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Original Article

Prevalence of Urinary Tract Infection and Diagnostic Accuracy of Pyuria as Screening Tool among Hemodialysis Patients in Mosul City

Raeed Mohammed ALsabawy [a,*], Siham Shakour Al-Salhi [b], Asal Aziz Tawfeeq [c],

[a] College of Health and Medical Techniques, Northern Technical University, 36001 Kirkuk, Iraq.
[b] Medical Laboratory Techniques Department, College of Health and Medical Techniques, Northern Technical University, 36001 Kirkuk, Iraq.
[c] Therapeutic Nutrition Techniques Department, College of Health and Medical Technology, Northern Technical University, 36001 Kirkuk, Iraq.

*Corresponding: Raeed Mohammed ALsabawy, Email: raeed.mohammed05@ntu.edu.iq

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Abstract

Background: Urinary tract infections (UTIs) are common among hemodialysis (HD) patients and are associated with an increased risk of complications; however, their diagnosis is often challenging due to frequent subclinical or atypical presentations. This study aimed to investigate the prevalence of UTIs in HD patients with renal failure and to evaluate the diagnostic accuracy of pyuria as a screening tool. Patients and Methods: A total of 200 hemodialysis patients were enrolled in the study, comprising 100 males and 100 females. Midstream, clean-catch urine samples were collected and subjected to standard urinalysis and culture. Significant bacteriuria was defined as $\geq 10^4$ CFU/mL in males and $\geq 10^5$ CFU/mL in females. Pyuria was defined as ≥ 10 neutrophils per high-power field. Results: Bacterial growth was detected in 75 urine samples (37.5%), while 125 samples (62.5%) showed no significant growth. Escherichia coli was the most frequently isolated organism (40%, n=30), followed by Klebsiella pneumoniae (n=10). Pyuria was present in (85/200) patients (42.5%), of whom 55 (64.7%) had culture-confirmed UTIs. Pyuria demonstrated a sensitivity of 73.3%, specificity of 76%, a positive predictive value of 65%, and a negative predictive value of 83%. Conclusions: The study demonstrated that UTIs among HD patients are more prevalent in females and the elderly, with E. coli as the predominant multidrug-resistant pathogen, while pyuria proved to be a useful supportive indicator for diagnosis, it should be interpreted in conjunction with urine culture to avoid both overdiagnosis and missed infections in hemodialysis patients.

Keywords: Hemodialysis, Urinary tract infection, Pyuria, Bacteriuria

Introduction

Dialysis is a medical procedure designed to remove excess fluids and solutes from the body. Currently, two main modalities are widely used in clinical practice: HD and peritoneal dialysis. In HD, blood is drawn from the patient through a specialized vascular access and directed into a dialysis machine, where it passes through a dialyzer that filters out waste products and excess fluids before the purified blood is returned to the circulation (1). In the international renal replacement therapy scenario, HD has been identified as the most commonly used modality (2). There are three main modalities used to restore or support renal function in patients with ESRD: hemodialysis, peritoneal dialysis, and kidney transplantation. None of these treatments is able to mimic the complexity of native kidney physiology, but dialysis is essential, as it is the only treatment that can sustain metabolic homeostasis by removing metabolic waste products and excess fluid (3). Patients undergoing HD are at increased risk of infections. This is mainly due to the invasive procedures involved in dialysis and the weakened immune system caused by chronic inflammation and uremia. In addition, the use of bio-incompatible dialysis materials can trigger strong inflammatory responses, leading to further immune system dysfunction (4).

UTIs are common in dialysis patients and are associated with an increased rate of complications. Diagnosing UTIs can be difficult due to their often-subclinical presentation. Additionally, pyuria is widespread in dialysis patients and may be related to the underlying cause of renal disease rather than an actual infection, limiting its diagnostic value in urinalysis(5). UTIs can cause major complications for HD patients. The initial diagnosis is complicated by difficulties in collecting urine samples from patients who are anuric (not producing urine) or oliguric (producing very little urine)(6). UTI is considered to be uncomplicated when it occurs in patients with urinary tracts that are normal from both a structural and functional perspective. Chronic Kidney Disease (CKD) is a common problem among males compared to females due to stress, alcoholism, hypertension and diabetes mellitus. Due to urinary stagnation, alkalization of urine and absence of flushing action, the presence of UTI in CKD of males is higher compared to normal males(7).

Several factors, such as age, gender, urological instruments, weakened immune systems, indwelling urinary catheters, poor kidney function that fails to filter bacteria and urinary stasis from incomplete bladder emptying, all contributing to increased infection risk(8). UTIs are primarily caused by Gram-negative bacilli from the Enterobacteriaceae family, *Uropathogenic E.coli* is indeed responsible for nearly 80–90% of UTIs worldwide. These strains differ from commensal *E.coli* by possessing acquired virulence and resistance factors that enable successful colonization and infection of the urinary tract. UPEC carries various virulence determinants, including adhesion mechanisms (regulated by genes such as fimH, sfa, and pap), toxin production (e.g., hemolysin encoded by hlyA), capsule formation (encoded by kpsMII), invasins (encoded by ompT), and iron acquisition systems. These factors are encoded on PAIs located on chromosomes or plasmids(9). The treatment of UTIs in patients on HD has become increasingly challenging due to the emergence of multidrug-resistant (MDR) bacteria. In particular, MDR strains of *E. coli* exhibit resistance to many commonly used antibiotics, complicating the management of these infections and often requiring alternative antibiotics that may have more severe side effects(11). Beta-lactam antibiotics, which are typically prescribed for UTIs, contain a β-lactam ring and function by inhibiting bacterial cell wall synthesis. However, their effectiveness is diminished against MDR strains due to the bacteria's production of β-lactamases and other resistance mechanisms. The rising problem of antibiotic resistance among pathogens responsible for UTIs presents significant difficulties in treating these infections, particularly in vulnerable populations such as hemodialysis patients with compromised immune systems (12).

Methodology

Study design and period

This cross-sectional study was conducted between September 2024 and April 2025 at the hemodialysis unit in Mosul, Iraq. A total of 200 hemodialysis patients were included.

Sampling techniques and procedure

Patients were chosen if they had been receiving hemodialysis for more than a month and had produced more than 30 milliliters of urine in between dialysis sessions.

Exclusion criteria

Patients who were receiving medications that could cause pyuria, or those with HIV, cancer, or other infectious conditions, were excluded from the study.

Sample collection and analysis

Urine samples were collected from HD patients in sterile containers and promptly transported to the laboratory. Standard diagnostic procedures were performed, including bacteriological culture and urine microscopy for pyuria. All laboratory analyses were conducted at the Microbiology Laboratory, Al-Salam Teaching Hospital, Nineveh Health Directorate.

Case definition

Bacteriuria was defined as $\geq 10^4$ CFU/mL in males and $\geq 10^5$ CFU/mL in females.

Pyuria was defined as ≥10 neutrophils per high-power field.

The growth of bacterial cultures was measured by counting the number of colonies per plate: less than 10 colonies per plate indicated less than 10^3 CFU/ml, 10 to 100 colonies per plate indicated 10^3 to 10^4 cfu/ml, 100 to 1000 colonies per plate indicated 10^4 to 10^5 CFU/ml, and more than 1000 colonies per plate indicated more than 10^5 cfu/ml.

Microorganisms isolated from all specimens were identified at species level according to standard microbiology methods, that's including: direct microscopic examination of gram stained preparations, biochemical profiling test, and then confirm by using vitek2 compact system.

Data analysis:

Data analysis was performed using SPSS version 16 and Microsoft Excel. Descriptive statistics were calculated for all variables. The accuracy of pyuria was assessed using sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Comparisons between categorical variables (e.g., gender, age groups, dialysis sessions) and the presence of urinary tract infection were conducted using the Chi-square test, while continuous variables were analyzed using the Independent t-test or Mann-Whitney U test, as appropriate. A P-value < 0.05 was considered statistically significant.

Ethical approval:

This cross-sectional study was conducted in hemodialysis centers in Mosul, Iraq, between September 2024 and April 2025. Urine samples were collected from hemodialysis patients after obtaining official approval from the Ministry of Health, Nineveh Health Directorate, and the Human Training and Development Center (Approval No. 35512, dated 10 September 2024).

Results and Discussion

Table 1 demonstrates the clinical presentation and demographic characteristics of the study participants. Among the 200 hemodialysis patients included, females had a higher prevalence of UTIs than males, with 42 (42%) versus 33 (33%), respectively. The incidence of UTIs increased with age, peaking among patients over 65 years. The study found that chronic illnesses were the primary causes of kidney failure, with hypertension being the most common (96 patients, 48%), followed by diabetes mellitus (80 patients, 40%) and other chronic disorders (24 patients, 12%).

Table 1. Clinical characteristics and demographic features of HD patients.

Characteristics		*Positive culture NO(%)*	*Negative culture NO(%)*	*Total NO. (%)*	*P. value*
Sex	**Male**	33(33%)	67(67%)	100(100%)	P= 0.188
	Female	42(42%)	58(58%)	100(100%)	
Age	**15–25**	6 (8%)	14 (11.2%)	20 (10%)	P = 0.66
	26–35	8 (10.7%)	17 (13.6%)	25 (12.5%)	

	36–45	10(13.3%)	20 (16%)	30 (15%)	
	46–55	12 (16%)	25 (20%)	37 (18.5%)	
	56–65	18 (24%)	24 (19.2%)	42 (21%)	
	>65	21 (28)%	25 (20%)	46 (23%)	
Frequency of dialysis	**Dialysis twice**	5 (6.7%)	45(36%)	50(25%)	P= 0.001
	Dialysis three times	70 (93.3%)	80(64%)	150(75%)	
Chronic disease	**Diabetes Mellitus**	40(53.3%)	40(32%)	80(40%)	P= 0.005
	Hypertension	30(40%)	66(52.2%)	96(48%)	P= 0.108
	Others	5(6.7%)	19(15.2%)	24(12%)	P= 0.116

According to the bacteriological analysis, 75 patients (37.5%) had significant bacteriuria ($\geq 10^5$ CFU/mL), while 125 patients (62.5%) showed no significant bacterial growth. Among the positive cultures, 55 isolates (27.5% of total samples; 73.3% of positive cultures) were Gram-negative bacteria, whereas 20 isolates (10% of total samples; 26.7% of positive cultures) were Gram-positive.

Regarding the diagnostic accuracy of pyuria as a screening tool for UTIs, the analysis revealed that 95 patients (40 women and 55 men) had normal urine, defined as the absence of both bacteriuria and pyuria. Pyuria alone was observed in 30 patients (20 men and 10 women), while bacteriuria alone was detected in 20 cases (12 men and 8 women). Both bacteriuria and pyuria were present in 55 patients (21 men and 34 women), as illustrated in figure 1

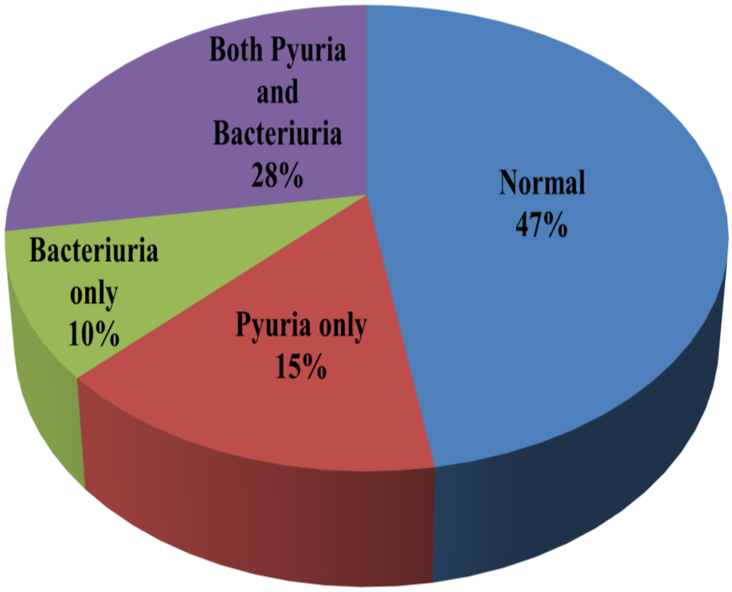

Figure 1. Distribution of Hemodialysis Patients According to Pyuria and Bacteriuria Status (n = 200).

Table 2 showed that pathogenic bacteria were isolated in 75 cases (37.5%). *Escherichia coli* was the most frequently isolated uropathogen, identified in 30 cases (40%) of positive cultures, whereas several other species, including *Enterobacter cloacae, Pseudomonas oleovorans, Providencia stuartii, and Klebsiella oxytoca,* were each detected in only one case (1.3%).

Table 2. Frequency of microorganisms identified from study participants' urine samples

Type of Bacteria	***No. &Percentage Bacteria***
Gram Negative Bacteria	
Escherichia coli.	30 (40%)
Klebsiella. pneumoniae.	10(13.3%)
Proteus spp.5 (6.6%)	5 (6.6%)
Burkholderia cepacia.	2(2.6%)
Pseudomonas aeruginosa	2 (2.6%)

Citrobacter spp.	2 (2.6%)
Enterobacter cloacae	1 (1.3%)
Pseudomonas oleovorans.	1 (1.3%)
Providencia stuartii .	1 (1.3%)
Klebsiella oxytoca.	1 (1.3%)
Gram Positive Bacteria	
Coagulase-negative Staphylococcu	8(10.6%)
Staphylococcu aureus	5 (6.6%)
Enterococcus spp	4(5.3%),
Streptococcus spp	3 (4%),
Total	75 (100%)

The diagnostic accuracy of pyuria in detecting a positive urine culture is presented in Table 3. The sensitivity and specificity of pyuria as a screening test for UTI were 73.3% and 77.8%, respectively. The positive predictive value (PPV) was 67%, and the negative predictive value (NPV) 83%. The diagnostic accuracy of pyuria as a screening test for UTI.

Table 3. The diagnostic accuracy of pyuria as a screening test for UTI.

Screening test	*Sensitivity*	*Specificity*	*Positive Predictive value*	*Negative Predictive value*
Pyuria	73.33%	76%	65%	83%

Discussion

The current study demonstrated the prevalence of urinary tract infections (UTIs) among hemodialysis (HD) patients and examined their association with selected clinical and demographic factors (Table 1). Among the 200 HD patients included, females showed a higher incidence of UTIs than males, with 42 (42%) versus 33 (33%), respectively. This finding is in agreement with previous reports (10), whereas other studies have reported a higher prevalence among males (11). The generally higher susceptibility of females to UTIs may be explained by anatomical and physiological factors, including a shorter urethra and hormonal influences. However, the difference between genders in the present study was not statistically significant (P = 0.188), suggesting that gender alone may not be a crucial factor in UTI development among HD patients. Other variables, such as comorbidities or catheter use, may have a greater impact on infection risk.

An age-related increase in UTI prevalence was observed, with the highest proportion among patients aged >65 years (28%) compared to 8% in the 15–25 years age group. This finding is in agreement with previous studies highlighting the increased vulnerability of elderly HD patients to infections (12). Factors contributing to this susceptibility include immunocompromised status, a higher prevalence of comorbidities such as diabetes and hypertension, overall frailty, reduced fluid intake, and urinary retention (13). Despite this gradual increase, the differences in UTI prevalence among age groups were not statistically significant (P = 0.66), indicating that age alone may not represent an independent risk factor; rather, the combination of comorbidities, dialysis duration, and catheter use likely plays a more prominent role.

The present study also identified dialysis frequency and diabetes mellitus as significant determinants of UTI risk. Patients undergoing dialysis three times per week had a markedly higher incidence of UTIs (70 cases, 93.3%) compared to those receiving dialysis twice weekly (5 cases, 6.7%), with a statistically significant association (P < 0.001). This finding is consistent with previous research (14), which suggests that more frequent dialysis sessions increase exposure to invasive procedures, such as vascular access manipulations and catheterization, thereby predisposing patients to infection. Additionally, the majority of patients (75%) received dialysis three times per week, reflecting the clinical reality of prolonged HD, which may impair immune function and heighten susceptibility to infections.

Diabetes mellitus was also significantly associated with UTIs in this cohort. Among diabetic patients, 53.3% experienced UTIs (P = 0.005). The elevated risk in diabetic patients may be attributed to chronic hyperglycemia, poor glycemic control, diabetes-related complications (e.g., nephropathy and cystopathy), advanced age, and immunocompromised status induced by renal impairment and prolonged HD (15).

In contrast, hypertension and other chronic diseases did not show statistically significant associations with UTI occurrence (P = 0.108 and P = 0.116, respectively). While these conditions contribute to overall morbidity among HD patients, their direct impact on UTI risk appears limited in this study population.

Regarding bacterial isolates (Table 2), *E. coli* was the most frequently isolated uropathogen among HD patients. This finding is in agreement with previous studies (16–19) and highlights the predominance of *E. coli* in UTIs among HD patients. Its high prevalence can be attributed to multiple virulence factors that facilitate colonization and infection, such as adhesion mechanisms, toxin production, capsule formation, invasion capabilities, and iron acquisition systems. These factors are often encoded within pathogenicity islands (PAIs) located on chromosomes or plasmids. In addition, host-related risk factors, including immunosuppression and frequent catheter use, further increase the susceptibility to infection (9).

The diagnostic accuracy of pyuria as a screening test for UTIs is shown in Table 3. Pyuria demonstrated a sensitivity of 73.33%, indicating its ability to detect a substantial proportion of true UTI cases. However, it failed to identify approximately 26.67% of infections. This result is consistent with the findings of (20), which reported that pyuria was absent in about 20% of asymptomatic HD patients with confirmed UTIs. Conversely, The present study's findings differ from those of (10), who reported a sensitivity of 100% for pyuria in similar cases.

The specificity of 76% indicates that pyuria was able to accurately distinguish 76% of non-UTI cases. This result aligned with the findings of (21), which reported a specificity of 80%, thereby reinforcing the role of pyuria as a reliable negative indicator for UTIs. In contrast, (10)reported a lower specificity of around 59%, which suggested that pyuria might have resulted from non-infectious conditions, leading to potential false positives.

The positive predictive value (PPV) of 65% indicated that when pyuria was present, there was a 65% probability that the patient had a true UTI. This finding was consistent with that of (21), which reported a PPV of 64%. However, it disagreed with the results of (10), which found a lower PPV of 46%.

The negative predictive value (NPV) of 83% observed in the present study indicates that most patients without pyuria were unlikely to have UTIs. However, this value is lower than that reported by study (10), which documented an NPV of nearly 100%. In contrast, study (21) reported a lower NPV of approximately 77%, suggesting that although pyuria effectively excluded many infections, some cases still occurred despite negative results. Variations in research findings may be attributed to differences in the definition of pyuria, patient populations, and methodological approaches across studies.

Conclusion

The study highlights that dialysis frequency and diabetes mellitus are key determinants of UTI risk among HD patients, while gender, age, hypertension, and other chronic diseases have a less direct effect. *E. coli* remains the predominant pathogen, and Pyuria was found to be a good supportive indicator for diagnosing.

Competing Interests

The authors should declare that there are no competing interests.

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