

Risk Factors of Catheter Related Bloodstream Infection in Hemodialysis Patients in Erbil City

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Original Article

Summary

The incidence of end stage renal diseases represented a big burden on national health institutes in Iraq. Hemodialysis is a common mode of treatment. Although the advantages, some adverse effects still reported particularly catheter related bloodstream infection. To identify the risk factors of catheter related blood stream infection among regular hemodialysis patients and its pathogens. A cross sectional study which carried out in Erbil Teaching Hospital-Dialysis Unit in Erbil city-Kurdistan region-Iraq through the period of six months from first of December, 2020 to 31st of May, 2021 on convenient sample of one hundred patients on regular hemodialysis. The catheter related blood stream infection diagnosis was done by researchers according to blood culture on the criteria of catheter related blood stream infection for dialysis catheter. Information regarding catheters and dialysis duration or catheters duration and hospital stay were collected by the researchers through the follow up of patients until their discharge. Findings of our study revealed 44% of patients had catheter related blood stream infection. The isolated pathogen were staphylococcus Epidermis (40%), staphylococcus Aureus (24%), E. Coli (10%), Klebsiella (10%) and Candida Sp. (6%), no pathogen was isolated in 10% of patients. Significant risk factors for catheter related blood stream infection were obesity, diabetes mellitus, increased number of catheters, long duration of hemodialysis, catheters maneuvering and severe anemia. In conclusion Catheter related blood stream infection among hemodialysis patients in Erbil city is high and the main microorganism for catheter related infection is Staphylococcus Epidermis.

Keywords: *End stage renal disease, Hemodialysis, Catheter related blood stream infection.*

Article information: Received: July , 2021, Accepted and Published September, 2021

How to cite this article: Haydari S, Nooraldin S, Mahmood M.. Risk Factors of Catheter Related Bloodstream Infection in Hemodialysis Patients in Erbil City. JMSP, 7 (3):275-290

1. INTRODUCTION

The chronic renal disease is a public health problem affecting about 10% of population all over the world. This higher proportion is related to high global prevalence of aging, obesity and non-communicable diseases. However, the renal replacement therapy provided a dramatic improvement in management of chronic renal disease and the hemodialysis represented the widely used replacement therapy in developing and developed countries (1). Hemodialysis is an artificial process aiming to remove wastes and excess water from blood by using machine 2. Since its first use at 1945, the hemodialysis is progressing to become the rescue treatment and improving quality of life for millions of patients with renal diseases worldwide (1,2). Although significance of hemodialysis in saving lives, numerous complications are reported specifically cardiac arrest and infection (3). The mechanism of hemodialysis depends mainly on excretion of toxins through application of external filter (dialyzer) that includes semipermeable membrane. Separation of wastes is accomplished by counter-current flow gradient, as the blood flows with one direction and dialyzer fluid flows in opposite way (1). Catheters used for hemodialysis are extracorporeal catheters that are commonly characterized by wide sinus central venous lines allowing blood to in and out of patients' vessels. These catheters help in temporarily transporting the blood from body to an extracorporeal machine to perform the hemodialysis. The hemodialysis catheters could be placed directly throughout skin to target vein or it could be placed under skin throughout the short subcutaneous tunnel into way to the vein that secured by cuff of local tissue depending on planned duration of hemodialysis (4).

Temporary vascular access of hemodialysis is achieved by central venous catheter. The central venous catheters are accompanied with many complications mainly the infection. The catheters related infections are either catheter related local infections or catheter related bloodstream infections. Catheters related infections mainly catheters blood stream related infections are associated with great burden on national health cost, many co-morbidities and high mortality rates (5-7). The main cause of high death rates in patients with end stage renal diseases on hemodialysis was the cardiovascular diseases followed by infection (8-10). Many authors identified temporary catheters related infection among hemodialysis patients in incidence of about 0.6 to 6.5 times/1000 catheters in one day (11-13). It was found that main microorganism responsible for temporary catheter related infection was staphylococcus

aureus (14,15). The urgent inserting of tunneled catheters is following difficulties facing permanent vascular catheters used for hemodialysis. The catheter related bloodstream infections of tunneled catheters present in range of 1.1–6.1 times/1000 catheter in one day (16). Exploring risk factors for catheters related infections in all types is essential in planning for development of prevention strategies and decreasing the incidence rates of infection and lowering morbidity and mortality rates. The risk factors for catheter related infection are variable with different literatures which might be elderly age, the duration of catheters application, diabetes mellitus, anemia and albumin level (17-19).

In Iraq, the chronic renal disease incidence is high with increasing demand for hemodialysis or kidney transplant (20). Patients with end stage renal diseases in Kurdistan region are unfortunately characterized by poor quality of life (21). Hemodialysis complications in Iraq are commonly mild to moderate including anemia, edema, hypertension and poor daily activities (22,23). The hemodialysis catheter related infections are frequent that need strict polices for prevention (24-26). This study aimed to identify the risk factors of catheter related blood stream infection in chronic kidney disease on regular hemodialysis and identify the microorganisms which are responsible for this by blood culture, through which we can decrease the intra-dialysis complications and costs of catheter changes and recurrent admission to hospital and ultimately patient survival on hemodialysis.

2. PATIENTS and METHODS

The current study design was a cross sectional study which carried out in Erbil Teaching Hospital-Dialysis Unit in Erbil city-Kurdistan region-Iraq through the period of six months from first of December, 2020 to 31st of May, 2021. The study population was all patients with end stage renal diseases on regular hemodialysis presented to Dialysis unit during study duration. Adult age (18-70 years) patients with end stage renal disease on regular hemodialysis with temporary catheter and tunneled subcutaneous catheter and patients with tunneled subcutaneous catheter were the inclusion criteria. Exclusion criteria were patients with end stage renal disease on regular hemodialysis on arteriovenous fistula, insertion of catheter was not done within study period, lost to follow up patients and refuse to participate in the study. The ethical considerations were implemented according Helsinki Declaration

regarding ethical approval of Health authorities; an ethical approval was taken from Kurdistan Board Ethical Committee, informed written consent of patients and management of catheters related complications accordingly. A convenient sample of 100 patients with ESRDs on regular hemodialysis was selected after eligibility to inclusion and exclusion criteria. The data were collected by the researchers through direct interview with selected patients in Dialysis unit and fulfilled in a prepared questionnaire. The questionnaire was designed by the researchers. The questionnaire included the following information: general characteristics of hemodialysis patients (age, gender, body mass index (BMI), smoking status and history of hypertension, diabetes mellitus, peripheral vascular diseases (PVD), autoimmune disease, cancer and immunosuppressive therapy), hemodialysis characteristics (catheters number, catheters type, insertion sites, duration of dialysis, duration of catheter, catheters maneuvering and hospital stay duration) and catheter related blood stream infection and isolated pathogens (culturing results). The catheter related blood stream infection diagnosis was done by researchers according to blood culture on the criteria of CRBSI for dialysis catheter 27. The age of hemodialysis patients was categorized into five groups (<40 years, 40-49 years, 50-59 years, 60-69 years and ≥ 70 years) and ranged from 18 years to 72 years. The gender of hemodialysis patients was distributed into male or female. The BMI was regarded overweight (if BMI=25 to 29.9 Kg/m²). The smoking status of patients grouped into current, no smoking and ex-smoking. The history of HT, DM, PVD, autoimmune disease, cancer and immunosuppressive therapy was taken from the patients. Information regarding catheters and dialysis duration or catheters duration and hospital stay were collected by the researchers through the follow up of patients until their discharge. The hemoglobin level was assessed in Laboratory of Erbil Teaching hospital. The blood culture was investigated in Bio-Laboratory in Erbil city. The data collected were analyzed statistically by Statistical Package of Social Sciences software version 22. Chi square and Fishers exact tests were applied accordingly. Level of significance (p value) was regarded statistically significant if it was 0.05 or less.

3. RESULTS

The current study included one hundred hemodialysis patients with mean age of (55.4 years) and range of 18-72 years; 14% of patients were in age group <40 years, 14% of them were

in age group 40-49 years, 26% of them were in age group 50-59 years, 32% of them were in age group 60-69 years and 14% of them were in age group of 70 years and more. Male gender patients were more than females with male to female ratio of 1.9:1. The mean body mass of hemodialysis patients was (23.09 Kg/m²); 28% of them were overweight. The smoking status of patients was categorized into; current (18%), no smoking (46%) and ex-smoking (36%). The past-medical history of hemodialysis patients included hypertension (92%), diabetes mellitus (70%), peripheral vascular diseases (2%), autoimmune diseases (6%), cancer (6%) and history of immunosuppressive therapy (14%). (Table 1) Mean catheters number was (2.6), 52% of patients had two catheters and 40% of them had three catheters, while 6% of patients had four catheters and 2% of them had five catheters. All catheters used for hemodialysis were temporary. The insertion sites of catheters were femoral (20%), right internal jugular (38%), right subclavian (26%) and left internal jugular (16%). The mean dialysis duration was (3.3 months); 12% of patients had less than one month dialysis duration, 60% 1-3 months and 28% of them had more than 3 months dialysis duration. Mean catheter duration was (1 month); 52% of patients had catheter duration of one month and more. Catheter maneuvering >3 days was observed for 34% of patients. Mean hospital stay duration of hemodialysis patients was (3.7 days); 84% of them had hospital stay duration of 3 days and more. Mean hemoglobin level of patients was (9.5 gm/dl); 91% of patients were anemic; the anemia was mild in 26.4% of them, moderate in 51.6% of them and severe in 22% of them. (Table 2). The prevalence of catheter infection among hemodialysis patients was (44%). The common isolated pathogen was staphylococcus Epidermis (40%), followed by; staphylococcus Aureus (24%), E. Coli (10%), Klebsiella (10%) and Candida Sp. (6%), while pathogen was not isolated in 10% of patients. (Table 3). No significant differences were observed between hemodialysis patients with catheter infection and hemodialysis patients without catheter infection regarding age (p=0.1), gender (p=0.6), smoking status (p=0.7), hypertension (p=0.7), PVD (p=0.1) and autoimmune diseases (p=0.2). The mean BMI was significantly higher among hemodialysis patients with catheter infection (p=0.02). There was a significant association between diabetes mellitus and hemodialysis patients with catheter infection (p=0.002). The hemodialysis patients with cancer and immunosuppressive therapy were significantly associated with no catheter infection (p=0.02, p=0.01, respectively). (Table 4) There was a

significant association between increased catheters number and catheter infection ($p=0.01$). No significant differences were observed between hemodialysis patients with catheter infection and hemodialysis patients without catheter infection regarding insertion site ($p=0.06$), catheter duration ($p=0.7$) and hospital stay ($p=0.1$). A significant association was observed between longer dialysis duration and catheter infection ($p=0.02$). There was a significant association between catheter maneuvering >3 days and catheter infection ($p=0.003$). The mean hemoglobin level was significantly lower among hemodialysis patients with catheter infection ($p=0.05$). A significant association was observed between severe anemia and catheter infection ($p=0.02$), (Table 5).

Table 1. General characteristics of hemodialysis patients (n=100).

| Variable | | No. | % |
|------------------------------------|-----------------------------------|-----|------|
| Age (year) | <40 | 14 | 14.0 |
| | 40-49 | 14 | 14.0 |
| | 50-59 | 26 | 26.0 |
| | 60-69 | 32 | 32.0 |
| | ≥ 70 | 14 | 14.0 |
| <i>Mean \pm SD</i> | <i>55.4 \pm 12.9</i> | - | - |
| Gender | Male | 66 | 66.0 |
| | Female | 34 | 34.0 |
| BMI | Normal | 72 | 72.0 |
| | Overweight | 28 | 28.0 |
| Mean \pm SD (kg/m ²) | 23.09 \pm 2.6 | - | - |
| Smoking | Current | 18 | 18.0 |
| | No smoking | 46 | 46.0 |
| | Ex-smoking | 36 | 36.0 |
| Hypertension | | 92 | 92.0 |
| Diabetes mellitus | | 70 | 70.0 |
| PVD | | 2 | 2.0 |
| Autoimmune disease | | 6 | 6.0 |
| Cancer | | 6 | 6.0 |
| Immunosuppressive therapy | | 14 | 14.0 |

Table 2. Hemodialysis characteristics (n=100).

| Variable | | No. | % |
|------------------------------|------------------------|------------|----------|
| Insertion site | Femoral | 20 | 20.0 |
| | Right Internal Jugular | 38 | 38.0 |
| | Right Subclavian | 26 | 26.0 |
| | Left Internal Jugular | 16 | 16.0 |
| Duration of dialysis (month) | <1 month | 12 | 12.0 |
| | 1-3 months | 60 | 60.0 |
| | >3 months | 28 | 28.0 |
| <i>Mean ± SD</i> | 3.3±2.4 | | |
| Duration of catheter (month) | <1 month | 48 | 48.0 |
| | ≥1 month | 52 | 52.0 |
| <i>Mean ± SD</i> | 1±0.7 | | |
| Catheter maneuvering>3 days | | 34 | 34.0 |
| Hospital stay (day) | <3 | 16 | 16.0 |
| | ≥3 | 84 | 84.0 |
| <i>Mean ± SD</i> | 3.7±1.3 | | |
| Hemoglobin level | Normal | 9 | 9.0 |
| | Anemic | 91 | 91.0 |
| <i>Mean ± SD</i> | 9.5±1.3 gm/dl | | |
| Anemia severity | Mild | 24 | 26.4 |
| | Moderate | 47 | 51.6 |
| | Severe | 20 | 22.0 |

*All catheters were temporary, SD: standard deviation

Table 3. Catheter infection and isolated pathogens (n=100).

| Variable | No. | % |
|---------------------------|-----|------|
| Catheter infection | | |
| Yes | 44 | 44.0 |
| No | 56 | 56.0 |
| Isolated pathogens | | |
| Staph. Epidermis | 40 | 40.0 |
| Staph. Aureus | 24 | 24.0 |
| E. Coli | 10 | 10.0 |
| Klebsiella | 10 | 10.0 |
| Candida Sp. | 6 | 6.0 |
| No Isolated Pathogen | 10 | 10.0 |

Table 4. Distribution of general characteristics according to catheter infection.

| Variable | | Catheter infection | | | | P |
|------------------------------------|------------|--------------------|------|----------|------|--------------|
| | | Yes | | No | | |
| | | No. | % | No. | % | |
| Age | <40 | 6 | 13.6 | 8 | 14.3 | 0.100 |
| | 40-49 | 8 | 18.2 | 6 | 10.7 | |
| | 50-59 | 14 | 31.8 | 12 | 21.4 | |
| | 60-69 | 14 | 31.8 | 18 | 32.1 | |
| | ≥70 | 2 | 4.5 | 12 | 21.4 | |
| Gender | Male | 28 | 63.6 | 38 | 67.9 | 0.600 |
| | Female | 16 | 36.4 | 18 | 32.1 | |
| BMI Mean ± SD (Kg/m ²) | | 23.7±2.6 | | 22.5±2.4 | | 0.020 |
| Smoking status | Current | 8 | 18.2 | 10 | 17.9 | 0.700 |
| | Non-smoker | 22 | 50 | 24 | 42.9 | |
| | Ex-smoking | 14 | 31.8 | 22 | 39.3 | |
| Hypertension | | 40 | 90.9 | 52 | 92.9 | 0.700 |
| Diabetes mellitus | | 38 | 86.4 | 32 | 57.1 | 0.002 |
| PVD | | 2 | 4.5 | 0 | - | 0.100 |
| Autoimmune disease | | 4 | 9.1 | 2 | 3.6 | 0.200 |
| Cancer | | 0 | - | 6 | 10.7 | 0.020 |
| Immunosuppressive therapy | | 2 | 4.5 | 12 | 21.4 | 0.010 |

| Table 5. Distribution of hemodialysis characteristics according to catheter infection. | | | | | | |
|---|------------------------|---------------------------|----------|------------|----------|--------------------------|
| Variable | | Catheter infection | | | | P |
| | | Yes | | No | | |
| | | No. | % | No. | % | |
| Catheters number | Two catheters | 20 | 45.5 | 32 | 57.1 | 0.01^S |
| | Three catheters | 16 | 36.4 | 24 | 42.9 | |
| | Four catheters | 6 | 13.6 | 0 | - | |
| | Five catheters | 2 | 4.5 | 0 | - | |
| Insertion site | Femoral | 12 | 27.3 | 8 | 14.3 | 0.06^{NS} |
| | Right Internal Jugular | 20 | 45.5 | 18 | 32.1 | |
| | Right Subclavian | 8 | 18.2 | 18 | 32.1 | |
| | Left Internal Jugular | 4 | 9.1 | 12 | 21.4 | |
| Duration of dialysis | <1 month | 8 | 18.2 | 4 | 7.1 | 0.02^S |
| | 1-3 months | 20 | 45.5 | 40 | 71.4 | |
| | >3 months | 16 | 36.4 | 12 | 21.4 | |
| Duration of catheter | <1 month | 22 | 50 | 26 | 46.4 | 0.7^{NS} |
| | ≥1 month | 22 | 50 | 30 | 53.6 | |
| Catheter maneuvering>3 days | Yes | 22 | 50 | 12 | 21.4 | 0.003^S |
| | No | 22 | 50 | 44 | 78.6 | |
| Hospital stay | <3 days | 10 | 22.7 | 6 | 10.7 | 0.1^{NS} |
| | ≥3 days | 34 | 77.3 | 50 | 89.3 | |
| Hemoglobin (Mean± SD) (gm/dl) | | 9.1±1.3 | | 9.7±1.3 | | 0.05^S |
| Anemia severity | Mild | 8 | 20 | 16 | 31.4 | 0.02^S |
| | Moderate | 18 | 45 | 29 | 56.9 | |
| | Severe | 14 | 35 | 6 | 11.8 | |

4. DISCUSSION

Many challenges are facing the national health care system in many countries due to the burden of increasing of end-stage renal disease prevalence that is related to high morbidity and mortality rates (28). The hemodialysis is an essential step in management of thousands of patients with end stage renal diseases. Venous catheter in hemodialysis has many advantages; although, it is accompanied by many complications like bloodstream infection, arthritis, endocarditis, epidural abscess which lead to higher rates of mortality (29). Present study found that prevalence of catheter related blood stream infection among hemodialysis patients in Erbil city was (44%). This prevalence is higher than prevalence of hemodialysis catheter related blood stream infection of (25%) reported by Jaudah and Musa cross sectional study in Iraq (30) on 80 patients with hemodialysis. Our study prevalence of (44%) for catheter related blood stream infection is also higher than results of Sahli et al. (31) study in Algeria which found that (20.3%) of hemodialysis patients had catheter related infection. Additionally, our study finding is higher than results of Martin et al. (16) study in Australia which reported that 17% of hemodialysis patients had catheter related blood stream infection. This high prevalence of catheter related blood stream infection in our center might be attributed to many reasons such as poor health infrastructure, low hygiene culture of community and factors related to methodology and sample size. However, our study prevalence of catheter related blood stream infection is lower than prevalence of (58.6%) reported by Al-Hchaim et al. (26) study in Iraq and prevalence of (64%) reported by Alirezai et al. (32) study in Iran. A study conducted in USA revealed that hemodialysis bloodstream infection rates differ in regard to vascular access sites with prevalence of (0.5%) for arteriovenous fistula, prevalence of (0.9%) for arteriovenous graft, prevalence of (4.2%) for long duration central venous catheter and prevalence of (27.1%) for short duration central venous catheter in one month (33). Indeed, multi-centers international surveys on seven thousands hemodialysis patients showed that catheter-related complications in general are detected commonly within the first three to six months following insertion of the catheter (34, 35). In current study, the common isolated pathogen was staphylococcus Epidermis (40%), followed by; staphylococcus Aureus (24%), E. Coli (10%), Klebsiella (10%) and Candida Sp. (6%). These findings are close to results of Farrington and Allon study in USA (36) reported than main microorganism detected by

culturing of catheter related blood stream infection for hemodialysis patients was staphylococcus Epidermis followed by staphylococcus Aureus. Inconsistently, Altaee et al. (24) study in Iraq reported the staphylococcus Aureus as the main isolated pathogen responsible for catheter related infection among hemodialysis patients. It was shown that gram positive and coagulase negative staphylococci are responsible for 40-80% of catheters related blood stream infections (37), while the gram negative pathogens responsible for 20-40% on infections and polymicrobial and fungal pathogens represented 10-25% (38). In present study, mean BMI was significantly higher among hemodialysis patients with catheter infection ($p=0.02$). This finding is similar to reports of Soi et al. (39) study in USA which documented that obesity play a major role in increasing incidence of catheter related blood stream infection in hemodialysis. Our study showed a significant association between diabetes mellitus and hemodialysis patients with catheter infection ($p=0.002$). This finding coincides with results of Sahli et al. 31 study in Algeria which reported the diabetes mellitus as common risk factor for catheter related blood stream infection. It was shown that elderly age, obesity, diabetes mellitus and poor vasculature are the main reasons for higher rates of emergency hemodialysis (40). Current study found that cancer and immunosuppressive therapy were significantly protective factors for catheter related infection. This finding might be attributed to fact that those patients received excessive care for catheters by health care staff than other patients. In current study, there was a significant association between increased catheters number and catheter related infection ($p=0.01$). Similarly, Shahar et al. (41) study in Malaysia reported that multiple uses of catheters in hemodialysis increases the chance of catheter related blood stream infection. Our study also showed a significant association between longer dialysis duration and catheter infection ($p=0.02$). This finding is consistent with results of Ali et al. (25) study in Iraq which revealed that longer duration of hemodialysis is accompanied with high rates of catheter related infection. Our study found a significant association between catheter maneuvering >3 days and catheter related blood stream infection ($p=0.003$). This finding coincides with results of Knežević et al. (42) study in Serbia which found that low hemoglobin level and catheters maneuvering are the main risk factors for catheter related blood stream infection. In present study, there was a significant association between anemia especially severe form and catheter related infection. Roberts et al. (43) study in USA documented that anemia is prevalent among chronic renal

diseases patients on hemodialysis and is related to high catheter related blood stream infection rates.

5. CONCLUSIONS

The prevalence of catheter related blood stream infection among hemodialysis patients in Erbil city is high. The main microorganism for catheter related infection is staphylococcus Epidermis. Risk factors for catheter related blood stream infection were obesity, diabetes mellitus, increased number of catheters, long duration of hemodialysis, catheters maneuvering and severe anemia. This study recommended improvement of hygienic status of Erbil hospitals, an appropriate selection of insertion site, better antiseptics, health and hygiene patients education, infection surveillance and specific care and monitoring of catheter

Ethical Clearance: Ethical clearance and approval of the study are ascertained by the authors. All ethical issues and data collection were in accordance with the World Medical Association Declaration of Helsinki 2013 for ethical issues of researches involving humans, informed consent obtained from all patients. Data and privacy of patients were kept confidentially.

Conflict of interest: Authors declared none

Funding: None, self-funded by the authors

Acknowledgement: Great thanks to all medical and health staff working in Erbil Teaching hospital-Dialysis center for their efforts and help to complete this study

REFERENCES

1. Dąbrowska-Bender M, Dykowska G, Żuk W, Milewska M, Staniszevska A. The impact on quality of life of dialysis patients with renal insufficiency. Patient Prefer Adherence 2018; 12:577-583.
2. Vadakedath S, Kandi V. Dialysis: A Review of the Mechanisms Underlying Complications in the Management of Chronic Renal Failure. Cureus 2017; 9(8):e1603.
3. Saha M, Allon M. Diagnosis, Treatment, and Prevention of Hemodialysis Emergencies. Clin J Am Soc Nephrol 2017; 12(2):357-369.

4. Huriaux L, Costille P, Quintard H, Journois D, Kellum JA, Rimmelé T. Haemodialysis catheters in the intensive care unit. *Anaesth Crit Care Pain Med* 2017; 36(5):313-319.
5. Blot SI, Depuydt P, Annemans L, Benoit D, Hoste E, De Waele JJ, et al.. Clinical and economic outcomes in critically ill patients with nosocomial catheter-related bloodstream infections. *Clin Infect Dis* 2005; 41:1591-1598.
6. Maki DG, Kluger DM, Crnich CJ. The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies. *Mayo Clin Proc* 2006; 81:1159-1171.
7. Warren DK, Quadir WW, Hollenbeak CS, Elward AM, Cox MJ, Fraser VJ. Attributable cost of catheter-associated bloodstream infections among intensive care patients in a nonteaching hospital. *Crit Care Med* 2006; 34: 2084-2089.
8. US Renal Data System. *USRDS 2009 annual data report: atlas of chronic kidney disease and end-stage renal disease in the United States*. Bethesda, MD: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Disease; 2009.
9. Katneni R, Hedayati SS. Central venous catheter related bacteremia in chronic hemodialysis patients: epidemiology and evidence based management. *Nat Clin Pract Nephrol* 2007; 3(5):256-266.
10. UK Renal Registry: new adult patients starting renal replacement therapy in UK in 2004. *UK Renal registry report*. Bristol, UK: Renal Registry; 2005; 12—26.
11. Onder AM, Chandar J, Simon N, Diaz R, Nwobi O, Abitbol CL, et al.. Comparison of tissue plasminogen activatorantibiotic locks with heparin-antibiotic locks in children with catheter-related bacteraemia. *Nephrol Dial Transpl* 2008; 23:2604-2610.
12. Power A, Duncan N, Singh SK. Sodium citrate versus heparin catheter locks for cuffed central venous catheters: a single-center randomized controlled trial. *Am J Kidney Dis* 2009; 53:1034-1041.
13. Saeed Abdulrahman I, Al-Mueilo SH, Bokhary HA, Ladipo GO, Al-Rubaish A. A prospective study of hemodialysis access related bacterial infections. *J Infect Chemother* 2002; 8:242-246.
14. Lok CE, Stanley KE, Hux JE, Richardson R, Tobe SW, Conly J. Hemodialysis infection prevention with polysporin ointment. *J Am Soc Nephrol* 2003; 14:169-179.
15. Nabi Z, Anwar S, Barhamein M, Al Mukdad H, El Nassri A. Catheter related infection in

- hemodialysis patients. *Saudi J Kidney Dis Transpl* 2009; 20(6):1091-1095.
16. Martin K, Lorenzo YSP, Leung PYM, Chung S, O'flaherty E, Barker N, et al.. Clinical Outcomes and Risk Factors for Tunneled Hemodialysis Catheter-Related Bloodstream Infections. *Open Forum Infect Dis* 2020; 7(6):ofaa117.
 17. Allon M. Dialysis catheter-related bacteremia: treatment and prophylaxis. *Am J Kidney Dis* 2004; 44:779-791.
 18. Taylor G, Gravel D, Johnston L, Embil J, Holton D, Paton S. Incidence of bloodstream infection in multicenter inception cohorts of hemodialysis patients. *Am J Infect Control* 2004; 32:155-160.
 19. Lemaire X, Morena M, Leray-Moragues H, Henriët-Viprey D, Chenine L, Defez-Fougeron C, et al.. Analysis of risk factors for catheter-related bacteremia in 2000 permanent dual catheters for hemodialysis. *Blood Purif* 2009; 28:21-28.
 20. Dhaidan FA. Prevalence of end stage renal disease and associated conditions in hemodialysis Iraqi patients. *Int J Res Med Sci* 2018; 6:1515-1518.
 21. Qader H, Naqshbandi V. Quality of Life of Patients Undergoing Maintenance Hemodialysis in Erbil City. *Erbil Journal of Nursing and Midwifery* 2019; 2(1): 19-25.
 22. Alyassin FF. The Patient Care and Complications of Hemodialysis Procedure for Renal Failure Patients: A Descriptive Study at al Nasiriya city, South of Iraq. *Journal of Global Pharma Technology* 2018; 10(03): 356-365.
 23. Ali S, Naqshbandi V, Sedeeq S. Dialysis-Related Factors Affecting Activities of Daily Living in Patients on Hemodialysis in Erbil City. *Erbil Journal of Nursing and Midwifery* 2021; 4(1): 1-14.
 24. Altaee KH, Theeb OA, Al-Timimi SM, Saeed HM, Alshamma I. Outcome and survival of temporary hemodialysis catheters: a prospective study from a single center in Iraq. *Saudi J Kidney Dis Transpl* 2007; 18(3):370-377.
 25. Ali SH, Hassan AS, Salih AK. Outcome of Vascular Access in Pediatric Haemodialysis of Baghdad Hospitals. *Medical Journal of Babylon* 2016; 13 (2): 435-444.
 26. Al-Hchaim MHS, Ali BRM, Abdullah AM. Double Lumen Subclavian Catheter Complications among Patients with End Stage Renal Disease on Continuous Hemodialysis. *Indian Journal of Public Health Research & Development* 2019; 10 (8):

- 2437-2441.
27. Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, et al.. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. *Clin Infect Dis* 2009; 49(1):1-45.
 28. Liyanage T, Ninomiya T, Jha V, Neal B, Patrice HM, Okpechi I, et al.. Worldwide access to treatment for end-stage kidney disease: a systematic review. *Lancet* 2015; 385(9981):1975-1982.
 29. D'Amato-Palumbo S, Kaplan AA, Feinn RS, Lalla RV. Retrospective study of microorganisms associated with vascular access infections in hemodialysis patients. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2013; 115(1):56-61.
 30. Jaudah AK, Musa AK. Incidence and risk factors of central venous catheter and blood stream bacterial infections in hemodialysis patients: A cross sectional study. *Life Science Archives (LSA)* 2017; 3 (1): 921-933.
 31. Sahli F, Feidjel R, Laalaoui R. Hemodialysis catheter-related infection: rates, risk factors and pathogens. *J Infect Public Health* 2017; 10(4):403-408.
 32. Alirezai AH, Massoudi N, Zare E, Nouri Y. Catheter related blood stream infections; the incidence and risk factors in Iranian hemodialysis patients. *J Nephroarmacol* 2019; 8(2):e17.
 33. Klevens RM, Edwards JR, Andrus ML, Peterson KD, Dudeck MA, Horan TC; NHSN Participants in Outpatient Dialysis Surveillance. *Dialysis Surveillance Report: National Healthcare Safety Network (NHSN) - data summary for 2006. Semin Dial* 2008; 21(1):24-28.
 34. Ravani P, Gillespie BW, Quinn RR, MacRae J, Manns B, Mendelssohn D, et al.. Temporal risk profile for infectious and noninfectious complications of hemodialysis access. *J Am Soc Nephrol.* 2013; 24(10):1668–1677.
 35. Ng LJ, Chen F, Pisoni RL, Krishnan M, Mapes D, Keen M, Bradbury BD. Hospitalization risks related to vascular access type among incident US hemodialysis patients. *Nephrol Dial Transplant* 2011; 26:3659–3666.
 36. Farrington CA, Allon M. Complications of Hemodialysis Catheter Bloodstream Infections: Impact of Infecting Organism. *Am J Nephrol* 2019; 50(2):126-132.

37. Lok CE, Mokrzycki MH. Prevention and management of catheter-related infection in hemodialysis patients. *Kidney Int* 2011; 79(6):587-598.
38. Miller LM, Clark E, Dipchand C, Hiremath S, Kappel J, Kiaii M.; Canadian Society of Nephrology Vascular Access Work Group. Hemodialysis Tunneled Catheter-Related Infections. *Can J Kidney Health Dis* 2016; 3:2054358116669129.
39. Soi V, Moore CL, Kumbar L, Yee J. Prevention of catheter-related bloodstream infections in patients on hemodialysis: challenges and management strategies. *Int J Nephrol Renovasc Dis* 2016; 9:95-103.
40. Saxena AK, Panhotra BR. Haemodialysis catheter-related bloodstream infections: current treatment options and strategies for prevention. *Swiss Med Wkly* 2005; 135(9-10):127-138.
41. Shahar S, Mustafar R, Kamaruzaman L, Periyasamy P, Pau KB, Ramli R. Catheter-Related Bloodstream Infections and Catheter Colonization among Haemodialysis Patients: Prevalence, Risk Factors, and Outcomes. *Int J Nephrol* 2021; 2021:5562690.
42. Knežević V, Mirković TD, Božić D, Majstorović GS, Mitić I, Gvozdrenović L. Risk factors for catheter-related infections in patients on hemodialysis. *Vojnosanit Pregl* 2018; 75(2): 159–166.
43. Roberts TL, Obrador GT, St Peter WL, Pereira BJ, Collins AJ. Relationship among catheter insertions, vascular access infections, and anemia management in hemodialysis patients. *Kidney Int* 2004; 66(6):2429-2436.