



Correlation of Pre-Operative Sonographic and Nuclear Scan Parameters with Intraoperative Renal Histopathology in Children with Congenital Pelviureteric Junction Obstruction

Fayaz Ahmad Najar¹, Ubayer Nabi¹, Faheem Ul Hassan Andrabi¹, Raashid Hamid¹, Waseem Jan Shah¹, Aejaz Ahsan Baba¹, Gowhar Nazir Mufti¹

¹ Department of Pediatric Surgery, Sher-i-Kashmir Institute of Medical Sciences, Soura, Srinagar, India

***Address for Corresponder:** Gowhar Nazir Mufti, Department of Pediatric Surgery, Sher-i-Kashmir Institute of Medical Sciences, Soura, Srinagar, India. (email: gowharmufti26@gmail.com)

How to cite this article:

Bihari Sharma Sh, Ashraf V, Sinha S, Gupta Sh, Kumar U, Kumar A, Sachan A. Ripped from the Cradle: Neonatal Gastric Perforation - A 10-Year Review of a Devastating Condition. Iranian Journal of Pediatric Surgery 2026; 12(1): 69 - 81.

DOI: <https://doi.org/10.22037/irjps.v11i2.49570>

Abstract

Introduction: Congenital pelviureteric junction obstruction (PUJO) is a leading cause of pediatric hydronephrosis and potentially reversible renal dysfunction. Pre-operative imaging plays a crucial role in surgical decision-making, yet its correlation with histopathologic renal injury remains underexplored.

To evaluate the relationship between pre-operative sonographic and nuclear scan parameters with intraoperative renal histopathology in children with congenital PUJO and identify imaging predictors of significant renal damage.

Materials and Methods: A prospective observational study was conducted among 60 children (<12 years) with unilateral PUJO undergoing Anderson–Hynes pyeloplasty. Pre-operative ultrasound parameters—Society for Fetal Urology (SFU) grade, anterior–posterior pelvic diameter (APD), cortical thickness, and Doppler resistive index (RI)—and nuclear parameters—differential renal function (DRF), drainage half-time ($T_{1/2}$), and renogram curve—were recorded. Renal cortical biopsies were graded using Elder’s histopathology scoring system. Significant histologic damage was defined as moderate/severe injury (score ≥ 6). Statistical correlations and ROC analyses were performed.

Results: High-grade hydronephrosis (SFU III–IV) was seen in 70%, APD ≥ 20 mm in 66.7%, and RI ≥ 0.70 in 45%. Nearly half had DRF $< 40\%$. On biopsy, 73.3% showed significant damage. Strong associations were observed for APD ≥ 20 mm ($p=0.017$), SFU $\geq III$ ($p=0.018$), and RI ≥ 0.70 ($p=0.030$). ROC analysis showed fair predictive accuracy—AUC: SFU = 0.707, RI = 0.697, APD = 0.640.

Conclusion: SFU grade $\geq III$, APD ≥ 20 mm, and RI ≥ 0.70 strongly correlate with histopathologic injury in PUJO and serve as practical, non-invasive predictors of parenchymal damage. Integrating these with renography may optimize surgical timing and preserve renal function.

Keywords

- APD
- Histopathology
- Pelviureteric junction obstruction
- Resistive index
- Ultrasound

Introduction

Congenital pelviureteric junction obstruction (PUJO) is the most common cause of antenatally detected hydronephrosis and a major contributor to potentially reversible paediatric renal

impairment¹. Its incidence is approximately 1 in 1000–1500 live births, with a male preponderance.² Early detection and timely surgical correction are essential to prevent irreversible

parenchymal loss. However, conventional imaging provides only indirect estimates of obstruction severity, and there is no universally accepted imaging parameter that accurately reflects histopathological damage.³

Ultrasound remains the cornerstone of evaluation, allowing assessment of hydronephrosis grade (SFU system), anterior–posterior pelvic diameter (APD), and cortical thickness. Yet, APD alone cannot reliably differentiate obstructive from non-obstructive dilatation.⁴⁻⁵

Quantitative Doppler indices such as the renal resistive index (RI) ≥ 0.70 have been proposed as markers of obstructive uropathy.⁶

Diuretic renography with Tc-99m MAG3 or DTPA assesses split renal function and drainage pattern. Differential renal function (DRF) $< 40\%$ or $T_{1/2} > 20$ minutes suggests functional impairment, but correlation with tissue damage remains imperfect.⁷⁻⁸

Histopathology, though invasive, remains the definitive indicator of renal parenchymal injury, reflecting the cumulative effects of obstruction.⁹ Correlating pre-operative imaging with histological findings can refine surgical timing and prognostication.²

Hence, this study aimed to correlate sonographic and nuclear scan parameters with intraoperative renal biopsy in children with PUJO, identifying imaging predictors of significant histologic injury.

Materials and Methods

A prospective observational study was conducted in the Department of Paediatric Surgery at Sher-i-Kashmir Institute of Medical Sciences, Srinagar, India. Data were collected from June 2022 to May 2025. The study was conducted in accordance with the Declaration of Helsinki and followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for reporting cohort studies.

Sample Size Calculation

Sample size was estimated using correlation-based methodology. Assuming an expected correlation coefficient $r = 0.4$ between imaging indices and biopsy grade, $\alpha = 0.05$, power = 0.80, the minimum sample required was $N = 47$ (calculated using the formula $n = [(Z\alpha + Z\beta)/0.5 \ln [(1 + r)/(1 - r)]]^2 + 3$). Accounting for 20% attrition, 60 patients were enrolled.

Inclusion and Exclusion Criteria

Children below 12 years of age with unilateral congenital pelviureteric junction obstruction (PUJO) confirmed on ultrasound and diuretic renography were included in the study. Only those cases who were planned for Anderson–Hynes pyeloplasty with intraoperative cortical biopsy were enrolled after obtaining informed parental consent.

Patients were excluded if they had secondary causes of obstruction such as calculi, trauma, vesicoureteric reflux, or posterior urethral valves. Cases with bilateral PUJO, solitary functioning kidney, or inadequate renal biopsy samples were also excluded. In addition, children with a history of prior pyeloplasty or any renal surgery were not considered eligible for inclusion.

Pre-operative Evaluation

Ultrasonography

All children underwent renal ultrasonography performed by a single paediatric radiologist using a high-frequency 7–10 MHz transducer. The assessment included Society for Fetal Urology (SFU) grade (I–IV), anterior–posterior pelvic diameter (APD, mm) in the transverse plane, cortical thickness (mm), and Doppler-derived renal resistive index

(RI). Parenchymal echogenicity, the presence of parenchymal thinning, and calyceal dilatation were also documented.

Nuclear Renograph

A standard diuretic renogram (Tc-99m DTPA or Tc-99m MAG3, as per institutional protocol) was performed pre-operatively. Recorded parameters comprised differential renal function (DRF, % for the affected side), drainage half-time ($T_{1/2}$, minutes), and the qualitative drainage curve pattern categorized as obstructed, equivocal, or non-obstructed.

Intraoperative Renal Biopsy

During Anderson–Hynes pyeloplasty, a small wedge cortical biopsy (~2 mm) was obtained from the lower pole of the affected kidney under direct vision, avoiding major vessels. The specimen was fixed in 10% buffered formalin and processed using routine hematoxylin–eosin and Masson's trichrome stains.

Histopathological grading was performed according to Elder's Histopathology Scoring System for obstructive nephropathy. Four histological parameters—glomerulosclerosis, tubular atrophy, interstitial fibrosis, and interstitial inflammation—were each scored from 0 to 3 (0 = none, 1 = mild < 25%, 2 = moderate 25–50%, 3 = severe > 50% involvement).

The total Elder's score (range 0–12) was obtained by summing the individual component grades and categorized as: 0–2: None, 3–5: Mild, 6–9: Moderate, 10–12: Severe.

For the purpose of analysis, significant histologic damage was defined as moderate or severe (Elder's score ≥ 6), corresponding to kidneys with notable interstitial fibrosis and tubular atrophy (IFTA) and/or inflammatory infiltration.

Statistical Analysis

Data was analyzed in SPSS v26. Descriptive statistics presented as mean \pm SD or n (%). Analytical tests used χ^2 /Fisher's exact for categorical data, *t*-test for continuous variables. ROC analysis determined optimal imaging cut-offs (Youden index). $p < 0.05$ considered significant.

Result

Table 1 shows the baseline profile of the study participants. Of the 60 children, males constituted two-thirds (39, 65.0%) and females one-third (21, 35.0%). The mean age was 4.3 ± 2.8 years, with more than half older than 5 years (32, 53.3%), followed by 1–5 years (21, 35.0%) and ≤ 1 year (5, 8.3%). Left-sided involvement predominated (40, 66.7%) over right-sided disease (20, 33.3%). Nearly half presented via antenatal detection of hydronephrosis (29, 48.3%), while symptomatic presentations included abdominal pain or mass (13, 21.7%) and urinary tract infection (12, 20.0%); incidental discovery accounted for a minority (6, 10.0%).

Variable	Category	n	%
Sex	Male	39	65.0
	Female	21	35.0
Age group (years)	≤ 1 y	5	8.3
	1–5 y	21	35.0
	> 5 y	32	53.3

Side involved	Left	40	66.7
	Right	20	33.3
Mode of presentation	Antenatal hydronephrosis	29	48.3
	Abdominal pain / mass	13	21.7
	UTI	12	20.0
	Incidental	6	10.0

Table 1: Baseline Characteristics of Study Participants

Table 2 summarizes the pre-operative ultrasound/Doppler profile. High-grade hydronephrosis was common, with SFU grade III–IV in 42 (70.0%) and I–II in 18 (30.0%). Pelvic dilatation was substantial: APD \geq 20 mm in 40 (66.7%) versus $<$ 20 mm in 20 (33.3%). Parenchymal

assessment showed cortical thickness 5–6.9 mm in 28 (46.7%), \geq 7 mm in 26 (43.3%), and $<$ 5 mm in 6 (10.0%), indicating a measurable subset with thinning. Nearly half demonstrated elevated intrarenal vascular resistance, with RI \geq 0.70 in 27 (45.0%).

Parameter	Category	n	%
SFU grade	I–II	18	30.0
	III–IV	42	70.0
APD (mm)	$<$ 20	20	33.3
	\geq 20	40	66.7
Cortical thickness (mm)	\geq 7	26	43.3
	5–6.9	28	46.7
	$<$ 5	6	10.0
Doppler RI	$<$ 0.70	33	55.0

	≥ 0.70	27	45.0
--	--------	----	------

Table 2: Pre-operative Imaging Parameters

Table 3 presents the pre-operative diuretic renography findings. Differential renal function (DRF) was ≥45% in 23 (38.3%), 40–44.9% in 8 (13.3%), 30–39.9% in 21 (35.0%), and <30% in 8 (13.3%), indicating that nearly half (29/60, 48.3%) had DRF <40% suggestive of functional

compromise. Consistent with this, drainage half-time (T½) was ≥20 minutes in 34 (56.7%), and the qualitative curve pattern was obstructed in 34 (56.7%), equivocal in 14 (23.3%), and non-obstructed in 12 (20.0%).

Parameter	Category	n	%
Differential Renal Function (DRF)	≥ 45%	23	38.3
	40–44.9%	8	13.3
	30–39.9%	21	35.0
	< 30%	8	13.3
Drainage half-time (T½)	< 20 min	26	43.3
	≥ 20 min	34	56.7
Drainage curve	Obstructed	34	56.7
	Equivocal	14	23.3
	Non-obstructed	12	20.0

Table 3: Pre-operative Nuclear Scan Parameters

Table 4 presents the renal histopathology results graded using Elder’s scoring system and the corresponding post-operative outcomes. Based on cumulative histologic

assessment, moderate-to-severe parenchymal injury (Elder’s score ≥ 6) was present in 44 (73.3%) cases, while only 16 (26.7%) showed none or mild changes.

Specifically, moderate IFTA was noted in 32 (53.3%) and severe IFTA in 12 (20.0%), mirroring the Elder's distribution. Inflammatory infiltrates were predominantly moderate to severe in 44 (73.3%), highlighting active interstitial changes accompanying fibrosis.

Postoperatively, 41 (68.3%) children demonstrated clinical or imaging improvement following pyeloplasty, while 19 (31.7%) remained stable or showed limited functional recovery, reflecting the influence of pre-existing histologic damage on early outcomes.

Variable	Category	n	%
IFTA grade	None / Mild	16	26.7
	Moderate	32	53.3
	Severe	12	20.0
Inflammation	None / Mild	16	26.7
	Moderate / Severe	44	73.3
Significant histologic damage	Yes	44	73.3
	No	16	26.7
Post-operative outcome	Improved	41	68.3
	Stable / Deteriorated	19	31.7

Table 4: Histopathology and Post-operative Outcomes

Table 5 shows the association between key pre-operative imaging markers and histologic injury. Kidneys with APD \geq 20 mm had a markedly higher prevalence of significant damage (84.6% vs 15.4% without damage; $p = 0.017$). Similarly,

high-grade hydronephrosis (SFU III–IV) was strongly associated with histologic injury (83.3% vs 16.7%; $p = 0.018$). A Doppler RI \geq 0.70 also aligned with substantial parenchymal injury (88.9% vs 11.1%; $p = 0.030$).

Imaging parameter	Histological damage		p-value
	Yes n (%)	No n (%)	
APD \geq 20 mm	33 (84.6 %)	6 (15.4 %)	0.017*
SFU grade III–IV	35 (83.3 %)	7 (16.7 %)	0.018*
RI \geq 0.70	24 (88.9 %)	3 (11.1 %)	0.030*

Table 5: Analytical Correlation Between Imaging and Histologic Damage

Figure 1 illustrates the discriminatory performance of the three pre-operative ultrasound markers against biopsy-defined significant histologic injury. SFU grade demonstrated the best accuracy (AUC = 0.707), followed by Doppler RI (AUC = 0.697) and APD (AUC = 0.640). Visually, the ROC for SFU grade sits furthest above the reference line across most of the false-

positive range, indicating stronger separation between damaged and non-damaged kidneys. The RI curve shows steady gains in sensitivity at modest false-positive rates, supporting its role as a functional adjunct to morphologic grading. The APD curve rises more gradually, suggesting lower stand-alone discriminative power.

Figure 1 (A–C): Receiver-Operating Characteristic (ROC) Curves for Imaging Predictors of Significant Histologic Injury

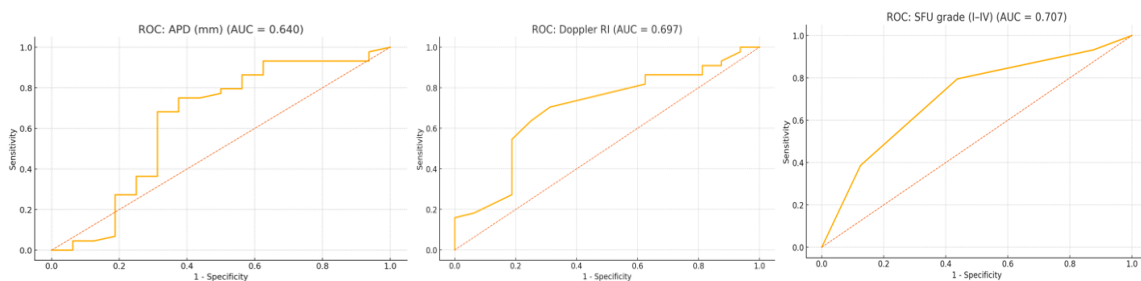


Table 6 summarizes the Youden-optimal thresholds and diagnostic metrics. An SFU cut-off \geq III yielded sensitivity 79.5% and specificity 56.2% with PPV 83.3%, indicating that high-grade hydronephrosis is a good “rule-in” indicator of histologic damage but may miss some milder cases. An RI threshold \geq 0.68–0.70 provided a

balanced profile (sensitivity 70.5%, specificity 68.8%, PPV 86.1%), reflecting the value of intrarenal hemodynamic in detecting clinically meaningful obstruction. APD \geq 20.1 mm achieved sensitivity 75.0% and specificity 62.5% with PPV 84.6%, supporting its pragmatic use as a simple morphometric trigger.

Marker	AUC	Optimal Cut-off	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
SFU grade	0.707	\geq III	79.5	56.2	83.3	50.0
Doppler RI	0.697	\geq 0.68	70.5	68.8	86.1	45.8
APD (mm)	0.640	\geq 20.1	75.0	62.5	84.6	47.6

Table 6: Diagnostic Performance of Imaging Parameters for Predicting Significant Histologic Injury on Biopsy

Discussion

Our study establishes a statistically significant correlation between pre-operative ultrasound parameters (SFU grade, APD, RI) and histopathological injury in children with PUJO. Nearly three-fourths of kidneys exhibited moderate-to-severe IFTA, signifying substantial

parenchymal compromise by the time of surgery.

Correlation of Ultrasound Parameters

The significant association of APD \geq 20 mm and SFU grade \geq III with histologic damage parallels findings by Passoni et al. and Viteri et al., who observed worsening

parenchymal injury with increasing hydronephrosis grade.²⁻³

Resistive Index ≥ 0.70 correlated with fibrosis severity, consistent with the functional obstruction threshold reported by Nam and Lee.⁶ Elevated RI reflects increased intrarenal vascular resistance secondary to chronic backpressure and interstitial edema.

Role of Nuclear Parameters

Although our analytical focus emphasized sonographic measures, more than half the cohort had delayed drainage ($T_{1/2} \geq 20$ min) and reduced DRF, indicating functional compromise. Similar findings were reported by a study, demonstrating moderate correlation between DRF decline and histopathologic scarring.⁷ However, due to overlap in intermediate DRF values, functional scans alone remain insufficient surrogates for tissue damage.

Histopathology as the Reference Standard

Biopsy findings of moderate/severe IFTA in 73 % emphasize that a large proportion of PUJO kidneys already harbour irreversible changes at presentation. Comparable proportions (60–75 %) were noted by Hassan et al. (2023) in paediatric

PUJO series.⁴ These highlight the necessity of timely surgical intervention guided by objective imaging criteria.

ROC-Derived Thresholds

Our ROC analysis identified SFU \geq III, APD ≥ 20 mm, and RI ≥ 0.70 as optimal cut-offs for predicting histologic damage (AUC ≈ 0.70). While modest, these metrics are non-invasive, inexpensive, and easily reproducible, rendering them clinically valuable for surgical decision-making—especially when renogram findings are equivocal.¹⁰

Clinical Implications

Integrating ultrasound + Doppler evaluation with nuclear renography enhances diagnostic confidence. A child demonstrating SFU \geq III with APD ≥ 20 mm or RI ≥ 0.70 warrants close surveillance or surgical intervention before irreversible fibrosis ensues.

Conclusion

Pre-operative ultrasonographic parameters—particularly SFU grade \geq III, APD ≥ 20 mm, and RI ≥ 0.70 —show significant correlation with renal histopathologic injury in children with

congenital PUJO. These metrics can serve as reliable, non-invasive indicators for surgical timing and prognostication, reducing reliance on invasive or equivocal diagnostic procedures.

Limitations, Future Directions, and Recommendations

Being a single-center investigation with a modest sample size, its findings may not be fully generalizable to broader populations. The biopsy sample was limited to a single cortical site, which might under-represent the overall renal parenchymal status. Additionally, the study lacked long-term postoperative follow-up, restricting evaluation of the relationship between preoperative imaging, histologic injury, and long-term renal function recovery. Minor operator-dependent variability in ultrasound and Doppler measurements may also influence reproducibility.

Ethical Consideration

Study was approved by Institutional ethics Committee of Sher-i-Kashmir Institute of Medical Sciences vide letter no. SIMS 131/IEC-SKIMS/2023-45 dated 04/04/2022.

Acknowledgment

Not applicable

Funding/Support

Not applicable

Conflict of interests

There is no conflict of interest

References

1. Klein J, Gonzalez J, Miravete M, Caubet C, Chaaya R, Decramer S, et al. Congenital ureteropelvic junction obstruction: human disease and animal models. *Int J Exp Pathol*. 2011 June;92(3):168–92 .
2. Viteri B, Calle-Toro JS, Furth S, Darge K, Hartung EA, Otero H. State-of-the-Art Renal Imaging in Children. *Pediatrics*. 2020 Feb;145(2): e20190829 .
3. Passoni NM, Peters CA. Managing Ureteropelvic Junction Obstruction in the Young Infant. *Front Pediatr*. 2020 May 27; 8:242 .
4. Hassan MG, Elmahdi TSA, Alotaibi M, Fallatah E, Nasser FA. Accuracy of Sonographic Renal Pelvic Diameter in Assessment of Renal Function among Patients with Ureteropelvic Junction Obstruction using Scintigraphy as a Gold Standard. *Int J Med Sci*. 2025 Jan 21;22(4):897–902 .
5. Zhang D, Sun X, Chen X, Yu B, Li T, Cheng Y, et al. Ultrasound evaluation for prediction of outcomes and surgical decision in fetal hydronephrosis. *Exp Ther Med*. 2019 Aug;18(2):1399–406 .
6. Nam JK, Lee SD, Chung MK. Modified Differential Renal Function Measurement Revised by Renal Cross-Sectional Area in Children with Ureteropelvic Junction Obstruction. *Korean J Urol*. 2010 Apr 1;51(4):271–5 .
7. Lee H, Han SW. Ureteropelvic Junction Obstruction: What We Know and What We Don't Know. *Korean J Urol*. 2009;50(5):423 .
8. Sachpekidis C, Schepers R, Marti M, Kopp-Schneider A, Alberts I, Keramida G, et al. 99mTc-MAG3 Diuretic Renography: Intra- and Inter-Observer Repeatability in the Assessment of Renal Function. *Diagnostics*. 2020 Sept 17;10(9):709 .
9. Kumar K, Ahmad A, Kumar S, Choudhry V, Tiwari RK, Singh M, et al. Evaluation of Renal Histopathological Changes, as a Predictor of Recoverability of Renal Function Following Pyeloplasty for Ureteropelvic Junction Obstruction. *Nephro-Urol Mon*. 2015 July 29;7(4): e28051 .
10. Mohammad SA, Rawash LM, AbouZeid AA. Imaging of urinary tract in children in different clinical scenarios: a guide for general radiologists. *Egypt J Radiol Nucl Med*. 2021 Dec;52(1):205.