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Should the CDC's recommendations for promptly removing unnecessary centrally inserted central catheters be enhanced? Ultrasound-guided peripheral venous cannulation to fully comply

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Abstract

Purpose: In an effort to reduce catheter-related bloodstream infection's incidence rates in an intensive care unit, several evidence-based procedures recommended by the Centers for Disease Control and Prevention for centrally inserted central catheters were implemented. A failure to fully comply with the recommendation for prompt removal of the centrally inserted central catheters was attributed, mainly to the difficulties and inadequacies raised from establishing peripheral venous access.

Methods: The ultrasound-guided peripheral venous cannulation method as a supplementary intervention to the Centers for Disease Control and Prevention's recommendations was incorporated and examined during the subsequent year.

Results: A significant reduction on catheter-related bloodstream infection incidence rates out of the expected range was found. Centrally inserted central catheters utilization ratios were reduced by 10.7% ($p < 0.05$; 58%–47%) and the catheter-related bloodstream infection incidence rate was reduced by 11.7 per thousand device–days (15.9–4.16/1000 centrally inserted central catheters days (2015–2016 group, respectively)).

Conclusion: The reduction of catheter-related bloodstream infection was higher than that described in the published literature. This probably shows that the combination of the five evidence-based procedures recommended by the Centers for Disease Control and Prevention together with that of ultrasound-guided peripheral venous cannulation method can increase the compliance with the Category IA recommendation for removal or avoidance of unnecessary placement of centrally inserted central catheters and decrease the catheter-related bloodstream infections in a more effective way, by affecting the patients' centrally inserted central catheter exposure.

Keywords

Centers for Disease Control and Prevention, centrally inserted central catheters, central venous catheter, ultrasound, bloodstream infection, peripheral venous access, intensive care, catheter-related bloodstream infection

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Background

Centrally inserted central catheters (CICC) are an important tool in modern medical practice, particularly in the intensive care units (ICUs). Although these catheters provide the necessary venous access for patient care, opening access to the central venous system of the patient risks serious complications such as systemic infections. The majority of serious catheter-related bloodstream infections (CR-BSI) are associated with CICC placed in the ICUs[1] and are considered to be one of the most costly and lethal type of healthcare-associated infections (HAIs) with a reported mortality ranging between 12% and 25%.[2–4] The Keystone Michigan ICU cohort study[5] has effected a reduction up to 66% by targeting clinicians compliance, on the five evidence-based procedures recommended by the Centers for Disease Control and Prevention (CDC) (hand hygiene, maximum barrier precautions, chlorhexidine site disinfection, avoiding the femoral site, and promptly removing unnecessary central venous catheters).[6]

Based on infection data recorded on patients admitted in the ICU of the study, CR-BSIs were found to be the most prevalent among all device-associated infections. Thus, it has been assumed that CICC utilization ratios (UR) and extended duration of use were probably additively responsible for the high CR-BSIs prevalence, as they were higher than reported in several studies.[7–10] In a way to reduce their incidence, the CDCs evidence-based procedures were implemented. Subsequently, the ultrasound-guided peripheral venous cannulation (UGPVC) method as a supplementary intervention to the CDCs recommendations was incorporated and the effectiveness was examined in the subsequent year.

Although the clinicians' (nurses and physicians) compliance was established through unit-based safety checklists, difficulties were found on adequately fulfilling the recommendation for removal of the CICCs as soon as it was no longer necessary. The main reason for failing was the difficulty in establishing a peripheral venous access (paucity or absence of visible or palpable peripheral veins due to obesity, underweight, or edema).[11–13] Difficulties in establishing a peripheral venous access is also a common indication for CICC placement.[14–16]

Accordingly, the implementation of the UGPVC method[17,18] has been decided, as a supplementary intervention to the CDCs evidence-based procedures in order to fully comply with the recommendation regarding the removal of unnecessary CICCs or avoid unnecessary placement. The use of UGPVC method can be very helpful in both of the cases, and it is very well described and increasingly used in the literature and clinical practice.[17,18] Randomized control trials and observational studies have concluded that it can reduce the risk of misplacement when difficulty is expected or when the traditional technique has no results.[19,20]

The aim of the study was the elimination of inadequacies or difficulties arising when establishing peripheral venous access as an indication for CICC use (avoid unnecessary placement or prompt removal) using the UGPVC method as a supplementary intervention to the CDC's recommendations and examine the effect during the subsequent year.

ICU report

In the case of a mixed ICU in the Republic of Cyprus, an active device-associated healthcare-associated infection (DA-HAI) surveillance that was conducted during 2015 found that CR-BSIs were the most observed DA-HAI (44.1% of DA-HAIs (21 cases), 15.93/1000 days (2015 data)). In addition, high CICC utilization ratio (58% (ICU patients hospitalized $>$ 48 h)) was observed with an extended duration of use per insertion (median 7 days (IQR: 4–12 days)).

The high utilization and device use rates were primarily due to difficulties (known or expected), similar to those described in other studies.[11–13]

On establishing peripheral venous access, the decision to remove or avoid insertion of CICCs was based on underlying disease and/or severity of the patient's condition and physician orders.

Study methodology, materials, and method

A retrospective cohort study was used for two periods of time. The first period started on 1 January and lasted until 31 December of 2015. During that period, active CR-BSIs surveillance was conducted with the use of a standardized survey record form for collecting patient data based on the ICU protocol (European Centre for Diseases Control (ECDC), HAI-ICU Protocol, v1.01 standard edition).[21] During the second period (1 January to 31 December 2016), the same protocol was used, along with the use of a survey record form dedicated to collecting patient's data regarding the UGPVC that was used on patients when traditional methods (palpation) were expected to be difficult or else failed.

During the first surveillance period (1 January until 31 December 2015), all patients who were admitted to the ICU and remained hospitalized for more than 48 h (n = 198) were monitored for CR-BSI events until their death or discharge. Demographics, CICC utilization, Acute Physiology and Chronic Health Evaluation (APACHE II), simplified acute physiology score (SAPS II)[22], days of patients device exposure, length of stay, and outcome on discharge from the ICU were recorded.

During the second surveillance period (1 January until 31 December 2016), the same surveillance protocol was used (n = 184) additionally with an UGPVC survey form for collecting patient data regarding the demographics, attempts of cannulation, number of succeeded or/and

failed cannulations, peripheral cannulation site, cannula diameter size, body mass index (BMI), and severity scores (APACHE II and SAPS II).

Ethics approval

The study protocol was approved by the Cyprus National Bioethics Committee (ΕΕΚΒ/ΕΠ/2015/37) as a part of a comprehensive device–associated infection control program and reviewed by the Republic of Cyprus Personal Data Commissioner. The Special Research Committee of the Ministry of Health has given its permission to conduct the study and collect patient data according to the principles of the Declaration of Helsinki.

CR-BSI definition

ECDC[21] definition was used. Accordingly, CR-BSI is a clinical definition, used when diagnosing and treating patients, that requires specific laboratory testing that more thoroughly identifies the catheter as the source of the BSI.

Blood samples were collected in case of a suspected blood stream infection. For CR-BSIs, the CICC was aseptically removed and the distal 4 cm of the catheter was separated and cultured.

Standard laboratory methods were used to identify microorganisms using an automated method with the Phoenix 100 and Vitek II.

UGPVC intervention method

After selecting a candidate patient,[11–13] an elastic tourniquet were placed over the bicep. Then, a high-frequency linear transducer (SonoSite MicroMaxx L38e/10-5MHz) using short-axis probe orientation method was used to examine forearm venous anatomy.

An appropriate target vessel was defined as fully collapsible, compressible on short axis orientation, nonpulsatile, and with a diameter greater than 2 mm. Subsequently, probe orientation was rotated to long axis,[23] and the site was cleaned with a solution of 2% chlorhexidine and 70% isopropyl alcohol. For maximal infection precautions, no ultrasound gel was used but the cleaning solution performed acceptably as the means for transferring ultrasound waves between transducer and skin.

Intravenous (IV) indwelling 16–18 gauge, 50-mm-long cannula (B-Brown Melsungen) were guided by ultrasound into the vessel. On observation of blood in the cannula's flashback chamber, the catheter of the cannula was advanced over the needle and into the vein. The needle was then withdrawn. Free normal saline infusion under gravity and free return of blood after lowering the saline container below the cannula level was checked. An IV extension tube with a three-way tap was attached and the cannula secured with a transparent, sterile dressing.

The intervention was performed by the caring team as part of the daily assessment of CICC exposure and CR-BSI prevention efforts.

Statistical analysis

Medians and interquartile ranges (IQR) were used to describe the distribution of continuous variables (e.g. age, ICU stay) and frequencies and percentages for categorical variables; 95% confidence intervals (CIs) for incidence rates were calculated based on the Poisson distribution for rare events. Analysis was performed in R version 3.1.3[24] using the packages exactci[25] that calculates exact Poisson rates and exact CIs of the rate ratios.

Intervention results

UGPVC was performed for 124 patients (in some patients more than once) of which 35 (28.2%) were females; 45 (36.3%) were obese, 49 (39.5%) were overweight, 26 (21%) had normal weight, and 4 (3.2%) were underweight. Patients had a mean SAPS II score of 60.43 (±19.71) and a mean APACHE II score of 31.28 (±10.54).

The main reasons for requesting UGPVC use were the followings: known or expected difficulties (79%), removal of CICC (37.1%), and avoidance of CICC placement (33.5%).

In 121 of the 124 (97.6%) patients, UGPVC was successful (two attempts were made for each of the three unsuccessful trials). Out of the 121 successful trials, 104(86%) were placed on the first and second attempts and 17 (14%) on the third.

Surveillance results

2015

During the first study period, surveillance data were collected for 198 patients hospitalized in the ICU for a total of 2269 ICU days (patient-days). The group included 73 (36.9%) females and 125 male patients. Median age was 68 years (IQR: 55–77 years). The median APACHE II score on admission was 22 (IQR: 16–28), whereas the median SAPS II score was 49 (IQR: 36–65). Median length of ICU stay was 6 days (IQR: 4–13). A total of 43 instances of DA-HAIs were detected in 25 of the 198 patients. CR-BSIs were the most commonly encountered type of infection accounting for 21 (48.8%) incidents and rate 15.93 (9.9–24.3) per 1000 CICC days (Table 1).

2016

During the second study period, surveillance data were collected for 184 patients hospitalized in the ICU for a total of 2029 ICU days (patient-days). The group included

Table 1. Demographics of 2015 and 2016 surveillance.

	2015		2016		p value[a]
	N (%)	Median (IQR)	N (%)	Median (IQR)	
Gender					0.729
Female	73 (36.9)		71 (38.6)		
Male	125 (63.1)		113 (61.4)		
Age in years		68 (55–77)		71.5 (59.5–78)	0.11
Days of ICU stay		6 (4–13)		6 (3–13)	0.139
APACHIE II score		22 (16–28)		29 (20.5–36)	<0.001
SAPS II		49 (36–65)		60 (42.5–73)	<0.001
Type of admission					0.167
Medical	141 (71.2)		127 (69)		
Scheduled surgical	3 (1.5)		9 (4.9)		
Unscheduled surgical	54 (27.3)		48 (26.1)		
Origin of patient					0.17
Community	63 (31.8)		60 (32.6)		
LTCF	4 (2)		9 (4.9)		
Other ICU	43 (21.7)		49 (26.6)		
Ward in this or other hospital	88 (44.4)		66 (35.9)		
Trauma	27 (13.6)		29 (15.8)		0.557
Antimicrobial treatment	180 (90.9)		167 (90.8)		0.960
Acute coronary care	49 (24.7)		39 (21.2)		0.410
Centrally inserted central catheters days		7 (4–12)		4 (3–11)	0.003
Incidence per 1000 device-days and device utilization	Rate (95% exact CIs)	Device utilization	Rate (95% exact CI)	Device utilization	
CR-BSIs	15.93 (9.9–24.3)	0.58	4.16 (1.1–10.6)	0.47	

IQR: interquartile range; ICU: intensive care units; APACHIE: Acute Physiology and Chronic Health Evaluation; SAPS: Simplified Acute Physiology Score; LTCF: long-term care facility; CR-BSI: catheter-related bloodstream infection; CI: confidence interval.

71 (38.6%) females and 113 male patients. Median age was 71.5 years (IQR: 59.5–78 years). The median APACHE II score on admission was 29 (IQR: 20.5–26), whereas the median SAPS II score was 60 (IQR: 42.5–73). Median length of ICU stay was 6 days (IQR: 3–13). A total of 24 instances of DA-HAIs were detected in 16 of the 184 patients. CR-BSIs was the least commonly encountered type of infection accounting for 4 (16.7%) incidents and rate 4.16 (1.1–10.6) per 1000 CICC days (Table 1).

Discussion

Despite the fact that the increasing use of CICCs led to an associated increase on the new cases of primary BSI,[2,26,27] in some areas, prevention efforts resulted in a significant decrease[2] from up to 66%.[5] CR-BSIs incidence rates (15.9/1000 device days (2015 group)) and device utilization ratios (58.1%) were much higher in this study compared to those reported in other studies.[7–10]

Despite the efforts to implement the five evidence-based procedures recommended by the CDC,[6] difficulties were found with the Category IA recommendation for removal of CICCs or avoiding placement altogether due to inadequate or difficult peripheral venous access.[11–13]

Since UR and extended CICC use has been considered to be important risk factors for the onset of an infection,[10] the effect of UGPVC method implementation as a supplementary intervention to the CDC recommendations was explored during the subsequent year (2016 group).

UGPVC was performed for 124 patients, with a success rate of 97.6% similar with that reported in another study[28] as 104 (86%) out of 121 successful trials were placed on the first or second attempt (at least two peripheral venous accesses for each patient). In these patients, mean severity scores (APACHE II and SAPS II) were found to be higher (higher score indicates higher underlying disease severity) than in the 2015 group and similar to 2016 (Table 1).

During the first surveillance period (2015), a total of 43 instances of DA-HAIs were detected in 25 of the 198 patients. CR-BSIs were the *most* commonly encountered type of infection accounting for 21 (48.8%) incidents and 15.93 instances (9.9–24.3) per 1000 CICC days. Although the CR-BSI incidence rates are less than those documented in the previous Cypriot report[29] (17.9/1000 days), they remain higher compared to the international benchmarks.[30]

During the second surveillance period (2016), a total of 24 instances of DA-HAIs were detected in 16 of the 184 patients. CR-BSIs were the *least* commonly encountered

type of infection accounting for 4 (16.7%) incidents (Table 1). Incidence rates per 1000 device days was reduced by 11.7 per 1000 devices days in the second surveillance period (2016) in contrast to the first period. Specifically, there was a reduction of 74% in the rate (RR = 0.26, 95% CI: 0.06–0.77). Reduction appears to be more than that reported in the Keystone Michigan ICU cohort study[5] (66%).

With respect to the device utilization rate in 2015, 125 patients had CICCs for 1318 days (CICC ratio = 58.1%), while in 2016, 122 patients had CICCs for 962 days (CICC ratio = 47.4%). There was a drop of 10.7 percentage points (356 days less) resulting in an 18% decrease from the first surveillance period (RR = 0.82, 95% CI: 0.75–0.89).

Although the severity of the underlying disease at the second period (2016 (SAPS II and APACHE II)) appears to be higher than in the baseline (2015 group), a reduction was observed. This finding indicates that even in the patients with high severity scores, a reduction of CR-BSIs rates is possible.

A reduction was also found in the duration of CICC use. In the 2015 group, mean CICC duration was found to be 7 days (IQR: 4–12 days), while in the 2016 group was 4 days (IQR: 3–11 days). Three days reduction in contrast to the first surveillance period accounts for nearly half of the initial group days (2015 group). Since central venous catheterization longer than 5–7 days was associated with a higher risk of catheter-related infection,[10,31–33] a reduction less than the cut-off point of 5 days may primarily explain the significant decrease of 74% (RR = 0.26, 95% CI: 0.06–0.77) on CR-BSI in the 2016 group.

Conclusion

The reduction of CR-BSI was higher than that described in the published literature. This probably shows that the combination of the five evidence-based procedures recommended by the CDC together with the use of UGPVC method can increase the compliance with the Category IA recommendation for prompt removal of CICCs or avoidance of unnecessary placement and decrease the CR-BSIs in a more effective way by affecting the patients' CICC exposure.

UGPVC could be considered as an enhancing element for improving compliance to the CDC's evidence-based procedures for CICCs. Larger studies on the effect of UGPVC method to CR-BSIs prevalence are probably warranted to verify these results.

Declaration of conflicting interests

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