

Original Article

Investigating Infections Related to Central Venous Catheters in Patients Undergoing Hemodialysis Therapy

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HIGHLIGHTS

- The mean duration of dialysis (years) was significantly longer than the non-infectious group.
- Staphylococcus aureus was the most common bacterium isolated from bloodstream infections.
- The group with a catheter insertion time greater than 4 weeks had the highest rate of infection.

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ABSTRACT

Introduction

Central venous catheter (CVC) infection is related to important morbidity and mortality in hemodialysis (HD) patients, even though they are routinely used as the primary vascular access for many HD patients. The goal of this study was to determine the prevalence and bacterial factors causing central venous catheter infections in hemodialysis patients in Abadan educational hospitals.

Methods

In this study, from March 21, 2019, to March 19, 2020, information about patients with End-Stage Renal Disease (ESRD) who were referred to educational hospitals of Abadan University of Medical Sciences, including Frequency distribution of patients by gender and age, Duration of hemodialysis, embedded catheters, underlying disease, signs of clinical infection of the insertion site of the catheter in patients, antibiotics used in infectious patients were obtained through checklists and medical records.

Results

Seventy-six specimens of central venous catheter-related infections occurred in patients' patients undergoing hemodialysis therapy. Among these cases, 40.8% (31) were male and 59.2% (45) were female. Forty-four (57.9%) patients with infection had femoral vein catheter placement. 82.9% of patients had more than twice-a-week hemodialysis sessions. Staphylococcus aureus was the most common bacterium isolated from bloodstream infections, accounting for 50% (45) of the cases.

Conclusions

Prolonged central venous catheter use is a major risk factor for infection in hemodialysis patients. For empirical treatment, both Staphylococcus aureus and Gram-negative microorganisms must be considered. Compliance with hygienic measures and the careful use of antibiotics are suggested for lowering the risk of drug resistance.

Keywords: Infections; Central Venous; Renal Dialysis

Introduction

End-stage renal disease (ESRD) is a significant global health burden, especially among elderly populations (1). According to available statistics, the prevalence of

ESKD is growing in both emerging and developed parts of the world (2). Although kidney transplantation is the preferred treatment for ESRD patients, dialysis is the most prevalent type of kidney replacement therapy (KRT)

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in many countries (3). Hemodialysis (HD) is the most common dialysis method (4). Vascular accesses, such as arteriovenous fistula (AVF), intravascular catheters, and vascular grafts (VGs), are necessary for conducting a hemodialysis procedure (5, 6).

A short-term Central venous catheter (CVC) is a commonly used alternative for HD in emergencies with no permanent and viable venous access for treatment (7). CVC plays an important role in the treatment of patients with ESRD. Despite efforts to enhance fistula establishment, over 80% of patients begin hemodialysis with a catheter (8). The insertion of HD catheters is relatively simple and can be immediately used in various patients with kidney failure. However, these catheters come with their own set of issues. The use of HD catheters is associated with a higher risk of infections, which can lead to increased levels of illness and death (9).

These catheter problems might be classified as infectious or non-infectious. Non-infectious consequences of HD catheters include catheter malfunction, central vein stenosis, and catheter-related thrombi. Furthermore, the most common infectious consequence of HD catheters is catheter-related bloodstream infection (CRBI) used to characterize bacteremia caused by an intravenous catheter (10). Previous research has shown that patients with ESRD who use a tunneled central venous catheter for HD are about 15 times more likely to develop CRBI than those who use an arterio-venous fistula (11).

Infections are the second leading cause of death and hospitalization among HD patients (12) since they lead to about >300 hospitalizations per 1000 patients (13). Infectious complications are more likely to occur within the first 3 months after the catheter is implanted (14). Several risk factors can lead to infections in HD catheters. These include contamination of dialysate or equipment, insufficient water treatment, reusing the dialyzer, taking higher doses of recombinant human erythropoietin, having peripheral vascular disease, and recent hospitalization (10).

According to recent reports, *S. aureus* is the most common bacterial infection in people with HD. It can cause minor skin infections or more serious conditions like bacteremia, osteomyelitis, necrotizing pneumonia, infective endocarditis, and toxic shock syndrome (TSS). It can also colonize various body areas, including the armpits, groin, and nose (15, 16). In recent years, *S.*

aureus isolates with decreased sensitivity to vancomycin and high-level resistance to linezolid have been obtained from dialysis patients (17). Given this population's fast increase, the frequency of infection, and the impact of antimicrobial resistance on morbidity and death rates, controlling the spread of antibiotic-resistant bacteria among chronic HD patients is critical. In this study, we aimed to investigate the prevalence and bacterial factors causing CVC infections in HD patients in Abadan teaching hospitals to prevent complications.

Methods

In this cross-sectional study, from March 21, 2019, to March 19, 2020, after obtaining permission from the Ethics Committee (IR.ABADANUMS.REC.1399.060), information about patients with ESRD who were referred to educational hospitals of Abadan University of Medical Sciences, including Frequency distribution of patients by gender and age, Duration of hemodialysis, embedded catheters, patients' jobs, underlying disease, signs of clinical infection of the insertion site of the catheter in patients, antibiotics used in infectious patients were obtained through checklists and medical records. Data analysis was performed using SPSS software version 16 at a significant level of 0.05.

Results

Out of the 615 patients with ESRD referred to the hospital for dialysis, 76 (12.35%) had blood infections. Among these cases, 40.8% (31) were male and 59.2% (45) were female. The infected subjects had a mean age of 59.3, ranging from 16 to 87 years old. Furthermore, 52.6% (40) cases were over 40 years old. According to the findings, out of the 76 infected individuals, 59 had an underlying disease. The statistical analysis revealed a significant correlation (P -value<0.05). It was discovered that 84.74% of the infected individuals (50 out of 59) had an underlying disease, with diabetic patients having the highest percentage. The mean duration of kidney disease in patients under hemodialysis treatment was 2.3 years. The mean time of dialysis (years) in patients infected (6.8 ± 5.0) was significantly more than the non-infectious group (2.3 ± 1.8) (P -value<0.05).

The study categorized catheter insertion times for patients with infections into three groups: less than one week, 2-4 weeks, and more than four weeks. The analysis

Table 1. Long-time embedded catheters in patients and infection

	Week	Number of Infection	Percent	P-value
Duration of catheter	Less than 1 week	1	1.3	0.05
	2-4 weeks	9	11.8	
	More than 4 weeks	66	86.9	

Table 2. Catheter placement in dialysis patients and evaluation of infection rate in these patients

	Frequency of infection	Percent	
Catheter location	Femoral	44	57.9
	Jugular	31	40.8
	Subclavian	1	1.3
	Total	76	100

Table 3. Number of weekly hemodialysis sessions and evaluation of infection in these patients

	Week	Number of Infection	Percent	P-value
Weekly hemodialysis sessions	Once a week	1	1.3	0.05
	Twice a week	12	15.8	
	More than twice a week	63	82.9	
	Total	76	100	

Table 5. Antibiotics used in infectious patients

	Type	Frequency	Percent
Antibiotics	Vancomycin	72	43.64
	Cefepime	34	20.6
	Clindamycin	31	18.78
	Ceftriaxone	25	15.16
	Ceftazidime	3	1.82

revealed that the group with catheter insertion time over four weeks had the highest infection rate, with 66 cases (86.9%). This difference was statistically significant (P -value<0.05) (Table 1). In 57.9% (44) patients, the catheter was placed in the femoral vein (Table 2). Moreover, 82.9% (63) of the patients underwent dialysis more than twice a week (Table 3). On the other hand, *Staphylococcus aureus* was the most common bacterium isolated from bloodstream infections, accounting for 50% (45) of the cases (Table 4). Vancomycin was the most commonly prescribed antibiotic in 32 cases, accounting for 43.64% of patients (Table 5).

Discussion

No doubt using CVCs to start hemodialysis saved the lives of patients who needed renal replacement therapy. Infection is the most common complication of CVC in hemodialysis. Identifying CVC-related infection (CVC-RI) risk factors and causative microorganisms is critical for developing preventative programs. CVC-RI has a great impact on the morbidity and mortality of HD patients and imposes significant costs on the healthcare system (18). Several factors can increase the risk of catheter infection. These include using the catheter for an extended period, having a history of catheter-related infection, undergoing recent surgery, having diabetes mellitus, having *Staphylococcus aureus* colonization in the nasal area, being elderly, having low levels of hemoglobin and serum albumin, having a compromised immune system, having atherosclerosis, and having hypertension, being immunocompromised, and having atherosclerosis (19). In hemodialysis patients, there is little information on health outcomes, service quality, and the causative bacteria of CRBIs. Furthermore, the antibiotic sensitivity of the

Table 4. Frequency of infectious agents in patients

	Type	Frequency	Percent
Bacteria	<i>Staphylococcus aureus</i>	45	50
	<i>Staphylococcus epidermis</i>	26	28.88
	<i>Klebsiella pneumoniae</i>	19	21.1
	Total	90	100

bacteria that cause CRBIs differs by geographic area. The prevalence of CRBIs reduces the health outcomes of hemodialysis patients.

For this research, we enlisted individuals who had central venous catheters inserted solely for hemodialysis purposes. Within the time frame of monitoring, 12.31% of these patients experienced a minimum of one instance of an infection related to the catheter. It is noteworthy that no occurrences of endocarditis or abscess were detected.

Infections associated with catheter-based hemodialysis are a primary cause of morbidity and mortality in patients with renal insufficiency (20). According to prospective multicenter research, an infectious etiology was responsible for 23% of all fatalities among 1,846 patients on long-term hemodialysis, with an annual infection incidence of 35% (21). Our study found that females had a significantly higher occurrence of positive blood culture than males, contradicting previous reports from Iran (22, 23). On the other hand, certain studies have found no significant difference in the occurrence of catheter-related bloodstream infections between males and females (24, 25). According to the report of Hemmati et al., (23) and Tokars et al., (26) as age increased, there was a noticeable drop of approximately 60% in the occurrence of catheter-related infections.

This disparity could be attributed to factors such as the notification criteria used, institutional protocols for the care and maintenance of indwelling venous catheters, patients' adherence to guidelines, and the proficiency of hemodialysis patients. Clear clinical guidelines must be promoted, as well as ongoing staff education to improve practice. Hand hygiene must be improved, but protective clothing, such as a mask and sterile gown, must also be used. Aseptic procedures used during the insertion, care, and manipulation of intravascular catheters are recognized to be effective CVC-RI precautions (18).

Our investigation revealed that longer durations of CVC usage (4 weeks) were significantly associated with the risk of CVC-RI, as reported by Lemaire et al., (27). Prolonged CVC use has been identified as a key risk factor for infection in hemodialysis patients (28). The prolonged use of CVCs was related to the difficulties of performing an arteriovenous fistula, which was a concern in patients. CVC-RI rates were high in femoral site CVC (57.9%), as mentioned by Sahli et al., (18), and Parienti et al., (29). Hence, precise care of dialysis catheters is essential to

ensure persistent vascular access in the patients.

Our investigation's most prevalent causal organisms were *S. aureus*, *S. epidermis*, *K. pneumoniae*, and coagulase-negative staphylococcus (CoNS). According to Gominet et al., despite all aseptic measures taken during catheter insertion, CoNS bacteria are the leading cause of nosocomial infections in CVC patients. CoNS proliferate on catheter tips, causing bacterial infection to spread and necessitating early catheter tip removal owing to infection (30).

Conclusions

Finally, the prevalence of CVC-RI in Hemodialysis patients is high. Prolonged CVC use is a major risk factor for infection in hemodialysis patients. Infection control procedures must be promoted by teaching and training health care professionals. A lot has to be done to shorten the length of fistula-created temporary vascular accesses. For empirical treatment, both *S. aureus* and Gram-negative microorganisms must be considered. Compliance with hygienic measures and the careful use of antibiotics are suggested for lowering the risk of drug resistance.

Authors' contributions

Conceptualization: SM, Investigation: SM, ER, SH, SMM, Methodology: SM, SMM, SH, AH, Project administration: SM, Validation: MR, HE, Writing – original draft: SMM, MR, Writing – review & editing: ER, MR, SM.

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Conflict of interest

All authors declare that there is no conflict of interest.

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Ethics statement

This study was approved by the Ethics Committee of Abadan University of Medical Sciences (IR. ABADANUMS.REC.1399.060).

Data availability

Data will be provided on request.

Abbreviations

AVF Arteriovenous fistula
CoNS Coagulase-negative staphylococcus

CRBI	Catheter-related bloodstream infection
CVC	Central venous catheter
CVC-RI	CVC-related infection
ESRD	End-stage renal disease
HD	Hemodialysis
KRT	Kidney replacement therapy
PMP	Per million populations
TSS	Toxic shock syndrome
VGs	Vascular grafts

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