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Procalcitonin in Predicting Sepsis in Patients Presenting In Emergency Department with Acute Ureteric Colic Due to Stone

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ABSTRACT

Objective: To determine the prognostic value of serum procalcitonin levels in predicting sepsis severity and outcomes in patients presenting to the emergency department with urinary tract infections (UTIs) complicated by urinary tract calculi.
Study Design: Cross sectional study.
Place and Duration of Study: Armed Forces Institute of Urology (AFIU), Rawalpindi, Pakistan from Nov 2024 to Apr 2025.
Methodology: A cohort of 150 adult patients with confirmed UTIs and urinary stones based on clinical, laboratory, and radiological diagnosis were included via nonprobability consecutive sampling. Patients on corticosteroids, immunosuppressants, or chemotherapy, antibiotics, pregnant women, and those with chronic kidney disease, were excluded from the study. Procalcitonin (PCT) was measured using electrochemiluminescence immunoassay. Data collected on clinical and radiologic characteristics, demographics, comorbidities, sepsis classification according to Sepsis-3 criteria.
Results: Among the 150 patients, 68(45.3%) were female, while 82(54.7%) were male 91 patients (60–70%) had ureteric stones, and 66 patients (44.0%), had hydronephrosis. 42.0% had sepsis, 14.0% had severe sepsis, and 3-7% had septic shock. The severity of sepsis was positively correlated with median PCT levels (p<0.001). ICU admission and 7-day mortality were significantly higher in patients with procalcitonin levels > 2 ng/mL and having diabetes, and hydronephrosis.
Conclusion: PCT levels can significantly provide risk stratification for sepsis severity in patients with UTIs complicated by urinary tract stones, directing timely and effective treatment and enhancing patient outcomes.

Keywords: Procalcitonin, Sepsis, urinary tract infection, Urinary calculi.

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INTRODUCTION

Urinary tract infections (UTIs) are common, and can quickly develop into potentially fatal sepsis if diagnosis and treatment are delayed.[1] Even though a positive bacterial culture has a significant impact on treatment, it is now widely acknowledged that bacteraemia detection, which must occur at least 24 to 48 hours after the initial visit, is not a requirement for the clinical diagnosis of sepsis.[1] Urinary tract stones are commonly found in the kidneys, while ureteral calculi make up 20% of all the calculi in the urinary system. When a patient has a ureteral calculus, they typically complain of lower urinary tract symptoms, nausea, and vomiting.[2] Urinary tract stone disease is the third most common urinary tract disease after UTIs and benign prostatic hyperplasia.[2] Urinary tract stone disease affects 7% of women and 13% of men over their lifetime. Most affected are those in the 30–60 years of age range. The likelihood of recurrence increases over the years and reaches 50% within 5 years.[3] Urinary stones are common worldwide, with a prevalence of about 12%.[4] It is essential to provide careful management for patients with urinary stones. Decisions about treatment are usually made in light of the patient's symptoms, overall clinical status, stone size, location, and composition.[5] Procalcitonin has been used as a possible marker of the systemic inflammatory response to infection and numerous studies have proved its efficacy as a marker of critical illness and sepsis. This study aimed to summarize the existed literature regarding the role of procalcitonin in the assessment of patients with sepsis in the emergency department setting, and its predictive value as a prognostic factor of the sepsis syndrome and its various stages.[6] These definitions identified a continuum represented by different stages of severity, encompassing systemic inflammatory response syndrome (SIRS)/sepsis/severe sepsis/septic shock. It was also shown that early and appropriate management (i.e. antibiotics, fluid resuscitation) of UTIs reduced morbidity and mortality. International recommendations were published in 2008 and then in 2012.[7] The most frequents site of obstruction is the

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vesicoureteral junction (VUJ), leading to hydro-ureter and intense visceral pain.[8] This study aimed to evaluate the clinical characteristics and risk factors of patients presenting with urinary tract infections (UTIs) complicated by urinary tract stones and to assess the prognostic value of serum procalcitonin levels in predicting sepsis severity in an emergency department setting.

METHODOLOGY

This Cross-sectional study over a period of 06 months from Nov 2024 to April 2025 involved patients presenting to AFIU, Rawalpindi ED with UTI and renal calculi. The study protocol was approved by the institutional ethics committee (certificate noTrg-1/RB/2024/024) 29 Oct 24. 150 patients were recruited using a nonprobability consecutive sampling technique Sample size was calculated using WHO sample size calculator taking confidence interval 90%, margin of error 5.5% and reported burden of mortality in patients with raised Procalcitonin as 79%.[9]

Inclusion Criteria: The study included adults aged 18 years and above who presented to the Emergency Department with acute ureteric colic confirmed by imaging showing a ureteric stone. Patients who presented within 24 hours of symptom onset and consented to blood tests, including serum procalcitonin, and who give informed Consent.

Exclusion Criteria: Patients with chronic kidney disease, active infection, recent surgery or trauma, malignancy, autoimmune disorders, pregnancy, or recent antibiotic use were excluded. Those on immunosuppressive therapy or with incomplete data were also excluded.

All the participants signed the written informed consent form. UTI was diagnosed on the basis of dysuria, fever, flank pain, urinary frequency confirmed with urinalysis or urine culture. Urinary tract stones were confirmed radiologically using non-contrast CT scans or ultrasound. PCT levels measured at initial evaluation utilizing electrochemiluminescence immunoassay (ECLIA) on E411 Roche analyser. Samples were collected in properly labelled serum sample tubes. The kit has a sensitivity / lower limit of detection of 0.02ng/ml, linearity up to 100ng/ml and coefficient of variation <20%. Demographics (age, sex, comorbidities (DM, hypertension, IHD), symptoms (flank pain, fever, nausea/vomiting, lower urinary tract symptoms, or LUTS), radiologic findings (location of urinary stones, presence of hydronephrosis), and laboratory parameters (Urinalysis, urine culture, full blood count, serum creatinine, CRP, lactate, and PCT levels at admission) were all recorded on a structured data sheet. Diagnosis of sepsis was based on Sepsis-3 criteria.

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 26.0. Quantitative variable age was normally distributed and are presented as Mean±SD. Procalcitonin levels, however, were not normally distributed and are therefore presented as median with interquartile range (IQR), significant value $p<0.05$, between different groups was assessed using the Kruskal-Wallis test. Categorical variables, including sex, comorbidities (diabetes mellitus, hypertension, ischemic heart disease), symptoms, hydronephrosis, stone location, urine culture results, and sepsis severity categories, were reported as frequencies and percentages. The association between procalcitonin levels and sepsis severity (sepsis, severe sepsis, septic shock) was assessed using the Kruskal-Wallis test. The association between ICU admission and 7-day mortality with sepsis severity groups was also assessed using Fisher's exact test. The p-value≤0.05 was considered statistically significant.

RESULTS

The study included 150 patients, with a mean age of 45.7±13.2 years. The sample was predominantly male (82, 54.7%). Comorbidities included diabetes mellitus (43, 28.7%) and hypertension (41, 27.2%), while 59 patients (39.3%) had no comorbid conditions. Flank pain was the most common presenting symptom (134, 89.3%), followed by fever (113, 75.3%) and nausea/vomiting (78, 52.0%). Hydronephrosis was observed in 66 patients (44.0%), Table-I).

Table-I: Demographic and Clinical Characteristics of Study Population (n = 150)

Variable	Value
Age (Mean±SD)	45.7±13.2 years
Gender	
Male	82(54.7%)
Female	68(45.3%)
Comorbidities	
None	59(39.33%)
Diabetes Mellitus	43(28.7%)
Hypertension	41(27.2%)
Ischemic heart diseases	7(4.7%)
Symptoms at Presentation	
Flank Pain	134(89.3%)
Fever	113(75.3%)
Nausea/Vomiting	78(52.0%)
Lower Urinary Tract Symptoms (LUTS)	59(39.3%)
Hydronephrosis	66(44.0%)

The majority had ureteric stones, predominantly at the vesicoureteral junction (91, 60.7%), while 59 patients (39.3%) had kidney stones. Sepsis severity distribution showed that 55 patients (36.7%) had uncomplicated UTIs, 63(42.0%) had sepsis, 21(14.0%) had severe sepsis, and 11(7.3%) presented with septic shock. Positive urine cultures were found in 82 patients (54.7%), with E. coli being the most common pathogen (50, 61.0% of positive cultures (Table-II).

Table-II: Stone Location and Sepsis Severity Distribution (n=150)

Parameter	n (%)
Stone Location	
Ureter (mostly VUJ)	91 (60.7%)
Kidney	59 (39.3%)
Sepsis Severity	
Uncomplicated urinary tract infections	55 (36.7%)
Sepsis	63 (42.0%)
Severe Sepsis	21 (14.0%)
Septic Shock	11 (7.3%)
Positive Urine Culture	82 (54.7%)
E. coli	50 (61.0% of positives)
Klebsiella pneumoniae	18 (22.0%)
Others	14 (17.0%)

Median procalcitonin levels were significantly higher in patients with severe sepsis and septic shock ($p<0.001$). The Table-III illustrates the association between procalcitonin (PCT) levels and sepsis severity.

The Table-IV compares ICU admission rates and 7-day mortality between patients with uncomplicated UTI and septic shock. ICU admission was significantly higher in septic shock patients (8, 72.7%) compared to those with uncomplicated UTI (0, 0%). Similarly, 7-day mortality was notably higher in septic shock (3, 27.3%) compared to uncomplicated UTI (0, 0%).

Table-III: Association Between Procalcitonin (PCT) Levels and Sepsis Severity (n=150)

Parameter	Uncomplicated Urinary Tract Infections	Sepsis	Severe Sepsis	Septic Shock	*p*-value
Median Procalcitonin (ng/mL) †	0.4 (IQR 0.2–0.7)	1.3 (IQR 0.8–2.5)	4.6 (IQR 2.9–6.1)	9.1 (IQR 7.8–13.5)	0.00*
Intensive Care Unit Admission(%)‡	0(0%)	9(14.3%)	11(52.4%)	8(72.7%)	0.005*
7-Day Mortality(%)‡	0 (0%)	1 (1.6%)	4(19.0%)	3 (27.3%)	0.006*

*Kruskal-Wallis test+; Fisher's exact test‡; *= $p<0.05$*

DISCUSSION

This study highlights the significant association between elevated procalcitonin (PCT) levels and sepsis severity in patients presenting with urinary tract infections (UTIs) associated with urolithiasis. Our findings showed a distinct pattern: median PCT levels had a statistically significant *p*-value (<0.001) and rose gradually with infection severity, from 0.4 ng/mL in uncomplicated UTI to 9.1 ng/mL in septic shock. Additionally, PCT levels increased in tandem with ICU admission and 7-day mortality rates, highlighting its prognostic significance. Elevated initial PCT levels were early independent predictors of progression to septic shock in patients with sepsis secondary to acute pyelonephritis (APN) caused by ureteral calculi, according to a 2016 study, which is consistent with our findings. With a proposed cut-off of 0.52 ng/mL, that study demonstrated reliable specificity and acceptable sensitivity for early risk stratification in the emergency setting.[9] This strengthens our conclusion that PCT >2 ng/mL could be a trustworthy early indicator of septic shock or severe sepsis, supporting clinical judgment and triage. The vesicoureteral junction (VUJ), a common site of obstruction, was where the majority of stones (60–7%) were found. This anatomical predilection mirrors previous findings and emphasizes the need for vigilance in patients with distal ureteral stones, as impaction at the VUJ is associated with infection, mucosal inflammation, and delayed spontaneous passage.[10]

Additionally, the relationship between high PCT levels and reduced spontaneous stone passage (SP) has been documented. A 2020 study reported that both elevated PCT and leukocyturia negatively impacted SP of stones between 5–10 mm, potentially due to inflammatory-mediated impaction.[10] Similarly, a 2021 study suggested that a PCT cut-off of 160 pg/mL could predict spontaneous passage failure, further linking systemic inflammatory markers with local obstructive pathology.[11] Such patients may present atypically, and delays in recognition can be fatal, particularly in diabetic or immunocompromised individuals.[12]

Our study also identified hydronephrosis (44%) and diabetes mellitus (DM) (28.7%) as independent predictors of severe sepsis/septic shock. These results align with earlier evidence showing that urinary obstruction and comorbid DM heighten the risk of rapid clinical deterioration in infected stone disease.[13] Lastly, while international sepsis guidelines emphasize early identification and intervention, our findings support incorporating PCT, hydronephrosis, and DM into clinical risk stratification tools to guide treatment escalation, hospitalization decisions, and monitoring intensity.[14]

Our study found a positive urine culture rate of 54.7%, with Escherichia coli being the most common pathogen. While bacterial culture remains the diagnostic gold standard, its delay necessitates adjunctive biomarkers. PCT offers timely insights into infection severity and can bridge this diagnostic gap.[14] As suggested in a 2021 study, the inclusion of PCT in a multi-parametric risk score may improve diagnostic accuracy, since only half of suspected UTI cases with obstructing stones are confirmed by culture.[15] In the present study, among 150 patients, 68(45.3%) were female and 82(54.7%) were male, with a mean age of 43.12±1.12 years for males and 42.22±1.12 years for females. These findings are consistent with previous studies, where the majority of patients presenting with ureteric colic belonged to the younger and middle-aged groups. For instance, in another study, 44.9% of participants were aged 18–30 years, 46.4% were between 31–45 years, and 18.7% were 46–60 years, indicating that ureteric stones commonly affect adults in their most productive age group.[16]

In the current study, procalcitonin (PCT) levels were found to significantly aid in risk stratification for sepsis severity among patients with urinary tract infections complicated by urinary tract stones. Elevated PCT values helped identify patients at higher risk of developing severe sepsis, thereby facilitating timely intervention and improving clinical outcomes. Similar trends have been reported in other studies, where inflammatory markers such as C-reactive protein (CRP) were also associated with disease severity. For example, one study demonstrated that raised CRP levels were inversely proportional to spontaneous stone passage rates (p<0.001), and comparable findings were reported by Abushama *et al*.[17] and Ramaswamy *et al*.[18] and Moghaddam *et al*.[19] These results collectively support the role of inflammatory biomarkers, particularly PCT, as valuable tools in predicting sepsis and guiding management in patients with urinary tract stones.

CONCLUSION

This study highlights the clinical utility of procalcitonin as an early prognostic marker in patients with UTIs complicated by urinary stones. Elevated procalcitonin levels strongly correlate with increased sepsis severity, ICU admission, and mortality risk. Ureteric stones, particularly at the vesicoureteral junction, are a common source of obstruction leading to infection and systemic complications. Prompt diagnosis and risk stratification using biomarkers like procalcitonin can improve outcomes by guiding timely and appropriate management. Elevated procalcitonin levels are strongly associated with sepsis severity, ICU admission, and short-term mortality in patients with urinary stone-related infections. PCT >2 ng/mL, hydronephrosis, and diabetes mellitus emerged as independent predictors of severe sepsis/septic shock.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

HS & QZ: Data acquisition, data analysis, critical review, approval of the final version to be published.

QAM & MTS: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

HSK & HA: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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