ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

# The Effect of the Central Venous Catheter Care Bundle on Intensive Care Unit Infection Level: Prospective Control Group Cohort Study

## Santral Venöz Kateter Bakım Paketinin Yoğun Bakım Ünitesi Enfeksiyon Düzeyine Etkisi: Prospektif Kontrol Gruplu Kohort Çalışması

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**ABSTRACT Objective:** This study aims to determine the effectiveness of a care bundle in preventing central venous catheter-associated bloodstream infections in patients treated in the intensive care unit. **Material and Methods:** A prospective control group cohort study design. Using 105 patients treated in the intensive care unit (ICU) of a state hospital located in northern Türkiye. Following the training provided to physicians and nurses working in the ICU regarding the care bundle, the intervention was implemented on the patients for 1 year, and daily follow-ups were conducted to monitor the development of catheter infections. Data were collected using patient information form and central venous catheter care bundle data. **Results:** No significant difference was found between the descriptive characteristics of the experimental and control group patients. Throughout the study period, 5 patients in the control group and only 1 patient in the experimental group developed a central venous catheter-associated bloodstream infection. A decrease in the rate of central venous catheter-associated bloodstream infection was identified in the experimental group (p<0.001). **Conclusion:** The implementation of the care package approach was found to be highly effective in preventing central venous catheter-associated bloodstream infections, so should be adopted as a routine protocol in patients hospitalized in the ICU with a catheter indication.

**Keywords:** Care bundle; nurse; central venous catheter; bacterial infections

**ÖZET Amaç:** Bu çalışmanın amacı, yoğun bakım ünitesinde tedavi edilen hastalarda santral venöz kateter ilişkili kan dolaşımı enfeksiyonlarını önlemede bakım paketinin etkinliğini belirlemektir. **Gereç ve Yöntemler:** Türkiye'nin kuzeyinde yer alan bir devlet hastanesinin yoğun bakım ünitesinde tedavi gören 105 hasta kullanılarak prospektif kontrol gruplu kohort çalışması tasarlanmıştır. Yoğun bakım ünitesinde çalışan hekim ve hemşirelere bakım demeti ile ilgili verilen eğitimin ardından, hastalara 1 yıl boyunca müdahale uygulanmış ve kateter enfeksiyonlarının gelişimini izlemek için günlük takipler yapılmıştır. Veriler hasta tanıtım formu ve santral venöz kateter bakım paketi verileri kullanılarak toplanmıştır. **Bulgular:** Deney ve kontrol grubu hastaların tanımlayıcı özellikleri arasında anlamlı farklılık bulunmadı. Çalışma süresi boyunca kontrol grubunda 5 hastada, deney grubunda ise sadece 1 hastada santral venöz kateter ilişkili kan dolaşımı enfeksiyonu gelişti. Deney grubunda santral venöz kateter ilişkili kan dolaşımı enfeksiyonu oranında azalma tespit edildi (p<0,001). **Sonuç:** Bakım paketi yaklaşımının uygulanması santral venöz kateter ilişkili kan dolaşımı enfeksiyonlarını önlemede oldukça etkili bulunmuştur, bu nedenle yoğun bakım ünitesinde kateter endikasyonu ile yatan hastalarda rutin bir protokol olarak benimsenmelidir.

**Anahtar Kelimeler:** Bakım paketi; hemşire; santral venöz katater; bakteriyel enfeksiyonlar

Central venous catheterization (CVC) is a widely used invasive procedure in the management and treatment of intensive care unit (ICU) patients and is a leading cause of healthcare-associated infections.[1-3]

CVC use is indicated for various diagnostic and therapeutic purposes, including long-term systemic chemotherapy, transfusion of blood and blood products, hemodialysis, plasmapheresis, stem cell collection, administration of hyperosmolar fluids or medications unsuitable for peripheral veins, hemodynamic monitoring, parenteral nutrition, and blood sampling for laboratory tests.[4-6] However, the increased use of CVCs for these indications presents a significant risk of complications, including mechanical injury, infection, and thrombosis, which are associated with their management.[7,8]

Among the potential complications, central catheter-associated bloodstream infection is especially concerning, as it can result in extended hospital stays, higher healthcare costs, and increased mortality rates.[9] Various risk factors significantly contribute to the development of CVC-associated bloodstream infections (BSIs) in patients. These factors include prolonged hospital stays, which increase the exposure to hospital-acquired infections; extended catheterization periods, which provide more opportunity for microbial colonization and biofilm formation on the catheter surface; emergency catheter insertions under suboptimal conditions, often in non-sterile environments, which can introduce pathogens; a preference for internal jugular and femoral catheterization, which have higher rates of infection compared to the subclavian site; and inadequate catheter care, including poor hygiene, improper dressing maintenance, and lack of regular monitoring, all of which can promote the entry of pathogens into the bloodstream. Studies have shown that improving catheter care protocols and choosing optimal catheterization sites can significantly reduce the incidence of CVC-related infections.[10,11] According to the National Hospital Infections Surveillance Network report published by the Ministry of Health in 2019, the incidence rate of central catheter-associated BSIs in ICUs varied between 0.0 and 8.0 per 1000 catheter days.[12]

To address and mitigate these complications, the Institute for Healthcare Improvement has introduced the concept of a "care bundle", designed to provide multidisciplinary patient care and assist in reducing infection rates.[13] Care bundles are a set of evidence-based practices designed to improve patient outcomes by standardizing care and promoting teamwork among healthcare providers. The key idea is that when all components of the care bundle are implemented together, they lead to a higher level of success than if each practice is implemented independently. Research supports that the combination of these evidence-based interventions, when used consistently, not only reduces variation in care but also fosters an environment where nurses have the autonomy to make decisions and collaborate more effectively with other members of the healthcare team.[14,15] Nurses are essential in the effective application of care bundles, ensuring that protocols are followed, patient progress is closely monitored, and early interventions are carried out when needed. Their duties encompass educating patients, maintaining accurate documentation, implementing infection prevention strategies, and working collaboratively with healthcare teams. Through active participation in clinical decisions and the application of their professional judgment, nurses play a key role in maximizing the impact of care bundles, ultimately enhancing patient safety and overall care quality.[15,16] A meta-analysis by Ista et al. involving 2,216 adult patients reported a reduction in the incidence of central catheter-associated BSIs from 5.7 to 2.0 per 1,000 days following the implementation of care bundle.[17]

The aim of this study is to evaluate the effectiveness of the CVC care bundle in preventing central line-associated BSI (CLABSI) in patients admitted to the intensive care unit. CLABSI is a serious infection that increases mortality and morbidity in intensive care patients, prolongs hospital stays, and raises healthcare costs. Today, care bundles are among the infection control strategies that play a significant role in reducing CLABSI rates. However, the effectiveness of these bundles may vary across different patient populations and clinical settings. Standardizing the use of the CVC care bundle is expected to re-

duce infection rates, improve the quality of patient care, and contribute to evidence-based nursing practice.

## MATERIAL AND METHODS

### TYPE OF RESEARCH

This study utilized a quasi-experimental control group pre-/post-implementation study design to evaluate the effectiveness of the CVC care bundle in preventing CVC-associated BSIs in patients receiving treatment in the intensive care unit. The article has been prepared in accordance with the Strengthening the Reporting of OBservational studies in Epidemiology guideline.

### PLACE AND TIME OF THE STUDY

The study was conducted in the general ICU of a state hospital located in northern Türkiye between January 1-December 30, 2023. The ICU involved in the study had a total of 8 beds, with 20 nurses working in the unit.

### POPULATION AND SAMPLE OF THE STUDY

The study's population consisted of inpatients admitted to the ICU of the state hospital in northern Türkiye. The sample included 105 patients, with 59 patients assigned to the experimental group and 46 patients to the control group. The inclusion criteria comprised patients with a central venous catheter inserted at the hospital, without any existing infection, and not using long-term antibiotics, glucocorticoids, or immunosuppressants.

### Research Question

Is the central venous catheter care bundle effective in reducing the rate of central catheter-associated bloodstream infection in ICU patients?

### DATA COLLECTION AND DATA COLLECTION TOOLS

The control group of the study consisted of patients whose care was performed in accordance with the standard practice of the hospital. Routine procedures were conducted the care of the patients in this group. The data of the experimental group were collected after the data of the control group were collected. Following the collection of control group data, nurses and physicians in the ICU were informed about the central venous catheter care plan through a combination of lecture and demonstration methods for 8 hours. A structured training program was used for the nurses in the intervention group. The training was organized for 2 days, 4 sessions and each session was 40 minutes. The training was conducted using face-to-face method with the help of slides. In the 1st session, general information about central venous catheters was presented and in the 2nd session, hand hygiene and barrier precautions were explained in the form of a presentation and then practiced. The 3rd session included selection of the catheter insertion site, assessment of catheter requirement and skin preparation with chlorhexidine. The last session was an interactive review of the topics discussed in the previous sessions.

Then, data from patients in the experimental group were collected. During the study period, the insertion sites of catheters and catheter covers were evaluated daily by the study supervisor or relevant nurses to identify any local infections or complications. Additionally, the following data were recorded daily for each patient in both groups: the number of blood products received through the central catheter, total parenteral nutrition treatments, hemodialysis treatments, local infection findings at the catheter site, and the requirements of existing catheters for each patient. For patients who developed central catheter-associated BSIs or whose catheter requirement ended, the catheters were with drawn, and their follow-up was terminated. Moreover, the follow-ups of patients whose catheters were accidentally removed, transferred to other services, or who passed away in the ICU were also discontinued. The rate of central catheter-associated BSIs developing in the ICU during the study period was analyzed as the "central catheter-associated bloodstream infection rate".

The data were collected with a patient information form consisting of 2 parts. The 1st part included sociodemographic characteristics of the patients, and the 2nd part included 21 questions, including patient information such as indication for catheter insertion, place of insertion, length of stay, duration of infection, and catheter types.

**Central Venous Catheter Care Bundle:** A care bundle consists of a combination of several interventions or interventions, each of which, when applied alone, positively affects the patient's recovery process and outcomes, and when all of them are applied together, a better result is achieved compared to their application alone. It is recommended that bundles include 4-5 components with the above-mentioned characteristics.[18] Hand hygiene, compliance with maximum barrier precautions when inserting central catheters, skin antisepsis with chlorhexidine, avoiding the use of femoral catheters, and immediate withdrawal of unnecessary catheters are examples of the practices included in bundle.[19] The follow-up of bundles is performed on an all-or-nothing basis. In the event of non-compliance with one of the components, it is assumed that the other components also do not comply with.[20]

## Intervention

This study consisted of 2 phases: the preimplementation period (January 1-March 30, 2023), implementation period and postimplementation period (April 1-December 30, 2023).

During the preimplementation period, the researchers implemented the CVC bundle by educating the nurse who works in the intensive care unit. The education program included an introduction to the CVC care bundle, importance of the CVC and CVC care bundle, and elements of the CVC bundle. During the preimplementation period, researchers also evaluated lack of accordance of CVC bundle care about, nurse and physician and To facilitate CVC bundle compliance, a CVC bundle poster was hung in the catheter application area in the intensive care unit.

During the implementation and postimplementation period, before groups ar assiged non-randomly, the patient group to whom a care package will be applied in the first 5 months of the study will be the patient group to whom a care package will not be applied in the last 5 months. The most important factor was the all-or-nothing rule in the care package application. If the physician or nurse misapplied any application from the package, the patient in the CVC care bundle group was excluded from the study. To obtain accurate data from both groups, all patients were monitored by one observer. The infection control nurse performed an impartial data collection phase. For this reason, only patients who underwent CVC in the ICU during in the morning shift were included and examined. During the study period, the compliance of all nurses and doctors with the care package was evaluated as 92%. Since the follow-up of the packages was developed with the all-or-nothing principle, any patient who was included in the experimental group but did not comply with the care package was not included in the study.

## DATA ANALYSIS

Statistical evaluation was performed with the SPSS 23 (IBM Corp., Armonk, NY, USA) bundle program. Compliance with the normal distribution was determined according to Skewness and Kurtosis values (-2 and +2). Descriptive statistics were given as numbers (n), percentages (%), and arithmetic mean±standard deviation. The chi-square test ($\chi2$) was used to analyze the data. $p<0.05$ was accepted as significant.

## ETHICS COMMITTEE APPROVAL

Before starting the research, the necessary ethics committee permission was obtained from the Gümüşhane University Scientific Research and Publication Ethics Committee (Date: July 27, 2022 Number: 2022/3). In addition, written permission was obtained from the relevant hospital by informing them of the scope of the research. The patients to be included in the study were informed about the study and were included in it after the voluntary consent form was filled out. The study was conducted following the Declaration of Helsinki.

# RESULTS

There was no significant difference between the experimental and control groups in terms of other descriptive characteristics except diet (p=0.003) and age (p=<0.001) (p>0.05) (Table 1). During the 1-year study period, the ICU utilized central catheters for a total of 1,589 catheter days in the experimental group, while the control group used central catheters for 736 catheter days. Within the study period, 5 patients in

**TABLE 1:** Comparison of the experimental and control group patients according to their descriptive characteristics

| Characteristics | Control group (n=46) n (%) | Experimental group (n=59) n (%) | $\chi^2$ | p value |
|---|---|---|---|---|
| Gender | | | | |
| Female | 23 (50.0) | 30 (50.8) | 0.007 | 0.931 |
| Male | 23 (50.0) | 29 (49.2) | | |
| Number of catheter lumens | | | | |
| 1 | 27 (58.7) | 33 (55.9) | 0.442 | 0.802 |
| 2 | 16 (34.3) | 20 (33.9) | | |
| 3 | 3 (6.5) | 6 (10.2) | | |
| Catheterized vein | | | | |
| Subclavian vein | 44 | 56 | 4.093 | 0.129 |
| Femoral vein | 2 | 3 | | |
| Catheter insertion site dressing | | | | |
| Daily | 39 | 44 | 1.626 | 0.202 |
| Weekly | 7 | 15 | | |
| Diet | | | | |
| Enteral | 5 | 26 | 13.898 | **0.003** |
| Parenteral | 38 | 30 | | |
| Enteral and parentaral | 3 | 3 | | |
| | $\overline{X}\pm SD$ | $\overline{X}\pm SD$ | ZMWU | p value |
| Age | 77.14±6.77 | 83.01±10.52 | 759.500 | **<0.001** |

$\chi^2$: chi$^2$ test; SD: Standard deviation; ZMWU: Mann-Whitney U; p<0.05

the control group developed infections, while only 1 patient in the experimental group experienced a central catheter-associated bloodstream infection. The calculated central catheter-associated bloodstream infection rate was 0.62 per 1,000 catheter days in the experimental group and 6.79 per 1,000 catheter days in the control group. Notably, the reduction in the rate of central catheter-associated BSIs in the experimental group was found to be statistically significant (p<0.001) (Table 2).

## DISCUSSION

Intravenous devices are an integrated part of modern medical practice. The significance of monitoring hemodynamic status in critically ill patients, administering intravenous fluids, drugs, and blood products, and ensuring the continuity of parenteral nutrition are key factors contributing to their preference.[21] However, the use of central venous lines entails a significant risk of bloodstream infections, making CVC infection development a notable complication. Existing literature reports on catheter-associated infections show varying outcomes, but it is established that they elevate the risk of mortality and impose adverse effects on healthcare costs.[22] Catheter-associated infections represent a considerable proportion, accounting for 10-20% of all nosocomial infections.[23] Additionally, the incidence of central line-associated bloodstream infection in ICUs has been documented to range from 1.6 to 6.8 per 1,000 catheter days.[24] In response to this concern, healthcare professionals and hospital administrators are actively formulating infection prevention strategies with the aim of achieving favorable patient outcomes and reducing the incidence of infections.[25] One of these preventive measures includes the implementation of "care bundles". Care bundles are structured sets of practice indicators that comprise evidence-based practices and interrelated interventions. These bundles are designed to enhance existing nursing practices, thereby improving nursing processes and patient outcomes.[26] The present study aimed to investigate the effectiveness of a CVC care bundle in preventing CVC-associated bloodstream infections. To conduct this research, a CVC care bundle team was formed, comprising 2 anesthesiologists and an infection control nurse. Furthermore, physicians, the infection control nurse, and all ICU nurses underwent comprehensive training encompassing collaborative practices to be carried out by physicians and nurses together, as well as individual practices, all in line with established guidelines. This study is one of the applications for

| TABLE 2: Comparison of experimental and control group data | | | |
|---|---|---|---|
| Characteristic | Control group (n=46) | Experimental group (n=59) | p value |
| Central venous catheter (day) | 736 | 1,589 | |
| Catheter-associated bloodstream infection | 5 | 1 | |
| Catheter-associated bloodstream infection rate | 6.79/1,000 | 0.62/1,000 | **<0.001** |

the effectiveness of the use of care bundles in the prevention of CVC-associated bloodstream infection.[27,28] The study adopted a quasi-experimental design. In total, 56 patients received the CVC care bundle intervention, while 46 patients did not receive the bundle and served as the control group. The results revealed that among the patients who did not receive the CVC care bundle, 5 developed catheter-associated infections. In contrast, only one patient among those who received the care bundle developed a catheter-associated infection. Notably, the incidence rate of central catheter-associated bloodstream infection was found to be 0.62/1,000 catheter days in the experimental group and 6.79/1,000 catheter days in the control group, indicating a significant difference between the groups. Similar to the findings of our study, a retrospective experimental study conducted in an ICU in Türkiye demonstrated a decrease in catheter-associated infection rates when comparing data from the previous year with the patients who received the care bundle interventi.[29] Furthermore, a study conducted across various clinics, including intensive care, reported an increase in compliance with the care bundle, leading to a reduction in catheter-associated infections, although the difference was not found to be statistically significan.[30] In the context of another quasi-experimental pretest-posttest study, the rates of central line-associated BSIs during specific time periods were investigated. The results indicated infection rates of 8.9, 4.2, and 9.9 per 1,000 catheter days in January-March, April-June, and July-September, respectively. However, the use of the care bundle did not yield a statistically significant difference based on pairwise comparisons.[31] Previous meta-analyses on the subject, a systematic review, and a meta-analysis focusing on 2,370 intensive care units, similar to our study, highlighted that the application of care bundles led to a reduction in catheter-associated infection rates.[32] Similarly, another meta-analysis study emphasized the significant decrease in CVC infection rates due to the use of care bundles.[33]

In some studies, partial compliance with care bundles has been associated with a decrease in the rates of CVC infections.[34,35] Conversely, a particular study highlighted that cases, where all principles of the care bundle were not fulfilled, resulted in a 2-fold increase in the incidence of infections. This emphasized the significance of fully implementing all elements of the care bundle by both physicians and nurses.[36] Moreover, it was stressed that the compulsory use of sterile drapes, which are part of the maximum barrier measures in the care bundle, is essential, as the incidence of infections may rise if they are not used.[26]

## LIMITATIONS

Researchers may face difficulties in accessing specific sources or data, and the fact that research findings may only be applicable to a particular geographical area or cultural group creates limitations in terms of generalizability.

## CONCLUSION

Based on the findings, it was concluded that the implementation of the CVC care bundle effectively reduced the incidence of central catheter-associated infections. Therefore, it is recommended to adopt the care bundle as a routine protocol in clinical settings. Further recommendations include conducting randomized controlled trials to assess the impact of the care bundle on variables such as the length of hospital stay, patient satisfaction status, and cost analyses. Additionally, exploring different methodologies in randomized controlled trials would provide valuable insights. The study's limitations, such as being conducted in a single ICU and the nutritional status differences between the experimental and control groups, were acknowledged. To address these limitations and enhance the study's generalizability, it is advised to replicate similar research with a larger sample size while standardizing nutrition protocols. It is particularly recommended to be added to routine medical and nursing practices.

vides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

## Conflict of Interest

*No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.*

## Authorship Contributions

*Idea/Concept:* Esra Özkan, Nurşen Kulakaç; *Design:* Esra Özkan, Nurşen Kulakaç; *Control/Supervision:* Esra Özkan, Nurşen Kulakaç; *Data Collection and/or Processing:* Reyhan İnce Kasap, Esra Özkan; *Analysis and/or Interpretation:* Nurşen Kulakaç; *Literature Review:* Esra Özkan, Nurşen Kulakaç, Reyhan İnce Kasap; *Writing the Article:* Esra Özkan, Nurşen Kulakaç, Reyhan İnce Kasap; *Critical Review:* Esra Özkan, Nurşen Kulakaç.

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