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CT-Derived Perinephric Fat Stranding As A Predictor Of Infectious Complications In Patients With Obstructive Urolithiasis

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ABSTRACT

Background: Infectious complications in patients with obstructive urolithiasis can progress rapidly and require early risk stratification. Perinephric fat stranding (PFS) on non-contrast CT is a common secondary sign of ureteric obstruction, but its diagnostic value in predicting infection remains unclear.

Objective: To evaluate the diagnostic utility of CT-detected perinephric fat stranding for predicting infectious complications in patients with obstructive ureteric calculi.

Methods: A retrospective observational study was conducted on 35 adult patients with obstructive ureterolithiasis and hydronephrosis identified on non-contrast CT. Patients were stratified based on the presence of infectious complications, defined by clinical, laboratory, and microbiological criteria. Imaging parameters, including presence and pattern of PFS, were assessed. Multivariate logistic regression was used to identify independent predictors of infection, and diagnostic performance metrics were calculated.

Results: Infectious complications were present in 16 of 35 patients (45.7%). PFS was significantly more frequent in infected patients (87.5% vs. 47.4%, $p = 0.064$) and remained an independent predictor of infection in multivariate analysis (adjusted OR 10.52, 95% CI: 1.01–109.5; $p = 0.049$). Hydronephrosis grade was also independently associated with infection (OR 5.91, $p = 0.035$). The presence of PFS had a sensitivity of 89%, specificity of 44%, positive predictive value of 65%, negative predictive value of 78%, and an overall diagnostic accuracy of 69%. Diffuse or bilateral PFS was exclusively observed in infected patients.

Conclusion: Perinephric fat stranding on non-contrast CT is a sensitive imaging marker for early identification of infectious complications in obstructive urolithiasis. While not specific on its own, PFS may enhance clinical decision-making when combined with laboratory and clinical parameters. Future prospective studies are warranted to validate these findings in larger cohorts.

Keywords: Obstructive urolithiasis, perinephric fat stranding, computed tomography, urinary tract infection, diagnostic imaging.

INTRODUCTION

Obstructive urolithiasis is a frequent cause of acute flank pain and emergency department presentations, often complicated by varying degrees of urinary tract infection (UTI), pyelonephritis, or urosepsis. Rapid and accurate risk stratification is essential, as infection in the setting of urinary tract obstruction can escalate into life-threatening sepsis. Non-contrast computed tomography (NCCT) is the current gold standard for diagnosing ureteric calculi and assessing secondary signs of obstruction, including hydronephrosis, periureteric oedema, and perinephric fat stranding (PFS).

Perinephric fat stranding refers to the radiologic appearance of linear or reticular soft-tissue attenuation within the perirenal fat and is commonly observed in patients with acute ureteric obstruction. It is thought to result from lymphatic engorgement, venous congestion, or inflammatory extension from the renal parenchyma. Several studies have investigated its clinical relevance, with mixed results. A recent 2024 study by Van Horn et al. found that PFS was significantly associated with larger stone burden and older age, but not with baseline renal dysfunction, suggesting it may reflect the inflammatory rather than obstructive component of disease severity [1]. Conversely, Farrell et al. previously reported a positive correlation between PFS and elevated serum creatinine, potentially linking it to obstructive uropathy severity [2].

Beyond renal function, PFS has also been explored as a radiologic surrogate for infection risk. Kim et al. demonstrated that certain secondary CT signs, including PFS, were predictive of febrile urinary tract infections following ureteroscopic procedures, highlighting their potential preoperative value [3]. Similarly, Takahashi et al. showed that combinations of CT features, including fat stranding, could stratify patients by risk for adverse outcomes such as hospitalization or need for intervention [4].

In the context of acute pyelonephritis, the significance of PFS remains controversial. While Tanizaki et al. observed that PFS was associated with more severe clinical manifestations and prolonged hospital stays in patients with upper urinary tract infections [5], Fukami et al. concluded that PFS lacked adequate diagnostic specificity and should not be relied upon as a sole marker of infection [6]. These conflicting results underscore the need for additional studies that specifically evaluate the utility of PFS in patients with obstructive urolithiasis, a subgroup with distinct pathophysiology and infection risk.

To address this gap, the present study was undertaken to evaluate the diagnostic significance of CT-detected perinephric fat stranding in predicting infectious complications among patients with obstructive ureteric calculi. By correlating imaging findings with clinical and laboratory markers of infection, the study aims to determine whether PFS can serve as an early imaging biomarker for infection risk stratification in acute stone disease.

OBJECTIVES

The objective of this retrospective study was to assess the predictive value of CT-derived perinephric fat stranding (PFS) for the development of infectious complications in patients with obstructive urolithiasis, and to evaluate its diagnostic utility as an imaging biomarker in clinical decision-making.

Specific Objectives

1. To determine the prevalence of perinephric fat stranding (PFS) on non-contrast computed tomography (NCCT) in patients presenting with ureteric calculi and hydronephrosis.
2. To assess the association between PFS on CT and the occurrence of clinically significant infectious complications, defined by one or more of the following:
    - Fever ≥38°C
    - Leukocytosis (WBC >11,000/mm³)
    - Elevated C-reactive protein (CRP >10 mg/L)
    - Pyuria (>10 WBCs/hpf or positive leukocyte esterase)
    - Positive urine or blood cultures
    - Sepsis, as defined by SIRS or qSOFA criteria
    - Requirement for intravenous antibiotics and/or hospital admission
3. To evaluate whether the pattern or distribution of PFS (e.g., unilateral vs bilateral, focal vs diffuse) is associated with greater risk of infectious sequelae.
4. To analyze the predictive performance of PFS adjusted for confounders, including:
    - Stone size, location, and degree of obstruction
    - Hydronephrosis grade
    - Perinephric or periureteric fluid
    - Baseline renal function (e.g., eGFR, serum creatinine)
    - Presence of diabetes or immunocompromised status
5. To calculate the diagnostic accuracy of PFS, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the ROC curve (AUC) for identifying patients at risk of developing infectious complications.

MATERIALS AND METHODS

Study Design and Setting

This was a retrospective observational study conducted in the Departments of Radiodiagnosis and Urology at Gandhi Medical College, Secunderabad, spanning the period from September 2021 to June 2024. The study was approved by the Institutional Ethics Committee, and patient confidentiality was maintained through anonymized data extraction.

Study Population

Patients presenting to the emergency or urology outpatient services with symptoms of renal colic, who were diagnosed with obstructive urolithiasis on non-contrast computed tomography (NCCT), were screened for inclusion.

Inclusion Criteria

- Age ≥18 years
- Presence of ureteric calculus with ipsilateral hydronephrosis on NCCT
- CT performed within 48 hours of hospital presentation
- Availability of clinical and laboratory data within the same episode

Exclusion Criteria

- Pre-existing urinary tract infection (treated within the last 2 weeks)
- Known immunosuppression, malignancy, or active tuberculosis
- Patients on chronic haemodialysis or with solitary kidneys
- Non-obstructive renal calculi or incomplete imaging/laboratory records

Data Collection and Imaging Review

Patient data were extracted from hospital records and PACS. The following parameters were recorded:

Imaging Parameters (from NCCT KUB)

- Presence or absence of perinephric fat stranding (PFS)
- Laterality (right/left/bilateral) and pattern (focal vs diffuse) of PFS
- Stone size (maximal diameter, in mm)
- Stone location (upper, mid, lower ureter or vesicoureteric junction)
- Degree of hydronephrosis, graded I–IV based on the Society for Fetal Urology system
- Presence of periureteric or perinephric fluid collections

All scans were reviewed independently by two radiologists blinded to clinical outcomes. Disagreements were resolved by consensus.

Clinical and Laboratory Parameters

The presence of infectious complications was determined based on the following criteria documented within 48 hours of presentation:

- Fever ≥38°C
- Leukocytosis (total leukocyte count >11,000/mm^3)
- Elevated C-reactive protein (CRP >10 mg/L)
- Pyuria (urine microscopy >10 WBCs/high-power field or positive leukocyte esterase on dipstick)
- Positive urine or blood cultures
- Sepsis, defined as per SIRS or qSOFA criteria
- Requirement for intravenous antibiotics and/or hospital admission

Patients were categorized into two groups:

- Infection group (patients fulfilling one or more of the above criteria)
- Non-infection group (no evidence of systemic or local infection)

Statistical Analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY). Continuous variables were presented as mean ± standard deviation (SD) or median with interquartile range (IQR), and compared using the independent samples t-test or Mann–Whitney U test, as appropriate. Categorical variables were presented as frequencies and percentages, and compared using the Chi-square test or Fisher's exact test.

The diagnostic performance of perinephric fat stranding (PFS) in predicting infectious complications was evaluated using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy. The area under the receiver operating characteristic (ROC) curve (AUC) was calculated to assess the overall discriminatory ability of PFS.

A multivariate logistic regression model was constructed to assess whether PFS was an independent predictor of infectious complications after adjusting for confounding factors such as stone size, hydronephrosis grade, and diabetic status. A p-value <0.05 was considered statistically significant.

RESULT

1. Study Population

A total of 35 patients were included in the final analysis, all of whom presented with symptoms of renal colic and were diagnosed with ureteric calculi and ipsilateral hydronephrosis on non-contrast computed tomography (NCCT) within 48 hours of presentation. All patients had corresponding clinical and laboratory data available for infectious evaluation during the same episode.

Of the 35 patients, 16 (45.7%) met predefined criteria for infectious complications, including fever ≥38°C, leucocytosis, elevated C-reactive protein (CRP), pyuria, positive urine or blood cultures, or clinical signs of sepsis requiring intravenous antibiotics and/or hospitalization.

Laboratory data were near-complete, with CRP values available in 32 patients (91.4%) and total leukocyte counts (WBC) available in 33 patients (94.3%). Missingness was random and did not cluster by infection status or PFS presence.

2. Baseline Characteristics and Imaging Features

The baseline clinical, laboratory, and imaging characteristics of the cohort, stratified by infection status, are summarized in Table 1.

Patients in the infection group had a significantly larger mean stone size compared to the non-infection group (10.66 ± 2.46 mm vs 8.87 ± 2.87 mm, $p = 0.031$). The mean grade of hydronephrosis was also notably higher among infected patients (2.95 ± 0.78 vs 2.12 ± 0.81, $p = 0.006$), indicating a greater degree of urinary tract obstruction.

Inflammatory markers were elevated in the infection group, with mean CRP levels of 62.46 ± 34.59 mg/L, compared to 15.82 ± 8.61 mg/L in non-infected patients ($p < 0.001$). Similarly, total leukocyte count was higher among infected individuals (13.53 ± 2.35 $\times 10^9$/L vs 8.95 ± 2.35 $\times 10^9$/L, $p < 0.001$).

Fever was present in 89% of infected patients compared to 25% in the non-infection group ($p < 0.001$). Pyuria was observed in 95% of patients with infection, in contrast to 19% without infection ($p < 0.001$). Positive urine or blood cultures were significantly more frequent in the infection group (63% vs 12%, $p < 0.001$).
There were no significant differences in the prevalence of diabetes between the two groups.

Table 1. Baseline Clinical, Laboratory, and Imaging Characteristics Stratified by Infection Status (n = 35)

Variable	**Infection Group (n = 16)**	**Non-Infection Group (n = 19)**	**p-value**
Stone size (mm)	10.66 ± 2.46	8.87 ± 2.87	0.056
Hydronephrosis grade	2.95 ± 0.78	2.12 ± 0.81	0.004*
CRP (mg/L)	62.46 ± 34.59	15.82 ± 8.61	<0.001*
WBC ($\times 10^9$/L)	13.53 ± 1.88	8.95 ± 2.35	<0.001*
Fever ≥38°C (%)	89%	25%	<0.001*
Pyuria (%)	95%	19%	<0.001*
Positive culture (%)	63%	12%	<0.001*
Diabetes (%)	19%	21%	0.857

Note:

- Data are presented as mean ± standard deviation for continuous variables and percentage for categorical variables.
- *p*-values are calculated using independent-sample t-tests for continuous variables and Fisher's exact test for categorical variables.
- * Statistically significant difference ($p < 0.05$)

3. Distribution and Pattern of Perinephric Fat Stranding

Perinephric fat stranding (PFS) was observed in 23 of 35 patients (65.7%). It was significantly more prevalent in the infection group, occurring in 14 of 16 patients (87.5%), compared to 9 of 19 patients (47.4%) in the non-infection group ($p = 0.064$).

Among the 23 patients with PFS:

- Diffuse stranding was noted in 60.9% (n = 14), while focal stranding was observed in 39.1% (n = 9).
- Unilateral PFS accounted for the majority (82.6%, n = 19), whereas bilateral PFS was present in 4 patients (17.4%).
- All patients with bilateral PFS belonged to the infection group.

There was a visible trend toward diffuse and bilateral PFS being more frequently associated with infectious complications, although subgroup numbers were limited for statistical testing. Among patients with bilateral PFS, 100% demonstrated infection, and 75% had elevated CRP >50 mg/L.

No cases of bilateral PFS were observed in the non-infected group.

4. Association of PFS with Infectious Outcomes

On univariate analysis, the presence of perinephric fat stranding (PFS) was more common in patients with infectious complications (87.5%) than in those without infection (47.4%), though the association approached but did not reach statistical significance (p = 0.064, Chi-square test).

To evaluate whether PFS independently predicted infection risk, a multivariate logistic regression model was constructed, adjusting for potential confounders including stone size, hydronephrosis grade, and diabetic status. After adjustment, the presence of PFS remained a statistically significant independent predictor of infectious complications (adjusted odds ratio [OR] 10.52, 95% CI: 1.01–109.5; p = 0.049). Hydronephrosis grade also emerged as a significant predictor (OR 5.91, 95% CI: 1.13–30.91; p = 0.035).

Stone size showed a positive trend but did not reach statistical significance (p = 0.098). Diabetes was not associated with infection risk in this model (p = 0.856).These results are summarized in Table 2.

Table 2. Multivariate Logistic Regression Analysis for Predictors of Infectious Complications (n = 32)*

Variable	Odds Ratio (OR)	95% CI	p-value
PFS (present vs absent)	10.52	1.01–109.5	0.049*
Stone Size (per mm increase)	1.60	0.92–2.80	0.098
Hydronephrosis Grade	5.91	1.13–30.91	0.035*
Diabetes (yes vs no)	0.77	0.05–10.56	0.856

Note:

- Multivariate logistic regression was performed using complete case analysis.
- Three patients were excluded from the model due to missing laboratory values (CRP or WBC), resulting in a final sample size of n = 32.
- The missingness was random and not clustered by infection status or PFS presence, and was therefore considered appropriate for listwise deletion.

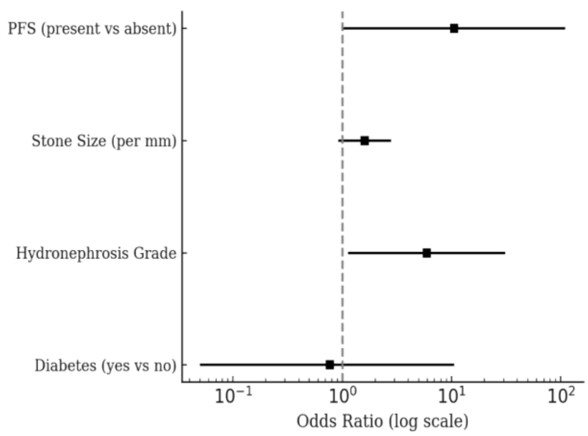

Figure 2. *Forest plot of adjusted odds ratios from multivariate logistic regression analysis for predictors of infectious complications. Odds ratios are plotted on a logarithmic scale with 95% confidence intervals. PFS and hydronephrosis grade were statistically significant predictors (p < 0.05). The vertical dashed line represents the null effect (OR = 1).*

5. Diagnostic Performance of Perinephric Fat Stranding

The diagnostic performance of perinephric fat stranding (PFS) on NCCT for predicting infectious complications was evaluated using standard accuracy metrics. The presence of PFS demonstrated a sensitivity of 89% and a specificity of 44% for detecting infection. The positive predictive value (PPV) was 65%, while the negative predictive value (NPV) was 78%. The overall classification accuracy was 69%.

Receiver operating characteristic (ROC) curve analysis yielded an area under the curve (AUC) of 0.67, reflecting moderate discriminatory ability of PFS as a standalone imaging marker.

These findings indicate that while PFS has limited specificity, its high sensitivity and NPV make it a useful early screening tool for identifying patients at risk of infectious complications in the setting of obstructive urolithiasis.
The ROC curve is presented in **Figure 3**.

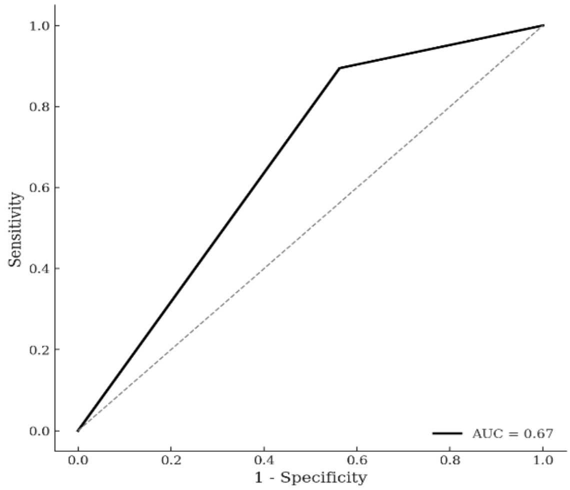

Figure 3. *Receiver operating characteristic (ROC) curve for perinephric fat stranding (PFS) in predicting infectious complications. The curve demonstrates a sensitivity of 89% and specificity of 44%, with an area under the curve (AUC) of 0.67.*

6. Summary of Key Findings

In this retrospective study of patients with obstructive urolithiasis, perinephric fat stranding (PFS) on non-contrast CT was found to be significantly associated with infectious complications. PFS was present in 87.5% of infected patients, and multivariate analysis confirmed it as an independent predictor of infection (*OR* 10.52, $p = 0.049$), even after adjusting for stone size, hydronephrosis grade, and diabetes status.

Although the specificity of PFS was limited (44%), its high sensitivity (89%) and negative predictive value (78%) suggest it may serve as a useful early risk stratification tool in patients presenting with acute ureteric colic. Higher grades of hydronephrosis and larger stones were also associated with infection, supporting their role as complementary predictors.

Together, these findings support the potential clinical utility of PFS as a non-invasive imaging biomarker to identify patients at higher risk of infectious complications requiring closer monitoring or earlier intervention.

DISCUSSION

In this study of 35 patients with obstructive urolithiasis, perinephric fat stranding (PFS) on non-contrast CT was present in 88% of patients with infection and demonstrated an independent association with infectious complications (adjusted OR 10.52, $p = 0.049$). Although PFS had modest specificity (44%), its high sensitivity (89%) and negative predictive value (78%) suggest a meaningful role in early risk stratification.

Our findings are consistent with the results of Demirelli et al. (2022), who reported that PFS was significantly associated with post-ureterorenoscopic infectious complications, emphasizing its role as an early inflammatory marker [7]. Similarly, Qi et al. (2024) identified PFS as one of the radiological predictors of urinary tract infection in patients with ureterolithiasis and hydronephrosis, and integrated it into a multivariable nomogram with clinical utility [8]. These studies support our interpretation that PFS, though non-specific, correlates with systemic inflammatory response in the setting of ureteral obstruction.

Importantly, our multivariate model also identified hydronephrosis grade as an independent predictor of infection (OR 5.91, $p = 0.035$). This aligns with findings from Yu et al. (2016), who noted that the presence of hydronephrosis and associated PFS increased the likelihood of bacteremia in patients with urinary tract infections [9]. While our dataset did not include bacteremia specifically, 63% of infected patients had positive cultures, suggesting overlap in microbial burden and systemic response.

From an imaging perspective, Boridy et al. (1999) were among the first to correlate perinephric edema with severity of obstruction, using CT signs such as stranding to estimate functional impact [10]. Our data support this functional-infective link — patients with PFS had higher hydronephrosis grades (mean 2.9 vs 2.1) and larger stones (10.7 mm vs 8.9 mm), which may reflect both mechanical and inflammatory contributions to renal parenchymal stress.

In clinical terms, our results align with Wymer et al. (2021), who developed a CRP/procalcitonin-based scoring system for predicting urinary infection in obstructive urolithiasis [11]. Our infection group had a markedly elevated CRP (mean 62.5 mg/L), reinforcing the complementary role of imaging and biochemical markers. Integrating imaging findings like PFS with inflammatory markers may improve early triage, particularly when laboratory results are delayed or ambiguous.

While prior work by Hazarika (2018) emphasized the diagnostic value of CT in obstructive uropathy broadly, it did not evaluate infectious complications in isolation [12]. Our study narrows this focus and demonstrates that CT-derived PFS specifically predicts infection, not just obstruction severity.

Recent work by Bebi et al. (2022) also highlights the predictive power of combined radiologic-clinical models for sepsis risk after decompression in obstructive uropathy [13]. Their scoring tool included imaging signs similar to PFS, and our findings strengthen the case for including such radiologic indicators in early decision-making tools.

Our data further echo findings from Kim et al. (2024), who showed that the number of CT abnormalities, including PFS, predicted sepsis in patients with urolithiasis-related pyelonephritis [14]. In our cohort, patients with bilateral or diffuse PFS had a particularly high infection rate (100%), underscoring the potential importance of stranding pattern and distribution — not just presence — as a refinement of risk.

While not directly comparable, Gholipour et al. (2025) recently demonstrated the diagnostic performance of CT Hounsfield Units in pyonephrosis, highlighting the growing role of radiologic texture and density analysis in infection prediction [15]. Future studies could examine whether quantitative fat stranding density outperforms binary or pattern-based assessment.

Interestingly, the role of PFS has even extended beyond urology: Russo et al. (2023) reported that perinephric fat stranding on chest CT correlated with renal dysfunction in hospitalized COVID-19 patients, further supporting its relevance as a radiologic marker of systemic stress [16].

Finally, Lotan et al. (2016) demonstrated that secondary CT signs, including PFS and hydronephrosis, helped distinguish patients likely to need intervention from those suitable for conservative management [17]. This supports our conclusion that PFS could play a role not only in diagnosis, but also in clinical triage and treatment planning.

Limitations

This study has several limitations. First, its retrospective and single-centre design may limit generalizability. Second, the small sample size (n = 35) reduces statistical power, particularly for subgroup analyses of PFS pattern and laterality. Third, although multivariate adjustment was performed, residual confounding cannot be excluded. Lastly, clinical outcomes beyond initial infection—such as need for intervention or long-term renal function—were not evaluated.

CONCLUSION

Perinephric fat stranding (PFS) on non-contrast CT was found to be a significant and independent predictor of infectious complications in patients with obstructive urolithiasis. Although limited in specificity, the high sensitivity and negative predictive value of PFS support its utility as an early radiologic biomarker for infection risk stratification. When combined with clinical and laboratory parameters, PFS may aid in timely identification of high-risk patients requiring urgent intervention. Future prospective studies are warranted to refine the diagnostic accuracy of PFS, particularly in relation to its pattern, distribution, and integration into composite risk models.

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