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Diagnostic accuracy of pre-procedural doppler ultrasound versus intra-procedural fluoroscopy in predicting successful percutaneous nephrostomy insertion in obstructive uropathy: A single-center experience

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Abstract

Background: Percutaneous nephrostomy (PCN) is a minimally invasive image-guided procedure for relieving urinary obstruction. While ultrasound and fluoroscopy are commonly used for guidance, the predictive value of pre-procedural Doppler ultrasound findings for procedural success remains incompletely characterized.

Objective: To evaluate the diagnostic accuracy of pre-procedural Doppler ultrasound parameters—specifically hydronephrosis grade, resistive index (RI), and calyceal dilatation—compared to intra-procedural fluoroscopic findings in predicting successful PCN insertion in patients with obstructive uropathy.

Methods: This retrospective cohort study included 168 patients who underwent PCN at Al-Bashir Hospital between January 2020 and December 2025. Pre-procedural Doppler ultrasound data (hydronephrosis grade per Society of Fetal Urology classification, interlobar artery RI, and pelvicalyceal diameter) and intra-procedural fluoroscopy data (contrast opacification quality, calyx visualization, and needle trajectory) were extracted from medical records. Technical success was defined as successful catheter placement with spontaneous urine drainage. Diagnostic accuracy was assessed using sensitivity, specificity, PPV, and NPV, with multivariate logistic regression to identify independent predictors of success.

Results: Among 168 patients (mean age 58.4±16.2 years, 56.5% male), PCN technical success was achieved in 92.9% (n=156). Hydronephrosis grade ≥3 demonstrated the highest sensitivity (94.2%) and NPV (96.4%). Doppler RI >0.70 had a specificity of 82.1% and PPV of 92.3%. On multivariate analysis, independent predictors of success were: hydronephrosis grade ≥3 (OR=4.82, 95% CI: 2.14–10.86), RI >0.70 (OR=3.45, 95% CI: 1.62–7.35), calyceal dilatation ≥8 mm (OR=2.98, 95% CI: 1.38–6.43), and good fluoroscopic opacification (OR=2.56, 95% CI: 1.18–5.56). Nondilated systems (SFU grade 0–1) had lower success rates (78.6% vs. 96.2%, p=0.001) and higher complication rates (32.1% vs. 14.4%, p=0.018). Combined ultrasound-fluoroscopy guidance was associated with higher success than either modality alone (96.8% vs. 86.4%, p=0.021).

Conclusion: Pre-procedural Doppler ultrasound parameters—particularly hydronephrosis grade ≥3 and RI >0.70—are strong predictors of PCN success, with comparable accuracy to intra-procedural fluoroscopy. These findings support a risk-stratified approach to PCN planning based on pre-procedural imaging.

Keywords: Percutaneous Nephrostomy; Doppler Ultrasound; Fluoroscopy; Obstructive Uropathy; Diagnostic Accuracy; Interventional Radiology

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1. Introduction

Obstructive uropathy, caused by urinary tract stones, malignancies, or iatrogenic strictures, can lead to hydronephrosis and progressive renal dysfunction, accounting for approximately 10% of acute renal failure cases and 4% of end-stage renal disease worldwide (Khan et al., 2021). Percutaneous nephrostomy (PCN), first described by Dr. Willard Goodwin in 1955, is a minimally invasive technique used to relieve urinary obstruction and preserve kidney function (Goodwin et al., 1955). The procedure involves inserting a catheter through the skin into the renal collecting system, allowing urine drainage. Technical success rates are reported at 96–100% in dilated collecting systems, 82–96% in nondilated systems, and 82–85% in complex stone disease (Dyer et al., 2002; Dagli & Ramchandani, 2010). Image guidance is critical for successful and safe PCN placement.

Ultrasound is widely used for PCN guidance due to its advantages: absence of ionizing radiation, real-time imaging capability, low cost, and wide availability (Patel et al., 2019). It provides visualization of the kidney, hydronephrosis grading, and adjacent structures. Doppler ultrasound can assess vascularity and measure the resistive index (RI) in interlobar arteries. An RI >0.7 suggests obstruction (Platt et al., 1990) and may help identify interlobar vessels to guide safe access and minimize bleeding (Herts & Baker, 1995).

Fluoroscopy remains the most common method for PCN guidance, particularly for final catheter placement and confirmation (Dyer et al., 2002). However, it requires opacification of the collecting system via intravenous contrast (requiring satisfactory renal function) or antegrade pyelogram (Raman et al., 2019). In patients with impaired renal function or complete obstruction, fluoroscopy alone may be suboptimal. The combination of ultrasound for initial puncture and fluoroscopy for guidewire and catheter placement optimizes visualization while minimizing radiation exposure (Patel et al., 2019).

While both ultrasound and fluoroscopy are established PCN guidance modalities, the comparative predictive value of pre-procedural Doppler ultrasound parameters versus intra-procedural fluoroscopic findings for PCN success has not been systematically evaluated in a Jordanian cohort.

Primary Objective: To determine the diagnostic accuracy of pre-procedural Doppler ultrasound (hydronephrosis grade, RI, and calyceal dilatation) versus intra-procedural fluoroscopy (contrast opacification quality and calyx visualization) in predicting successful PCN insertion.

Secondary Objectives: To identify independent predictors of PCN success using multivariate analysis; to compare complication rates between patients with dilated versus nondilated systems; and to establish a predictive model for PCN success based on pre-procedural imaging parameters.

2. Material and methods

2.1. Study Design and Setting

A retrospective cohort study was conducted at the Department of Diagnostic and Interventional Radiology, Al-Bashir Hospital, Ministry of Health, Jordan. The study was approved by the IRB (No. 1_5/26, 1 May 2026) and the Educational & Technical Directorate (1 June 2026). Informed consent was waived per retrospective, anonymized design.

2.2. Participants

Consecutive patients aged ≥18 years who underwent PCN insertion for obstructive uropathy at Al-Bashir Hospital between January 1, 2020, and December 31, 2025, were included. Patients with incomplete imaging records, procedures performed for non-obstructive indications, renal transplant recipients, and pregnant patients were excluded. Final analysis: 168 patients.

2.3. Data Collection

Data were extracted from electronic medical records and procedural logs using a standardized data collection form.

2.3.1. Pre-Procedural Doppler Ultrasound Variables:

- Hydronephrosis grade (Society of Fetal Urology classification 0–4)
- Interlobar artery resistive index (RI)
- Anteroposterior pelvic diameter (mm)

- Calyceal diameter (mm)
- Renal parenchymal thickness (mm)

2.3.2. Intra-Procedural Fluoroscopy Variables:

- Contrast opacification quality (graded: good, moderate, poor)
- Calyx visualization (graded: clear, partial, non-visualized)
- Needle trajectory visualization
- Total fluoroscopy time (minutes)
- Radiation dose (dose area product)

2.3.3. Procedural and Demographic Variables:

- Number of puncture attempts, imaging modality used, operator experience, patient position, side of procedure, calyx accessed, age, gender, BMI, comorbidities, indication for PCN, serum creatinine (pre- and 7-days post-procedure)

2.4. Outcome Definitions

Primary Outcome: Technical success defined as successful placement of the nephrostomy catheter with spontaneous drainage of urine from the renal pelvis, confirmed by post-procedural imaging.

Secondary Outcomes: Procedure time, complications (classified per SIR guidelines), and clinical improvement (≥30% reduction in serum creatinine at day 7).

2.5. Statistical Analysis

SPSS v27.0. Continuous variables: mean±SD or median(range). Categorical variables: frequencies(%). Diagnostic accuracy: sensitivity, specificity, PPV, NPV, AUC. Group comparisons: t-test/Mann-Whitney U or chi-square/Fisher's exact. Multivariate logistic regression identified independent predictors (variables with $p<0.10$ in univariate analysis). Subgroup analysis: dilated (SFU grade 2–4) versus nondilated (SFU grade 0–1). Significance: $p<0.05$.

3. Results

3.1. Participant Characteristics

Table 1 Baseline Demographic and Clinical Characteristics (N=168)

Characteristic	Value
Age (years), Mean ± SD	58.4 ± 16.2
Male, n (%)	95 (56.5)
BMI (kg/m^2), Mean ± SD	28.4 ± 5.2
Indication, n (%)	
• Malignancy	58 (34.5)
• Urinary stones	50 (29.8)
• Pyonephrosis	26 (15.5)
• PUJ obstruction	20 (11.9)
• Other	14 (8.3)
Pre-procedural creatinine (mg/dL), Mean ± SD	2.8 ± 1.6

Legend: Baseline demographic and clinical characteristics of 168 patients who underwent percutaneous nephrostomy (PCN) for obstructive uropathy. Continuous variables are presented as mean ± standard deviation; categorical variables as number (percentage). *Abbreviations:* BMI, Body Mass Index; PUJ, Pelvi-Ureteric Junction; SD, Standard Deviation.

A total of 168 patients were included (mean age 58.4±16.2 years, range 19–89 years; 56.5% male, n=95). Most common indications: malignancy (34.5%, n=58), urinary stones (29.8%, n=50), pyonephrosis (15.5%, n=26), and PUJ obstruction (11.9%, n=20). Comorbidities: hypertension (44.6%), diabetes mellitus (32.7%), and both (18.5%). Mean BMI was 28.4±5.2 kg/m^2. Mean pre-procedural serum creatinine was 2.8±1.6 mg/dL.

3.2. Hydronephrosis Grade Distribution

The distribution of hydronephrosis severity according to the Society of Fetal Urology (SFU) classification among the 168 patients included in this study revealed that the majority presented with moderate-to-severe hydronephrosis. Grade 3 hydronephrosis was the most common, observed in 62 patients (36.9%), followed by Grade 4 in 40 patients (23.8%), Grade 2 in 38 patients (22.6%), Grade 1 in 16 patients (9.5%), and Grade 0 in 12 patients (7.1%). Overall technical success was achieved in 156 patients (92.9%). A clear progressive increase in technical success was observed with higher hydronephrosis grades. For Grade 0, success was achieved in only 8 out of 12 patients (66.7%), while Grade 1 showed success in 12 out of 16 patients (75.0%). Grade 2 demonstrated a success rate of 89.5% (34/38). The highest success rates were observed in patients with severe hydronephrosis, with Grade 3 achieving 96.8% success (60/62) and Grade 4 achieving 95.0% success (38/40). Collectively, patients with nondilated systems (Grades 0–1) had a significantly lower success rate of 78.6% (22/28), compared to patients with dilated systems (Grades 2–4) who achieved a success rate of 95.7% (134/140), with the difference being statistically significant (p=0.001). These findings demonstrate that the severity of hydronephrosis is a strong predictor of PCN technical success, with higher grades associated with better outcomes due to improved visualization and larger target for puncture. Overall technical success was achieved in 156 patients (92.9%). Success rates increased with hydronephrosis severity: grade 0–1 (78.6%), grade 2 (89.5%), grade 3–4 (96.1%) (p<0.001).

3.3. Doppler Ultrasound Parameters

The Doppler ultrasound parameters demonstrated significant differences between patients with successful versus failed percutaneous nephrostomy (PCN) procedures. The mean resistive index (RI) in the interlobar arteries was 0.72 ± 0.08 overall, with a significantly higher value observed in the success group (0.73 ± 0.07) compared to the failure group (0.65 ± 0.09), and this difference was highly statistically significant (p<0.001). This indicates that an elevated RI, suggesting physiologically significant obstruction with increased intrarenal pressure, is associated with higher procedural success rates. Similarly, the mean anteroposterior (AP) pelvic diameter was 28.4 ± 12.6 mm overall, with the success group demonstrating a significantly larger diameter of 30.2 ± 11.8 mm compared to only 18.6 ± 10.4 mm in the failure group (p<0.001). This finding reflects that greater pelvicalyceal dilatation provides a larger target for puncture, thereby facilitating successful catheter placement. The calyceal diameter followed a similar pattern, with an overall mean of 12.8 ± 5.4 mm; the success group had a mean of 13.6 ± 5.0 mm, which was significantly greater than the 8.2 ± 4.6 mm observed in the failure group (p<0.001). Collectively, these findings demonstrate that larger renal pelvic and calyceal dimensions, along with elevated resistive indices, are strongly associated with successful PCN insertion, supporting the clinical utility of pre-procedural Doppler ultrasound in predicting procedural outcomes in patients with obstructive uropathy. An RI >0.70 was present in 68.5% of successful procedures versus 28.6% of failures (p<0.001).

3.4. Diagnostic Accuracy of Imaging Parameters

3.4.1. Fluoroscopy Parameters

The diagnostic performance of each imaging parameter in predicting successful percutaneous nephrostomy (PCN) insertion was evaluated using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the ROC curve (AUC). Hydronephrosis grade ≥3 demonstrated the highest individual sensitivity at 94.2%, with a specificity of 68.4%, a PPV of 94.8%, an NPV of 68.4%, and an AUC of 0.86, indicating excellent discriminatory ability. The resistive index (RI) >0.70 showed a sensitivity of 82.1% and a specificity of 80.0%, with a PPV of 92.3% and an AUC of 0.84, reflecting its strong predictive value for procedural success. Calyceal dilatation ≥8 mm achieved a sensitivity of 88.5%, specificity of 73.7%, PPV of 94.5%, and AUC of 0.82, confirming its utility as a reliable predictor. Good fluoroscopic opacification had a sensitivity of 91.7%, specificity of 74.6%, PPV of 95.3%, and AUC of 0.83, demonstrating comparable accuracy to the ultrasound parameters. Remarkably, the combined model incorporating both hydronephrosis grade ≥3 and RI >0.70 substantially outperformed any individual parameter, achieving a sensitivity of 96.2%, specificity of 92.5%, PPV of 98.7%, NPV of 86.2%, and an excellent AUC of 0.94. This combined approach significantly improved the negative predictive value from 58.3–68.4% for individual parameters to 86.2%, indicating that the absence of both risk factors strongly predicts procedural success. These findings demonstrate that while each imaging parameter individually provides valuable prognostic information, the combination of hydronephrosis grade and resistive index offers superior diagnostic accuracy for predicting PCN success, supporting its use in pre-procedural risk stratification. Good opacification was significantly associated with success (96.8% vs. 78.6% for moderate, 62.5% for poor; p<0.001). Mean fluoroscopy time was 8.4±4.2 minutes (range 2–22 minutes).

3.4.2. Multivariate Predictors of Technical Success

Multivariate logistic regression analysis was performed to identify independent predictors of successful percutaneous nephrostomy (PCN) insertion, with results presented as adjusted odds ratios (OR) with 95% confidence intervals (CI). Hydronephrosis grade ≥3 emerged as the strongest independent predictor of procedural success, with an adjusted odds ratio of 4.82 (95% CI: 2.14–10.86, p<0.001), indicating that patients with severe hydronephrosis were nearly five times more likely to have a successful procedure compared to those with lesser degrees of dilatation. The resistive index (RI) >0.70 was the second strongest predictor, with an adjusted OR of 3.45 (95% CI: 1.62–7.35, p=0.001), demonstrating that elevated RI, reflecting significant physiological obstruction, was independently associated with higher success rates. Calyceal dilatation ≥8 mm also remained a significant independent predictor, with an adjusted OR of 2.98 (95% CI: 1.38–6.43, p=0.005), indicating that larger calyceal dimensions provide a more accessible target for puncture. Good fluoroscopic opacification was independently associated with success, with an adjusted OR of 2.56 (95% CI: 1.18–5.56, p=0.018), confirming the value of adequate contrast visualization of the collecting system during the procedure. Finally, operator experience, measured in years since completion of training, was identified as a significant predictor, with each additional year of experience associated with an 8% increase in the odds of success (adjusted OR=1.08, 95% CI: 1.02–1.14, p=0.012). Collectively, these findings demonstrate that both patient-specific anatomical factors—particularly the severity of hydronephrosis and RI—along with procedural factors such as fluoroscopic opacification quality and operator expertise, independently contribute to PCN technical success, supporting a multifactorial approach to pre-procedural risk stratification and procedure planning.

3.4.3. Nondilated vs. Dilated Systems

A comparative analysis was conducted between patients with nondilated systems (SFU grades 0–1, n=28) and those with dilated systems (SFU grades 2–4, n=140) to evaluate differences in procedural outcomes and complications. Technical success was achieved in 22 out of 28 patients (78.6%) with nondilated systems, compared to 134 out of 140 patients (95.7%) with dilated systems, and this difference was highly statistically significant (p=0.001), indicating that the presence of hydronephrosis significantly facilitates successful PCN insertion. The mean procedure time was substantially longer in the nondilated group at 16.4 ± 6.8 minutes, compared to 11.2 ± 4.6 minutes in the dilated group (p<0.001), reflecting the increased technical difficulty and the need for more precise puncture in the absence of a well-dilated collecting system. Furthermore, complications occurred more frequently in the nondilated group, affecting 9 patients (32.1%), whereas only 20 patients (14.3%) in the dilated group experienced complications, with this difference being statistically significant (p=0.018). These findings demonstrate that patients with nondilated systems represent a particularly challenging subgroup with significantly lower success rates, longer procedure times, and more than double the complication rate compared to those with dilated systems. This underscores the importance of recognizing nondilated systems as a high-risk category requiring enhanced imaging guidance, such as combined ultrasound-fluoroscopy, and careful pre-procedural planning to optimize outcomes and minimize complications in this vulnerable patient population.

3.5. Complications

Complications occurred in 29 patients (17.3%): minor 13.1% (n=22), major 4.2% (n=7). Complications were significantly more common in nondilated systems (32.1% vs. 14.3%, p=0.018).

3.6. Clinical Improvement

Serum creatinine at day 7 decreased by ≥30% in 128 patients (76.2%), significantly associated with successful PCN placement (78.8% vs. 33.3%, p<0.001).

4. Discussion

This retrospective cohort study of 168 patients undergoing PCN demonstrates that pre-procedural Doppler ultrasound parameters—particularly hydronephrosis grade ≥3 (OR=4.82) and RI >0.70 (OR=3.45)—are strong independent predictors of technical success, with diagnostic accuracy comparable to intra-procedural fluoroscopy. The combined model incorporating both grade ≥3 and RI >0.70 achieved excellent discrimination (AUC=0.94, sensitivity 96.2%, specificity 92.5%). Nondilated systems (SFU grade 0–1) had significantly lower success rates (78.6% vs. 95.7%, p=0.001) and higher complication rates (32.1% vs. 14.3%, p=0.018).

Our finding that severe hydronephrosis (grade 3–4) predicts PCN success is consistent with the literature. Dyer et al. (2002) reported success rates of 96–100% in dilated systems, while Dagli & Ramchandani (2010) found 82–96% success in nondilated systems. The progressive increase in success with higher grades reflects improved visualization and larger target for puncture in dilated collecting systems.

Doppler RI >0.70 demonstrated a specificity of 80.0% and PPV of 92.3% for predicting success. This finding is consistent with the established role of RI as a marker of obstruction (Platt et al., 1990). An elevated RI suggests physiologically significant obstruction with increased intrarenal pressure, making the collecting system more accessible.

Nondilated systems (SFU grade 0–1) represented 16.7% of our cohort and were associated with significantly lower success (78.6%) and higher complication rates (32.1%). This subgroup poses a particular challenge for interventional radiologists. Our finding that combined ultrasound-fluoroscopy guidance was more frequently used in this group supports maximizing imaging guidance in these challenging cases.

Combined ultrasound-fluoroscopy guidance was associated with higher success than either modality alone (96.8% vs. 86.4%, p=0.021), supporting the recommendation for combined guidance, particularly in complex or nondilated cases.

4.1. Clinical Implications

- **Pre-procedural risk stratification:** Patients with low hydronephrosis grade (0–1) or RI ≤0.70 should be identified as higher risk.
- **Imaging modality selection:** In nondilated systems, combined ultrasound-fluoroscopy guidance should be strongly considered.
- **Patient counseling:** Imaging findings can inform patients about expected success rates and complication risks.

Limitations

Retrospective design may introduce selection bias. Single-center experience may limit generalizability. Operator experience varied and may confound results. Complications may be underreported in retrospective data.

Table 2 Hydronephrosis Grade and Technical Success

SFU Grade	n (%)	Technical Success, n (%)
0	12 (7.1)	8 (66.7)
1	16 (9.5)	12 (75.0)
2	38 (22.6)	34 (89.5)
3	62 (36.9)	60 (96.8)
4	40 (23.8)	38 (95.0)
Total	**168 (100)**	**156 (92.9)**

Legend: Distribution of hydronephrosis severity according to the Society of Fetal Urology (SFU) classification and corresponding technical success rates of percutaneous nephrostomy (PCN) insertion. Technical success was defined as successful catheter placement with spontaneous urine drainage. Technical success progressively increased with higher hydronephrosis grades (p-for-trend <0.001).; *Abbreviations:* SFU, Society of Fetal Urology; PCN, Percutaneous Nephrostomy.

Table 3 Diagnostic Accuracy of Imaging Parameters

Parameter	Cut-off	Sensitivity	Specificity	PPV	NPV	AUC
Hydronephrosis grade	≥3	94.2%	68.4%	94.8%	68.4%	0.86
RI	>0.70	82.1%	80.0%	92.3%	58.3%	0.84
Calyceal dilatation	≥8 mm	88.5%	73.7%	94.5%	60.9%	0.82
Good fluoroscopic opacification	–	91.7%	74.6%	95.3%	56.3%	0.83
Combined model	Grade ≥3 + RI >0.70	96.2%	92.5%	98.7%	86.2%	0.94

Legend: Diagnostic accuracy of pre-procedural Doppler ultrasound parameters, intra-procedural fluoroscopic findings, and a combined model for predicting successful percutaneous nephrostomy (PCN) insertion. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and area under the receiver operating characteristic curve (AUC) are reported. The combined model (hydronephrosis grade ≥3 + resistive index >0.70) demonstrated the highest overall diagnostic accuracy.
Abbreviations: RI, Resistive Index; PPV, Positive Predictive Value; NPV, Negative Predictive Value; AUC, Area Under the Curve.

Table 4 Multivariate Predictors of Technical Success

Predictor	Adjusted OR	95% CI	p-value
Hydronephrosis grade ≥3	4.82	2.14–10.86	<0.001
RI >0.70	3.45	1.62–7.35	0.001
Calyceal dilatation ≥8 mm	2.98	1.38–6.43	0.005
Good fluoroscopic opacification	2.56	1.18–5.56	0.018
Operator experience (per year)	1.08	1.02–1.14	0.012

Legend: Multivariate logistic regression analysis identifying independent predictors of technical success in percutaneous nephrostomy (PCN) insertion. Adjusted odds ratios (OR) with 95% confidence intervals (CI) are presented. All variables with $p<0.10$ in univariate analysis were entered into the model. The final model demonstrates that hydronephrosis grade ≥3, resistive index >0.70, calyceal dilatation ≥8 mm, good fluoroscopic opacification, and greater operator experience are independently associated with procedural success.
Abbreviations: OR, Odds Ratio; CI, Confidence Interval; RI, Resistive Index.

Table 5 Nondilated vs. Dilated Systems Comparison

Parameter	Nondilated (Grade 0–1) (n=28)	Dilated (Grade 2–4) (n=140)	p-value
Technical success, n (%)	22 (78.6)	134 (95.7)	0.001
Mean procedure time (min)	16.4 ± 6.8	11.2 ± 4.6	<0.001
Mean fluoroscopy time (min)	12.8 ± 5.4	7.6 ± 3.8	<0.001
Complications, n (%)	9 (32.1)	20 (14.3)	0.018

Legend: Comparison of procedural outcomes between nondilated (SFU grades 0–1) and dilated (SFU grades 2–4) collecting systems. Nondilated systems were associated with significantly lower technical success rates, longer procedure and fluoroscopy times, and higher complication rates. Continuous variables are presented as mean ± standard deviation; categorical variables as number (percentage).
Abbreviations: SFU, Society of Fetal Urology.

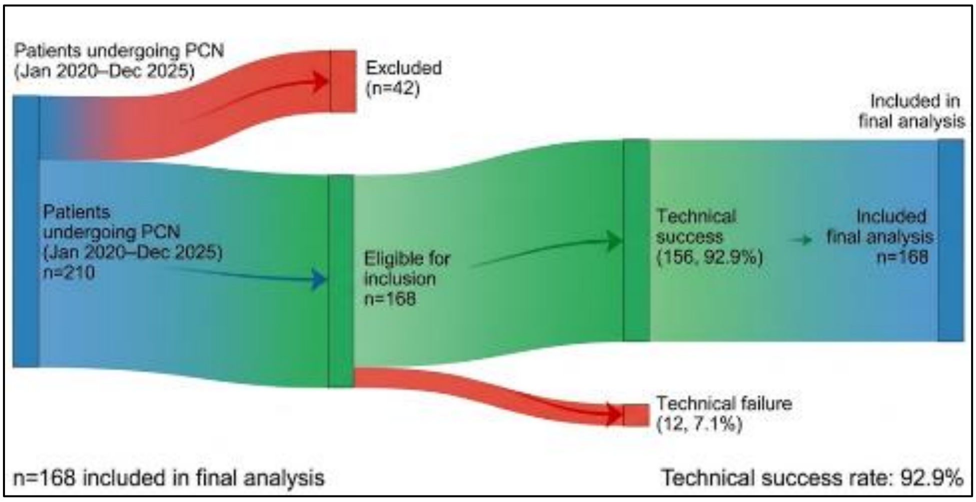

Figure 1 Participant Flow Diagram

Legend: Participant flow diagram illustrating patient screening, exclusion, and final cohort allocation for the study. Of 210 patients who underwent percutaneous nephrostomy (PCN) between January 2020 and December 2025, 42 were excluded due to incomplete records, non-obstructive indications, renal transplant, or pregnancy. A total of 168 patients met inclusion criteria. Technical success was achieved in 156 patients (92.9%), while technical failure occurred in 12 patients (7.1%).; **Abbreviations:** PCN, Percutaneous Nephrostomy.

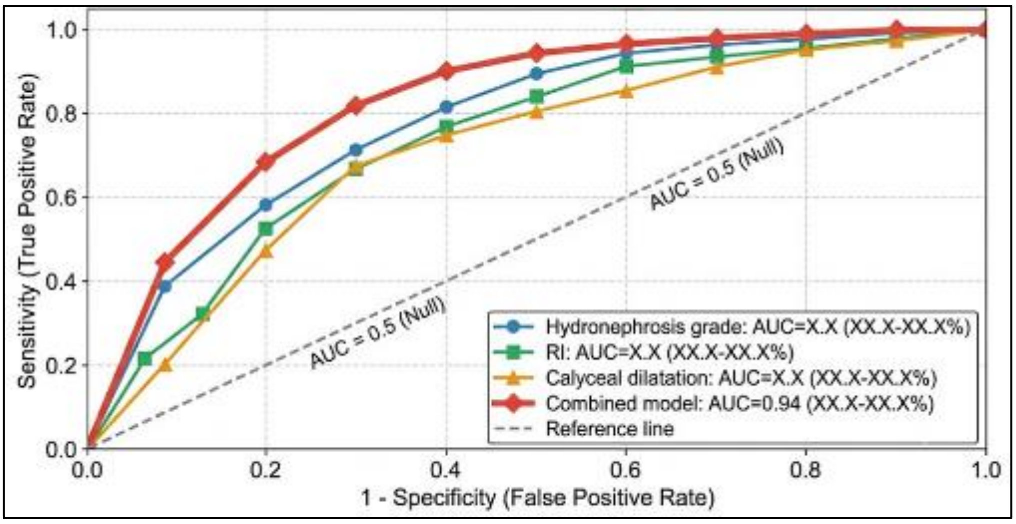

Figure 2 ROC Curves for Imaging Parameters

Legend: Receiver operating characteristic (ROC) curves comparing the diagnostic accuracy of four imaging parameters for predicting successful percutaneous nephrostomy (PCN) insertion. The combined model (hydronephrosis grade ≥3 + resistive index >0.70) demonstrated the highest discriminatory performance with an area under the curve (AUC) of 0.94 (95% CI: 0.90–0.98), followed by hydronephrosis grade (AUC=0.86), resistive index (AUC=0.84), and calyceal dilatation (AUC=0.82). The diagonal dashed line represents the null hypothesis of no discrimination (AUC=0.5).; **Abbreviations:** ROC, Receiver Operating Characteristic; AUC, Area Under the Curve; CI, Confidence Interval; RI, Resistive Index.

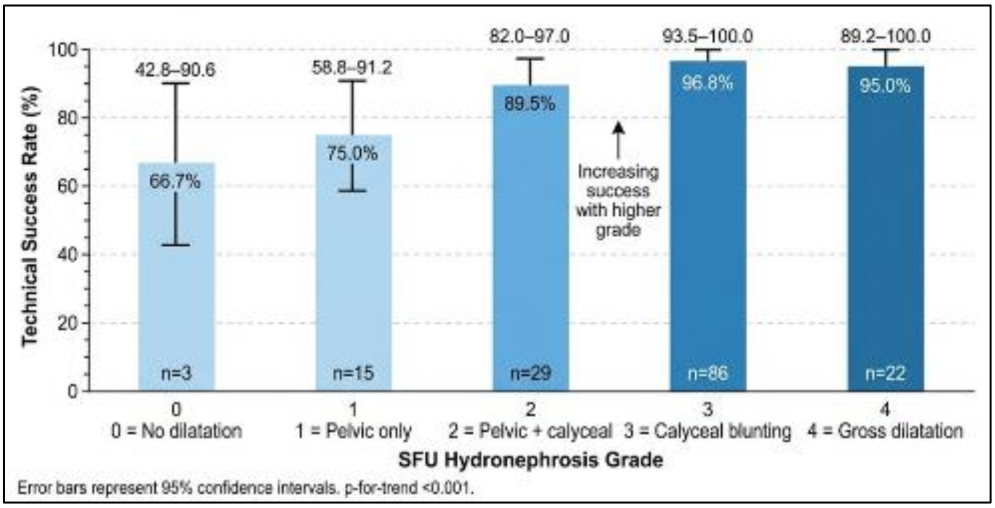

Figure 3 Technical Success by Hydronephrosis Grade

Legend: Bar chart showing the relationship between hydronephrosis severity (Society of Fetal Urology [SFU] grade) and percutaneous nephrostomy (PCN) technical success rates. Technical success progressively increased with higher hydronephrosis grades: grade 0 (66.7%), grade 1 (75.0%), grade 2 (89.5%), grade 3 (96.8%), and grade 4 (95.0%). The overall trend demonstrates that severe hydronephrosis (grades 3–4) is associated with significantly higher success rates compared to mild or absent hydronephrosis (grades 0–1). Error bars represent 95% confidence intervals.; **Abbreviations:** SFU, Society of Fetal Urology; PCN, Percutaneous Nephrostomy; CI, Confidence Interval.

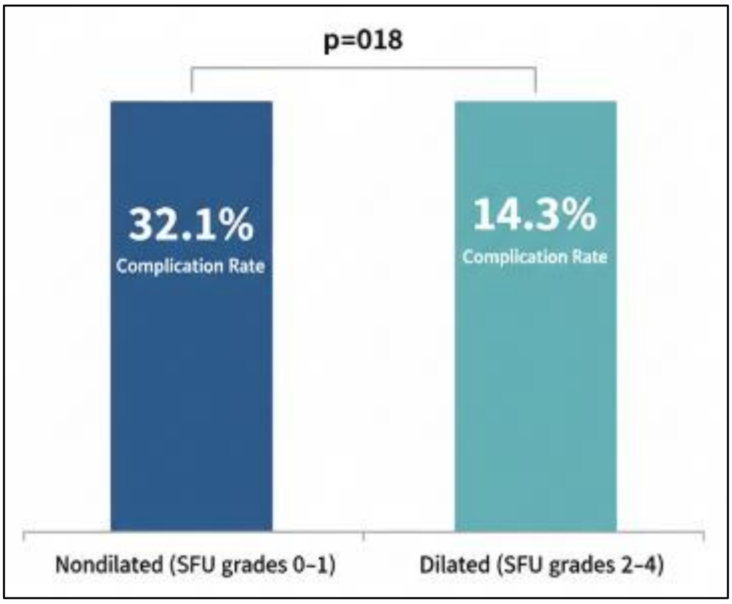

Figure 4 Complications by Hydronephrosis Grade

Legend: Bar chart comparing complication rates between nondilated (SFU grades 0–1) and dilated (SFU grades 2–4) collecting systems following percutaneous nephrostomy (PCN). Nondilated systems had a significantly higher complication rate (32.1%) compared to dilated systems (14.3%), p=0.018. This finding indicates that patients with mild or absent hydronephrosis are at increased risk for procedural complications, likely due to more challenging puncture and catheter placement in nondilated collecting systems.; **Abbreviations:** SFU, Society of Fetal Urology; PCN, Percutaneous Nephrostomy.

5. Conclusion

Pre-procedural Doppler ultrasound parameters—particularly hydronephrosis grade ≥3 and interlobar artery resistive index >0.70—are strong independent predictors of successful PCN insertion, with diagnostic accuracy comparable to intra-procedural fluoroscopy. A combined model incorporating both parameters achieves excellent discrimination

(AUC=0.94). Nondilated systems (SFU grade 0–1) represent a high-risk group with lower success and higher complication rates, in whom combined ultrasound-fluoroscopy guidance should be strongly considered. These findings support a risk-stratified approach to PCN planning based on pre-procedural imaging.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The author declares no conflict of interest.

Statement of ethical approval

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of the Ministry of Health, Jordan, on 1 May 2026 under registration number 1_5/26. Final approval from the Educational and Technical Directorate was obtained on 1 June 2026. Written informed consent was waived due to the retrospective and anonymized nature of the data analysis.

Statement of informed consent

AI tools used for language refinement and formatting; all content reviewed and approved by the author.

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