MICROSCOPIC FINDINGS IN URINARY TRACT INFECTIONS (PUS CELLS, RBCS, CRYSTALS)

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Abstract

Background: *Urinary tract infections (UTIs) affect approximately 150 million people annually and are among the most prevalent infectious diseases globally. Despite the availability of urine culture as the diagnostic gold standard, its 24–48 hour turnaround limits timely clinical decision-making. Urine microscopy offers a rapid, cost-effective alternative, yet its full diagnostic potential remains underutilised particularly in resource-limited settings.*

Methods: *This cross-sectional study enrolled 65 female patients with suspected or confirmed UTIs from the Department of Pathology, Mayo Hospital Lahore, over three months. Midstream urine samples were processed and microscopically examined for pus cells (WBC/HPF), red blood cells (RBC/HPF), bacteriuria morphology, crystal types, and cast formation. Data were analysed using SPSS v25 with Mann-Whitney U, Kruskal-Wallis H, Chi-square, and Spearman correlation tests.*

Results: *Acute uncomplicated cystitis was the predominant diagnosis (53.8%). Mean pus cell count was 34.77 WBC/HPF (SD = 26.84), with a significant linear correlation between pyuria severity and bacteriuria burden ($p = .036$). Microscopic isomorphic haematuria was identified in 64.6% of patients, and RBC counts varied significantly across haematuria types ($H = 45.139$; $p < .001$). Urine pH strongly predicted crystal type ($H = 40.105$; $p < .001$): triple phosphate crystals predominated in alkaline urine and uric acid crystals in acidic urine. Pyuria and haematuria showed a significant positive correlation (rho = .562; $p < .001$).*

Conclusion: *Routine urine microscopy is a diagnostically powerful tool capable of characterising UTI severity, predicting bacteriuria burden, and identifying crystal-forming conditions. Its wider adoption in resource-constrained environments is strongly justified.*

INTRODUCTION

Urinary tract infections are responsible for an estimated 150 million cases annually worldwide, carrying a baseline mortality of 2.3% that escalates to 26% when complicated by bacteraemia or septic shock. Women are disproportionately affected owing to anatomical and hormonal factors, though infections occur across all age groups.

Urine culture remains the diagnostic gold standard, but its 24–48 hour turnaround time compels clinicians to initiate empirical antibiotic therapy a practice that contributes to antimicrobial resistance. Dipstick testing, though rapid, is limited by high false-positive rates. Against this backdrop, microscopic urinalysis offers an underutilised intermediate: it is immediate, affordable, and capable of providing rich clinical information through quantification of pus cells, red blood cells, crystal morphology, and bacterial load.

This study evaluated the diagnostic utility of structured urine microscopy in a cohort of UTI patients at a tertiary care centre in Lahore, Pakistan, aiming to characterise the spectrum of microscopic findings and their clinical correlations.

Objectives

- To determine the frequency of microscopic findings (crystals,red blood cell and pus cells) in urine samples from people with suspected UTIs
- To evaluate the relationship between microscopic haematuria (RBCs) and the type or severity of UTIs
- To determine the kinds and frequency of urine crystals in UTI patients.
- To examine the connection between urine culture results and microscopic observations (pus cells, RBCs, crystals).

Females get higher UTIs in the years after their first year of life due to structural abnormalities and a shorter urethra. Recurrent UTIs are important from a clinical standpoint. Two weeks are needed after a first UTI to ascertain if the illness is recurring due to a reinfection or a relapse. Reinfection indicates that the aetiology was distinct from the first infection, whereas relapse indicates that the same causative agent was the issue. Numerous epidemiological surveys on children in Spain have shown that E. coli is the primary cause, accounting for 60% to 80% of cases. The risk of infection with other bacterial species, including K. pneumoniae (3%–5%) and P. mirabilis (6%–10%), is increased by a history of antibiotic therapy and prior urinary tract abnormalities (Pérez, Ortega et al. 2019). Establishing prospective patient cohorts and promoting collaborative data analysis across institutions will be critical steps in addressing existing knowledge gaps. These initiatives will promote the ongoing enhancement of patient care in specialised UTI clinics in addition to deepening our understanding of the best UTI therapy techniques.(Lambregts, Lidén et al. 2024)

2. MATERIALS AND METHODS

Study design and setting. A cross-sectional study was conducted at the Department of Pathology, Mayo Hospital Lahore over a three-month period. Sixty-five female patients with suspected or confirmed UTIs (by positive urine culture or dipstick) were recruited via random sampling. Patients with mixed bacterial growth, asymptomatic status, or samples of insufficient volume were excluded.

SAMPLE SIZE

Sample size was calculated using the expected prevalence of microscopic abnormalities (pus cells, RBCs, crystals) in UTI-suspected urine samples.

SAMPLING TECHNIQUE

A random sampling technique was used to select urine samples fulfilling inclusion criteria.

Microscopic analysis. Midstream clean-catch urine samples were centrifuged and the sediment examined under light microscopy. Variables recorded included pus cell count (WBC/HPF), RBC count (RBC/HPF), haematuria type (absent, microscopic isomorphic, macroscopic), bacteriuria morphology, crystal type, WBC casts, and RBC casts.

Statistical analysis. IBM SPSS v25 was used. Continuous variables were assessed for normality via Kolmogorov-Smirnov and Shapiro-Wilk tests. Non-parametric tests applied included Mann-Whitney U (pus cells by gender), Kruskal-Wallis H (RBC counts by haematuria type; urine pH by crystal type), Chi-square with linear-by-linear association (pus cells vs. bacteriuria), and Spearman rank-order correlation (pus cells, RBCs, and urine pH). Significance was set at $p < .05$.

3. RESULTS

3.1 Patient Demographics and Clinical Diagnoses

Table 3.1

Demographic and Clinical Characteristics of Patients (N = 65)

Variable	n (%) / Mean ± SD
Age (years)	42.15 ± 21.57
Female	51 (78.5)
Male	14 (21.5)
Acute uncomplicated cystitis	35 (53.8)
Acute pyelonephritis	11 (16.9)
Asymptomatic bacteriuria	9 (13.8)
Recurrent UTI	6 (9.2)
Complicated UTI	4 (6.2)

Note. *Values are presented as mean ± SD or frequency (%).*

The cohort comprised 65 patients (78.5% female; 21.5% male), aged 8–85 years (mean 42.15 ± 21.57). Acute uncomplicated cystitis was the most common diagnosis (53.8%), followed by acute pyelonephritis (16.9%), asymptomatic bacteriuria (13.8%), recurrent UTI (9.2%), and complicated UTI (6.2%). The symptom cluster of dysuria, fever, and urgency was most prevalent (52.3%). Turbid or cloudy urine was the most frequent macroscopic finding (40.0%).

Microscopic Findings

Table 3.2

Microscopic Urinary Findings Among Patients With UTI (N = 65)

Variable	Result
Pus cells (WBC/HPF), Mean ± SD	34.77 ± 26.84
RBCs (/HPF), Mean ± SD	13.07 ± 15.29
Urine pH	6.15 ± 1.14
Microscopic hematuria	42 (64.6%)
Macroscopic hematuria	4 (6.2%)
No hematuria	19 (29.2%)
WBC casts present	6 (9.2%)
RBC casts present	3 (4.6%)
Crystalluria present	43 (66.2%)
Triple phosphate crystals	16 (24.6%)
Calcium oxalate (Envelope)	7 (10.8%)
Calcium phosphate	6 (9.2%)
Calcium oxalate (Dumbbell)	5 (7.7%)
Uric acid	5 (7.7%)

Variable	Result
Cystine	4 (6.2%)

Note. *HPF = High-power field.*

Tests of Normality

Table 3.4

Tests of Normality for Continuous Variables

Variable	Shapiro–Wilk W	p	Distribution
Age	0.963	.049	Non-normal
Urine pH	0.914	< .001	Non-normal
Pus cells	0.879	< .001	Non-normal
RBCs	0.768	< .001	Non-normal

Note. *Variables with* p < *.05 were considered non-normally distributed.*

All continuous variables deviated significantly from normality. Therefore, non-parametric statistical tests were used for inferential analyses.

Association between Pyuria and Gender

Table 3.5

Mann–Whitney U Test Comparing Pus Cell Counts Between Male and Female Patients

Statistic	Value
Mann–Whitney U	283.50
Z	–1.17
P	.241

Female patients had higher mean ranks for pus cell counts than males; however, the difference was not statistically significant (*p* = .241), indicating comparable pyuria severity between genders.

Association between Pyuria and Bacteriuria

Table 3.6

Test	χ^2	df	P
Linear-by-linear Association	4.389	1	.036

Association between Urine pH and Crystal Type

Table 3.7

Kruskal–Wallis Test Comparing Urine pH Across Crystal Types

Statistic	Value
H	40.105
Df	6
P	< .001

Urine pH differed significantly among crystal types (H = 40.105, p < .001). Triple phosphate crystals were predominantly associated with alkaline urine, whereas uric acid crystals occurred mainly in acidic urine.

Association Between RBC Count and Hematuria Type

Table 3.8

Kruskal–Wallis Test Comparing RBC Counts Among Hematuria Categories

Statistic	Value
H	45.139
Df	2
P	< .001

RBC counts differed significantly among hematuria categories (H = 45.139, p < .001), with the highest counts observed in patients with macroscopic hematuria, followed by microscopic hematuria.

Correlation Among Microscopic Findings

Table 8

Spearman Correlation Matrix of Microscopic Parameters

Variable	Pus Cells	RBCs	Urine pH
Pus cells	1	.562**	.044
RBCs	.562**	1	–.052
Urine pH	.044	–.052	1

Note. p *< .01.*

A significant positive correlation was observed between pus cell and RBC counts (ρ = .562, p < .001), indicating that patients with greater pyuria also tended to exhibit more severe hematuria. Urine pH was not significantly correlated with either pus cell or RBC counts.

Discussion

This study confirms that microscopic urinalysis provides a clinically rich and actionable profile of urinary tract infection (UTI) pathology. The wide range of pyuria (4.2–115.8 WBC/HPF) reflects the broad clinical spectrum of UTIs, ranging from uncomplicated cystitis to ascending pyelonephritis. Furthermore, the significant linear association between pus cell counts and bacteriuria density (p = .036) supports pyuria as a reliable surrogate marker of bacterial burden, consistent with previous studies demonstrating a positive correlation between leukocyturia and bacteriuria in symptomatic UTIs (Christy et al., 2022; Hamza et al., 2025; Neupane et al., 2022). The absence of a significant gender difference in pyuria suggests that the inflammatory response is primarily determined by infection severity rather than patient sex, a finding that agrees with previous reports (Christy et al., 2022; Mancuso et al., 2023). A significant association between urine pH and urinary crystal type (p < .001) highlights the influence of urinary chemistry on crystal formation. Triple phosphate (struvite) crystals predominated in alkaline urine, reflecting infection with urease-producing organisms such as *Proteus mirabilis* and *Klebsiella* species, whereas uric acid crystals were associated with acidic urine. These findings are consistent with established evidence regarding crystal formation in UTIs and reinforce the clinical utility of urinary crystal analysis during routine microscopy (Simhadri et al., 2024; Zagaglia et al., 2022). Additionally, the identification of cystine crystals in a small proportion of patients suggests the need for further metabolic evaluation to exclude hereditary cystinuria (Simhadri et al., 2024). The present findings are consistent with the growing body of literature supporting structured urine microscopy as an effective diagnostic tool for UTI management. Previous systematic reviews have demonstrated that point-of-care urine microscopy improves the early identification of infection and assists clinical decision-making, particularly in primary care and resource-limited settings where urine culture is not immediately available (Beyer et al., 2019; Lambregts et al., 2024). Likewise, our findings indicate that a single microscopic examination can simultaneously assess infection severity, estimate bacteriuria burden, identify haematuria, detect urinary casts, and characterize crystal morphology, thereby providing substantially greater diagnostic information than dipstick urinalysis alone (Christy et al., 2022; Mancuso et al., 2023).

Limitation

The study was limited by its single-centre design, relatively small sample size, predominance of female participants, and cross-sectional methodology. Additionally, the absence of concurrent urine culture and antimicrobial susceptibility testing limited confirmation of organism-specific microscopic findings.

Recommendations

Routine urine microscopy should be used as an early, cost-effective diagnostic tool for UTIs, particularly in resource-limited settings. Future multicentre prospective studies with larger sample sizes should combine urine microscopy with culture and antimicrobial susceptibility testing to improve diagnostic accuracy and evaluate the prognostic value of microscopic urinary findings.

5. CONCLUSION

Structured urine microscopy reliably characterises the pathological landscape of UTIs through the integrated assessment of pyuria, haematuria, bacteriuria morphology, and crystal formation. Pus cell counts correlate with infection severity; haematuria reflects mucosal inflammation; and urinary crystals respond to pH shifts driven by uropathogens. These findings collectively advocate for the systematic adoption of microscopic urinalysis as a rapid, affordable, first-line diagnostic tool particularly in settings where urine culture capacity is limited and timely clinical decisions are critical.

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