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ORIGINAL RESEARCH

Pattern and Sensitivity of Bacterial Colonization on the Tip of Non-Tunneled Temporary Hemodialysis Catheters: Results of a Tertiary Hospital in Somalia

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Introduction: Bacterial colonization on the tip of non-tunneled temporary hemodialysis catheters (NTHCs) and associated catheter-related infections (CRI) is a common complication in hemodialysis (HD) patients. In this study, we aimed to investigate the pattern of bacterial colonization formed on the tip of non-tunneled temporary hemodialysis catheters and their antibiotic sensitivity.

Methods: This retrospective analysis was performed in the HD unit of an Education and Research Hospital that follows up a universe of approximately 300 patients, primarily from Mogadishu, Somalia. From September 2020 to September 2021, a total of 137 temporary HD catheters were removed and their tips were sent for culture after there was a suspicion of CRI and other sources of infection were excluded. HD Catheter tips were cultured semi-quantitatively, and the antibiogram of the positive cultures was studied.

Results: Gram-positive cocci were found to be the most predominant bacterial organisms in positive cultures with 27 (31.0%) for *Staphylococcus aureus*, 9 (10.3%) for *Staphylococcus haemolyticus* and 5 (5.7%) for *Staphylococcus epidermidis*. We found Enterococci to be 5.7% of the isolated microorganisms. Gram-negative pathogens isolated included *Escherichia coli* 13 (14.9%) as the most common, followed by *Klebsiella pneumoniae* 10 (11.5%) and *Acinetobacter baumannii* (4.6%). Methicillin-resistant *Staphylococcus aureus* (MRSA) was found to be 9.4%. Gram-positive isolates showed high sensitivity (100%) to Linezolid, Daptomycin, Vancomycin, and Tigecycline, but a low sensitivity rate to Oxacillin (41.2%). Gram-negative isolates had the highest sensitivity to Tigecycline (100%), Imipenem (88.9%), and Amikacin (87%) but low sensitivity to Ampicillin (4.8%), Trimethoprim/Sulfamethoxazole (TMP-SMX) (23.1%), and Ceftazidime (7.1%).

Conclusion: We conclude that each institution should have its own antibiogram in the management of HD CRIs. According to our findings in this study, we recommend intravenous Vancomycin and Imipenem as empirical therapy in patients with suspected HD CRIs.

Keywords: antibiogram, antibiotics, bacterial colonization, catheter-related infection, hemodialysis, temporary catheters

Introduction

HD is essential for patients with acute or chronic kidney disease. Its use is a frequent and growing practice worldwide. Every year, millions of intravascular catheters are used in healthcare centers to establish vascular access sites through the insertion of a catheter into a femoral, subclavian or internal jugular vein if a fistula is not present.[1,2] NTHCs are usually used when there is an urgent need for vascular access in patients who require immediate HD.[3] Unfortunately, the discouraging fact is that the use of these catheters is associated with bacterial colonization that produces a biofilm (a slimy mucopolysaccharide

matrix) on the catheter surface. The biofilm forms a shield for the microorganisms protecting them from innate immune defenses. Bacterial biofilm is associated with catheter-related bloodstream infections (CRBSI) followed by serious complications that may lead into patient morbidity and mortality.[4,5] CRBSI and related complications requiring hospitalization account for nearly one-third of the cost of chronic kidney disease management with reported mortality rates of 12–25.9%.[6] Timely diagnosis and management of the responsible microorganism with appropriate antibiotics are crucial to prevent infectious complications. Therefore, a better understanding of the pathogenesis of these infections is important in developing management strategies to reduce the occurrences of catheter-related sepsis.

In Somalia, NTHCs are commonly used as a source of temporary vascular access for the initiation of HD in both acute and chronic kidney disease patients, and to our knowledge, there are no previous studies on the pattern and sensitivity of bacterial colonization at the tip of hemodialysis catheters. This present study aimed to investigate the pattern of bacterial colonization formed on the tip of non-tunneled temporary hemodialysis catheters and their antimicrobial susceptibility.

Methods

We conducted this retrospective analysis in the HD unit of Education and Research Hospital that follows up a universe of approximately 300 patients, primarily from Mogadishu, Somalia.

We carried out the study from September 2020 to September 2021. A total of 137 temporary hemodialysis catheters were removed and their tips were sent for culture. Catheters were removed and sent for culture when there was a suspicion of CRI and other sources of infection were excluded. All catheters which were removed due to other reasons were excluded from the study. Catheter-related infection was suspected when the patients present with fever, chills, rigors and pus at the catheter site. Peripheral blood cultures were also recorded. Catheter colonization was defined as a significant growth of a microorganism of >15 Colony Forming Units (CFUs) in the semiquantitative culture of the catheter tips.[7] CRBSI was diagnosed if the same microorganism was grown from peripheral blood culture and catheter tip culture at least once.[8]

The catheters were removed under aseptic precautions by one investigator after obtaining informed consent from the patient. A 5-cm segment of the tips was cultured semi-quantitatively, by rolling them back and forth across the surface at least four times, on a blood agar plate. Colonies were counted after 24 hours of incubation at 37°C. The criteria of positivity were based on when more than 15 CFUs were isolated.[7]

Not all positive cultures were tested for the same list of antibiotics, as some bacteria were tested according to the availability of that antibiotic at the center or antibiotics upon special request. Cultures and antibiotic sensitivity to the bacteria were performed by the Infectious and Microbiology department of the Hospital following the standard laboratory protocols. The findings of bacterial microorganisms were achieved by using a BD BBL crystal identification system, as well as biochemical tests, including oxidase, coagulase, citrate, and catalase tests. Finally, antibiogram was performed using the standard Kirby–Bauer disk diffusion method and commercial disks (Oxoid discs). Cefoxitin-resistant *Staphylococcus aureus* was considered methicillin-resistant *Staphylococcus aureus* (MRSA), and the extended-spectrum beta-lactamase (ESBL) was identified using Cephalosporins (cefuroxime + ceftriaxone) and Amoxicillin-Clavulanic acid combination discs. Enterococcus antimicrobial susceptibility was assessed using blood agar.

Antibiotic susceptibility of the pathogens was studied by using Ciprofloxacin 5 mcg, Levofloxacin 5 mcg, piperacillin/tazobactam 100/10 mcg, Imipenem 10 μg, Amikacin 30 mcg, Tigecycline 15 ug, Penicillin G 1 U, Ampicillin 10 μg, Amoxicillin + Clavulanic Acid 20 + 10 μg, Ceftazidime 30 ug, Linezolid 30 mcg, Clindamycin 2 mcg, Gentamicin 120 μg, Daptomycin 30 mcg, TMX-SMX 1.25/23.75 mcg, Vancomycin 30 mcg, Tetracycline 30 mcg, Cefoxitin 30 mcg, Cefuroxime 30 μg, and Ceftriaxone 30 μg.

This study was carried out according to the Helsinki Declaration, and Ethical approval of this research was obtained from the research ethics committee of Mogadishu Somali Turkey Recep Tayyip Erdogan Training and Research Hospital with a reference number of MSTH/3784. The study's objective was explained to the participants and all patients provided informed consent to participate in this study.

Patient demographics, including gender, age, and presence of concurrent disease states and cause of catheter removal were collected. Results of catheter tip cultures and antibiotic sensitivity were also recorded. Data were analyzed by using Statistical Package for Social Sciences (SPSS) version 23. Tables and figures were presented with Microsoft Word.

Table 1 Patient Characteristics

	Patients with Positive Cultures Results	Patients with Negative Culture Results	Total
Number	85(62.0%)	52(38.0%)	137(100%)
Age (years)	51 ± 18	51± 17	51± 18
Sex — M/F	49/36	32/20	81/56
History of Diabetes mellitus	34(61.8%)	21(38.2%)	55(100%)
History of Hypertension	38(58.5%)	27(41.5%)	65(100%)
History of heart failure	4(%)	3(%)	7(100%)
Hemoglobin (g/dL)	9.0 ± 0.58	9.0± 0.68	9.0± 0.68

Results

This retrospective study included a total of 137 patients in which their temporary HD catheters were removed after catheter infection was suspected between September 1, 2020, and August 31, 2021. Eighty-one (59.1%) of the patients were male and 56 (40.9%) female. The average age was 51 years (range: 10–87 years).

The most significant comorbid diseases included anemia (94%), hypertension (47.4), diabetes mellitus (40.1%), and congestive heart failure (5.1%) (Table 1).

The presenting signs and symptoms are seen to be fever most commonly (72%), pus at the catheter site (64%), chills (56.1%), and rigors (51.8%) (Figure 1).
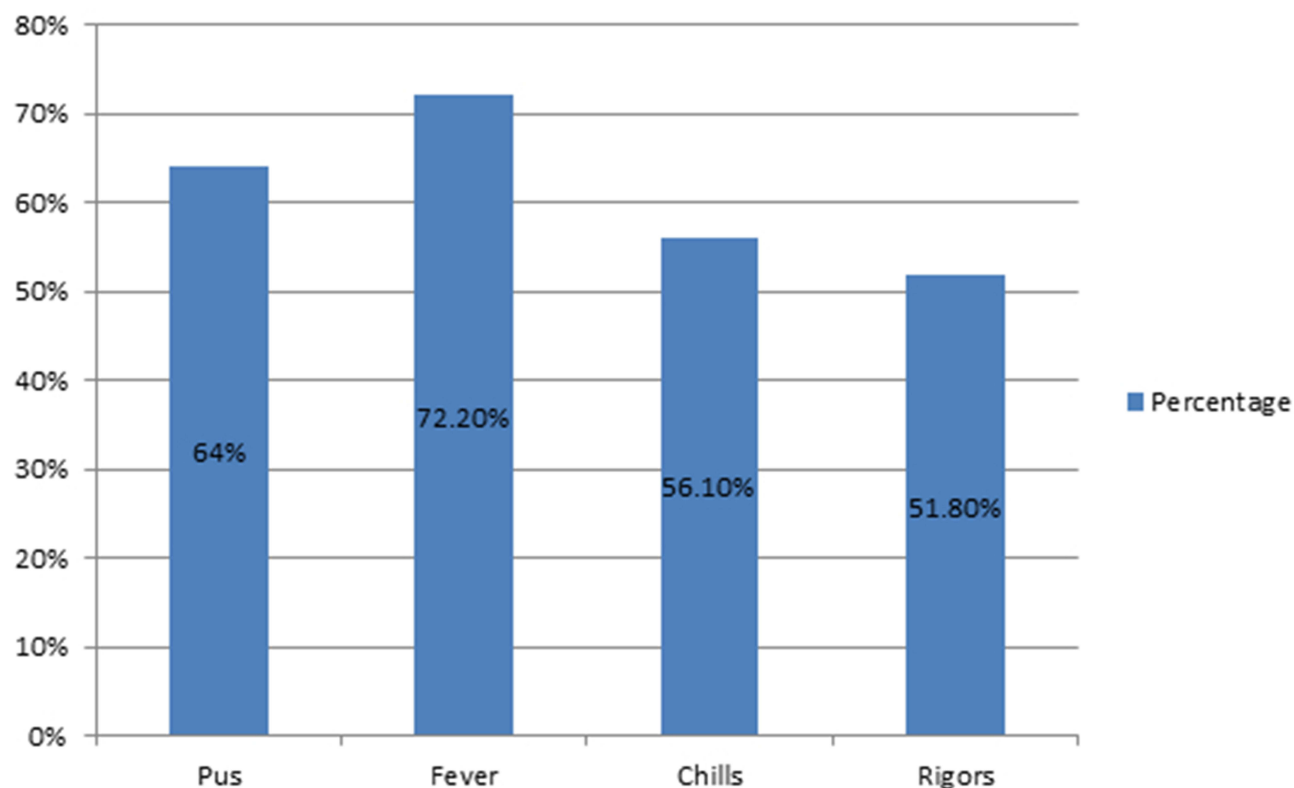

Figure 1 Presenting signs and symptoms of patients with confirmed catheter-related infections.

Table 2 Pattern of Microorganisms Responsible for Hemodialysis Catheter Tip Bacterial Colonization

Type of Microorganisms	No. Patients	Percentage
Staphylococcus aureus **MRSA**	27 8	31.8%
Coagulase negative staphylococci	14	16.5%
Enterococcus faecalis **VRE**	5 0	5.9%
E. coli **ESBL producing *E. coli***	13 3	15.3%
Klebsiella pneumoniae **ESBL producing *Klebsiella***	10 3	11.8%
Acinetobacter baumannii **ESBL producing enterobacter**	4 1	4.7%
Enterobacter cloacae	3	3.5%
Pseudomonas aeruginosa	2	2.3%
Other Gram negative bacteria **ESBL**	7 1	8.2%
Total	85	100.0%

HD catheter tip bacterial colonization was positive (>15 CFUs) in 85 (62.0%) patients and 52 (38.0%) were negative (no growth or <15 CFUs). According to the positive cultures, 46 (54.1%) were gram-positive and 39 (45.9%) were gram-negative. In our study 59 (69.4%) of the catheters with bacterial colonization at the tip of the catheter showed same organism growth at the peripheral blood culture confirming the presence of HD CRBSIs based on our study criteria.

Gram-positive cocci were the most predominant bacterial biofilm in positive cultures with a 27 (31.2%) for *Staphylococcus aureus*, 9 (10.6%) for *Staphylococcus haemolyticus*, and 5 (5.9%) for *Staphylococcus epidermidis*. Enterococci were found to be 5 (5.9%) of the isolated microorganisms (Table 2).

Gram-negative pathogens isolated included *Escherichia coli* 13 (15.3%), *Klebsiella pneumoniae* 10 (11.8%), and *Acinetobacter baumannii* 4 (4.7%).

Antibiotic sensitivities tested against staphylococcal species indicated that they were completely sensitive (100%) to antibiotics like Linezolid, Daptomycin, Vancomycin, and tigecycline. Other antibiotics sensitivity to *staphylococcus* were as following Clindamycin 80.6%, Gentamicin 66.7%, Cefoxitin 63.9%, Tetracycline 55.6%, and Ciprofloxacin 51.4%. Gram-positive pathogens revealed the lowest sensitivity rate to Oxacillin (41.2%) (Table 3).

The prevalence of Methicillin-resistant *Staphylococcus aureus* (MRSA) was found to be 9.4% (8 patients), and Vancomycin-Resistant Enterococci (VRE) was not found in our study.

Regarding Gram-negative pathogens, they displayed complete sensitivity (100%) to Tigecycline, 88.9% to Imipenem, 87% to Amikacin, 73.3% to cefoxitin, 70.4% to Gentamicin and Ciprofloxacin.

Gram-negative pathogens revealed the lowest sensitivity to Ampicillin (4.8%), Trimethoprim/Sulfamethoxazole (TMP-SMX) (23.1%), and Ceftazidime (7.1%). The prevalence of extended ESBLs among gram-negative cultures was found to be 20.5% (8 patients) (Table 4).

Table 3 *Staphylococcus aureus* and *Staphylococcus haemolyticus* Catheter Tip Culture Susceptibilities

Medications	Staphylococcus aureus	Staphylococcus haemolyticus	Total/Sensitive
Cefoxitin	19/27(70.4%)	4/9(44.4%)	23/36(63.9%)
Oxacillin	7/14(50.0%)	0/3(0.0%)	7/17(41.2%)
Gentamicin	23/27(85.2%)	1/9(11.1%)	24/36(66.7%)
Ciprofloxacin	16/27(59.3%)	2/8(25.0%)	18/35(51.4%)
Levofloxacin	10/18(55.6%)	1/5(20.0%)	11/23(47.8%)
Tetracycline	16/27(59.3%)	4/9(44.4%)	20/36(55.6%)
Clindamycin	22/27(81.5.0%)	7/9(77.8%)	29/36(80.6%)
Linezolid	27/27(100.0%)	9/9(100.0%)	36/36(100.0%)
Daptomycin	19/19(100.0%)	6/6(100.0%)	25/25(100.0%)
Vancomycin	27/27(100.0%)	9/9(100.0%)	36/36(100.0%)
Tigecycline	18/18(100.0%)	5/5(100.0%)	23/23(100.0%)

Table 4 *E. coli*, *Klebsiella pneumoniae* and *Acinetobacter baumannii* Catheter Tip Culture Susceptibilities

Medications	E. coli	Klebsiella pneumoniae	Acinetobacter baumannii	Total/Sensitive
Cefoxitin	6/8(75.0%)	5/7(71.4%)	–	11/15(73.3%)
Gentamicin	10/13(76.9%)	7/10(70.0%)	2/4(50.0%)	19/27(70.4%)
Ciprofloxacin	6/13(46.2%)	7/10(70.0%)	2/4(50.0%)	19/27(70.4%)
Trimethoprim/Sulfamethoxazole	3/13(23.1%)	3/10(30.0%)	0/3(0.0%)	6/26(23.1%)
Ampicillin	1/10(10.0%)	0/8(00.0%)	0/3(00.0%)	1/21(04.8%)
Cefuroxime	4/13(30.8%)	1/8(12.5%)	–	5/21(23.8%)
Ceftriaxone	3/12(25.0%)	2/10(20.0%)	–	5/22(22.7%)
Ceftazidime	1/5(20.0%)	0/6(00.0%)	0/3(0.0%)	1/14(07.1%)
Amoxicillin-Clavulanate	3/13(23.1%)	3/10(30.0%)	0/3(0.0%)	6/26(23.1%)
Piperacillin-Tazobactam	5/7(71.4%)	6/7(85.7%)	1/4(25.0%)	12/18(66.7%)
Imipenem	13/13(100.0%)	10/10(100.0%)	1/4(25.0%)	24/27(88.9%)
Amikacin	10/11(90.9%)	7/8(87.5%)	3/4(75.0%)	20/23(87.0%)
Tigecycline	10/10(100.0%)	6/6(100.0%)	4/4(100.0%)	20/20(100.0%)

Discussion

Uncuffed, NTHCs are considered as the preferred way to gain immediate access for dialysis, although bacteremia is the primary complication that limits their use.[3,9]

This study aimed to reveal the bacterial colonization on the tip of NTHCs and their antibiotic sensitivity. Bacterial colonization on HD catheters is associated with a high rate of HD CRI. De Freitas et al reported a high correlation of 93.3%, between the catheter tip cultures and the peripheral blood cultures.[2] To the authors' knowledge, this is the first study to obtain data on HD catheter bacterial colonization and antibiotic sensitivity in Somalia.

Our results suggest that presenting signs and symptoms of chills, fever, rigors, and redness at the catheter site could be a good indicator of bacterial infection and bacterial colonization at the tip of the catheter in approximately 50% of cases.

The bacterial organisms isolated from catheter tip cultures were consistent with that associated with CRIs, indicating that gram-positive organisms including *Staphylococcus aureus* (*S. aureus*) and *Staphylococcus* coagulase-negative remain the most common organisms isolated. Similar results were found by Dopairak et al, Sathish et al, Blakestijin et al and Kairaitis et al.[10–13]

We identified *Escherichia coli* as the most common gram-negative organism followed by *Klebsiella pneumoniae* and *Acinetobacter baumannii*. This is comparable with the results found by Eleanor et al.[14]

Antibiogram is a list of laboratory testing used to examine the susceptibility of bacterial isolates to different types of antibiotics. To avoid bacterial resistance, a careful selection of antibiotics is crucial. Since trends of bacterial resistance change over time, bacterial susceptibility has to be reviewed regularly, and this is particularly important in developing countries.[15,16]

Based on this study, the pattern of antimicrobial sensitivity differed in the different classes of antibiotics and the pathogens isolated from the culture. We noted that all gram-positive bacteria were sensitive to Linezolid, Vancomycin, Daptomycin, and Tigecycline, including methicillin-resistant *staphylococcus aureus*. These were followed by Clindamycin, Gentamicin, and Cefoxitin, which showed 80.6%, 66.7%, and 63.9% sensitivity, respectively. In our study, Ceftazidime showed high resistance rates to gram-negative isolates contrary to the finding of Abdul Gafor et al, and this could be due to the widespread use of ceftazidime in our center as empirical therapy.[15]

Due to the occurrence of MRSA isolates in our study, we recommend Vancomycin as empirical therapy as recommended by the guidelines of Infectious Diseases Society of America (IDSA).[7] Interestingly, oxacillin showed lower rates of sensitivity (41.2%) to staphylococcal isolates, contrary to the IDSA recommendation of its use to methicillin-sensitive staphylococcal species. We found that 29.6% of S. aureus were characterized as methicillin-resistant; this is nearly the occurrence of MRSA associated with hemodialysis catheter-related bacteremia reported by Elisabeth et al.[5]

As recommended by IDSA, empirical coverage of gram-negative bacilli is usually based on the local antimicrobial susceptibility data and the severity of the disease.[7] Our current study shows the sensitivity of all gram-negative bacteria to Imipenem, except *Acinetobacter baumannii*. Tigecycline showed sensitivity to all gram-negative bacteria, while Amikacin had low resistance rates. The high multidrug resistance rate of *Acinetobacter baumannii* in hemodialysis catheter culture was also reported by Sahli et al.[17]

Before this study, the empirical antibiotics for HD CRBSIs in our Hospital were intravenous Ceftazidime and Vancomycin, but after this study, we noted that most of the gram-negative bacteria were resistant to Ceftazidime but sensitive to Imipenem and Amikacin. Thus, following these results, empirical antibiotics for HD CRBSIs in our center were switched to intravenous Imipenem and Vancomycin.

The limitation of this study is that it is a retrospective study that is conducted in a single-center, which limits its generalizability to other centers, although this is the largest hemodialysis center in Somalia at the time of this study. We also could not correlate catheter vascular insertion site and infection rates since there were no recorded data about the insertion sites.

Conclusion

Our study revealed that the staphylococcal bacteria are the most common organisms responsible for non-tunneled temporary hemodialysis catheter tip bacterial colonization. We highly recommend that each institution should have their own antibiogram in the management of HD CRBSIs. Based on our findings in this study, we also recommend intravenous Vancomycin and Imipenem as the empirical therapy in patients with suspected HD CRIs.

Data Sharing Statement

Datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

Consent for publication was obtained from the patients. Ethical approval of this research was obtained from the research ethics committee of the Hospital with reference number MSTH-3784.

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Disclosure

The authors declare that they have no conflicts of interest regarding the publication of this article.

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