Hemodialysis catheter-related infections: Results of a tertiary care center study in Saudi Arabia

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ABSTRACT

Background: Catheter-related bloodstream infection (CRBSI) is frequent causes of mortality and morbidity in dialysis patients, and the sensitivity pattern of antimicrobials varies across different dialysis centers. **Objectives:** The present study aimed to investigate the pattern of microbes grown from catheter sites, blood and the sensitivity pattern. The data could help in initiating an empiric antimicrobial therapy. **Materials and Methods:** This was an observational retrospective study at Regional Kidney Center at King Abdul Aziz Specialist Hospital, Taif, in the western region of Saudi Arabia. The data collected were related to patients' demographics, etiology of renal failure, presence of comorbidities, site of catheter insertion, and duration. Furthermore, microbiological data including cultures from catheter sites, blood, and catheters' tips and antibiotic sensitivity. **Results:** Data on 130 patients (66 females, 50.8%) undergoing hemodialysis from June 2017 to March 2018 were analyzed. The infection rate was 23.6% in this study. In all patients with CRBSI, the catheters were removed, and antibiotics given. The highest infection rates (38.4%) were noted with femoral vein inserted catheters. However, the clinical sepsis was more with jugular catheters. *Staphylococcus aureus* was prevalent organism, and cephalosporins had the highest sensitivity. Ten catheters found to be mal functional were replaced. **Conclusion:** Chronic kidney disease patients with diabetes and ischemic heart disease were more prone to CRBSI. Femoral catheters had significantly higher infection rates. *S. aureus* was the most common type of isolated bacterial strain and cephalosporins showed the highest sensitivity for the isolated bacteria.

KEY WORDS: Hemodialysis; Hemodialysis Access; Vascular Access Catheter-related Bloodstream Infection

INTRODUCTION

Hemodialysis is an important life-saving procedure in patients with acute kidney injury (AKI) and chronic kidney disease (CKD). About 25% of patients receive dialysis utilizing catheters to begin with which are invariably removed in patients with AKI.[1] While in the setting of AKI initiation of hemodialysis via a catheter is logical continuing in CKD patients catheter use should be minimized to avoid its complication. Unfortunately, there is always reluctance among CKD patients for undergoing arteriovenous (AV) fistula, so the catheter remains *in situ* for a longer time in some patients. This highlights the need for public awareness among CKD patients. In addition, the poor vascular tree

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precludes the creation of AV fistula in some CKD patients. The major complication of catheter is catheter-related bloodstream infection (CRBSI). The current literature states that rates of CRBSI range between two and five patients per 1000 catheter days.[2] Infection is considered to be the second most common risk for mortality in hemodialysis patients and a leading cause of hospitalization. Thus, utilization of central venous catheters to obtain vascular access for dialysis can have a significant impact on morbidity and mortality in hemodialysis patients.[3] Central venous catheters are linked to a 15-fold increased risk for septicemia in comparison to the AV fistula,[4] Moreover, it is highly linked to morbidity, in addition to the elevated risk of infective endocarditis.[5] Furthermore, there is a 10% increased risk of mortality with CRBSI. The data from France suggest that there is an overall incidence of colonization of 38.9 and bloodstream infection of 1.9/1000 catheter-days.[6] The process of CRBSI can be prevented by adopting stringent infection control measures and hand hygiene protocols.[7] Bacteria can cause CRBSI by entering the extra or intraluminal side of the inserted catheter, where it can reside and get involved in biofilm formation permitting continued colonization.[8] The vast majority of blood stream infections are due to intraluminal contamination.[9] While stringent precautions, especially hand hygiene, cannot be underestimated to prevent CRBSI, it is crucial to initiate rapid empiric antibiotic therapy in a given patient till cultures become available. For this reason, knowledge of epidemiological data of common pathogens and their antibiotic sensitivity pattern in a given center becomes indispensable. Furthermore, periodic surveillance to investigate the resistant microbes becomes imperative; hence, we were promoted to undertake this study at our center. Although standard CDC guidelines[10] and stringent precautions are followed at our center, CRBSI is still unavoidable. The present study aimed to investigate CRBSI and the sensitivity pattern so that the data could help in initiating an empiric antimicrobial therapy at the earliest sign of catheter infection.

MATERIALS AND METHODS

Study Design

This was an observational retrospective study from June 2017 to March 2018. The data on 130 dialysis patients at Regional Dialysis Center at King Abdul Aziz Specialist Hospital (KAASH), Taif, Saudi Arabia, were analyzed.

Inclusion Criteria

The catheters were placed under all aseptic precautions. All patients were followed for dressing soakage in addition to features of sepsis. Blood cultures including swabs from catheter sites were taken in all patients where catheter site infection was clinically noted. Each catheter was observed from the time of placement until a CRBSI, removal for other reasons (clotting, malfunction, or no longer medically necessary).

Exclusion Criteria

The patients were excluded if they were as follows:

- <18 years of age.
- Or were currently being treated for a CRBSI at time of enrollment (a lapse interval of 2 weeks was required between last administration of antibiotic and recruitment).

This study was conducted in adherence to the Declaration of Helsinki good clinical practice and the research guidelines of the center.

Catheter Maintenance Protocols at KAASH

Catheter care at KAASH follows established policies and procedures related to hemodialysis initiation, discontinuation, dressing changes, and exit site care. Standard precautions using aseptic technique are followed, including masking of the patient and staff in addition to the staff gowns, and clean gloves in accordance with CDC guidelines.[10] Catheter dressing is changed at each hemodialysis session and a through visual inspection for indurations, discharge is done. Then, cleansing of the exit site with alcoholic povidone iodine is carried out at each hemodialysis session.

Data Collection and Definitions

The data were extracted from patients' records. Data included patients' demographics, diagnosis, the presence of comorbidities, site, and duration of catheter insertion. Microbiological data were collected including cultures results from catheter sites, blood, and catheters' tips in addition to antibiotic sensitivity.

Criteria established by the CDC were used to classify an infection as a CRBSI. In summary, the patient whose HD was initiated with a catheter and was documented to have a recognized pathogen (e.g., *Staphylococcus aureus, Enterococcus* spp., *or Escherichia coli*) cultured from one or more blood cultures, and no other source of infection was taken up for the study.

A patient with the catheter in situ who had features of sepsis in the form of fever >38 C , chills or hypotension. Blood culture were drawn in addition to swab from exit site.

Statistical Analysis

All data were recorded in a predesigned and validated excel sheet. Data were represented in terms of frequencies (number of patients/cases) and valid percentages for categorical variables. Data were further analyzed using IBM SPSS (Statistical Package for the Social Sciences; IBM Corp, Armonk, NY, USA) to perform all statistical calculations, version 21 for Microsoft Windows.

RESULTS

There were 151 catheters in 130 patients with renal failure (AKI and CKD) in whom hemodialysis was initiated using a catheter. The catheter infection rate was 23.6% in this study. CRBSI was as such not a cause of mortality in this study. However, a 55-year-old male with CKD developed endocarditis on catheter during the study period.

Patients Demographics

Of 130 patients, there were 66 (50.8%) females. The mean age of the study population was 57.0 ± 14.4 years and range was 27-76 years.

Type of Renal Impairment

One hundred and eleven (71.6%) had CKD and 19 (12.3%) patients had AKI. CKD due to diabetes mellitus outnumbered other etiologies. In this study cohort there were Diabetes 37 (33 34%) Hypertension-attributed 35(31.8%) CGN 10 (9%) Autosomal dominant polycystic kidney disease 5 (4.5%) Unknown etiology 10 (9%) others Systemic lupus erythematosus, reflux and obstructive uropathy 12 (10.8%). There were 2 patients (1.5%) who had failed renal grafts.

Site of Catheter Insertion

Catheters were inserted through femoral, jugular, and subclavian (left side or the right side). CKD patients on hemodialysis showed higher rates of CRBSI compared to AKI patients in this study.

Among AKI patients, the highest rate of infection (63.2%) was in catheters inserted into jugular vein and lowest when inserted in the femoral vein.

Among CKD patients, the right femoral catheter insertion site had higher infection rates (39.6%) followed by the right jugular site (35.1%). The left subclavian site had the least percentage of infection (0.9%). Figure 1 and Figure 2 describe in details the varying infection rates in AKI and CKD patients, respectively.

Duration of Catheter Insertion

The catheter duration was recorded and evaluated in the study cohort as shown in Table 1. Majority of catheters in this study cohort had remained for 1 week. During the study period, 10 catheters were found to be malfunctional and were changed.

Bacterial Cultures

Culture for the swab from the site of insertion

The swab from exit site was repeated every time patient presented for HD and results were recorded.

Gram-positive cocci were the predominant bacterial strain in positive cultures with a 21.4% for *S. aureus* in the first swab, 27.5% for *Staphylococcus epidermidis* in the second swab, 29.6% for *S. aureus* and equal proportion for *S. epidermidis* in the third swab, and finally, 25.7% for *S. aureus* and similarly *S. epidermidis* in the fourth swab. Table 2 describes in details the percentage of each bacterial strain in the catheter swab. However, majority of swabs were sterile [Table 1].

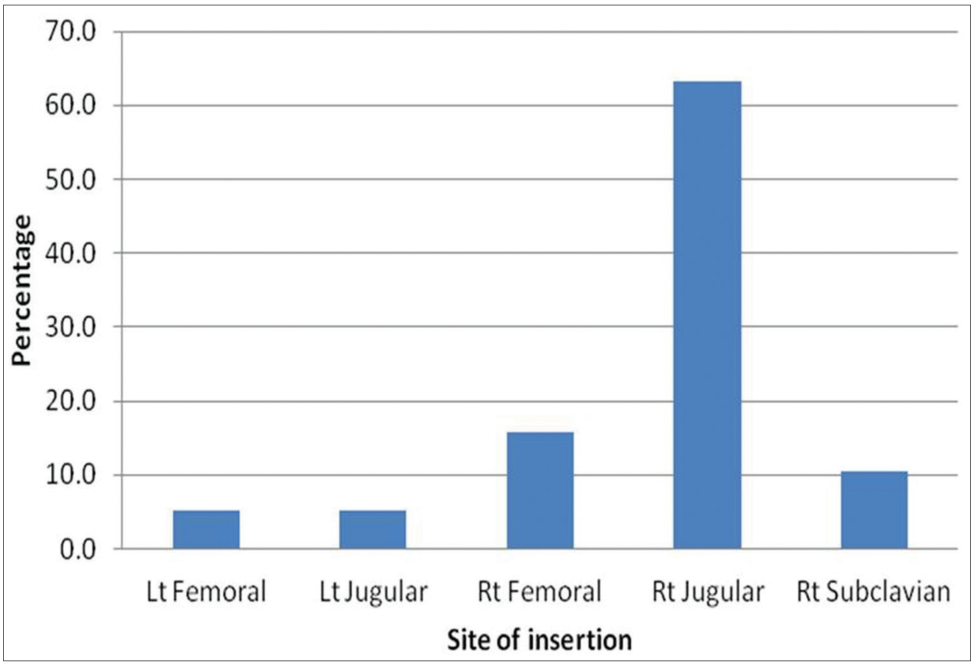

Figure 1: Sites of catheter infection in Acute Kidney Injury

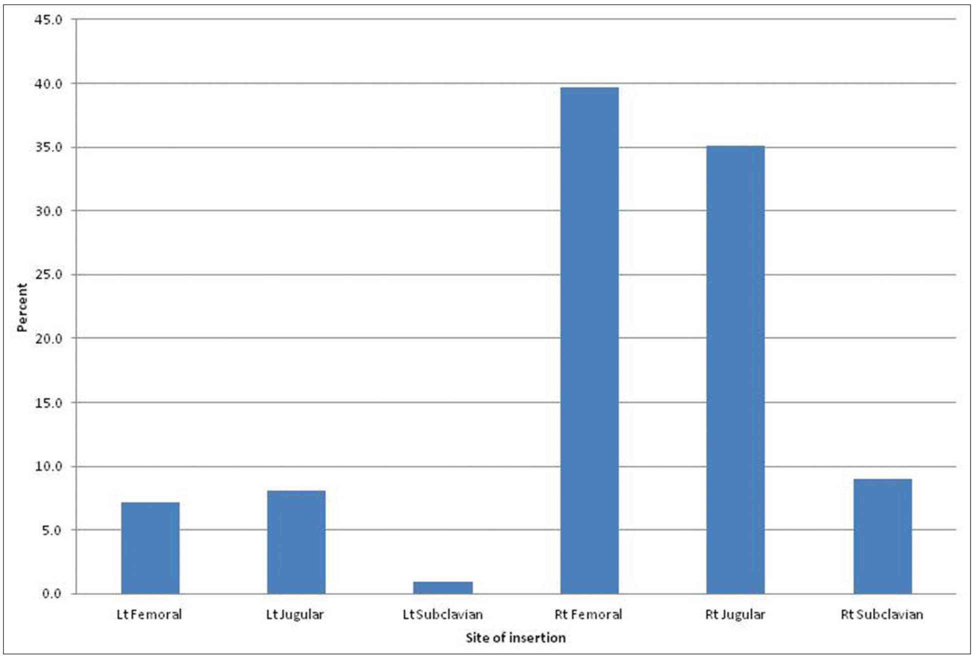

Figure 2: Sites of catheter infection in CKD

Table 1: Distribution of bacterial strains in percentages over the four swabs from sites of catheter insertion

Bacterial strain	Swab 1 (*n*=112)	Swab 2 (*n* =80)	Swab 3 (*n*=54)	Swab 4 (*n*=35)
No growth	54.4	46.3	37	28.6
Enterococci	0.9	0	0	2.9
S. epidermidis	15.2	27.5	29.6	25.7
S. aureus	21.4	20	29.6	25.7
Klebsiella	1.8	1.3	0	2.9
Acinetobacter	0.9	0	0	2.9
E. coli	3.6	2.5	1.9	0
Enterobacter	0.9	0	1.9	0
Candida	0.9	1.3	0	2.9
Pseudomonas aeruginosa	0	1.3	0	5.7
Proteus mirabilis	0	0	0	2.9

S. aureus: Staphylococcus aureus, E. coli: Escherichia coli, S. epidermidis: Staphylococcus epidermidis

Table 2: Distribution of bacterial strains in percentages of blood cultures

Bacterial strain	Culture 1 (*n*=108)	Culture 2 (*n*=69)	Culture 3 (*n*=48)	Culture 4 (*n*=31)
No growth	75.9	84.1	77.1	71
Enterococci	0	0	0	3.2
S. epidermidis	6.5	5.8	14.6	9.6
S. aureus	8.5	5.8	8.3	12.9
Klebsiella	0	1.4	0	0
Acinetobacter	0.9	1.4	0	0
E. coli	1.9	0	0	3.2
Pseudomonas aeruginosa	1.9	0	0	0
Proteus mirabilis	0.9	0	0	0
Xanthomonas malvacearum	0.9	0	0	0
Pneumococcus	0.9	0	0	0
Salmonella	0	1.4	0	0

S. aureus: Staphylococcus aureus, E. coli: Escherichia coli, S. epidermidis: Staphylococcus epidermidis

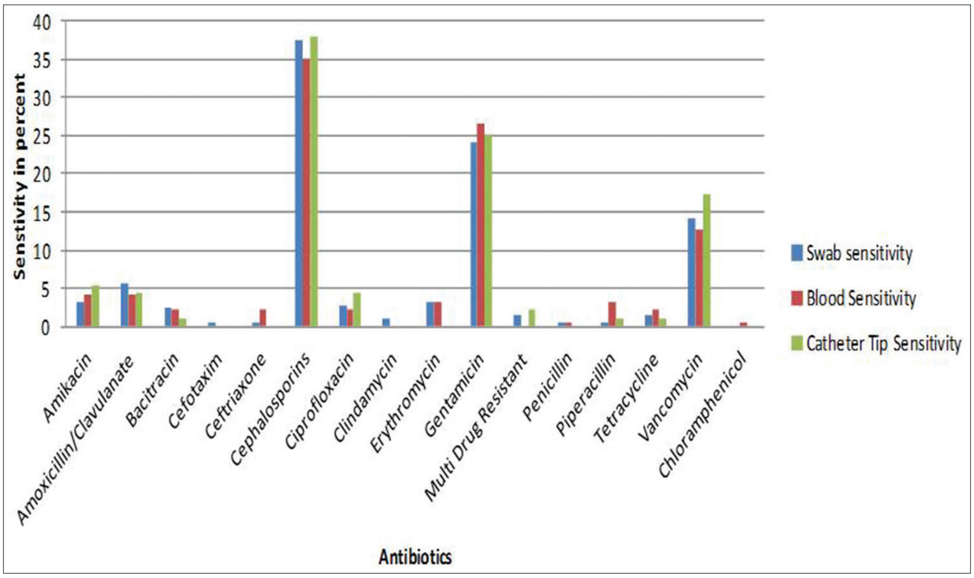

Figure 3: Sensitivity pattern of various cultures

Blood cultures

Blood cultures were drawn during HD. The blood culture followed the same figures as for swab cultures. Most of the cultures' results were sterile. Moreover, Gram-positive cocci were common infecting organisms. Table 2 shows the percentages of different bacterial strains in blood cultures.

Cultures from tips of the catheter

Tips of catheters were cultured, once the catheter was removed. Following the same pattern of blood and swab cultures, the most common result was the absence of bacteria, on culture. Of the positive cultures, the most frequent organism was *S. epidermidis* (25.3%).

Antimicrobial Sensitivity

Positive bacterial cultures were further tested for antimicrobial sensitivity. It was shown that cephalosporins were the most sensitive antibiotics followed by gentamicin. It is worth to mention that the incidence of multidrug resistance was 3.7% blood cultures, on 1.5% in the swab culture and 2.2% in the catheter tip cultures. Figure 3 describes the antimicrobial sensitivity in percentages for all isolated bacterial strains.

DISCUSSION

The CRBSIs were more frequent among CKD patients on HD compared to AKI in this study. Possibly, the number of CKD patients requiring catheters was more in number and the duration of catheter was longer among them. In addition, catheters at the right femoral site had the highest rates of infection, with Gram-positive cocci including *S. aureus* and *S. epidermidis* as predominating bacterial strains grown on cultures. The present study found that CKD patients with diabetes, hypertension, and ischemic heart diseases were more prone to get CRBSI. This was shown by Soleymanian and his colleagues as well.[11] More than half of their study cohort had diabetes, and about 80% of the patients had hypertension. While end-stage renal disease per se is an immune compromised condition diabetes mellitus augments this immune suppressed state. Powe *et al*. demonstrated that old age and diabetes mellitus were independent risk factors for septicemia among HD patients. The authors further demonstrated that temporary vascular access, especially among patients with low serum albumin, was additional risk factors of sepsis among HD population.[12] Rich and Lee in an animal model demonstrated that diabetic animals were unable to clear the infection over a 10-day period. They further observed reduced tissue inflammation proportional to glycemic control and decreased *in vitro* phagocyte activity against *Staphylococcus* (respiratory burst in response to *S. aureus* bacteremia) among animals with diabetes mellitus compared to controls.[13] Their results highlight that to circumvent CRBSI among diabetics stringent precautions are mandatory. Apart from diabetes, patients with ischemic heart disease had higher infection rates in this study. There is a synergetic relationship between coronary heart disease and CKD. Studies have shown a paucity of regulatory T cells and their dysfunction in a variety of cardiovascular diseases (hypertension and heart failure) making these patients susceptible to CRBSI.[14] These may be some of the reasons explaining our results but warrant more studies to confirm the association. Aspirin has been shown to have specific anti-*Staphylococcal* effects among HD population (the most common cause of CRBSI). The data on 872 HD cohort by Sedlacek *et al*. showed that HD population treated with Tab. aspirin 325 mg had lower rates of catheter-associated *Staphylococcus* bacteremia than those who were not treated with aspirin.[15] Thus, cardiovascular comorbidity among CKD patients must be meticulously managed in HD patients.

Various catheter-related factors responsible for CRBSI include time of use and the absence of tunnel, the expertise of nurses, dressing types, and frequency of changes in dressings and above all the catheter material as the additional factors contributing to CRBSI.[16,17] The highest rate of infection (36.8%) in this study was observed in catheter inserted for 1 week. This could be explained because the majority of the catheters remained for 1 week in this study. Better hand hygiene and frequent changing of dressing have been found to reduce the rate of infection by Wang *et al*.[18] In another study by Harwood *et al*., the authors concluded that negative cultures were more frequent with catheters having frequent dressings and the authors emphasized stringent precautions to be observed in HD center to reduce CRBSI.[19] We found that the most common bacterial strains were Gram-positive cocci with *S. aureus* coming at the top of the list followed by *S. epidermidis*. This is in compliance with the finding of Ramanathan *et al*.[20] who observed that a thick biofilm around the dialysis catheter had a higher microbial yield and *S. aureus* was the most common causative bacteria in CRBSI. These Gram-positive cocci are known to form biofilms on indwelling catheters, and due to this ability, these are the most frequent causes of CRBSI. The antimicrobial sensitivity of the isolated bacterial strains in this study showed the highest sensitivity to cephalosporin, and very low incidence of multidrug resistance (3.4%).

The limitations of our study, we believe, are that the sample size was small; nevertheless, the current study highlighted the sensitivity pattern of microbes associated with CRBSI at our center. Further, we demonstrated the growth of organisms in serial cultures emphasizing that blood cultures and swabs must be regularly taken from patients with catheter *in situ* to tailor the antibiotic therapy as per the sensitivity pattern. Having deduced the sensitivity pattern of CRBSI at our center, it is prudent to mention that to prevent antibiotic resistance; the foremost strategy will be the prevention of infection by stringent hygiene and early diagnosis of CRBSI. The antibiotics must be wisely used, and all efforts must be utilized to prevent transmission of infection. It may not be out of place to mention that meticulous care of HD catheters must be observed; only then, morbidity and mortality due to CRBSI can be improved.[21]

CONCLUSION

The conclusions drawn from this study are that CKD patient with diabetes and ischemic heart disease are more prone to CRBSI. The femoral site was significantly associated with CRBSI among CKD patients. While the majority of cultures were sterile, *S. aureus* was the most common type of isolated bacterial strain and cephalosporins showed the highest sensitivity for the isolated bacteria.

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