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Original Article

Evaluation of effectiveness of central venous catheter related bloodstream infections in the antesty and reanimation intensive care units of the bundle

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Abstract

Aim: The aim of this study is to evaluate the efficacy of prevention bundle study on central venous catheter-associated bloodstream infection (CLABSI) in the Anesthesia and Reanimation Intensive Care Unit (ICU) patients who have central venous catheter. Invasive vehicle related infections, especially CLABSIs, are one of the most difficult infections in ICUs. It has been reported that the use of proven interventions as a bundle to prevent infections associated with invasive tools is effective in reducing infection rates.

Materials and Methods: The study was conducted interventionally between July and December 2017. Data, physician and nurse information form, CLABSI package tracking form, CLABSI package information test form, CVC insertion process observation form, bedside CLABSI package tracking form, and CLABSI package tracking form. Ethics committee permission was obtained for the study. Approval was obtained from nurses and doctors. The study was carried out in three stages. Number, Percentage, Chi-square, Fisher Exact Chi-square Test and Wilcoxon Test were used in the research.

Results: The overall compatibility of ICUs for the CLABSI bundle was 61%, 65% and 70%, respectively. As a result of the Bundle study, CLABSI rates per 1000 catheter days were decreased, from 11.3 to 9.5 in ICU1, from 9.4 to 6.8 in ICU2, and from 17.1 to 10.6 in ICU3.

Conclusion: As a result, it was seen that CLABSI precaution bundle study prepared with evidence based guidelines decreased infection rates. The bundle is recommended for use in intensive care units.

Keywords: Bundle; CLABSI; CVC; healthcare-related infection; invasive vehicle-related infection

INTRODUCTION

Healthcare-associated infections (HAIs) are defined as infections that develop on the third day of the patient's hospitalization or later (1). HAIs increase the duration of hospitalization, mortality, morbidity and treatment costs. Moreover, HAIs are accepted to constitute the most significant indicator for the quality of healthcare (2). AS In developed countries, HAIs affect more than two million people and lead to the deaths of 90000 patients each year. It was reported that, in the European Union (EU), HAIs lead to the deaths of 37000 people directly and 110000 people indirectly (3,4). More than 75% of these infections are associated with invasive tools (5).

It was determined that 6% of hospitalized patients needed central venous catheter (CVC), and it was stated that the central venous catheter-associated bloodstream infection (CLABSI) caused by CVC ranks fourth among all infections with a rate of 12%. Although the incidence of CLABSIs in the United States of America (USA) was reduced by 80% by implementing appropriate infection management precautions, they are still considered to have a high rate of inflicting additional costs among HAIs (6). In Turkey, the Ministry of Health in 2018 Nosocomial Infections Surveillance System (INFLINE) reported in particular, the rate of Anesthesia and Reanimation Intensive Care Units (ICU) CLABSI has been reported to range from 0 to 3,9 percentile range per 1000 catheter days (7). As in the case of all infections associated with invasive tools, it is also believed to be possible to reduce CLABSI rates by bundle treatments.

Provision of qualified and safe care at all services provided by hospitals has the top priority for both patient treatment and prevention of HAIs. Bundle practices cover which parameters need to be complied with in preventing CLABSIs in terms of CVC placement, usage and maintenance. A bundle consists of evidence-based interventions each of which affects the patient's recovery

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process positively by itself but allows reaching a better outcome in combination with others (4).

Especially ICUs have a significant position in terms of reducing infection rates and providing quality healthcare in bundle studies towards preventing CLABSIs that involve the entire ICU team.

BACKGROUND

This study is an interventional study that aimed to investigate the effectiveness of bundle practices on preventing CLABSIs. The study was carried out by combining the role of physicians in medical treatment and the role of nurses in providing healthcare.

As in the case of all infections associated with invasive tools, it is also believed to be possible to reduce CLABSI rates by bundle treatments. Bundle studies have been carried out in Turkey for all infections related to invasive tools. However, in these studies, only a few infections were discussed, or only one infection was evaluated in the light of all precautions in available guides (Web search date: 23.03.2020). The characteristic of this study is that it is the first study in Turkey that included physicians in the CVC team and nurses in the healthcare team to focus solely on CLABSIs by using bundle items consisting of six parameters (Web search date: 23.03.2020). From this perspective, this study is believed to contribute to the existing scientific knowledge and nursing literature by determining the effectiveness of a CLABSI precaution bundle.

MATERIALS and METHODS

Study Design

The hypotheses of the study were as the following:

$H_{0\text{-}1}$: Training provided about prevention and management of HAIs does not have an effect on the knowledge levels of the physician and nurse groups.

$H_{1\text{-}1}$: Training provided about prevention and management of HAIs has an effect on the knowledge levels of the physician and nurse groups.

$H_{0\text{-}2}$: Bundle practices do not have an effect on prevention of CLABSI at Anesthesia and Reanimation ICUs.

$H_{1\text{-}2}$: Bundle practices have an effect on prevention of CLABSI at Anesthesia and Reanimation ICUs.

Study Setting

The study was carried out at the adult ICUs of a research and training hospital in a metropolitan city in Turkey between the dates of 1 July 2017 and 31 December 2017.

Samples

All patients whose CVCs were placed as a part of their intensive care at the Anesthesia and Reanimation ICUs of a research and training hospital between 1 July and 31 December 2017 were included. The patients who were directed from operating rooms, emergency services and clinics with their CVCs attached were not included. During the study period, 52 patients and 64 catheters were monitored in total.

Data Collection

The data collection instruments were developed by the researcher based on the Centers for Disease Control and Prevention (CDC) criteria and guides prepared by the Society of Hospital Infections and Control and by reviewing the literature (8,9,10,11). The study was carried out with five different forms.

Form I included questions on the age and gender of the physicians and nurses, their school of graduation, total duration of service as healthcare personnel, total duration of service as ICU personnel, whether or not they previously received training on HAIs and if they did, where and when.

Form II contained the pretest and posttest question form to measure the knowledge levels of the physicians and nurses on preventing CLABSIs. The knowledge test is a test that questions the levels of the knowledge of respondents related to infection management methods, definition and prevention of CLABSI, bundle methods and significance of bundle practices. To assess its content validity, the knowledge test was examined by three faculty members who are experts in their fields, three infection management physicians and five infection management nurses. The content validity index of the questions was calculated as 0.74 (α=0.05 significance level).

Form III (Bundle) contained the CLABSI prevention bundle compliance form. The CLABSI Prevention Bundle Compliance Form covered both the catheter application and daily maintenance of the catheter based on the bundle parameters. For collecting the data for the CLABSI Prevention Bundle Compliance Form in a healthier way, the researcher developed the "CVC Placement Operation Observation Form" and the "Point-of-Care CLABSI Prevention Bundle Compliance Form."

Form IV covered the CVC placement part of the CLABSI prevention bundle process. This form contains patient information and all stages of installing SVK.

Form V covered the daily CVC maintenance part of the CLABSI prevention bundle process. The "Point-of-Care CLABSI Prevention Bundle Compliance Form" was prepared by the researcher to be able to monitor the daily observation parameters during the process in which the catheter was attached. This form was prepared in a way to achieve daily follow-up of the name-surname of the patient, department of hospitalization, name-surname of the observer, data of observation, day of catheterization and precaution package containing hand hygiene, suitable covering material and catheter necessity. The form was distributed beforehand by the researcher to the ICUs weekly.

INTERVENTION

The implementation process of the study took place at three stages. These were CLABSI prevention bundle formation by analysis of the CLABSI results of the ICUs, bundle training and implementation of the study.

Stage I: The CLABSI results of the ICUs were analyzed, and the bundle parameters were determined. The total

number of CLABSIs for the year 2016 for all ICUs under surveillance at the hospital was 62, while this number was 34 for the Anesthesia and Reanimation ICUs. Only the Anesthesia and Reanimation ICUs constituted 55% of the CLABSIs in total. Among the 34 CLABSI diagnoses at the Anesthesia and Reanimation ICUs, 19 involved catheters placed into the femoral blood vessels, while 15 were placed into the jugular blood vessels. Therefore, it was seen that the CLABSI prevention bundle was applicable for the Anesthesia and Reanimation ICUs. It was decided to plan the study in the first six months of the year 2017 and conduct it in the second six-month period.

The CLABSI prevention bundle parameters were determined by the researcher based on the CDC criteria, CDC instructions, guides prepared by the Turkish Society of Hospital Infections and Control and by reviewing the literature. Opinions of three infection management physicians and four infection management nurses who are experts in their field were collected (9,10,12-14) (Table 1).

Table 1. CLABSI prevention bundle parameters

1	Hand hygiene
2	Compliance with maximum barrier measures during SVK tooling
3	Avoiding the use of femoral vein for CVC
4	Use of chlorhexidine for skin cleansing during CVC insertion
5	Use of appropriate catheter insert covers after insertion of CVC
6	Evaluation of daily CVC requirement in the patient

Stage II: This stage covered the preparation of the bundle training content. The training was prepared by the researcher by a literature review to be presented to the physicians and nurses working at the ICUs (9,10,15). The content validity of the training content that was prepared was examined by three faculty members who are experts in their fields, three infection management physicians and five infection management nurses. The content validity index of each section was calculated as 0.95 (α=0.05 significance level).

The trainings on CLABSI prevention bundle practices started in June of the year of 2017, and the trainings continued on different days and at different times for all employees to be able to actively participate.

Stage III: This was the analysis process of the study. Firstly, the adaptation process of the included ICUs was started before the date of 1 July 2017 when the study would be started, and the adaptation rate of 83% was obtained. In this process, the bundle parameters were explained by implementation at point-of-care, and questions of the teams were answered by the researchers. For all employees to be able to participate in the CLABSI prevention bundle trainings, the trainings were provided in 12 sessions on 12 different workdays.

Statistical Analysis

IBM SPSS Statistics 20.0 (2015-IBM-SPSS Statistics Standard Pack 21 V: IBM Corp.) was used for the statistical analyses and calculations. The continuous variables in the study such as age, duration of service and knowledge scores were tested for normal distribution by using Shapiro Wilk test due to the numbers of units. Regarding the descriptive information, mean ± standard deviation values were used for the normally distributed continuous variables, the minimum-maximum values were used for the non-normally distributed continuous variables, and frequencies (%) were used for the categorical variables.

RESULTS

Characteristics of the participants

The ages of the nurses who participated in the study varied between 24 and 44, while their mean age was 33.13 ± 6.05 years. 87.5% of the nurses were women (n=24). 60% of the nurses are graduates and 40% are associate degrees. All the nurses participating in the study are intensive care nursing for two years or more. The ages of the physicians who participated varied between 25 and 50, while their mean age was 30.2 ± 7.2 years, and 80% were women (n=10). 50% of the physicians participating in the study are rotational for the intensive care unit, and the rotation period is at least three months. Other physicians are the responsible physicians of the intensive care units. All physicians and nurses who participated in the study received HAI-related training in the year 2017.

Table 2. Distribution of the responses of the nurses and physicians to the knowledge test

Knowledge Test	$\bar{X}$ ±SS	Min-Max	Wilcoxon Testi z	p
Nurse (n=24)				
Distribution of points before training	6.8 ± 1.6	4-10	-4.128	0.001
Score distribution after training	10.6 ± 1.05	8-12		
Physician (n=10)				
Distribution of points before training	5.4 ± 1.65	4-9	-2.844	0.004
Score distribution after training	9.5 ± 0.85	8-11		

The mean scores of the participants in the tests applied before and after the CLABSI prevention bundle training are shown in Table 2. The scores of both the physicians and nurses significantly increased after the training (p<0,05, p=0,001; p<0,05, p=0,004).

HAIs bundle compliance

While it is not included in the table, the total intervention number was calculated for the daily follow-up parameters of the CLABSI prevention bundle practice. The total intervention numbers calculated by multiplying the number of catheters implemented and number of days of catheterization were 8792 for REA-1 ICU, 11414 for REA-2 ICU and 1880 for REA-3 ICU (Table 3).

Table 3. Distribution of compliance with the CLABSI prevention bundle parameters of ICUs

CLABSI Prevention Bundle Parameters		ICU			Total Accordance
		REA-1 ICU	REA-2 ICU	REA-3 ICU	
		n (%)	n (%)	n (%)	n (%)
Hand hygiene compliance	There is	28 (100.0)	26 (100.0)	10 (100.0)	64 (100.0)
	No	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Barrier measures compliance	There is	26 (92.8)	26 (100.0)	10 (100.0)	62 (96.8)
	No	2 (7.2)	0 (0.0)	0 (0.0)	2 (3.1)
*Avoidance of femoral vein	There is	27 (100.0)	25 (100.0)	9 (100.0)	61 (100.0)
	No	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Use of 2% chlorhexidine	There is	17 (60.7)	18 (69.2)	8 (80.0)	43 (67.2)
	No	11 (39.3)	8 (30.7)	2 (20.0)	21 (32.8)
Appropriate closure cover	There is	28 (100.0)	26 (100.0)	10 (100.0)	64 (100.0)
	No	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Questioning daily catheter requirement	There is	28 (100.0)	26 (100.0)	10 (100.0)	64 (100.0)
	No	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	Total	28 (100.0)	26 (100.0)	10 (100.0)	64 (100.0)

*In three ICUs, femoral catheters were inserted due to medical conditions such as pneumothorax, hemothorax and cardiac arrest
All the catheters except the three femoral catheters had full compliance with the relevant parameter

While this information is not included in the table, between the dates of July and December 2017 in which the study was carried out, among the ICUs, REA-1 ICU applied CVCs on 22 patients and monitored them for 314. REA-2 ICU applied CVCs on 23 patients and monitored them for 439 days. REA-3 ICU applied CVCs on 7 patients and monitored them for 188 days. A total of 52 patients and 64 catheters were followed-up by the ICUs during the studied period (Table 4).

Table 4. Bundle compliance distribution of ICUs

	ICU		
	REA-1 ICU (%)	REA-2 ICU (%)	REA-3 ICU (%)
*CLABSI bundle total accordances	61.0	65.0	70.0
CLABSI general accordances of bundle parameters			
Hand hygiene compliance	100.0	100.0	100.0
Barrier measures compliance	92.8	100.0	100.0
**Avoidance of femoral vein	96.4	96.2	90.0
Use of 2% chlorhexidine	60.7	69.2	80.0
Appropriate closure cover	100.0	100.0	100.0
Questioning daily catheter requirement	100.0	100.0	100.0

*The CLABSI bundle total accordance was calculated for catheters with full compliance with all six parameters in the precaution package.
**In three ICUs, femoral catheters were inserted due to medical conditions such as pneumothorax, hemothorax and cardiac arrest

Infection Rates before and after the CLABSI Bundle

While there was a reduction in the infection rates after the intervention at the ICUs, there was no statistically significant difference (Table 5) (p>0.05).

Table 5. Distribution of infection rates before and after CLABSI prevention bundle

ICU	Rate of infection before intervention* ‰	Rate of infection after intervention* ‰	z	p
REA-1 ICU	11.3	9.5	0.023375	0.072
REA-2 ICU	9.4	6.8	0.040538	0.055
REA-3 ICU	17.1	10.6	0.072468	0.069

*(Number of infections developed in the monitoring period/Invasive tool day)×1000

Table 6. Distribution of patient numbers, patient days and CVC usage days before and after CLABSI prevention bundle intervention

ICU		Before the intervention	After the intervention
REA-1 ICU	Number of patients	145	159
	Patient day	1033	1072
	Catheter use day	353	314
REA-2 ICU	Number of patients	141	125
	Patient day	1017	1083
	Catheter use day	530	439
REA-2 ICU	Number of patients	54	21
	Patient day	537	478
	Catheter use day	350	188

While there was no significant change in the patient days at the included ICUs before and after the CLABSI prevention bundle intervention, there was a reduction in the CVC usage days (Table 6).

DISCUSSION

Bundle practices for preventing HAIs that are seen as medical errors have provided a significant opportunity in the quality of care provided to patients (16). In this study, it was aimed to prevent CLABSI, and the CLABSI prevention bundle which consisted of six parameters was applied on physician and nurse groups.

One of the most significant obstructions is lack of knowledge among healthcare professionals in bundle practices that are constructed with evidence-based activities. Lack of knowledge reduces the effectiveness of the bundle. In a study that was carried out in Osaka towards reducing CLABSIs, it was determined that an actively provided infection management training was effective in reducing CLABSI rates (17). In this study, the correct answers of the nurses and physicians to the knowledge test significantly increased after the CLABSI prevention bundle training (Nurse, p=0,001; Physician, p=0,004; Table 2). In the study, it was found that the participants had general knowledge on infection management precautions and CLABSIs, but they needed detailed knowledge.

In bundle implementations, in addition to training programs, adaptation to the implementation and following this adaptation are also substantially important. There are studies which demonstrated that there were reductions in infection rates at ICUs where adaptation to bundle practices was high (16,18). According to a meta-analysis study on CLABSI prevention, the rates of CLABSI decreased by 80% in cases of complete adaptation to bundle treatment (19). Lin et al. (2017) conducted a CLABSI bundle study in the period of 2009-2013 and found that CLABSI rates significantly decreased as adaptation to the package increased through the years.

In this study, in the six-month period where the bundle practice continued, the bundle adaptation results were higher than average among the ICUs, and these results affected the infection rates positively (Table 5). Collaboration of the physician and nurse groups brought success in infection management. The professional disciplines that had a role in CVC placement and maintenance at the ICUs applied the bundle parameters completely. With this aspect of it, this study is the first one in Turkey that focused solely on CLABSI in terms of professional disciplines.

This study investigated six evidence-based parameters in the bundle practice in detail. Non-compliance with even one parameter was accepted as non-compliance with the bundle. In the trainings for the nurses and physicians, these parameters were examined based on a cause and effect relationship. Hand hygiene compliance was at the top of these parameters. A study conducted by Musu et al. (2017) at five different centers found that control checklists and hand hygiene observations for reducing CLABSIs were effective in reducing CLABSI rates (20). A multi-center study in Canada concluded that contamination of the hands decreased in the case of suitable application of hand hygiene, and this directly affected the rates of CLABSIs (21). In this study, it was observed that hand hygiene practices were not completely performed during the CLABSI prevention bundle activities at the ICUs (Table 4). The researcher's frequent visits to the ICUs and emphasis on hand hygiene in the trainings were effective in increasing the adaptation rates.

The second parameter of this study was compliance with the maximum barrier precautions during CVC placement. An almost complete compliance rate was obtained for this parameter in the study (Table 4). In a CLABSI bundle study carried out in Brazil at 34 different points, increased compliance with the maximum barrier precautions reduced the infection rates proportionately (22). Another study on preventing CLABSIs determined that compliance with the maximum barrier precautions during placement of catheters reduced contamination, as well as increasing the awareness of personnel (4). Looking at the results of this study, presence of patients who received catheterization treatment under emergency conditions in addition to routine CVC placement at REA-1 ICU in difference to the other two ICUs affected compliance with the maximum barrier precautions. With this parameter, the physician group was studied in person. Providing the physician group with detailed information increased awareness on infection management.

The third parameter of the bundle practice consisted of avoiding usage of the femoral vein as the place of CVC. In this study, a total of 64 catheters were implemented at the ICUs, and only 3 of them were applied on the femoral region. Studies on reducing CLABSIs at adult ICUs determined that the vast majority of infections that are detected occur with CVCs applied on the femoral region, and it was concluded that usage of this region should be avoided (23,24). In this study, there was an almost 100% compliance with the criterion of avoiding usage of femoral catheters at the ICUs (Table 4). With this parameter, awareness among the physician group was increased. The participants were careful in selecting locations of catheterization except for emergency conditions and medical necessities. Care of the physician group in selecting locations of catheterization for preventing CLABSIs increased their sensitivity towards precautions against infections.

The fourth parameter of the bundle practice was usage of 2% chlorhexidine for skin cleansing during CVC placement. In the literature, it was reported that 2% chlorhexidine is more effective against skin contamination in comparison to alcohol-based antiseptic solutions and povidone iodine (25,26). 2% chlorhexidine gluconate affects catheter colonization in particular (6). The results in this study on the rate of using 2% chlorhexidine gluconate were higher than average (Table 4). Brief reminders after the general trainings and making observations at different

times of implementation were effective in speeding up the behavioral changes in the participants.

Usage of suitable catheter entry point covers after placing CVCs was discussed as the fifth parameter of the CLABSI prevention bundle practice. In the literature, studies reported that catheter entry point covers are effective in reducing CLABSIs, and they affect catheter entry point colonization directly (2,18,27,30). In this study, the ICUs completely complied with the parameter of using suitable catheter entry point covers (Table 4). During the study, while translucent covers were used in cases without discharge such as edema and bleeding, gauze patches were used to cover the catheter entry points of the patients in cases where translucent covers could not be used due to cases such as edema, bleeding and sweating. The care applied for the region of catheter entry revealed the effectiveness of professional nursing care on preventing CLABSIs.

Assessment of daily necessity for CVC in patients was discussed as the last parameter of the CLABSI prevention bundle practice. Daily questioning of catheter necessity was reflected on the CVC usage days throughout the study (Table 6). Hsin, Hsu and Shieh (2017), in their CLABSI bundle research, achieved successful results on CLABSI rates by removing long-term catheters from the patient (28). Mheen and Bodegom-Vos (2017) conducted a meta-analysis study on preventing CLABSIs and found that significant reductions in CLABSI rates were achieved by short-term catheterization (29). In this study, the ICUs completely complied with this parameter (Table 4). Considering the implementation rate of the relevant parameter, the CLABSI prevention bundle practice created awareness in the physician and nurse groups at the ICUs in terms of catheter usage.

In this study, CLABSI prevention bundle study aimed to decrease the rate of infection, focusing on a single infection with a multidisciplinary approach, not only nurse groups but also physician groups, was the main outline of the study.

While the above-mentioned results were experienced, there were some limitations in this study. These; The study included the Anesthesia and Reanimation ICUs at one research and training hospital in a metropolitan province in the Central Anatolia Region of Turkey. Results on the period after the study (observation period in the study) could not be included as a transition was made to new diagnosis criteria for determining infection diagnoses associated with healthcare services by the Department of Contagious Diseases at the General Directorate of Public Health at the Turkish Ministry of Health.

CONCLUSION

Healthcare institutions and especially ICUs must be established under infection management conditions, and all healthcare personnel that are involved should be trained. In preventing HAIs, healthcare practices should be offered as bundle practices, healthcare professionals should be trained with this approach, and they should be included in the bundle practice. Bundle practices for infection management should be maintained by improvement at especially ICUs.

Competing interests: The authors declare that they have no competing interest.

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Ethical approval: Before starting the study, in order to evaluate the ethical suitability of the study, the approval date of 12.06.2017 and the Ethics Committee numbered 39/20 were obtained. Place: Diskapi Yildirim Beyazit Training and Research Hospital.

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