Original research

Pathophysiological evaluation of venous catheter infections in hemodialysis patients

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Abstract

Central venous catheters (CVC) for blood withdrawal and return to dialysis is a method commonly applied. The increasing use of CVC and following that complications arising from the use of these catheters is more critical. Therefore, this study aimed to investigate and determine the microbiological characteristics of bloodstream infection caused by intravascular device catheters. The study included 87 patients with chronic renal failure, with venous catheters and with or without infection in the age group over ten years for hemodialysis patients referred to Shahid Beheshti hospital in Babol, the North of Iran. Bacterial isolation and identification were carried out using standard microbiological and biochemical techniques. Of the 87 hemodialysis patients, 77 patients received hemodialysis three times a week, eight patients twice a week and two patients received hemodialysis only twice a year. In this study, out of 87 patients undergoing hemodialysis, 60 (69%) samples had positive cultures. Of which, 56 bacterial isolates (64.4%), and 4 (5%) fungal samples were isolated. The most obtained isolates were coagulase-negative staphylococci (23%) and the least episode was *Escherichia coli* (2%). In addition, all patients with fungal infections (candidiasis) also had diabetes. In conclusion, our study showed that the most common cause of bloodstream infection among patients was bacterial and *S. saprophyticus* was more common than others. This practical study helped us to understand the effect of using catheters for patients who had an emergency and were unable to reach a blood vessel for hemodialysis.

Keywords: Hemodialysis, Intravenous catheter, Bacterial infection, Blood cultures

1. Introduction

Central venous catheters (CVC) are often used as vascular access for dialysis patients, but the resulting infectious complications remain a significant clinical problem. This method allows a suitable and special treatment in different and difficult conditions [1, 2]. In the late seventies, with the invention of central venous catheters for hemodialysis, a fundamental change occurred and now the use of venous catheters to remove the blood and return it for dialysis is a practical and common method in these patient [3]. CVC is a useful method for prescribing medication and nutrition to specific patients, which is usually not possible through a peripheral vein. Recently, adequate access to central veins, especially for chemotherapy patients, has been widely used in their injectable nutrition [4, 5]. Catheter components are different; currently the most suitable materials are polyurethane and silicone [6]. It has been observed that this tool has fewer side effects and makes it easy to stop using and is more accepted by the patient [7]. Making a CVC is not easy because, as we know, the blood flow through

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a catheter must be at a speed of at least 200 ml per minute for at least 2 hours, which is very sensitive and somewhat unpredictable. The catheter efficiency is proven by passing this amount [8]. Venous catheter placement, even in the internal jugular vein, which is the most suitable place for implantation, may be associated with complications and mortality [9].

Both local and systemic infections can occur following contamination of intravascular equipment. Catheter-associated bloodstream infection has increased the length of hospital stay from 2.4 days to 7.5 days, with an increased mortality rate. Temporary hemodialysis catheters are often associated with complications, including early and delayed complications [10]. Catheter infection is often the most common delayed complication and is one of the main causes of catheter withdrawal and hemodialysis patients that should be considered [11]. The most common complications of using venous catheters related to trauma at the implant site are pneumothorax, hemothorax, arterial hematoma, and damage to the brachial plexus [12]. Early side effects of using these catheters include air embolism and cardiac arrhythmias. Among the most common long-term complications of using this type of catheter are arteriovenous fistula between carotid and jugular arteries, infection and central venous thrombosis [13]. Acquaintance with these complications on the one hand and also recognizing the benefits of these catheters based on the catheter installation site, in addition to making us more familiar with the real benefits and complications of these catheters based on the site involved, will help us in future planning in this regard [13, 14]. In general, with common differences in the type of use and treatment, commonly involved microorganisms are *Staphylococcus aureus,* enterococci, coagulase-negative staphylococci (CoNS) and rarely *Candida* and *Malassezia*. Therefore, the most common complication involving catheters is infections [15]. Knowledge of the types of these infections and their therapeutic option, in addition to increasing the life of catheters, certainly reduces the cost of treatment and speeds up the operation and improves the quality of treatment for these patients. Therefore, identifying the types of microbes that infect the catheter and the order of their frequency in the first step is of particular importance [16]. Considering that so far, in the city of Babol, which is one of the main and most populous dialysis centers in Mazandaran province and the north of the country, a comprehensive study has not been conducted in this field. This study aimed to determine and identify microorganisms isolated from the blood culture of hemodialysis patients with and without symptoms using venous catheters (temporary and permanent).

2. Materials and Methods

2.1 Study Design and patients

This descriptive cross-sectional study was performed for a period of one year from April 2015 to March 2016. After catheter placement, in a simple or simple non-random method (Census), if there were inclusion criteria, patients were included in the study. The study included 87 patients with chronic renal failure, with venous catheters and with or without infection in the age group over ten years for hemodialysis patients referred to Shahid Beheshti hospital in Babol, the North of Iran.

2.2 Demographic details and clinical data

All hemodialysis patients with temporary catheters experienced fever, chills, purulent discharge from the catheter site, erythema, tenderness over the exit site, and signs of bacteremia in the absence of any focus of infection on clinical and laboratory examinations were included in this study. While, patients without use CVC, patients with a previous systematic infection and patients with underlying coagulation disease were excluded. Patients' data: diabetes, high blood pressure, advanced liver cancer and alcohol poisoning, purulent angina and hereditary background were collected.

2.3 Isolation and identification

Peri-catheter skin samples were obtained using sterile and were transported to the microbiology laboratory of Shahid Beheshti hospital, where they were immediately streaked onto plates containing tryptic soy agar with 5% sheep blood and mannitol-salt agar. All cultures were incubated at 35 °C for 24 hours. Identification was determined by using standard microbiological procedures.

2.4 Statistical analysis

The data were analyzed using the Statistical Package for Social Sciences (SPSS™) software (IBM Corp, USA), version 22.0. The results are presented as descriptive statistics in terms of relative frequency. The

descriptive analysis in terms of relative frequency was used.

3. Results

Of 87 hemodialysis patients, 77 patients received hemodialysis three times a week, 8 patients twice a week and two patients received hemodialysis only twice a year.

Of 87 hemodialysis patients studied, 43 (49%) were male and 44 (51%) were female, as a result of which 80 patients (92%) were married and seven patients (8%) were single. In this study, 40 patients (45%) were employed and 47 (55%) were unemployed or housewives. Moreover, 65 patients (74%) were literate and 22 patients (26%) were illiterate. Patients were divided into age groups with an interval of ten years, the absolute and relative frequency of patients in each age group is given in Table 1.

Our study showed that the most common underlying disease that patients with chronic renal failure is diabetes. In this study, 67% of patients had temporary catheter, subclavian and gingival infections, 23% had a femoral, 10% had permanent catheter and subclavian infection (Table 2).

In this study, out of 87 patients undergoing hemodialysis, 60 (69%) samples had positive cultures. Of which, 56 bacterial isolates (64.4%), and 4 (5%) fungal samples were isolated. The most obtained isolates were CoNS (23%) and the least episode was *Escherichia coli* (2%) (Table 3). In addition, all patients with fungal infections (candidiasis) also had diabetes.

4. Discussion

Because of the increased use of venous catheters in recent years, catheter-related bloodstream infections are commonly recognized as one of the most serious health-care concerns of the modern era. In this study, we looked at the prevalence and cause of catheter-related bloodstream infections in hospitalized patients [17]. In this study, 87 patients undergoing hemodialysis were studied, of which 43 (49%) were male and 44 (51%) were female. Differences in geographical distribution, infection control measures, the investigated population, and catheterization-related factors could all explain regional variance in healthcare associated infection (HCAI) prevalence [18].

Our study showed that a significant number of patients treated in the study center are infected at least once, but according to previous studies, it can be said that the rate of infectious complications in our country even exceeds the rate. In the type of underlying disease in the studied patients, 61% had diabetes, 17% had high blood pressure, 11.5% had purulent angina, 4.5% had a hereditary background and 1% had advanced liver cancer and alcohol poisoning.

According to our findings, most of patients had temporary catheter, subclavian and gingival infections, then some of them had femoral infection, permanent catheter and subclavian infection. However, catheter site infection was the main complication, which has been confirmed many times in previous studies. Though, in some studies, there is no difference in frequency between thrombosis and infection. Some studies have even suggested that thrombosis is more common than infection. In a study performed by Santoro et al. found that a patient was more likely to become infected if they had more than one catheter for dialysis. This study showed that the prevalence of bacterial infections leading to bacteremia is increasing in these patients [8].

Hung et al. examined 168 dialysis patients for an average of 27 days and found that catheter-dependent bacteremia developed in 21.4% of these patients. This infection rate reached 75% after four weeks [19]. A study which was done by Boersma et al. in 2008 showed that complications of CVC were more related to thrombosis than to catheter infection. Of course, when systemic infections such as sepsis are added to this set of infections, then the rate of infection as a general complication will definitely be much higher than thrombosis. This result is also confirmed in our study [20].

The present study showed that the incidence of catheter infection in women was slightly higher than in men, which according to most studies was similar. Still, no relationship was found between the patient's age and catheter-related infection. The most common episode isolated from catheters was S. saprophyticus. Despite further investigation, we could not identify specific factors as independent risk factors. The only risk factor found was the catheter site, which has more to do with placing the catheter in the right jugular.

A study by Hasannejad-Bibalan et al. in 2021 showed that Gram-positive cocci, are generally considered the most common cause of catheter-

related bloodstream infections, particularly staphylococci [17]. In a similar study in Taiwan, twelve bacterial species were identified from the catheter-related bloodstream infection cases, with *S. aureus* being the most frequent (41.9%), followed by *Pseudomonas aeruginosa* (16.1%) [20, 21].

According to our research, 5% of fungal infections were all associated with C. albicans, which created difficult conditions for treatment. Studies have shown that infections in dialysis patients are often bacterial and followed by infection with various types of staphylococci, which is associated with higher mortality (8 to 25%) in these patients [22].

Table 1. Demography of the 87 patients included in the study

Order	Age	Sex	Number	Type of catheter	Type of treatment
1	10 to 20	Male	1	Subclavian	hemodialysis
2	10 to 20	Female	1	Subclavian	hemodialysis
3	21 to 30	Male	4	Subclavian	hemodialysis
4	21 to 30	Female	1	Subclavian	hemodialysis
5	31 to 40	Male	3	Femoral	hemodialysis
6	31 to 40	Male	5	Subclavian	hemodialysis
7	31 to 40	Female	7	Subclavian	hemodialysis
8	41 to 50	Male	5	Subclavian	hemodialysis
9	41 to 50	Male	2	Femoral	hemodialysis
10	41 to 50	Female	7	Subclavian	hemodialysis
11	50 to 60	Male	5	Subclavian	hemodialysis
12	51 to 60	Female	7	Subclavian	hemodialysis
13	51 to 60	Female	3	Femoral	hemodialysis
14	Over 61	Male	14	Subclavian	hemodialysis
15	Over 61	Male	4	Femoral	hemodialysis
16	Over 61	Female	16	Subclavian	hemodialysis
17	Over 61	female	2	Femoral	hemodialysis

Table 2. Absolute and relative frequency of patients in terms of CVC embedding sites

Catheter site	Number	Frequency (%)
Temporary, subclavian and gingival	58	67
Permanent, subclavian	9	10
Femoral	20	23

Table 3. Number of episodes and frequency of isolated bacteria in diabetic patients with arterial and venous catheters treated with hemodialysis

Group of bacteria	No. of episodes	Frequency (%)
S. saprophyticus	20	23
S. aureus	15	17
Enterobacter spp.	10	12
Pseudomonas spp.	6	7
Candida albicans	4	5
CoNS	3	3
E. coli	2	2

In this regard, Qazvini et al. examined blood samples from 69 hemodialysis patients. Reports revealed that, 28 samples (40.5%) were infected with *S. aureus* [23]. Also, in our study, 10 cases (12%) of *Enterobacter* spp. were involved in venous catheter infection.

In conclusion, our study showed that the most common cause of bloodstream infection among patients is bacterial and CoNS was more common than others. Moreover, our study was performed with a good sample size but covered only the information about a medical center. Considering the important results obtained from this study, it is recommended that subsequent studies similar to this project, it be done in several centers and it is better to do it in several provincial centers so that in addition to confirming the results, geographical dispersion factors can also be included the level of health care in different parts of the country in this kind of study. This practical study helped us to understand the effect of using catheters for patients who had an emergency and were unable to reach a blood vessel for hemodialysis.

Authors' contributions

Concept and Study design: HAF and ANO. Methods and experimental work: HAF. Results analysis and conclusions: HAF and MH. Manuscript preparation: HAF, ANO and MH. All authors read and approved the final version of manuscript.

Conflict of interests

No potential conflict of interest was reported by the authors.

Ethical declarations

This study was in accordance with the declaration of Helsinki and study design approved by Vice President of Research and Technology, Tonekabon Branch, Islamic Azad University. However, because we only used leftovers from clinical specimens, the local committee waived the need for informed consent.

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