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Epidemiology of Central Venous Catheters Infection in Hemodialysis Patients

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ABSTRACT

Background: Vascular access infections in hemodialysis patients increase by 2-3 folds in central venous catheters compared to arteriovenous fistula or graft. Among these infections exit site infections, tunnel infections and catheter-related bloodstream infections (CRBSI), are the most common complications. CRBSIs are major risk of hospitalization as well as mortality in hemodialysis patients.

Objective: To study the epidemiology of central venous catheter related infections (CVC-RI), patterns of microbial infections and antibiotic sensitivity among our hemodialysis patients.

Patients and methods: 94 ESRD patients on hemodialysis with temporary central venous catheter (CVC) inserted for more than 48 hours, monitored for the development of CVC related infections (CVC-RI) and divided into two main groups according to presence of catheter infection; (A) non-infected catheter patients and group (B) infected catheter patients

Results: The rate of CVC-RI is high in our hemodialysis patients (42.5 %). There was a significant difference between the two studied groups as regard duration of HD and catheterization duration. Patients with evident catheter infections had significantly higher total leucocytic count (TLC) and C-reactive protein (CRP) values. There was a significant positive correlation between CRP with catheter duration and TLC. Staphylococcus aureus was the most prevalent isolated bacteria. Vancomycin was the most common used antibiotic among infected patients.

Conclusion: CVC-RI rate is high in our hemodialysis patients (42.5 %). Prolonged duration of CVC usage and diabetes are major risk factors related to infections. Both S. aureus and Gram-negative micro-organisms were the most common organisms found in our study. Vancomycin and imipenem were the most common effective antibiotics according to our blood cultures.

Keywords: Hemodialysis catheters, Infection, Renal failure.

INTRODUCTION

The number of end-stage renal disease (ESRD) patients in need of renal replacement therapy (RRT) has been increased over the last decades and it is expected that this increase will continue in the next years. Hemodialysis (HD), which is the main modality of RRT, requires long-term and effective vascular access [(1)]. Hemodialysis (HD) patients are at a great risk of infection as the process of HD necessitates frequent insertion of needles or use of catheters to access the blood stream. In addition to impaired immunity, increasing their risk for infection, they also require frequent hospital admissions and surgery where they might caught an infection [(2)].

In patients with ESRD, insertion of large-bore double-lumen catheters in the central venous system are usually necessary till a functioning permanent vascular access is established. Vascular access in ESRD patients requiring acute hemodialysis remain a great challenge despite recent advances in technics of percutaneous venous cannulation [(3)].

Vascular access (VA) infection is a major issue in chronic HD patients. Catheter-related infections include local infections, exit site infections, pocket infections, tunnel infections and bloodstream infections. Arteriovenous fistula (AVF) is the preferred access for most HD patients as it provides the best outcomes compared with tunneled cuffed dialysis catheter (TDC) or arteriovenous graft (AVG) [(4)].

The risk of infection with catheters is much higher than with arteriovenous fistulas (AVF) with a relative risk for bacteremia in patients with HD catheters almost 10-fold the risk [(5)]. Catheter access has been used in 10% of HD patients in China and in 15% of HD patients in the US [(6)].

According to Dialysis Outcomes and Practice Patterns Study (DOPPS) Practice Monitor (DPM) data, despite a great effort to reduce its use. Landmark-guided internal jugular vein (IJV) cannulation still a basic skill, which every nephrologist and anesthetist is expected to acquire. A successful first attempt is required as each attempt increases the chance of complications. Right internal jugular vein (IJV) is a preferable route for tunneled hemodialysis catheters, meanwhile both right and left external jugular veins are alternative routes in case the right IJV isn't suitable for catheter placement [(7)].

NKF-KDOQI (National Kidney Foundation–Kidney Disease Outcomes Quality Initiative) in its clinical practice guidelines recommended the right IJV as a preferred route for HD catheters, because it is easy

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to identify, big size and it has a straight passage to the right atrium. The left internal jugular vein and both subclavian veins cannulation carries the risk of thrombosis and central stenosis as well as high incidence of procedural complications so used for secondary access by most clinicians [8].

The aim of this work was to study the epidemiology of central venous catheter related infections (CVC-RI). Patterns of microbial infection and antibiotic sensitivity among our hemodialysis patients.

PATIENTS AND METHODS

A case control study carried out at Nephrology and Microbiology, Departments, Zagazig University Hospital during a period from November 2019 to April 2020. 94 ESRD patients on hemodialysis with temporary central venous catheter (CVC) inserted for more than 48 hours, monitored for the development of CVC related infection (CVC-RI) and divided into two main groups according to presence of catheter infection; (A) non-infected catheter patients and group (B) infected catheter patients.

From our work we excluded patients who had no complete treatment record regarding the vascular access database, patients with symptomatic bilateral or unilateral extremity edema and patients with cardiac rhythm management devices, peripherally inserted central catheters, or other central venous catheters.

Ethical consideration: Written informed consent was taken from the all patient to participate in the study. **Approval for performing the study was obtained from Internal Medicine and Microbiology Departments, Zagazig University Hospitals after taking Institutional Review Board (IRB) approval.**

All participants of this study were subjected to the following:

I. Thorough clinical examination including:

1) **Full history:** thorough history taking regarding age, sex, comorbidities (diabetes, immunosuppression, and malignancy), presence of fever, chills, presence of discharge, tenderness at JVC site, prior antibiotic use and JVC insertion date, insertion site and insertion duration focusing on previous kidney disorders or predisposing factors preceding kidney disease and other risk factors.

2) **Full general examination and anthropometric measurements including**: Pulse examination**,** blood pressure measurement, body temperature**,** respiratory rate, body mass index (BMI) "kg/m^2"**.**

II. Laboratory investigations:

a) Routine investigations: Complete blood picture (CBC), serum creatinine and blood urea and prothrombin time (PT).

b) Microbiological investigation: CVC-RLI: a positive semi quantitative culture of an intravascular catheter segment (more than 15 colony-forming units). CVC-RBI: according to the criteria of the Centers for Disease Control and Prevention, presence of one or more positive blood cultures and a positive catheter tip culture, whereby the same organism is isolated and not related to another site of infection [9].

Blood sample for blood culture:

Hand washing with soap and water with friction for 15 seconds or by alcohol based hand rub. Preparation of the puncture site with 70% alcohol to cleanse the skin in a circle approximately 5 cm in diameter. Starting with the center of the circle after dryness of the skin, 2% tincture of iodine was applied in ever widening circles until the entire circle was saturated with iodine and allowed to dry on the skin for at least 1 minute to avoid introducing skin flora into the bottle, producing a false positive blood culture.

In most cases blood specimen was not collected from lines, but by venipuncture and if the patient had an existing IV line, the blood was withdrawn below it to avoid blood dilution with infusion fluid. One ml collected blood was injected into blood culture bottle.

The bottles were gently rotated to mix the blood and the broth. Patients' labels placed on each bottle and label culture bottle with the site of specimen collection.

Blood culture bottles were sent to the laboratory as soon as possible and incubated for up to ten days in 37˚C and were checked daily for evidence of bacterial growth. When macroscopic evidence of growth was apparent, a gram stained smear of an air-dried drop of the medium was performed, subcultures were made on solid media (Blood agar and MacConkey agar) and were incubated in 37˚C aerobically and anaerobically for 24 to 48 hours. If no evidence of bacterial growth after 10 days of incubation, gram stains and blind subcultures were done before considering the cultures as negative [10].

The isolated organisms were identified as follow: Culture appearance on different culture media, e.g. α or β- hemodialysis on blood agar, rose pink (lactose-fermenting) or pale yellow (lactose non-fermenting) colonies on MacConkey's agar and Sabouraud's agar (for suspected Candide species) plates.

Microscopic examination of gram stained film of the obtained growth:
Gram positive cocci were identified by catalase test, coagulase test, and bacitracin test. Gram negative bacilli were identified by motility test, oxidase test, citrate utilization test, indole test, sugar fermentation test and hydrogen sulphide [(10)].

Statistical analysis: all data were collected, tabulated and statistically analyzed using SPSS 24.0 for windows (SPSS Inc., Chicago, IL, USA). Data were tested for normal distribution using the Shapiro Wilk test. Qualitative data were represented as frequencies and relative percentages. Chi square test (χ^2) was used to calculate difference between qualitative variables. Quantitative data were expressed as mean ± SD (Standard deviation) for parametric and median and range for non-parametric data. Independent T test and Mann Whitney test were used to calculate difference between quantitative variables in two groups for parametric and non-parametric variables respectively.

RESULTS

There was no significant difference between the two studied groups as regard age, sex and BMI. But there was a significant difference between the two studied groups as regard duration of HD and catheterization duration **(Table 1).**

Table (1): Demographic characteristics and clinical data of the two-studied groups

Variable		**Group A** (n=54)	**Group B** (n=40)	**P**
Age (years) Mean ± SD Range		45.11 ± 8.75 22 – 59	47.03 ± 5.89 32 - 58	>0.05
Sex	Female	28 (53.1%)	21 (52.2%)	>0.05
	Male	26 (46.9%)	19 (47.8%)	
Body mass index (BMI) kg/m2 Mean ± SD		27.62 ± 1.67	27.92 ± 1.55	>0.05
Duration of HD (years) Mean ± SD		7.31±3.25	7.81±3.52	0.050
Catheterization Duration (days) Mean ± SD		10.22±2.34	14.21±4.33	0.012
Comorbidities	DM	25 (46.2%)	23 (57.5%)	>0.05
	Steroids	10 (18.5%)	6 (15%)	
	Immunosuppressant	5 (9.2%)	4 (10%)	

The rate of CVC-RI was high in our hemodialysis patients (42.5).

There was a highly significant difference between the two studied groups as regard TLC and CRP, so that Patients with evident catheter infections had significantly higher TLC and CRP values **(Table 2).**

Table (2): Laboratory parameters of the two studied groups

Variable	**Group A** (n=54)	**Group B** (n=40)	**P**
Hb (g/dL) Mean ± SD	9.91 ± 1.38	10.15 ± 1.75	>0.05
TLC (10^3 /µL) Mean ± SD	7.83 ± 2.22	13.68 ± 2.35	<0.001
Platelets (10^3 /µL) Mean ± SD	343.49 ± 70.56	345.94 ± 71.88	>0.05
CRP (U/L) Mean ± SD	7.24 ± 2.19	89.97 ± 4.05	<0.001
FBS (mg/dL) Mean ± SD	134.87 ± 8.39	136.38 ± 5.23	>0.05

Staphylococcus aureus was the most prevalent isolated bacteria. Vancomycin was the most commonly used antibiotic among infected patients according to culture and sensitivity results **(Table 3).**

Table (3): Causative organism and antibiotic sensitivity among the two studied groups

Antibiotics	**Escherichia coli (n=12 (30%)**		**Klebsiella pneumonia (n= 3 (7.5%)**	
	Sensitive	**Resistant**	**Sensitive**	**Resistant**
Imipenem	9 (75%)	3 (25%)	2 (75%)	1 (25%)
Cefotaxime	6 (60%)	9 (90%)	2 (100%)	0 (0%)
Gentamycin	2 (20%)	8 (80%)	0 (0%)	3 (100%)
Ciprofloxacin	0 (0%)	12 (100%)	0 (0%)	3 (100%)
Amikacin	0 (0%)	12 (100%)	0 (0%)	3 (100%)
Ceftriaxone	0 (0%)	12 (100%)	0 (0%)	3 (100%)
Ampicillin	0 (0%)	12 (100%)	0 (0%)	3 (100%)
Azithromycin	2 (16.6%)	10 (83.4%)	0 (0%)	3 (100%)
Ampicillin/Clavulanic acid	0 (0%)	12 (100%)	0 (0%)	3 (100%)
Antibiotics	**Staph. Aureus (n=**15 (37.5%)		**Staph. Epidermidis (n=**10 (25%)	
	Sensitive	Resistant	Sensitive	Resistant
Vancomycin	13 (86.6%)	2 (13.4%)	9 (90%)	1 (10%)
Gentamycin	0 (0%)	15 (100%)	0 (0%)	10(100%)
Ciprofloxacin	0 (0%)	15(100%)	0 (0%)	10 (100%)
Ampicillin	4 (26.6%)	11 (73.4%)	2 (20%)	8 (80%)
Linezolid	0 (0%)	15 (100%)	0 (0%)	10 (100%)
Cefoxitin	0 (0%)	15 (100%)	0 (0%)	10 (100%)
Clindamycin	0 (0%)	15 (100%)	0 (0%)	10 (100%)
Amoxicillin/Clavulanic acid	5 (33.4%)	10 (66.6%)	3 (30%)	7 (70%)

There was a significant positive correlation between CRP with catheters duration and TLC **(Fig. 1)**

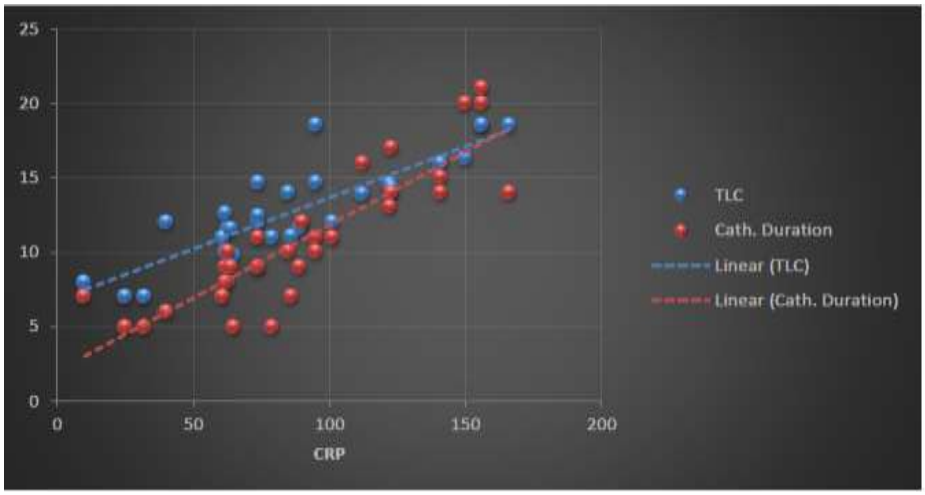

Fig. (1): Correlation between CRP and TLC and catheter duration in infected catheter patients.

DISCUSSION

In hemodialysis treatment vascular access is an important aspect where arteriovenous (AV) fistula has been described as the most preferable for patients in need of chronic dialysis [11]. Infection is common complication among chronic hemodialysis patients. Hemodialysis patients with a catheter have double fold risk of hospitalization because of infection and death compared to patients with an arteriovenous fistula or artificial grafts [12, 13].

42.5% of our patients developed CVC-RI. This incidence was similar to those mentioned by **Mattous *et al.*** [14] in Morocco who reported incidence of CVC-RI was 39%. However, **Sahli *et al.*** [2] reported CVC-RI incidence of 20%. Our CVC-RI high rate can be explained by a low compliance with different hygiene measures, and infection control policies.

In our study we found that the infected catheter patients were significantly older compared to those not infected, but the two groups were similar regarding gender and BMI. **Sahli *et al.*** [2] reported similar findings.

We found that Staphylococcus aureus was the most common causative organism. This results was similar to reports of **Sahli *et al.*** [2]**, Lemaire *et al.*** [15] **and Nabi *et al.*,** [16]**.** The most antibiotic used in our study were vancomycin and imipenem. This is in contrast to **Sahli *et al.*** [2] who reported that cefotaxime was the highest used antibiotic in their study. This may be due to different antibiotic resistance within each community. Antibiotic resistance could be explained by empirical using of antibiotics and by insufficient compliance to hygiene measures.

Our study showed that the risk factor of diabetes and longer duration of hemodialysis catheter use (more than 10 days) were significantly associated with higher risk of CVC-RI.

This result was similar to studies done by **Lemaire *et al.*** [15] **and Sahli *et al.*** [2]. Also, **Wang *et al.*** [17] reported that diabetes and prolonged duration of catheter usage are major risk factors for infection in hemodialysis patients. This was in line with our study.

Prolonged duration of hemodialysis catheter usage was due to difficulty and delay of establishing an arteriovenous fistula which was a big problem encountered in diabetic and non-diabetic patients. This is in agreement with **Sahli *et al.*** [2] **and Lemaire *et al.*** [15] reports. This may be explained, at least in part, by the relatively small sample size and the frequently use of antibiotic combinations, which may result in an increase of resistant bacteria. Hygienic measures have to fight multidrug resistant micro-organism infection and secondary intensive antibiotic use [2].

Our study had some limitations; for example, some patients like immunosuppressed ones had antibiotic treatment prior to the study which might affect the result of the culture and sensitivity.

CONCLUSION

The rate of CVC-RI in our hemodialysis patients is high (42.5%). Prolonged duration of CVC usage and diabetes were major risk factors related to infection in our hemodialysis patients.

RECOMMENDATION

Promotion of the infection control precautions by educating and training the health providers is needed. A lot must be done to reduce the duration of temporary vascular accesses by early creation of fistulas. Both S. aureus and Gram negative microorganisms must be taken into account for empirical therapy.

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