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Access- and non-access-related infections among patients receiving haemodialysis: Experience of an academic centre in Oman

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ABSTRACT

Objective: The aim of this study was to examine the epidemiology of access and non-access-related infections in patients receiving haemodialysis at an academic tertiary hospital in Oman.
Methods: This was a retrospective observational study of 287 hospitalized patients who received haemodialysis during the period January 2018 to December 2019 at Sultan Qaboos University Hospital, Muscat, Oman.
Results: A total of 202 different infections were documented in 142 of the 287 patients (49.5%). Pneumonia was the most common infection in the patients examined, accounting for 24.8% (50/202) of the total infections. This was followed by bloodstream infections, with a prevalence of 19.8% (40/202). *Klebsiella pneumoniae* was the most prevalent isolate (19.0%; 47/248). The highest number of multidrug-resistant infections were caused by multidrug-resistant *K. pneumoniae* (29.9%; 23/77).
Conclusions: Infections in patients undergoing haemodialysis are common and are dominated by non-access-related infections. Pneumonia was found to be the most prevalent infection in this population. Gram-negative bacteria, predominantly *K. pneumoniae*, were the most prevalent isolates. The study reported an alarming number of multidrug-resistant organisms, accounting for 31.0% of the total bacterial isolates from various clinical specimens.

1. Introduction

Infection is a major cause of morbidity and mortality in patients receiving haemodialysis (HD) and is the second most common cause of death after cardiovascular disease in this patient population [1–3]. The heightened risk of infection is largely attributable to vascular access, the process of the dialysis itself, and iron overload [4], in addition to common predispositions in patients with chronic kidney disease (CKD) such as advanced age, comorbidities, uraemia, anaemia, and malnutrition.

In 2014, a total of 29 516 bloodstream infections (BSIs) were reported among outpatients receiving chronic HD in the United States; 76% of these infections were related to vascular access. The predominant causative organism was *Staphylococcus aureus*, accounting for 30.6%; of these, 39.5% were methicillin-resistant *S. aureus* (MRSA) isolates. *Enterococcus* species caused 5.5% of the BSIs, with 11.5% being resistant to vancomycin. A total of 15% of the infections were due to gram-negative resistant pathogens including *Escherichia coli, Enterobacter cloacae, Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*. Overall, 17.8% of *E. coli* isolates were resistant to third-generation cephalosporins, and 14.6% of *Klebsiella* species were also resistant to cephalosporins [5].

There is scant literature on the epidemiology of infections and their causative organisms in patients receiving HD in Oman and the region. Hence, the aim of this study was to identify the most common infections and their aetiologies in patients receiving HD at an academic centre in Oman.

2. Methods

This was a retrospective study of patients who received HD at Sultan Qaboos University Hospital (SQUH), Muscat, Oman over 2-year period (January 2018 to December 2019). Patients were identified using the SQUH dialysis registry.

The inclusion criteria were hospitalized adult inpatients (age ≥18 years) who had received at least one session of intermittent HD or continuous venovenous HD at SQUH during the period January 2018 to December 2019.

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A record of all patients who received HD in the dialysis unit at SQUH was obtained. Data of 287 patients who met the inclusion criteria were extracted by reviewing their medical records using the SQUH hospital information system. The data included patient demographics (age, sex, weight, and height) and comorbidities (hypertension, dyslipidaemia, diabetes mellitus, cardiovascular disease, respiratory disease, previous or current cancer, chronic liver disease, and prior history of renal transplant), type of vascular access (fistula versus vascular catheter), infection site (see below), and causative pathogen.

Infections were classified as respiratory tract infections (RTIs), skin and soft tissue infections, vascular access infections (VAIs), BSIs, urinary tract infections, gastrointestinal tract infections, other infections (eye, nose, ear infections, bone and joint infections, infections of the reproductive system), and unknown source of infection.

The criteria for classifying each type of infection were based on the US Centers for Disease Control and Prevention National Healthcare Safety Network (CDC/NHSN) surveillance definition of nosocomial infections in the acute care setting. Furthermore, the same reference was used to differentiate between colonization and true infection (CDC/NHSN surveillance definition of healthcare-associated infection and criteria for specific types of infections in the acute care setting, 2013).

2.1. Statistical analysis

Descriptive statistics were used to describe the data. Categorical variables were presented as frequencies and percentages, and differences analysed using the Chi-square test (or Fisher's exact test for expected cells of <5). Continuous variables were presented as means and standard deviations along with the range (age and body mass index). An a priori two-tailed level of significance of <0.05 was set. The data analysis was performed using Stata software version 16.1 (StataCorp, College Station, TX, USA).

3. Results

3.1. Patient demographics

Table 1 illustrates the patient demographics and clinical characteristics. The mean age of the patients was 58 ± 17 years; 62.7% (n = 180) of the patients were male and 37.3% (n = 107) were female. Thirty-one percent (89/287) of the patients died within a year of admission. Hypertension, diabetes mellitus, and cardiovascular disease were the most common comorbidities found in the study, with a prevalence of 80.1% (230/287), 59.9% (172/287), and 48.8% (140/287), respectively. Out of the 287 inpatients, 31 (10.8%) had chronic liver disease. The indication for HD was classified as acute kidney injury in 30.0% (86/287) and CKD stage 5 (G5) in 70.0% (201/287). The major cause of CKD was diabetic nephropathy. Permacath and arteriovenous fistula were the most common vascular access for HD (44.6% and 39.0%, respectively). Anuria was reported in 20.6% (59/287) of the patients at presentation. Pneumonia was a major contributor to death (72%; 36/50).

Table 1
Patient demographics and clinical characteristics.

Variable	N = 287 patients
Age (years), mean ± SD (range)	58 ± 17 (18–95)
Sex, n (%)	
Male	180 (62.7%)
Female	107 (37.3%)
BMI (kg/m^2), mean ± SD (range)	28 ± 12 (22.4–30.4)
Survival, n (%)	
Alive	192 (66.9%)
Died same year	89 (31.0%)
Died next year	6 (2.1%)
Smokers, n (%)	22 (7.7%)
Comorbidities, n (%)	
Previous or current cancer	25 (8.7%)
Chronic liver disease at enrolment	31 (10.8%)
Chronic pulmonary disease	33 (11.5%)
Dyslipidaemia	50 (17.4%)
Cardiovascular disease	140 (48.8%)
Diabetes mellitus	172 (59.9%)
Hypertension	230 (80.1%)
Renal failure, n (%)	
Acute kidney injury	86 (30.0%)
Chronic kidney disease category 5	201 (70.0%)
Diabetes mellitus	63 (22.0%)
Hypertension	48 (16.7%)
Systemic lupus erythematosus	12 (4.2%)
Focal segmental glomerulosclerosis	5 (1.7%)
Others/unknown	73 (25.4%)
Vascular access at enrolment, n (%)	
Arteriovenous graft	8 (2.8%)
Quinton	90 (31.8%)
Arteriovenous fistula	112 (39.0%)
Permacath	128 (44.6%)
Haemodialysis frequency, n (%)	
Twice weekly	36 (12.5%)
Three times weekly	165 (57.5%)
Not fixed (acute kidney injury)	86 (30.0%)
Previous kidney transplant, n (%)	30 (7.3%)
Presence of anuria at enrolment, n (%)	59 (20.6%)

BMI, body mass index; SD, standard deviation.

3.2. Most common infections and causative organisms

A total of 202 different infections were documented in 142 of the 287 patients (49.5%). Figure 1 shows that the most common infection in the study sample was pneumonia, which accounted for 24.8% (50/202) of the total infections, followed by BSIs with a prevalence of 19.8% (40/202). VAIs were documented in 18.8% (38/202) of total infections. The remaining 36.6% (74/202) were other types of infection (see Figure 1).

A total of 81.2% (233/287) of the microbiological cultures were done, of which 60.9% (142/233) were positive. A total of 248 bacterial isolates were identified from the different clinical samples (Table 2): 151 (60.9%) gram-negative bacteria and 97 (39.1%) gram-positive bacteria.

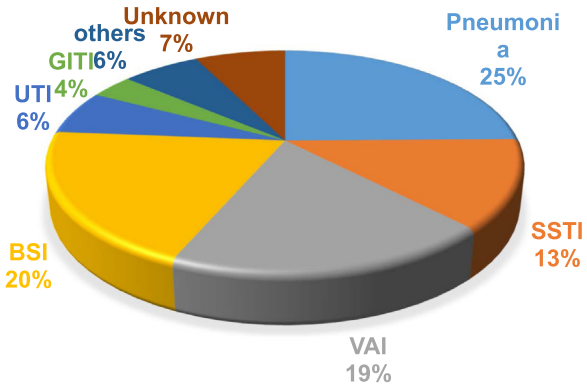

Figure 1. The most common infections among the patients.
SSTI, skin and soft tissue infection; VAI, vascular access infection; BSI, bloodstream infection; UTI, urinary tract infection; GITI, gastrointestinal tract infection.

Seventy-seven (31.0%) of these isolates were identified as multidrug-resistant (MDR).

The predominant causative organism was *K. pneumoniae* (19.0%; 47/248), followed by *S. aureus* (14.5%; 36/248) and *P. aeruginosa* (13.3%; 33/248). The greatest number of MDR infections were caused by MDR *K. pneumoniae* (29.9%; 23/77) (Table 3).

Infections by two concurrent organisms were common. For example, *P. aeruginosa* and *K. pneumoniae* were more likely to present together

Table 2
Numbers of isolated bacteria from the microbiological cultures

Gram-positive isolates	*n*	Gram-negative isolates	*n*
Staphylococci		*Pseudomonas aeruginosa*	33
S. aureus	36	Non-aeruginosa *Pseudomonas*	4
CoNS	24	*Klebsiella pneumoniae*	47
Streptococci		*Escherichia coli*	14
S. pneumoniae	4	*Enterobacter cloacae*	6
S. agalactiae	2	*Acinetobacter baumannii*	21
S. mitis	1	*Klebsiella aerogenes*	1
S. dysgalactiae	1	*Enterobacter kobei*	1
S. pyogenes	1	*Proteus mirabilis*	9
S. intermedius	1	*Citrobacter koseri*	2
Enterococci		*Bacteroides fragilis*	2
E. faecium	9	*Serratia marcescens*	2
E. faecalis	4	*Achromobacter*	1
E. avium	1	*Mycoplasma*	1
E. casseliflavus/flavus/gallinarum	1	Others	7
Micrococcus luteus	3		
Finegoldia magna	1		
Clostridium difficile	2		
Corynebacterium species	2		
Bacillus cereus	1		
Propionibacterium acnes	1		
Others	2		

CoNS, coagulase-negative staphylococci.

Table 3
Numbers of isolated multidrug-resistant bacteria

MDR Klebsiella pneumoniae	23
MDR Acinetobacter baumannii	16
MRSA	11
ESBL Escherichia coli	7
Stenotrophomonas maltophilia	9
ESBL Klebsiella pneumoniae	3
MDR Pseudomonas aeruginosa	4
ESBL Proteus	2
MDR Escherichia coli	2
Total number	77

ESBL, extended-spectrum beta-lactamase producing; MDR, multidrug-resistant; MRSA, methicillin-resistant *Staphylococcus aureus*.

(21%). The same was found for infections by MDR *K. pneumoniae* and MDR *Acinetobacter baumannii* (31%).

4. Discussion

Infection-related data of 287 hospitalized patients receiving HD during the period from January 2018 to December 2019 were analysed. Two studies similar to the current study have been performed, one in the United States and the other in Australia. The United States study included 278 outpatients [6] and the Australian one was on 114 patients [7]. Similarly to the current study, there were more male patients than female patients (62.7% vs 37.3% in the current study), and the most common cause of CKD necessitating HD was diabetic nephropathy. The mean age of patients in the current study was 58 years. However, the other studies documented a median age of 64 years and 66.7 years, respectively [6,7]. The present study included patients with acute kidney injury and CKD G5, receiving acute and chronic HD; this is in contrast to the other studies, which were limited to patients receiving regular HD. The use of arteriovenous fistula as a vascular access for HD was common in the other studies. However, a permacath was the most common vascular access in the present study cohort (44.6%), followed by arteriovenous fistula (39.0%).

A high mortality rate was evident among the patients receiving HD in this study. Approximately one-third of the patients died within a year of admission or in the subsequent year. As expected, a higher mortality rate was reported in the present study than in an Ethiopian study, which was done on patients receiving chronic HD at three different hospitals [8]. The Ethiopian study reported that 17% of the study population died during the follow-up period of 4 years. This difference between the studies is probably attributable to the fact that the current study also included patients on HD for acute kidney injury or on acute dialysis. The presence of comorbidities like hypertension, diabetes mellitus, and cardiovascular disease, along with infection, contributed significantly to death in the HD population, and they are considered as risk factors for increased mortality [8].

This study included culture-proven infections, with a total of 202 infections in 49.5% of the studied population. A study conducted in a tertiary care centre in Beirut supports this finding, reporting 220 infections in 46.6% of the study population [9]. Similar to previous studies, most of the infections among patients receiving HD were not access-related [3,4,9]. Regardless of the dialysis vascular modality, access-related infections seem to have diminished significantly over time [3].

The most common type of infection in the current study was pneumonia, accounting for one-fourth of total infections. This finding is supported by Hui et al. (2017) [7], who reported RTIs as being the most common. A study published in 2004 revealed that infections below the knee were more prevalent than RTIs in 433 patients receiving long-term HD [10]. However, the latest study included both fungal and bacterial infections. In the current study, BSIs were the second leading infections among inpatients, followed by VAIs. In another previous study, BSIs were more common than RTIs, although with a minor difference in incidence (33.2% vs 32.7%) [9]. Previous studies have shown more occurrences of skin and soft tissue infections [7,10].

The total number of microbiological cultures done was 233, of which 61% were positive, with 248 isolates. Overall, 60.9% of the bacterial isolates were gram-negative bacteria, and the most common causative organism of infection was *K. pneumoniae* (19.0%). The current study is novel in reporting a predominance of gram-negative bacteria in the HD population. In other studies, S. aureus was more common, and gram-positive bacteria were predominant [3,7,9]. Only 35% of gram-negative bacteria are part of the respiratory tract and skin's normal flora, and infections by these organisms are generally more associated with hospital settings. Furthermore, patients receiving HD are expected to be infected by these bacteria more often due to frequent antibiotic use, clustering in HD units, and the presence of indwelling medical devices [7]. *S. aureus* was the second most common bacterium, with a prevalence of 14.5%. This study also documented a large number of MDR bacteria, reaching 31.0% of the total isolates. This finding is comparable to that reported in a study by Rteil et al. (2020) [9], who found 31.4% MDR pathogens among all infection episodes. Patients who receive chronic HD are frequently hospitalized; this contributes to their acquisition of infection, and in particular infection by resistant pathogens [11]. Unlike in the other studies [6,7], MDR gram-negative bacteria were noticeably more common in the current study (85.7% of total MDR bacteria), with MDR K. pneumoniae and MDR A. baumannii being the most common. Different geographical regions will have different patterns of resistance. For example, a study in Denmark reported 0% of MRSA among *S. aureus* isolates causing BSIs. However, an Algerian single-center study showed 100% [3,12]. The worrying aspect of MDR organisms is their association with increased morbidity and mortality [9].

In conclusion, infections were found to be common in these hospitalized patients requiring haemodialysis, with respiratory tract infections being the most prevalent. Gram-negative bacteria, predominantly *Klebsiella pneumoniae*, were found to be the major causative organisms. This study observed an alarming number of multidrug-resistant organisms, accounting for 31.0% of the total isolated bacteria. Judicious use of antibiotics is critical to reduce the emergence of an alarming number of multidrug-resistant organisms in the future.

Declarations

Funding: This study was a thesis project of an MSc student (Najwa Al Himali, first author) and did not receive any specific grant from any agencies in the public, commercial, or not-for-profit sectors.

Ethical approval: Ethical approval for this study was obtained from the Medical Research Ethics Committee (MREC), College of Medicine and Health Sciences, Sultan Qaboos University, Muscat, Oman (MREC # 2070; dated February 13, 2020). The study was also performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Since personal identification information was marked prior to the analysis, informed consent was not sought in this retrospective study.

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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