A Study of Central Line Associated Blood Stream Infections among Patients on Hemodialysis before and after Implementation of a Catheter Care Bundle

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Abstract Background: Central venous catheters (CVCs) are often used as a vascular access in patients with end stage renal diseases when emergency hemodialysis is required, before maturation of arteriovenous fistula or graft, or when a permanent access becomes non-functioning. The most common complication following insertion of a CVC is infections including exit site infection, tunnel infection, or central line related blood stream infections (CLABSIs). Preventing such complications is crucial in these vulnerable patients and this can be accomplished by strict adherence to infection control guidelines. This study aimed to evaluate the efficacy of implementation of a CVC care bundle composed of best evidence based practices to see whether the rates of CLABSIs rates would decrease. **Methods:** the study was divided into pre and post intervention phases. The duration of each phase was 6 months during which rates of confirmed CLABSIs per 1000 catheter days as well as the causative microorganisms were recorded. The data were then compared and analyzed to evaluate the intervention. **Results:** CLABSIs rates decreased from 6.7 in phase 1 to 4.1 in phase 2. The relative risk reduction was 0.39. **Conclusions:** Implementation of bundles for insertion and maintenance of CVCs can help preventing CRBSIs which is very important to improve patient care.

Keywords Central Line Associated Blood Stream Infections, CLABSIs, Central Venous Catheter, CVC, Bundle

1. Introduction

One of the major health problems in the world is the end-stage renal disease (ESRD) [1]. Vascular access is

considered the bridge between the patient and the machine circuit. That is why it is called the “Achilles heel of hemodialysis” [2]. The good performance of dialysis vascular access is the main factor that affects the survival and quality of life of patients with ESRD [3]. Arteriovenous fistula (AVF), arteriovenous graft and central venous catheter (CVC) are the main three vascular accesses used in hemodialysis. Usually, CVCs are required in case of emergency hemodialysis, either when a permanent access becomes non-functioning or at the time of initiation of renal replacement therapy [4].

Chronic hemodialysis patients are at high risk to infection especially those with CVCs as patients with catheters have a 2 to 3 folds increased risk of hospitalization for infection and death compared with patients with an AVF or graft [5]. Common infections related to hemodialysis CVC usage include central line associated bloodstream infections (CLABSIs), exit-site infections, and tunnel infections. CLABSIs lead to increased morbidity, hospitalization, and death [6].

CLABSI means the presence of bacteraemia originating from a central line catheter [7]. CLABSI is a common cause of health care associated bacteraemia and septicemia, and it is a major cause of morbidity and mortality. Considering device related infections, CVCs are associated with a greater risk of device related infections compared to any other medical device [8].

In order to cause infections, microorganisms must have an access to the catheter, either through the extra-luminal surface or intra-luminal surface of the catheter, in which they usually form a biofilm. This access occurred at the time of the CVC insertion through percutaneous route or a few days afterwards, or through catheter hub (and lumen) contamination when the catheter is inserted over a percutaneous guide wire or when it is later manipulated [9]. Hematogenous dissemination of the microorganisms from

elsewhere and contamination of the infusion liquid are other possible causes of infections [10].

The diagnosis of CLABSI depends on isolation of the same microorganism from the catheter tip and at least one blood culture, with presence of clinical manifestations of infection and no other detectable source of infection [11]. Causative microorganisms that cause CVC infections are almost bacteria, with a significant percentage of multi-drug resistant bacteria. The Gram-positive cocci are the principle causative bacteria, especially *Staphylococcus aureus* with great consideration to *Methicillin-resistant Staphylococci*, *coagulase-negative Staphylococci* including *Methicillin-resistant Staphylococcus epidermidis* (MRSE), and *Enterococci* including *Vancomycin-resistant Enterococci* (VRE) [12-16].

The ability to Control infection in hemodialysis patients is a challenging task for healthcare staff specially because catheters are often manipulated during hemodialysis session and the hemodialysis patients are immunocompromized [17]. However, with focus on education and strict implementation of the infection prevention and control programs, CLABSI rates could be decreased [18].

2. Methods

Study Design

This study was carried out at Hemodialysis Unit, Internal Medicine department, Faculty of Medicine, Tanta University. The study was designed in 2 phases; phase 1 was in the period from May to October, 2016. Phase 2 was in the period from December to May, 2017. During phase 1, education and training of the health care workers in the unit was done to prepare for implementation of CLABSI prevention bundle (from November, 2016). The care bundle was adopted from center for disease control and prevention (CDC) evidence based practices for insertion and maintenance of CVCs. Throughout the study, the numbers of CLABSIs, the rates of infection were calculated, and causative microorganisms were detected.

Patients

Inclusion Criteria of the patients were any patient with CVC who developed signs and symptoms suspicious of CLABSI before or during hemodialysis session (core temperature of $> 38^{\circ}\text{C}$ or $< 36^{\circ}\text{C}$, tachycardia > 90 / min, tachypnea > 20 / min, or transient hypotension, chills, malaise, abdominal pain, nausea, vomiting, diarrhea, anxiety, shortness of breath and confusion). Patients were included only if the catheter was in place for > 2 calendar days on the date of event. Exclusion Criteria were patients taking antibiotic treatment, and patients on hemodialysis with arteriovenous (AV) fistula or any vascular access

other than CVC [19].

Microbiological Workup

Blood Cultures

Blood samples were collected under complete aseptic conditions from the catheter hub and a peripheral vein. Hubs and circuit ports were first cleansed with alcohol based chlorhexidine. CLABSI was confirmed when the same microorganism was isolated from simultaneous quantitative cultures of blood samples with a ratio of $\geq 3:1$ (catheter versus peripheral).

Catheter Tips

If the catheter was removed, distal 5 cm of catheter segment was cut aseptically, and it was cultured by Maki's standard semi-quantitative method. A colony count of ≥ 15 was considered significant [20].

Events of CLABSIs were diagnosed based on the definition criteria set by National Healthcare Safety Network of the US Center for Disease Control and Prevention [19].

Identification and antibiotic sensitivity testing of the isolated microorganisms was done using automated vitek2 system (Biomérieux, France) in the Microbiology and Immunology Department, Faculty of Medicine, Tanta University.

Implementation of CLABSI Prevention Bundle

The bundle was adopted from best evidence-based practices [16] and was implemented from November, 2016. The bundle included:

1. Hand hygiene; surgical hand hygiene either with alcohol-based hand rub or hand wash with antiseptic soap. Hand hygiene should be performed before and after palpating catheter insertion sites as well as before and after inserting, replacing, accessing, repairing, or dressing an intravascular catheter site.
2. Maximal barrier precautions; a mask, a cap, a sterile gown, and sterile gloves were used during insertion. A large (head-to toe) sterile drape over the patient was also used during the placement or exchange of a CVC catheter.
3. Prepare and clean the skin site with an alcoholic chlorhexidine solution containing a concentration of > 0.5 chlorhexidine and 70 % alcohol before central venous catheter insertion and during dressing changes. If there is a contraindication to chlorhexidine, tincture of iodine, an iodophor, or 70 % alcohol can be used.
4. Optimal site selection; for short term hemodialysis, use internal jugular or less preferable femoral vein.
5. Using either sterile transparent, semipermeable dressing, or gauze to cover the catheter site.

6. Scrubbing the catheter ports and hub with an appropriate antiseptic.

Statistical Analysis

Baseline (pre-intervention) and post-intervention rates of CLASBIs in the unit were calculated as the sum of all CLASBIs reported during the study period. Unit level CLASBIs rate was calculated as $\frac{\text{CLASBIs}}{\text{central line days}} \times 1000$ [21]. Compliance to the bundle were measured by the number of patients in the unit with central line for whom elements of the bundle were fulfilled and documented divided by the total number of the unit patients with central line [22]. Data were analyzed using SAS version 9.3 (SAS Institute Inc. 2011. Base SAS® 9.3 Procedures Guide. Cary, NC: SAS Institute Inc.).

3. Results

During the pre-intervention phase, 19 CLABSI events were recorded in 66 patients in whom 94 CVCs were inserted for 2820 days. CLASBIs rates were 8.5, 6.1, 4.1, 6.7, 7, and 8 during May, June, July, August, September, and October, 2016 respectively. The average rate was 6.7. However, during the post-intervention phase, 13 CLABSI events were recorded in 75 patients in whom 91 CVCs were inserted for 3133 days. CLASBIs rates were 5.8, 4, 6, 3.8, 4.1, and 1.6 during December, 2016, January, February, March, April, and May, 2017 respectively. The average rate was 4.1 (Fig.1). The relative risk reduction was 0.39 after implementation of the bundle.

Figure 2 presents the percentages of compliance of nurses and resident doctors in the unit to the implemented catheter care elements. Compliances to hand hygiene, Maximal barrier precautions, skin anti-sepsis, optimal site selection, sterile dressing use, and scrubbing catheter ports and hub were 92%, 73%, 100%, 87%, 100%, and 83% respectively, while compliance to all bundle elements together was 69%.

During the study period, 37 microorganisms could be isolated from 32 confirmed CLASBIs. The most commonly isolated bacteria were *Staphylococcus aureus* (35.1%), followed by *Coagulase Negative Staphylococci* (29.7%), *Pseudomonas aeruginosa* (18.9%), *Klebsiella pneumoniae* (10.9%), *Enterobacter cloacae* (2.7%), and *Acinetobacter baumannii* (2.7%). Eighty-one percent of the isolated organisms were multidrug resistant (MDROs) (Fig.3).

Figure 1. Comparison of CLABSI rates (per 1000 catheter days) in pre and post-intervention phases of the study

Figure 2. Compliance to the bundle elements.

Figure 3. Percentage distribution of isolated microorganisms

Table 1. Numbers and rates of CLABSIs in pre and post-intervention phases

	Pre-intervention phase	Post-intervention phase
Total catheter days	2820	3133
Confirmed CLBSIs	19	13
CLBSIs/1000 catheter days	6.7	4.1

4. Discussion

This study demonstrated that the application of CVC care bundle at a hemodialysis unit in Tanta university hospitals was able to reduce the incidence of CLABSIs. CLABSI rate per 1000 catheter days has been decreased from 6.7 in the pre-intervention phase to 4.1 in the post-intervention phase with a relative reduction risk of 0.39. Although the reduction was expected to be higher, but we could state that with close adherence to the bundle, a further reduction could be achieved in the next months. Many authors reported that CLABSIs can be effectively controlled by applying a multidisciplinary infection control process. Despite the fact that the bundle components in each study may not be identical, these different bundles reduced the rates of infection through their implementation [23-29].

The rates of CLABSIs per 1000 catheter-days in phase 1 (pre-intervention) of the present study were closely related to those mentioned by Guerin et al, 2010 [30] who reported a pre-intervention rate of 5.7. After implementation of different infection control measures included in their post-insertion bundle, the infection rates decreased markedly to 1.1. Our results in phase 2 were high compared to those of Guerin et al., which may be explained by defect in using complete protective barriers, also defect in applying aseptic techniques during insertion and maintenance of CVC related to proper hand hygiene. Also, several studies recorded nearly similar results to ours in phase 1 but their results were lower than our results after bundle implementation [31-33].

The overall compliance rate of the respondents in this study was (69%) which was lower than the compliance in Miller's study which was (84% for insertion-bundle and 82% for maintenance-bundle). During their study, they formed collaborative teams responsible for training of health care workers (HCWs) and for bundles implementation [34]. Controversy, comparing our results to that reported by Sahli et al., 2017 in Algeria [35], it was found that in our study there was higher compliance concerning hand hygiene (92%), skin antisepsis prior to CVC insertion (100%) and barrier precautions application (73%).

Not surprising that the rate of infection decreased to its minimal rates (1.6/ 1000 catheter days) in the last month of phase 2 in the present study, a finding that could be attributed to increased awareness of HCWs together with increased compliance to the bundle elements. Our reports

showed that the rates of infection had declined more in each month with more compliance. Auditing in phase 2 played an important role in increasing the compliance. Continuous staff education, training on insertion and maintenance of CVC, and regular auditing are very important and highly recommended.

Regarding the isolated microorganisms, *Staphylococcus aureus* was the most commonly isolated organisms (35.1%) in our study followed by *Coagulase negative Staphylococci* (29.7%). This result was in parallel with the results of several studies [36-40]. In the present study, Gram-negative micro-organisms played an important role in CLABSIs in which *Pseudomonas aeruginosa* caused 18.9% of infections followed by *Klebsiella pneumonia* (10.9%), *Enterobacter cloacae* (2.7%) and *Acinetobacter baumannii* (2.7%). This should be taken into consideration for the empirical treatment of CLABSIs.

5. Conclusions

We could conclude that strict adherence to the bundle elements together with periodic surveillance; recording the infection rates and comparing with that of others will make a change.

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Competing Interest

None declared.

Authors' Contributions

Marwa Mostafa Shalaby designed the study, analyzed, interpreted the data and performed the statistical analysis. Kareman Ahmed Eshra, Radwa Abd El moteleb Essa and Ghada Mahmoud Alghazaly collected and analyzed the data. All the authors carefully revised the article and gave final approval of the article.

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