Infection and Drug Resistance

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ORIGINAL RESEARCH

Catheter-Related Blood Stream Infections and Associated Factors Among Hemodialysis Patients in a Tertiary Care Hospital

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Introduction: Non-tunneled central venous catheter remains the preferred vascular access at hemodialysis initiation in developing countries despite a high burden of infection complications. The goal of this study was to determine the burden, risk factors, and microbiological spectrum of catheter-related bloodstream infections at a tertiary care center in Ethiopia.

Methods: A retrospective cross-sectional study design was applied among patients who underwent central venous catheter insertion for hemodialysis between January 2016 and June 2022 with no native arteriovenous fistula and stayed more than 48 hours. Data were collected from the patient's registration book, patient charts, and microbiology registry and analyzed using SPSS 21. Binary logistic regression was applied to assess the relationship between the independent and outcome variables. P-values less than 0.05 with AOR and 95% CI were used as statistically significant variables.

Results: In this study, 353 patients were included. The mean age was 39±17.9 years and the average duration of catheter stay was 58 ±95 days. A hundred thirty-five (38.2%) CRBSIs were documented with an incidence rate of 7.74 episodes per 1000 catheter days. The causative microorganism was predominantly gram-negatives (57.6%). Duration of a catheter (AOR: 0.3; P < 0.001), previous CVC infection (AOR: 11.9; P < 0.001), high white blood cell count (AOR: 0.31; P<0.001), urban residence (AOR: 1.92; P<0.05), and low hemoglobin levels (AOR: 2.78; P < 0.05) were independently associated with catheter-related bloodstream infections.

Conclusion: In conclusion, the incidence of catheter-related bloodstream infection among patients on hemodialysis was high with gram-negative predominance. Early fistula must be planned to reduce the duration of temporary vascular access.

Keywords: catheter-related bloodstream infection, hemodialysis, risk factors, microorganism, central venous catheter

Introduction

Hemodialysis (HD) is an important life-saving procedure in patients with acute kidney injury (AKI) and chronic kidney disease requiring renal replacement therapy. Well-functioning vascular access (VA) is a mainstay for performing an efficient HD procedure.[1]

There are three main types of access: native arteriovenous fistula (AVF), arteriovenous graft (AVG), and central venous catheter (CVC) tunneled or non-tunneled catheters. CVCs have become an important procedure for emergencies requiring vascular access and an adjunct in maintaining patients in HD.[1,2] However, catheter-related bloodstream infections (CRBSIs) are a conspicuous barrier to the use of these catheters. CRBSI ranks as the second leading cause of mortality in patients undergoing hemodialysis following cardiovascular disease.[3] There are three distinct types of CVC-related infections: exit-site, tunnel, and Catheter-related bloodstream infections. Among those, CRBSIs are a major cause of hospitalization and mortality in hemodialysis patients.[3,4]

Recent researches underscored that the incidence rate of CRBSIs ranges from 3.25 to 10.8 and 0.55 to 4.4 episodes per 1000 catheter days for temporary and permanent CVCs, respectively. Understanding the risk factors associated with

Received: 20 February 2023
Accepted: 15 May 2023
Published: 22 May 2023

CRBSIs is crucial for setting up preventive strategies. Patients receiving HD through CVC are at higher risk of bloodstream infection compared with patients receiving via arteriovenous fistula or graft. Moreover, prolonged duration of CVC, diabetes mellitus, old age, low hemoglobin, history of previous catheter-related bacteremia and low serum albumin levels were associated with bloodstream infection.[3,5,6]

The causative agent for CRBSIs are mostly gram-positives such as *Staphylococcus aureus* and coagulase-negative staphylococci accounting up to 80%. Other infections are attributed to gram-negatives including *Pseudomonas aeruginosa*, *Escherichia coli*, and *Klebsiella pneumonia*.[6–8]

In Ethiopia, non-tunneled catheters are commonly used as a source of temporary vascular access for the initiation of HD and there is a paucity of data on CRBSIs. This study aimed to estimate the incidence and assess factors associated with CRBSIs among patients undergoing hemodialysis at Ayder Comprehensive Specialized Hospital. It has also investigated the spectrum of bacterial isolates and their antibiotic resistance patterns. This information will help in decreasing morbidity and mortality among this patient population by aiding in the establishment, revision, and modification of empirical treatment guidelines based on local data.

Methodology

Study Design and Area

A retrospective cross-sectional study design was used to assess the incidence and associated factors of CRBSI. This study was conducted at Ayder Comprehensive Specialized Hospital (ACSH), which is located in Mekelle, Tigray region, Northern Ethiopia. The hospital provides referral services to approximately 9 million people in its catchment areas of Tigray, Afar, and Amhara regional states. ACSH hemodialysis unit is the only dialysis center in the region, staffed with one general practitioner, 11 dialysis nurses, and three nephrologists (two adults and one pediatric). It has 12 dialysis machines and serves both adult and pediatric patients with acute or chronic kidney problems who need renal replacement therapy.

Source and Study Population

All renal patients underwent tunneled and non-tunneled central venous catheter insertion for hemodialysis from January 2016 up to June 2022 in ACSH.

Eligibility Criteria

Inclusion Criteria

All patients with CVC inserted during the study period staying more than 48 hours.

Exclusion Criteria

Patients with CVC inserted for non-renal indication (poisoning, ultrafiltration, central venous monitoring), having naïve AV fistula, and patients with missing or incomplete data.

Variables

The dependent variable is Catheter-Related Bloodstream Infection.

Independent variables: socio-demographic factors (age, gender, and address), clinical and laboratory parameters, comorbidities (diabetes, hypertension), associated factors, Microbiological data, and vascular access type were considered as independent variables.

Data Collection Tools and Procedures

After the data abstraction tool was prepared, relevant patient details were collected and documented in the data collection tool, which includes the patient's socio-demographic characteristics, presence of clinical signs and symptoms of infection, comorbidities, type and cause of kidney failure (AKI, CKD), site and duration of catheter insertion and microbiological data. All those data were collected from the patient's medical records, dialysis registration, and microbiology registry book by trained data collectors. Information regarding the specimens, types of microorganisms, and antibiotic susceptibility of CRBSIs was collected from the microbiology department.

Definitions of CRBSIs

In patients with fever with chills and rigors, unexplained hypotension, and altered sensorium with a normal catheter exit site or tunnel, CRBSI was classified into ();

Definite

The same organism should be found from catheter tip culture (>15 colony forming units per catheter segment) as well as blood culture with no other obvious source of infection.

Blood Cultures

Blood was collected from the dialysis circuit (if symptoms were during dialysis) or a peripheral vein (if symptoms occurred off dialysis) and the dialysis catheter (10 mL each under sterile conditions).

Catheter Tip

The final three inches cut of catheter tip was sent for only few patients because there was catheter salvage practice in our set up.

Probable

Symptoms should subside with antibiotic therapy with or without catheter removal and organisms grow only in blood culture with no growth from the catheter tip or not done.

For this study, we defined cases of CRBSI as patients with an indwelling dialysis catheter in situ, who presented with signs and symptoms of infection like fever (>38°C) or chills with no other obvious source of infection, where blood cultures via catheter hub and percutaneous peripheral vein were taken simultaneously and empirical antibiotics for CRBSI were administered.[1]

Catheter Salvage

Included those which were catheter retained and clinical improvement was observed with systemic antibiotics and antibiotics lock.

Immunosuppression

Patients having HIV/AIDS, cancer, diabetes mellitus and taking immuno-suppressive drugs like steroid, antineoplastic were considered immuno-suppressed participants.

Management of CRBSIs

The empirical antibiotic regimen at our Center for the Management of CRBSI is intravenous (IV) vancomycin (20mg/kg post-dialysis) and IV ceftazidime (1g post-dialysis). This antibiotic regimen was continued or modified based on the type of organisms and antibiotic sensitivity pattern.

Micro-Organisms and Antibiotics Susceptibility

We isolate bacteria and do antimicrobial sensitivity testing according to the standard operational procedure (SOP) of the microbiology laboratory of the Hospital. Blood samples were inoculated into aerobic and anaerobic media and incubation was continued for up to 7 days or until a positive culture was observed. Identification of Gram-positive bacteria was done using Gram Stain, hemolytic activity on sheep blood agar plates, catalase reaction, and coagulase test. Similarly, Gram-negative bacteria were identified based on colony morphology on blood agar and MacConkey agar, followed by biochemical reactions namely oxidase, triple sugar iron (TSI), Sulphur Indole, and motility (SIM) citrate, Lysine decarboxylase (LDC) and urease tests.

Since some bacteria were tested according to the availability of that antibiotics, we did not test the same list of antibiotics for all positive blood cultures. Antibiotic susceptibility of the pathogens was done on Mueller–Hinton agar using the Kirby-Bauer disk diffusion method for Ciprofloxacin (CIP) 5µg, ampicillin (AMP) (10µg), ceftriaxone (CRO) 30µg, piperacillin/tazobactam 100/10 mcg, Imipenem 10 µg, Amikacin 30 mcg, Penicillin G 10IU, Amoxicillin + Clavulanic Acid 20 + 10 µg, Ceftazidime 30 ug, Linezolid 30 mcg, Clindamycin 2 mcg, Gentamicin 120 µg, TMX-SMX 1.25/23.75 mcg, Vancomycin 30 mcg and oxacillin (OX) (1µg).[1]

Data Analysis

Data were entered into epi-data 3.1 and analyzed using SPSS 21.0. The number of catheter days was calculated as the number of days from catheter insertion to removal, and the CRBSI rate was calculated similarly to incidence density as the number of CRBSI episodes/1000 catheter days (episodes of CRBSI/total sum of catheter days × 1000).[1] Categorical variables were described as numbers and percentages; Continuous variables were described as means ± standard deviation (SD) and median ± Inter Quartile Range (IQR). Binary logistic regression analysis was done to compare the independent and outcome variables. Variables with a P-value less than 0.25 in the bivariate analysis were exported to multivariable analysis. In multivariable analysis P-value <0.05 with AOR and 95% CI was accepted as statistically significant variables. Multicollinearity was done to check any confounding variables and the final fitness of the model was checked by Hosmer and Lemeshow.

Results

Socio-Demographic Characteristics

During the study period, there were a total of four hundred eighteen catheters in 395 patients in whom hemodialysis was initiated. Forty-two patients were excluded as they have a non-renal indication, had naïve AV fistula, incomplete chart, and dialyzed less than 48 hours. The final study population included 353 patients, who met the inclusion criteria (Figure 1).

The mean age of the participants was 39.3 (±17.9) years. More than half of the participants were male 203 (57.5%) and rural residents 204 (57.8%). The etiology of end-stage renal disease (ESRD) for the study population was hypertension attributed (26.4%), chronic glomerulonephritis (19.4%), diabetic nephropathy (14.8%), and polycystic kidney disease (4.6%). The most common comorbidities were hypertension, diabetes mellitus, and cardiac diseases. The patient's characteristics are summarized in Table 1.

Clinical Parameter

This study revealed that the indication of CVC insertion for hemodialysis was chronic kidney disease (55.2%) and acute kidney injury (44.8%). The majority of the patients 332 (93.9%) had a temporary catheter and the most common puncture site was the right internal jugular vein. The average duration of stay for the first catheter was 57.9 (±95.5) days and 80.9 (±107.4) days for the second catheter. The inserted catheters were removed mostly due to medical improvement, infection, death, and change to AVF. Table 2 illustrates the clinical parameter of the study participants.

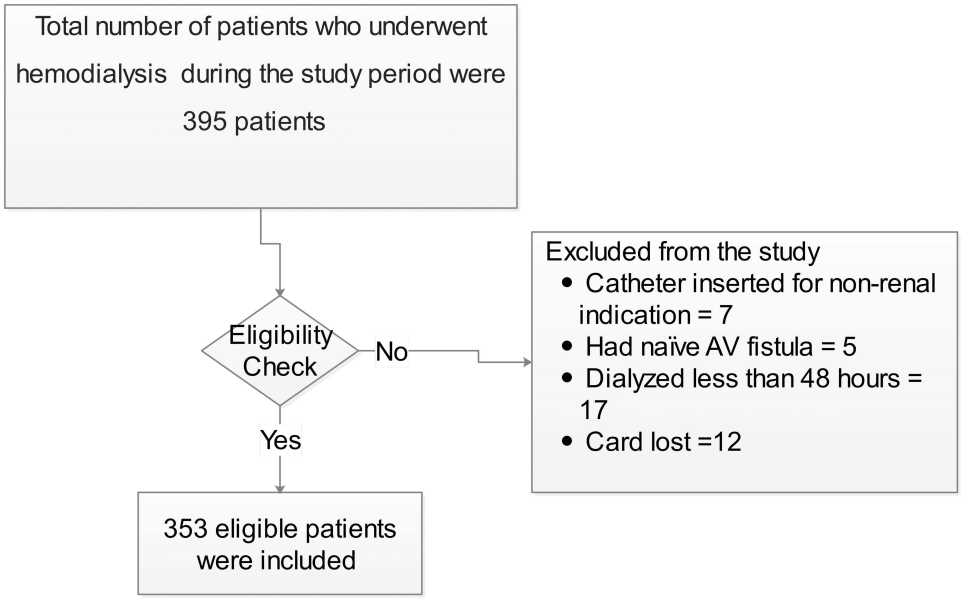

Figure 1 Participants flow diagram.

Table 1 Socio-Demographic Characteristics of Patients Undergoing Hemodialysis in ACSH, Tigray 2022

Variables	Categories	Total Participant N=353	Percentage (%)
Age in years	<18	38	10.8
	18–40	167	47.3
	41–65	116	32.9
	>65	32	9.1
Sex	Male	203	57.5
	Female	150	42.5
Address	Urban	204	57.8
	Rural	149	42.2
Cause of ESRD	Hypertension	51	26.4
	Chronic GN	38	19.4
	Diabetic nephropathy	29	14.8
	Obstructive nephropathy	26	13.3
	ADPKD	9	4.6
	Lupus nephritis	7	3.5
Comorbidity	Hypertension	135	38.2
	Diabetes	49	13.8
	Cardiovascular disease	44	12.4
	HIV/AIDS	24	6.7
	Cancer	15	4.2
	Viral hepatitis	12	3.3

Table 2 Clinical Parameters of Patients Undergoing Hemodialysis in ACSH, Tigray 2022

Variables	Categories	Total No (%)	CRBSI	
			Yes (%)	No (%)
Renal failure type	AKI CKD	158 (44.8) 195 (55.2)	50 (37) 85 (63)	108 (49.5) 110 (50.5)
Presence of comorbidity	Yes No	223 (63.2) 130 (36.8)	95 (70.4) 40 (29.6)	128 (58.7) 90 (41.3)
Immunosuppression	Yes No	80 (22.7) 273 (77.3)	29 (21.5) 106 (78.5)	51 (23.4) 167 (76.6)
Type of catheter	Temporary Tunneled	331 (93.8) 22 (6.2)	127 (94.8) 7 (5.2)	204 (93.6) 14 (6.4)

(*Continued*)

Table 2 (Continued).

Variables	Categories	Total No (%)	CRBSI	
			Yes (%)	No (%)
Inserted site of catheter	Femoral Rt internal Jugular Lt internal Jugular Subclavian	4 (1.1) 329 (93.2) 17 (4.8) 3 (0.8)	1 (0.7) 124 (91.9) 7 (5.2) 3 (2.2)	3 (1.4) 205 (94) 10 (4.6) 0
Duration of catheter	< 30days ≥30 days	200 (56.7) 153 (43.3)	50 (37) 85 (63)	150 (68.8) 68 (31.2)
Reason for catheter removal	Renal recovery Infection Change to AVF Death Malfunction Others	132 (39.3) 86 (25.6) 56 (16.6) 26 (7.7) 6 (1.7) 30 (8.9)		

Table 3 shows the laboratory profile of patients undergoing dialysis. More than half (60.6%) of the participants had less than 10,000 cell/mm3 white blood cell count. The average hemoglobin count of the participants was 9.3 mg/dl with 83.9% of them having less than 12 mg/dl. The mean value of albumin was 2.7 mg/dl.

Incidence of Catheter-Related Bloodstream Infection

A total of one hundred fifty-eight episodes of CRBSIs occurred in 135 patients. Twenty-two (16.2%) patients had two episodes of infection and one patient had three episodes. Overall, 104 (67%) episode of infection was confirmed by laboratory findings. There were a total of 20,423 catheter days with the incidence of CRBSIs 7.74 episodes per 1000 catheter days.

Microbiology and Antibiotic Sensitivity Pattern

In the contemporary study, *Staphylococcus aureus*, *Escherichia coli*, and *Klebsiella pneumonia* were the most common isolated microorganisms. CRBSI was essentially caused by *S. aureus* (20%); but considering all Gram-negative micro-

Table 3 Laboratory Result of Patients Undergoing Hemodialysis in ACSH, Tigray 2022

Variables	Category	Frequency (%)	CRBSI		Mean (±SD)
			Yes (%)	No (%)	
WBC count	≤10,000 >10,000	214 (60.6) 138 (39.1)	60 (44.4) 75 (55.6)	154 (71) 63 (29)	10,348.6 (±7796.8)
Neutrophil percentage	<65% ≥65%	31 (8.8) 320 (90.7)	9 (6.70) 126 (93.3)	22 (10.2) 194 (89.8)	79.4 (±11)
Albumin	<3.5 mg/dl ≥3.5 mg/dl	312 (88.4) 13 (3.7)	122 (96.1) 5 (3.9)	8 (40) 190 (960)	2.7 (±0.6)
Haemoglobin	<12 mg/dl ≥12 mg/dl	296 (83.9) 56 (15.9)	124 (91.9) 11 (8.1)	172 (79.3) 45 (20.7)	9.3 (±2.5)
MCV	<70 70–100 >100	6 342 3			83.1 (±6)

organisms, they were responsible for a significant proportion (57.6%) of CRBSIs. We identified Escherichia coli as the most common gram-negative organism followed by *Klebsiella pneumonia* and *Pseudomonas aeruginosa* (Figure 2).

In this study, 79 patients develop drug resistance and Figure 3 indicates the drug sensitivity result. In our study, we have identified more than one bacteria (isolate) from 19 patients. Therefore, both figures in Figure 3 shows the drug sensitivity result for both the isolated bacteria. Of the total 99 patients who had bacterial isolation, 80 had isolation one, and 19 participants for isolation two (Figure 3).

Vancomycin was used in 86.2% of CRBSI cases, followed by ceftazidime 66% and meropenem (19.3%) of CRBSI cases. Regarding Antibiotics resistance, most microorganisms were resistant to ampicillin, augmentin, and penicillin and were sensitive to metronidazole, clindamycin, and vancomycin. Cloxacillin resistance was seen in 86.2% of *S. aureus* isolates. Moreover, among the most commonly isolated gram-negative organisms, *E. coli*, 75% were resistant to ceftazidime. Overall, most gram-negative isolates were sensitive to imipenem and amikacin, but they were resistant to ampicillin, augmentin, and ciprofloxacin (Figure 3).

Risk Factors for CRBSI

Table 4 shows the results of the logistic regression analysis. In bivariate analysis, variables significantly associated with the occurrence of CRBSI (had a p-value of <0.25) were age, address, type and duration of the catheter, comorbidity, immunosuppression, previous CVC infection, WBC count, hemoglobin level and albumin level. In the multivariable logistic regression model, address, duration of the catheter, previous CVC infection, WBC count, and hemoglobin level were independently associated with catheter-related bloodstream infection after adjusting for all other variables.

Patients residing in the urban area (OR: 1.92; CI 95%: 1.15–3.21; P<0.05) were 1.9 times higher risk of CRBSI than those who reside in the rural areas and patients who had less than a thirty-day duration of the catheter (OR: 0.3, CI 95%: 0.18–0.5; P < 0.001) were 70% less likely to contract CRBSI than those who stayed for more than 30 days. Similarly, previous CVC infection (OR: 11.9; CI 95%: 3.07–45; P < 0.001) in which a catheter was removed for infection had twelve times higher risk. Patients with WBC count (OR: 0.31; CI 95%: 0.19–0.52; P<0.001) of less than 10,000 cells per high power field at presentation were 69% less likely to develop CRBSI than those with greater than 10,000 cells per high power field. Hemoglobin levels (OR: 2.78; CI 95%: 1.28–6.01; P < 0.05) of less than 12mg/dl were 2.78 times higher risk of CRBSI than those who had more than 12 mg/dl.

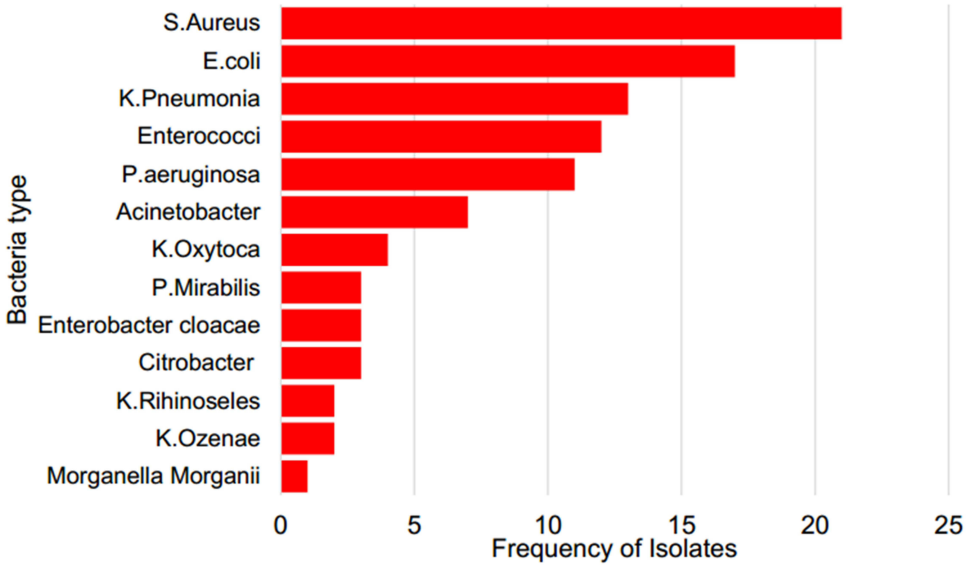

Figure 2 Bacteria isolate among patients undergoing hemodialysis.

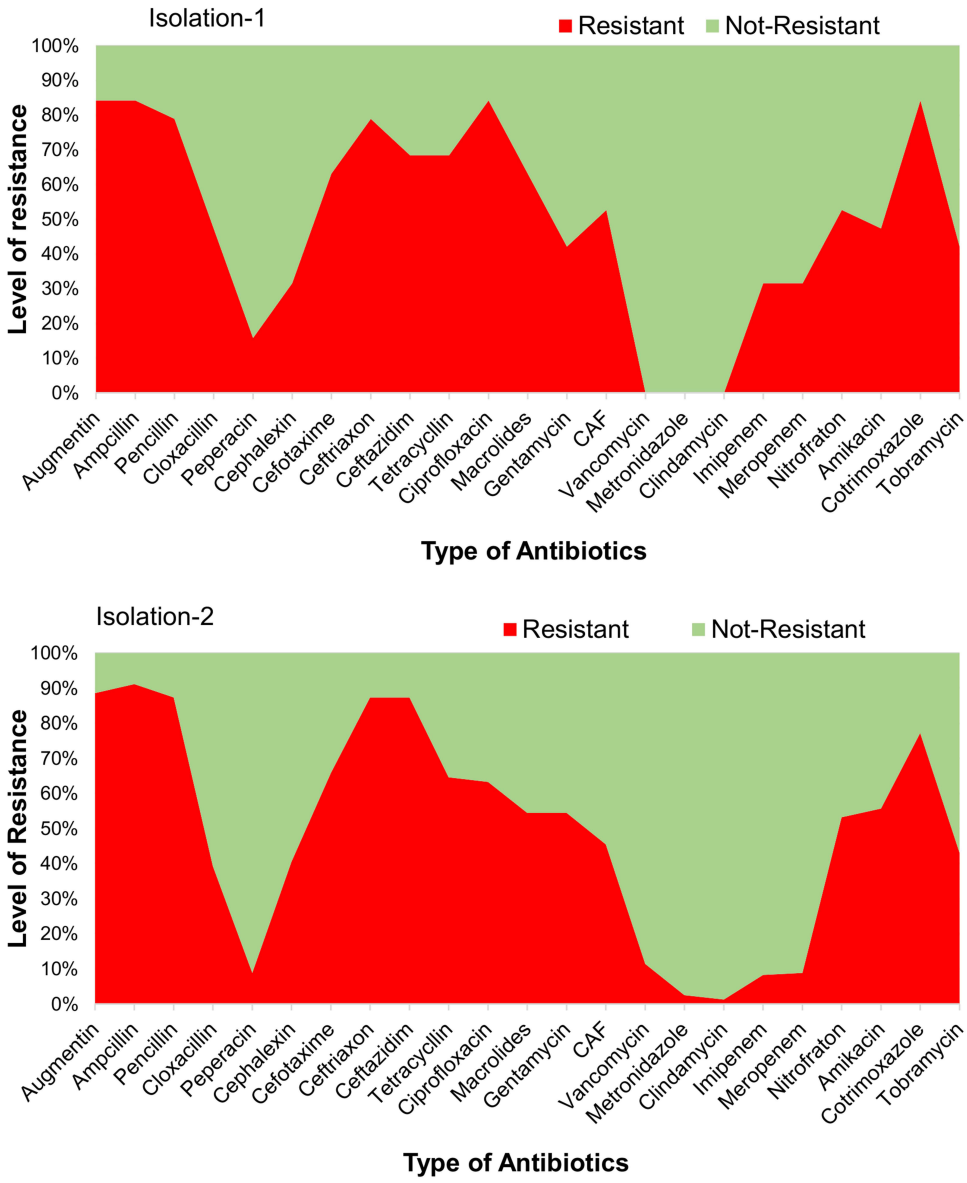

Figure 3 Level of antibiotics resistance and sensitivity among patients undergoing hemodialysis.

Discussion

The result of this 6 years' retrospective study reported that (i) an overall high incidence of CRBSI, (ii) the predominant microorganisms isolated were *S. aureus, E. coli* and *K. pneumonia*, and (iii) significant risk factors for the development

Table 4 Associated Risk Factors Among Patients Undergoing Hemodialysis in ACSH, Tigray 2022

Variables	Categories	No (%)	COR (95% CI)	AOR (95% CI)
Age in years	<18 18–40 41–65 >65	38 (10.8) 167 (47.3) 116 (32.9) 32 (9.1)	2.07 (0.76–5.63) 1.8 (0.79–4.13) 1.34 (0.57–3.18)	2.2 (0.67–7.22) 1.87 (0.71–4.91) 1.25 (0.46–3.37)
Gender	Male Female	203 (57.5) 150 (42.5)	1.44 (0.93–2.24)	1.18 (0.7–1.98)

(*Continued*)

Table 4 (Continued).

Variables	Categories	No (%)	COR (95% CI)	AOR (95% CI)
Address	Urban Rural	149 (42.2) 204 (57.8)	2.51 (1.59–3.96)	1.92 (1.15–3.21)*
Renal failure type	AKI CKD	158 (44.8) 195 (55.2)	0.6 (0.39–0.93)	1.24 (0.67–2.26)
Presence of comorbidity	Yes No	223 (63.2) 130 (36.8)	1.67 (1.06–2.64)	1.23 (0.73–2.09)
Duration of catheter	<30 days ≥30 days	200 (56.7) 153 (43.3)	0.27 (0.17–0.42)	0.3 (0.18–0.5)**
Previous CVC infection,	Yes No	23 (6.5) 330 (93.5)	12.57 (3.66–43.21)	11.9 (3.07–45)**
WBC count	≤10,000 >10,000	214 (60.6) 138 (39.1)	0.33 (0.21–0.51)	0.31 (0.19–0.52)**
Hemoglobin level	<12 mg/dl ≥12 mg/dl	296 (83.9) 56 (15.9)	2.93 (1.47–5.93)	2.78 (1.28–6.01)*

Notes: Asterisks denote significant p-value *<0.05, **<0.001.

of catheter-related infection in this study were the persistence of CVC catheter for a longer duration (>30 days), urban residence, previous CVC infection, low hemoglobin level, and high WBC count.

In this study, the incidence rate of CRBSIs was 7.74 episodes per 1000 patient days, which is higher than the findings from studies in Canada, Uganda, Saudi Arabia, Nepal, and India (ranging between 0.19 and 6.7/1000 catheter days).[2–5,9] The reasons for the high incidence rate could be attributable to the greater utilization of temporary dialysis CVCs (93.9%), in our study population. Temporary dialysis CVCs are known to carry a significantly higher risk of infection compared with tunneled cuffed catheters in patients with chronic HD.[6,7] Moreover, the study used the less stringent CDC criteria to define CRBSI. This higher incidence rate was also reported by Agrawal et al who used the same CRBSI definition like that as ours.[4]

Regarding the spectrum of microorganisms implicated in CRBSIs, our study showed that most of the episodes (57.6%) were caused by Gram-negative. Similar finding was reported from India, Uganda, and Jeddah with 54.7%, 61.3%, and 54.6%, respectively.[4,8–10] However, when we see each microorganism, a significant proportion of CRBSIs was caused by *S. aureus* (20%). This result also implied a growing proportion of Gram-negative bacteremia in patients with indwelling CVCs.[9] The epidemiological shift might have resulted from the promotion of CVC care approaches that focus on the control of Gram-positive bacterial infections or contamination.[10] Furthermore, these infections were largely nosocomial in origin, because our HD unit is located within the hospital; contact with admitted patients may have played a role. But, in contrary to our ascertained microbial pattern, many studies reported Gram-positive organisms were implicated for majority of the CRBSIs.[11–13]

Knowing the antibiotics sensitivity pattern of bacterial isolate or growth in HD unit is significant to select the suitable empiric antibiotics. In the current study, more than half of the *S. aureus* isolates were cloxacillin resistant, in line with this study, Fram and his associates reported that 38.5% of their *S. aureus* isolates were oxacillin resistant.[7] However, less than 10% of the recovered microorganisms from our patients showed resistance to vancomycin and imipenem. This indicates the importance of adding vancomycin as part of empiric antibiotics coverage for catheter-related infection in our setup. On the other hand, almost all of the isolate were resistance to penicillin and Augmentin, showing unwise use of these antibiotics in outpatient setting.

Escherichia coli was the most common gram-negative organism identified, followed by *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. This is similar to the result found by Abdinafi et al which was done in a similar setup in Somalia.[12] Regarding Gram-negative pathogens, they displayed 90% sensitivity to Imipenem, 87% to Amikacin, and 63.3% to

Gentamicin. Gram-negative pathogens revealed the lowest sensitivity to Ampicillin (4.8%), Augmentin (13.1%), and Ceftazidime (7.1%). Other than that, 12.7% of the recovered isolates were multidrug-resistant (MDR). These high rates of antimicrobial resistance highlight the need for stringent infection-control measures and antibiotics stewardship.

Our study confirmed the association between longer duration of CVC usage and CRBSI. Based on the KDOQI (2019) guideline, the use of a double lumen temporary catheter for more than 14 days is not recommended.[14] Similarly, many African countries, Middle East and European studies reported a significant association between the incidence of CRBSIs and longer duration of CVC insertion.[10,15,16] In CKD patients, the possible reasons for the prolonged duration of CVC usage were due to the difficulty of performing an arteriovenous fistula (AVF). This is a common problem encountered in our center. The reason behind this might be due to the late presentation of the patients, cost issues, and unavailability of competent vascular surgeons.

In the current study, urban resident registered patients were at high risk of developing CRBSI than rural residents. This study is unlike to Wang et al showing patients living in urban settings were better educated than those living in the countryside and less likely to contract CRBSIs.[16] In this study, it is difficult to differentiate between urban and rural resident patients as our hemodialysis unit is the only center in the region, with patients from rural residents living in the urban area to avoid the distance barrier.

In this study, patients who had a prior history of CVC infection were found to be twelve-fold more likely to develop a subsequent infection. This risk factor has already been reported in different studies.[7,9,17,18] The association might be due to an attempt to salvage the catheter, this in return is because most of our patients were unable to afford the costs of new CVCs, and permanent catheters were largely unavailable. Moreover, the formed biofilms in CVCs have been found to imped pathogenic bacteria clearance by the antibiotics.[9]

Low hemoglobin level at baseline was associated with a three-fold higher risk of CRBSI. Anemia has been previously reported in many studies as a risk factor for bacterial infections.[6,9,19] This may be associated with the risk of iron overload, which may lead to the enhancement of bacterial growth and impairment of phagocytic function.[9] However, we did not do a ferritin-level study because of its unavailability. Moreover, many patients in our setup did not receive the minimum frequency of dialysis per week, which is an indication of chronic inflammation from poor control of the uraemic milieu, predisposing to immune dysregulation and resultant elevated risk of infection. Similarly, leukocytosis during admission was significantly associated with the development of CRBSI which is in line with the Iran study.[20]

Among those patients who had a diagnosis of diabetes (13.9%), a statistically significant association with the development of CRBSI was not evidenced in this study with OR (1.73), 95% CI (0.3–1.63) ($p = 0.26$), although it was more frequently reported in other studies to be significant.[10,16,18] Similarly, the femoral site of catheter insertion was considered a high-risk factor for bacteremia compared to subclavian and internal jugular insertion sites.[16,18] However, due to the small number of non-internal jugular sites, comparisons between different CVC insertion site was not reliable or informative in the current study.

Limitations of the study worth mentioning are : (i) it is a retrospective and single hospital study, which might limit its generalization and make it liable for bias even though this is largest and only hemodialysis center in the Tigray region. (ii) we did not study the exit site infection rate, as we could not retrieve the required data from patient's medical records or dialysis registry. (iii) this study might have underestimated the true rate of CRBSI because the blood culture was commonly obtained in our setup after starting empirical antibiotics.

The strengths of the study are (i) this is the first study that reports the incidence and associated risk factors of CRBSIs with the long-term use of hemodialysis catheters in Ethiopia, to the best of our knowledge. (ii) the results of this study were comparable with the majority of the studies we came across.

In conclusion, use of central venous catheter for long standing hemodialysis was associated with an unacceptably high incidence rate of CRBSIs which can be reduced by the creation of an AV fistula. Since most infections were caused by Gram-negative and *S. aureus*, they should be taken into account in the initial empirical therapy. Prolonged duration of CVC usage, previous CVC infection, low hemoglobin level, and high WBC count are major risk factors related to infection in hemodialysis patients.

Abbreviations

ACSH, Ayder Comprehensive Specialized Hospital; ADPKD, Autosomal Dominant Polycystic Kidney Disease; AKI, Acute Kidney Injury; AOR, Adjusted Odd Ratio; AVF, Acute Venous Fistula; AVG, Arteriovenous Graft; CKD, Chronic Kidney Disease; CRBSI, Catheter-Related Bloodstream Infection; CVD, Cardiovascular Disease; CVC, Central Venous Catheter; ESRD, End-Stage Renal Disease; HD, Hemodialysis; HIV, Human Immunodeficiency Virus; SPSS, Statistical Package for Social Science; SD, Standard Deviation; WBC, White Blood Cells.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request at the following address: meskelu.wkidu@gmail.com.

Ethical Approval and Consent to Participant

Ethical approval was obtained from Mekelle University, College of Health Sciences Institutional Review Board (IRB) with ethical clearance number MU-IRB: 1995/2022. Administrative clearance was also obtained to access patients' files from the medical director of ACSH. The ethics committee of the institute gave a waiver for informed consent because the data that were collected were secondary data. The investigation conforms to the principles outlined in the declaration of Helsinki.

Acknowledgments

The authors would like to thank Mekelle University, college of health science for providing an opportunity to carry out this study. We also offer our deepest thanks to the nursing staff of Ayder Comprehensive Specialized Hospital Hemodialysis Unit for their help in data collection.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

No specific funding was received.

Disclosure

The authors declare that they have no competing interests in this work.

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