS: Catheter-Related Infections; Patient Care Bundles; Nursing Care; Cross Infection; Intensive Care Units

RESUMO

Introdução: Infecções primárias de corrente sanguínea relacionadas ao cateter (IPCS-CVC) estão associadas a desfechos desfavoráveis em saúde, particularmente nos pacientes críticos. São eventos evitáveis por meio da manutenção adequada dos dispositivos pela equipe multiprofissional. O sistema infusional fechado compõe o *bundle* de manutenção dos cateteres venosos (CVC) recentemente adotado na unidade de terapia intensiva (UTI) visando à redução das complicações relacionadas aos CVC, principalmente as infecções. **Objetivo:** Avaliar a adesão às medidas do *bundle* de manutenção de CVC na UTI e relacioná-la às taxas de IPCS-CVC. **Método:** Estudo transversal quantitativo, realizado em uma UTI de um hospital público no Sul do Brasil. Foram observadas sete práticas de adesão ao *bundle* em setembro e outubro/2022. Para avaliar a conformidade das práticas, foi utilizado o Índice de Positividade de Carter. **Resultados:** Foram realizadas 322 avaliações de CVC. A prática

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com maior conformidade foi curativo válido de CVC (97%); 78% das observações apresentaram $\geq 80\%$ de adesão ao *bundle*, indicando assistência segura. A taxa de IPCS-CVC reduziu de 7,0/1.000 cateter/dia de 2019 a 2020 para 6,7/1.000 cateter/dia no período de 2021 a 2022, sem significância estatística ($p = 0,351$). Em comparação ao período pós-implantação, há uma tendência à diminuição das taxas de IPCS-CVC $[-0,1$ (IC95% $-0,42$ - $0,21$)] ($p = 0,522$). **Conclusões:** Os resultados possibilitaram avaliar a adesão das medidas referentes ao *bundle* de manutenção de CVC e, assim, a qualidade da assistência de enfermagem e fragilidades a serem trabalhadas com as equipes. A adequada adesão ao *bundle* impacta positivamente a assistência e servirá como um dos pilares para a diminuição de IPCS-CVC nas UTIs.

PALAVRAS-CHAVE: Infecções Relacionadas a Cateter; Pacotes de Assistência ao Paciente; Cuidados de Enfermagem; Infecção Nosocomial; Unidades de Terapia Intensiva

INTRODUCTION

It is estimated that around 90% of hospitalized patients have a vascular access device¹. According to the indications and profile of the patients, intensive care units (ICUs) have most short-stay central venous catheters (CVCs), as critically ill patients often require vaso-active drugs, volume expanders, blood products, administration of vesicant medications, drug incompatibilities, parenteral nutrition, and dialysis therapies².

Central Line-Associated Bloodstream Infection (CLABSI) are part of healthcare-associated infections (HAIs) and are closely linked to negative outcomes in the healthcare context, such as mortality, increased length of stay and hospital costs related to treatment³, especially in ICU patients, due to the high rate of CVC use⁴. The multicenter Brazilian Surveillance and Control of Pathogens of Epidemiological Importance (SCOPE) study, which included 2,563 patients from 16 hospitals, has shown a mortality rate of 40% among patients with CLABSI⁵.

The reduction in CLABSI outcomes is directly influenced by the adoption of adherence measures for proper device maintenance. A systematic review, which analyzed 34 studies, has shown that care developed by teams in the form of bundles, combined with continuing education, can reduce CLABSI rates significantly⁶.

After insertion of the device, care for its maintenance is mainly carried out by the nursing team, with some care being the sole responsibility of the nurse. The implementation of maintenance bundles - which include hand hygiene, inspection of the insertion site, changing dressings, disinfecting connections and administering medication, using valved connectors, and flushing - are responsible for reducing complications related to the length of time the device is left in place^{2,7}.

The implementation of a closed infusion system is a way of minimizing excessive manipulation of CVCs. These actions include: the use of valved connectors; the standardization of infusions in specific access routes; the scheduled change of the infusion system on fixed days of the week, respecting the precepts of infection control; and the manipulation of the catheter hub exclusively by nurses.

Faced with the problem of CLABSI and its consequent negative outcomes, the ICU in this study, which already carried out the checklist during catheter insertion, implemented the closed

infusion system as an additional measure to the CVC maintenance bundle, to prevent CLABSI in during patient care and reduce complications related to CVC use.

In addition, monitoring indicators of adherence to the bundle and of CLABSI rates is an important strategy for identifying gaps and provides information for the development of continuing education activities aimed at improving the quality of care. As a result of the new process adopted by the institution, the objective of this study is to assess adherence to the measures in the CLABSI prevention bundle in the ICU and relate it to CLABSI rates.

METHOD

This is a cross-sectional study, with a quantitative approach, carried out in a level III ICU of a public hospital in southern Brazil, which has 59 beds and treats clinical and surgical patients. The implementation of the closed infusion system began in July 2021 and was extended to all ICU beds between August and September of the same year. The first few months were considered to be a period of adaptation and a learning curve for the professionals and were, therefore, not included in data collection.

The nursing team was trained in the care areas and in educational activities practiced by the nurses responsible for changing the routine. Support materials were also developed for quick reference, which were disseminated through the media already used by the service.

The sample size for estimating adherence to the bundle was calculated using the online version of the PSS Health tool. Considering a 95% confidence level, Wald's method for estimating the confidence interval and an expected proportion of adherence to the bundle of 75%, 289 observations were obtained; adding 10% of possible losses, the sample size resulted in 322 observations⁸. Observations of all CVCs of patients admitted to the ICU were included, regardless of the patients' sociodemographic and clinical characteristics. Observations of CVCs of patients admitted during the observation shift or in conditions that made evaluation impossible (exams and procedures) were excluded.

Data collection took place in September and October 2022 by the main researcher, who at the time was a resident at the



service, trained by the nurses responsible for implementing the bundle. Data on adherence to the bundle was collected on site, on two days of the week, to include the evaluation one day after the standard change of the infusion system, according to the institution's protocol, and also in electronic medical records. Data related to the incidence of CLABSI was provided by the Hospital Infection Control Commission (CCIH) of the study institution.

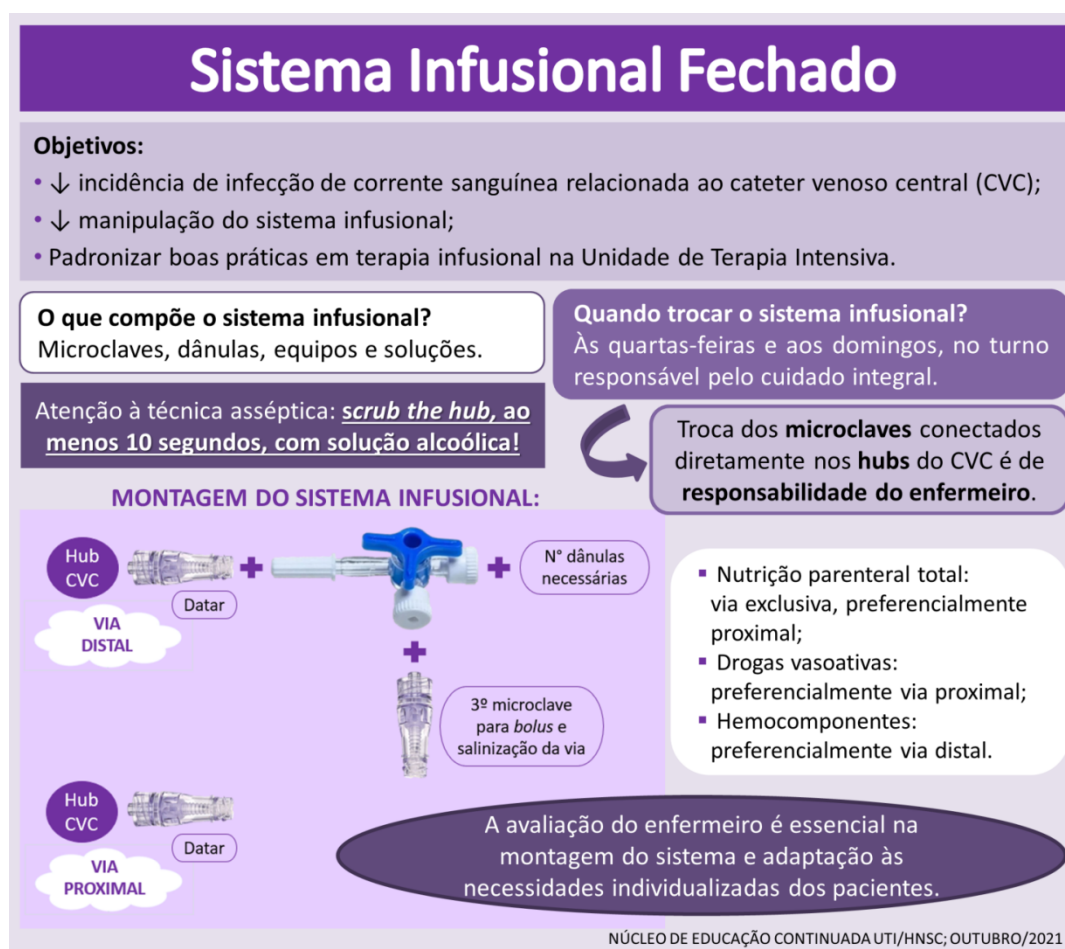
Seven bundle adherence practices were observed: dated and valid valved connectors (four days)³; dated and valid infusions (depending on the solution); assembly of the infusion system according to the institutional protocol⁸ (Figure 1); adequate number of cannulas according to continuous infusions of the medical prescription; flushing the equipment with saline solution after intermittent infusions (taking into account the evolution in the medical records and entering the volume in the water balance); intact and valid CVC dressings (gauze and sterile film for 48 hours; sterile film for seven days)³.

The practices observed include those related to the systematization of care, since the standardization of the closed system takes place through the assessment of the medical prescription by the

nurse who will be installing the system, as well as the integrity of the dressings and infusions, all of which are assessed or carried out directly by the nurse or by the technical team under their supervision. Hand hygiene is part of the bundle and, given its significance, is assessed using its own indicator, in observations made by the sector itself and also by the CCIH.

In order to establish the conformity of the practices evaluated, Carter's Positivity Index (PI)^{10,11} was used and consisted of the following criteria: when the practice analyzed had 100% accuracy or conformity, it corresponds to desirable care; from 99 to 90%, adequate care; from 89% to 80%, safe care; from 79% to 70%, borderline care; and less than 70%, undesirable or poor care. Following these criteria, the expected compliance for this study was set at PI > 80%, which corresponds to safe care.

The Statistical Package for the Social Sciences software v. 20.0 was used to analyze the data. Categorical variables were expressed as absolute numbers and percentages. The relationships between the infection rate variables were analyzed using Pearson's chi-square test according to the distribution of the data. From the slope estimated for each line



Source: Continuing Education Center⁹.

Figure 1. Proper assembly of the infusion system according to the institutional protocol.



segment (regression coefficient), the variation in rates per period and their statistical significance were calculated, estimated by the generalized linear model, assuming that the rates follow a Poisson distribution. A p -value < 0.05 was considered statistically significant.

The study followed the guidelines and regulatory standards for research involving human beings and was approved by the Ethics and Research Committee of the participating institution, under No. 57595722.0.0000.5530. As this was a study with secondary data collection, a term of commitment was used for the use of data.

RESULTS

Between September and October 2022, 322 inpatient CVC assessments were carried out. Table 1 shows the individual compliance rates for each of the practices analyzed.

The practice that achieved the highest compliance was the presence of valid CVC dressings during the observation days, in 315 (97.8%), followed by dated and valid valved connectors with 91.9% adherence, classified as adequate care according to PI criteria. Considering the overall rate of adherence to the bundle, among the 322 evaluations in the period, 251 (78%) had a compliance rate of $> 80\%$, indicated as safe care practice.

The practice with the lowest adherence rate was flushing the equipment, with 120 (52.9%) adequate observations, indicating undesired care. Other data is shown in Table 2, analyzed using PI.

Figure 2 shows incidence densities of CLABSI from 2019 to 2022, structured by month, and analyzed in the pre- and post-implementation periods of the closed infusion system. The dashed line in September 2021 represents the start of implementation of the maintenance bundle.

Using the CLABSI rates, there was a reduction in the average from 7.0 per 1,000 catheter/day in the period 2019-2020 to 6.7 per 1,000 catheter/day in the period 2021-2022, but without statistical significance ($p = 0.351$).

The analysis using the generalized linear model has shown that, during the pre-implementation period of the closed system, a statistically significant tendency on increasing CLABSI rates was observed, according to the angular coefficient 0.11 (95%CI 0.02-0.21; $p = 0.011$). Compared to the post-implantation period, a downward trend in CLABSI rates [-0.1 (95%CI -0.42-0.21)] was observed, although not statistically significant ($p = 0.522$). This trend can be confirmed by extending the period analyzed after implementation and improving adherence rates to the bundle.

Table 1. Compliance index of practices in the bundle for the prevention of primary bloodstream infections related to central venous catheters.

| Observed practice | Compliance n (%) | Total (n) |
|-------------------------------------|------------------|-----------|
| 1. Dated and valid valve connectors | 296 (91.9) | 322 |
| 2. Dated and valid solutions | 258 (90.2) | 286 |
| 3. Proper assembly of the system | 291 (90.4) | 322 |
| 4. Adequate number of granules | 273 (84.8) | 322 |
| 5. Flushing the equipment | 120 (52.9) | 227 |
| 6. Intact CVC dressings | 275 (85.4) | 322 |
| 7. Valid CVC dressings | 315 (97.8) | 322 |

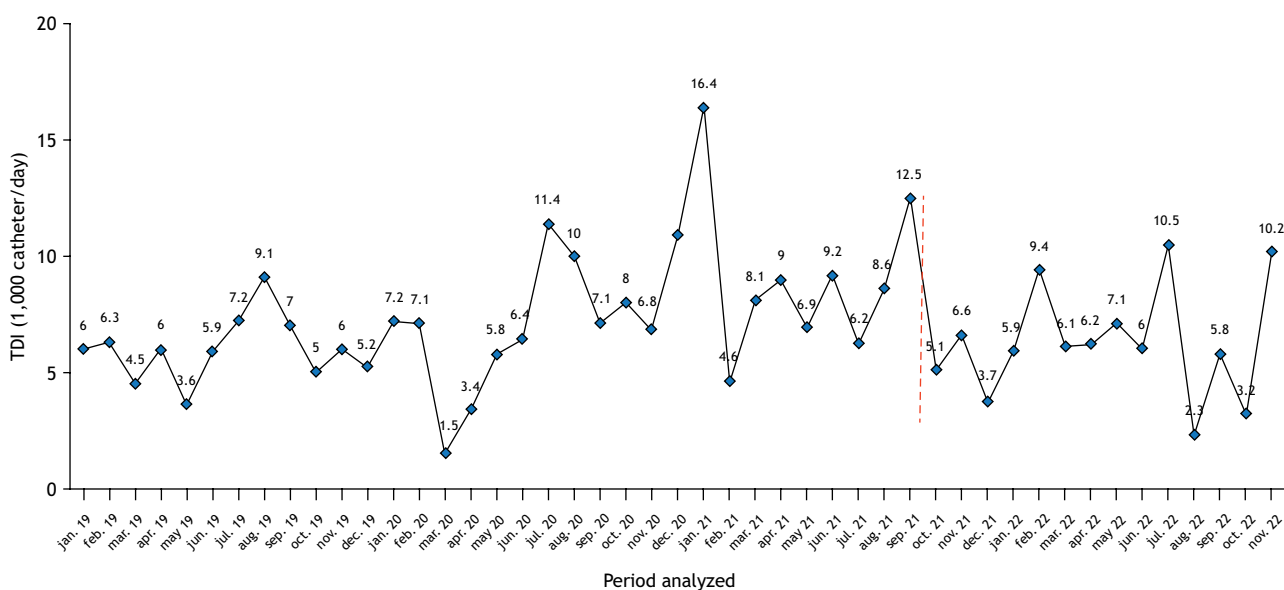
CVC: Central venous catheter.

Categorical variables expressed in absolute numbers and percentages.

Table 2. Evaluation of the quality of care by practice of the central venous catheter maintenance bundle, according to the positivity index.

| Observed practice | Positivity rate (%) | Quality of care |
|-------------------------------------|---------------------|------------------|
| 1. Dated and valid valve connectors | 91.9 | Adequate care |
| 2. Dated and valid solutions | 90.2 | Adequate care |
| 3. Proper assembly of the system | 90.4 | Adequate care |
| 4. Adequate number of granules | 84.8 | Safe care |
| 5. Flushing the equipment | 52.9 | Undesirable care |
| 6. Intact CVC dressings | 85.4 | Secure care |
| 7. Valid CVC dressings | 97.8 | Adequate care |

CVC: Central venous catheter.



Source: Prepared by the authors, 2023.

Figure 2. Comparison of CLABSI density rates, month by month, from January 2019 to November 2022.

DISCUSSION

In this study, compliance with seven practices that make up the ICU CVC maintenance bundle was observed. Adequate adherence to the bundles promotes the prevention of health-related infections, allows nursing care to be assessed and serves as an indicator of quality of care. According to a systematic review which aimed to evaluate similar bundles, 65%-70% of infection cases could be prevented by adopting bundles with good device insertion and maintenance practices¹².

As for infusion system maintenance activities, this study has shown 90% adherence to assembly according to the protocol, 90% for dated and valid infusions and 84% for the appropriate number of cannulas. According to the guidelines proposed by the Centers for Disease Control and Prevention (CDC) and the Brazilian National Health Surveillance Agency (Anvisa), changing the equipment within 72 to 96 hours considerably reduces central catheter infections¹³.

The practices relating to the conditions of the central catheter dressing, in terms of validity and integrity, indicated adequate and safe care, with 97% and 85%, respectively. Dressing, when in proper condition, is the way to protect the insertion site of the device against microorganisms that could colonize the ostium. According to the guidelines, impermeable coverings should be used to allow visualization of the ostium and to prevent moisture and possible contaminants from entering the catheter^{3,14}.

The two practices with the lowest compliance rates were equipment flushing and the adequate number of connections on the catheter, aimed at maintaining the permeability of the pathways and minimizing the entry points for microorganisms

into the bloodstream, respectively. These actions can be readjusted through training and feedback to the team. As found in a recent quasi-experimental study carried out in the United Kingdom, which evaluated the impact of education programs for nursing teams in intensive care settings, the team's knowledge and skills were responsible for adjusting actions and reducing infection rates and other complications related to catheter use¹⁵.

The CLABSI rates published by the institution's CCIH are analyzed according to the diagnostic criteria for CLABSI included in the Anvisa manual, which include: patient signs and symptoms; clinical history; laboratory tests; epidemiological criteria and classification (whether the infection is healthcare-associated or community-acquired, depending on the origin and context)¹³. The study considered CLABSI based on the two main mechanisms, extra- and intraluminal. The latter arises from the proliferation of intraluminal catheter pathogens (mainly due to contamination during handling or through biofilm colonization). On the other hand, extraluminal pathogens enter the system through contamination of the skin, essentially through lack of care at the insertion site¹³.

The higher rates of CLABSI in 2019/2020 can be explained by the context of the scenario, since the COVID-19 pandemic has had numerous impacts on hospitals and ICUs, including a substantial increase in HAI rates, such as CLABSI, ventilator-associated pneumonia, and urinary tract infections¹⁶. In a retrospective study carried out in 78 hospitals in the United States, the rates of CLABSI were shown to increased by 51% during the pandemic period, from 0.56 to 0.85 per 1,000 days/catheter ($p < 0.001$)¹⁷.



Regarding the overall rate of adherence to the bundle, 78% of the evaluations in the period had an adherence rate of > 80%, as recommended. The data from the short period of observation of the recent bundle shows a positive trend, with the potential to reduce CLABSI rates, positively impacting care and the outcome of individuals. However, data from a North American study carried out in ICUs of 441 hospitals has shown that, to significantly reduce the rates of CLABSI, it would be necessary to achieve an adherence rate to the bundles of approximately 95%¹⁸, which was not observed in the present study.

Infection rates also suffered from the seasonal period, the addition of numerous team members, and the COVID-19 pandemic, which may have influenced the CLABSI rates assessed. That said, additional studies with more robust samples and a longer observation period are recommended to investigate the long-term effects of implementing and adhering to the CVC maintenance bundle in the ICU setting.

CONCLUSIONS

This study allowed to assess adherence to measures related to the infusion system in the CLABSI prevention bundle. The results have shown an adequate PI in the items that make up the bundle, showing, for the most part, adequate and safe care in the maintenance of CVCs.

When comparing infection rates over period, it can be inferred that the closed infusion system has contributed as one of the actions to the downward trend in CLABSI rates and that, with the proper training of the team and appropriation of the institutional protocol, it will show more significant reductions over the coming months.

These indicators will be used to assess the quality of the nursing care provided and the possible weaknesses that need to be addressed with the team. The findings of this study reaffirm the importance of investing in permanent and continuing education activities for the team that performs CVC maintenance. Adequate maintenance of adherence rates to the bundle will serve as one of the pillars for reducing CLABSI in ICUs.

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Authors' Contribution

Ferro EB, Barilli SLS - Conception, planning (study design), data acquisition, analysis, interpretation, and writing of the paper. Santos ND, Silva RC - Writing of the paper. All the authors approved the final version of the paper.

Conflict of Interest

The authors inform that there is no potential conflict of interest with peers and institutions, political or financial, in this study.



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