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Original Research

Accuracy of non-contrast-enhanced magnetic resonance urography for measuring split renal function in children with ureteropelvic junction-type hydronephrosis: A feasibility diagnostic accuracy study

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Summary

Background
Hydronephrosis due to ureteropelvic junction obstruction (UPJO) is a common cause of paediatric urological morbidity. Split renal function (SRF), a key determinant in management, is traditionally assessed using renal dynamic scintigraphy (RDS), which involves ionizing radiation. This feasibility study evaluated whether non-contrast-enhanced MR urography (NCE-MRU) derived split renal volume (SRV) could serve as a radiation-free surrogate for SRF in children with UPJO-type hydronephrosis before pyeloplasty.

Methods
Twenty consecutive children (13 males, 7 females; 40 renal units) with UPJO-type hydronephrosis underwent ultrasound, RDS, and NCE-MRU prior to surgery. Renal volumetry was performed on T2-weighted images using manual segmentation in Horos software (Horos Project, Annapolis, MD, USA), by two independent observers (a paediatric surgeon and a radiologist). SRV was calculated for each renal unit and compared with RDS derived SRF using Pearson's correlation. Interobserver agreement was assessed with intraclass correlation coefficient (ICC) and Bland–Altman analysis. An exploratory threshold-based analysis was performed using an SRF cut-off of 40% to assess the diagnostic performance of MRU-derived SRV for identifying impaired renal units.

Results
Of the 40 renal units, 21 (Left 13, Right 6, Bilateral 1) demonstrated obstruction. SRV showed strong correlation with SRF for all renal units (Observer 1: $R = 0.948$, $p < 0.00001$; Observer 2: $R = 0.919$, $p < 0.00001$). Strong correlations were also observed in obstructed ($R = 0.888$ and 0.810) and non-obstructed units ($R = 0.890$ and 0.793). Inter-observer agreement was excellent ($ICC = 0.932$ overall), with minimal median bias on Bland–Altman analysis. In the threshold-based analysis, SRV showed 90.9% sensitivity, 89.7% specificity, 76.9% positive predictive value, 96.3% negative predictive value, and 90.0% overall accuracy for identifying impaired renal units. Threshold-based agreement was 90.0%, with threshold discordance and clinical misclassification in 4/40 and 1/40 renal units respectively.

Conclusions
NCE-MRU-derived SRV demonstrated strong correlation with RDS-derived SRF, excellent interobserver reproducibility, and high agreement with the clinically relevant 40% SRF threshold. These findings support NCE-MRU volumetry as a non-invasive, radiation-free complementary tool for functional assessment in selected cases of UPJO-type hydronephrosis rather than as a routine replacement for RDS. However, larger multicentric studies are needed to validate threshold agreement and define its role in longitudinal follow-up.

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Introduction

Ureteropelvic junction obstruction (UPJO) is the leading congenital cause of hydronephrosis in children and a major contributor to potentially preventable chronic kidney disease if not recognised and treated in time [1–3]. Across neonatal screening programmes and tertiary paediatric urology services, a large proportion of infants and children present with unilateral or bilateral pelvicalyceal dilatation that requires longitudinal functional assessment to decide between observation and surgical intervention, most commonly dismembered pyeloplasty [4–6]. Although ultrasound (US) is indispensable for surveillance because of its accessibility and absence of ionising radiation, US measurements of pelvic diameter and parenchymal thickness do not directly quantify kidney contribution to overall function, and interobserver variability can be substantial in borderline cases [7]. Consequently, split renal function (SRF) derived from renal dynamic scintigraphy (RDS) remains the reference test in clinical algorithms, with thresholds such as SRF $<$40% or a fall of $>$10% over time often triggering operative management [8,9]. However, RDS entails exposure to ionising radiation, limited anatomical information, need for venous cannulation and diuretics, and logistic dependence on nuclear medicine facilities—factors that are particularly relevant in young children and in resource-constrained settings [7].

Magnetic resonance urography (MRU) has matured into a comprehensive modality that unites anatomical depiction with functional assessment while avoiding ionising radiation [8,10]. Two broad MRU paradigms exist. Dynamic contrast-enhanced MRU (fMRU) uses gadolinium chelates to generate time–intensity curves that recapitulate perfusion, filtration, and excretion, closely mirroring radionuclide renography but with superior spatial resolution and the added ability to interrogate drainage patterns [9–11]. Non-contrast-enhanced MRU (NCE-MRU) relies primarily on heavily T2-weighted sequences to display static fluid and parenchyma and can be combined with diffusion-weighted imaging (DWI) and other non-contrast techniques to augment tissue characterisation [7]. While fMRU can reproduce renographic parameters, it requires gadolinium administration and post-processing expertise; conversely, NCE-MRU eliminates contrast-related risks and can be completed rapidly with fewer workflow constraints, which is advantageous in children and in centres seeking to minimise sedation or general anaesthesia [11].

As a surrogate for SRF on RDS, an appealing simplification is to use parenchymal volumetry on NCE-MRU based on the physiological premise that, in the absence of acute oedema or severe dysplasia, the relative volume of functioning renal parenchyma approximates its relative contribution to global function [12,13]. Several paediatric series and reviews have proposed or demonstrated strong correlations between volumetric indices and differential renal function, with the added benefit that MRU simultaneously clarifies anatomical variants, crossing vessels, and extra-renal pelvis configurations relevant to surgical planning [14–17]. In parallel, unenhanced MRI has been shown to match 99mTc-DMSA for cortical scar detection, illustrating that MRI can substitute selected nuclear studies when protocols are optimised [18]. Against this background, we conducted a feasibility diagnostic accuracy study to evaluate whether NCE-MRU-derived split renal volume (SRV%) can estimate SRF% from RDS in children with UPJO, and whether such measurements are reproducible across two independent observers, a paediatric surgeon and a trained radiologist, reflecting real-world multidisciplinary practice.

Materials and methods

Study design

This prospective, single-centre, feasibility study of consecutive children with UPJ-type hydronephrosis was conducted in the Department of Paediatric Surgery at a tertiary care centre in India. Ethics approval was obtained from the institutional ethics committee (Ref no: AIIMSA3639/08.04.2025), and the procedures conformed to the principles of the Declaration of Helsinki. A written informed consent was secured from legal guardians for imaging and data usage in the study. An assent was also sought from the participants as age appropriate. All imaging for the index MRU was scheduled prior to definitive surgery to avoid post-operative confounding.

Participants

A total of twenty children were consecutively recruited in this study. The diagnosis of UPJO (unilateral/bilateral) was based on clinical presentation and findings of radionuclear studies [5]. For this feasibility study, inclusion was limited to children aged 5 years and above to allow effective communication and ensure adequate cooperation during MRU acquisition. Prior to imaging, children and their caregivers were counselled in detail regarding the MRU procedure to encourage cooperation and alleviate anxiety. This approach helped minimise motion artefacts and ensured high-quality imaging within the shortest feasible acquisition time. All MRU examinations were successfully completed without sedation or general anaesthesia. Exclusion criteria were children having recurrent UPJO and requiring redo-pyeloplasty, or other renal surgery, or those with contraindications to MRI.

Reference test

RDS served as the clinical reference because of its widespread adoption and explicit reporting of differential function despite known limitations in anatomical resolution [19]. Each patient underwent RDS using technetium-99m–labelled L,L-ethyl cysteine (99mTc-LLEC) as the radionuclide according to departmental protocol (F = 0) to obtain SRF (%) for left and right kidneys [20]. Drainage patterns were evaluated using time–activity curves and delayed images, and classified as non-obstructive or obstructive based on tracer clearance. Renal units demonstrating no significant tracer clearance up to the 4-h delayed image were categorized as having obstructive drainage.

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Index test

NCE-MRU was performed on a single platform using a standardised protocol comprising coronal and axial T2-weighted fat-saturated and T2-weighted non-fat-saturated sequences along with DWI at b = 50, 300, and 400 s/mm^2 with ADC maps. The slice thickness was 0.4 cm, with an interslice gap of 0.04 cm. No diuretics or gadolinium contrast were administered. Bilateral kidneys were scanned in their entirety to capture the full parenchymal extent and pelvicalyceal system even in markedly dilated cases.

Segmentation and volumetry

Two observers independently analysed the T2 stacks in Horos, an open-source DICOM viewer (Horos Project, Annapolis, MD, USA, www.horosproject.org). Using a closed-polygon tool, the observers traced kidney outlines on each slice to include only renal parenchyma, excluding the collecting system and sinus vessels (Fig. 1). Per-slice areas were multiplied by the known slice thickness and summed to generate per-kidney parenchymal volume.

Volume calculation: Renal parenchymal volume was calculated using a slice summation method, where:

- Volume = Σ (Area of ROI per slice × Effective slice thickness).
- Effective slice thickness = Slice thickness + interslice gap = 4.0 mm + 0.4 mm = 4.4 mm (0.44 cm).

Thus, for each slice: Volume per slice (cm^3) = ROI area (cm^2) × 0.44 cm.

Split renal volume (SRV, %) was computed as the kidney's parenchymal volume divided by the bilateral total volume × 100. The entire process of segmentation and volumetry was performed by a paediatric surgeon (Observer 1) and a trained radiologist (Observer 2) who were blinded to one another's measurements and to RDS values.

Outcomes

The primary outcome was the correlation between SRV (%) and RDS-derived SRF (%) across all renal units. Secondary outcomes included observer-specific correlations; subgroup analyses in obstructed versus non-obstructed renal units. Interobserver agreement between Observer 1 and 2 estimated by intraclass correlation for absolute agreement (ICC [1,2]); and Bland–Altman bias and limits of agreement (LoA). We additionally reported the median percentage error (Observer 1 minus Observer 2) to evaluate whether volumetric analysis could be performed reliably even in the absence of a trained radiologist.

Statistical analysis

The statistical analyses were performed using R software (version 4.5.2). Normality of the MRU-derived renal parenchymal volumes (estimated by each observer) was assessed using the Shapiro–Wilk test, which did not show significant deviation from normality (Observer 1:

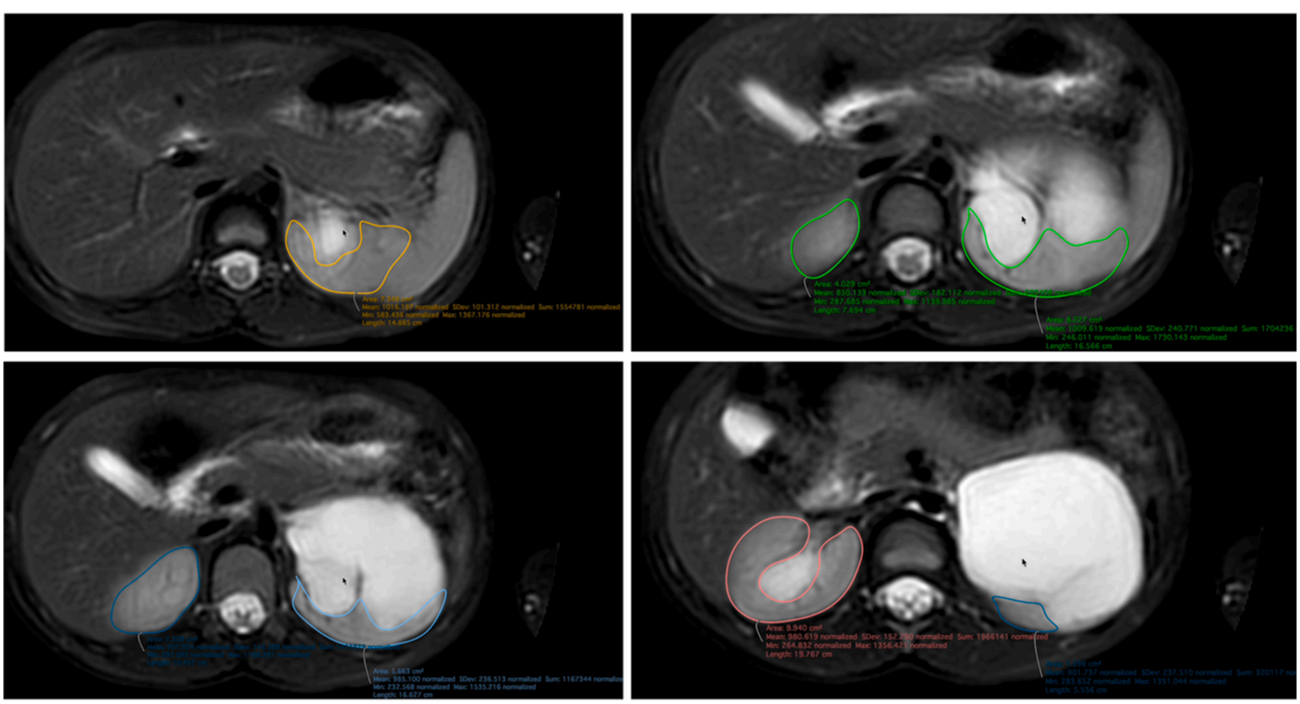

Fig. 1 Axial T2-weighted non-contrast-enhanced magnetic resonance urography (NCE-MRU) images showing manual polygon-based segmentation of renal parenchyma for volumetric analysis in a child with left ureteropelvic junction obstruction (UPJO). Slice-wise regions of interest exclude the pelvicalyceal system and renal sinus, enabling calculation of cumulative renal parenchymal volume and split renal volume.

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W = 0.965, p = 0.241; Observer 2: W = 0.962, p = 0.198). Linearity between SRV% and SRF was assessed by visual inspection of scatter plots, which demonstrated an approximately linear relationship; accordingly, Pearson's correlation coefficient was used to quantify linear association between SRV% and SRF. Interobserver reliability was evaluated using a two-way random-effects, absolute-agreement ICC (2,1), reflecting typical reproducibility between readers in clinical practice. Bland–Altman analysis was performed to assess bias and limits of agreement between observers. All analyses were performed kidney-wise to reflect clinical decision-making at the renal unit level. Also, the results were stratified by obstruction status.

Threshold-based diagnostic performance analysis

For exploratory threshold-based diagnostic performance analysis, impaired renal function was defined as SRF <40% on RDS, and the same threshold was applied to MRU-SRV. For this analysis, a single SRV value per renal unit was derived by averaging the observer-specific SRV measurements. Using RDS-based SRF as the reference standard, we calculated sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of MRU-derived SRV for identifying impaired renal units. We also assessed threshold-based agreement between SRV and SRF and recorded formal threshold discordance, defined as opposite classification by SRV and SRF taking the 40% cut-off. In addition, discordant cases were reviewed in their clinical context to distinguish threshold discordance from potential clinical misclassification.

Results

A total of 40 renal units from 20 children (13 males, 7 females) with a mean age of 7.7 ± 2.1 years (range: 5–12 years) were included. Antenatal hydronephrosis was documented in 10 patients (50%). The most common clinical presentation was asymptomatic follow-up of antenatally detected hydronephrosis (n = 8), abdominal pain (n = 5), abdominal lump (n = 4), incidental detection on imaging (n = 2) and urinary tract infection (n = 1). Out of the 40 renal units studied, 21 were obstructed and 19 were non-obstructed. One child had bilateral obstruction while left-sided disease predominated in the remaining children (13/20; 65%).

Analysis of all renal units together demonstrated that SRV% on NCE-MRU correlated strongly with SRF% from RDS. For Observer 1, R = 0.9483 (95% CI 0.9037 to 0.9725); R^2 = 0.8992, $p < 0.00001$; for Observer 2, R = 0.9191 (95% CI 0.8514 to 0.9567); R^2 = 0.8448; $p < 0.00001$ (Fig. 2a and b). Interobserver agreement for SRV% was excellent with ICC(2,1) = 0.932 (95% CI 0.875 to 0.963). Bland–Altman analysis demonstrated a negligible mean bias (approximately 0%), with LoA −19.77%–19.77%, and the median percentage error was −0.27%, confirming minimum systematic difference between observers (Obs1–Obs2) (Fig. 2c).

Correlations remained high for obstructed renal units (n = 21). For Observer 1, R = 0.888 (95% CI 0.740 to 0.954); R^2 = 0.7885; $p < 0.00001$ while for Observer 2, R = 0.810

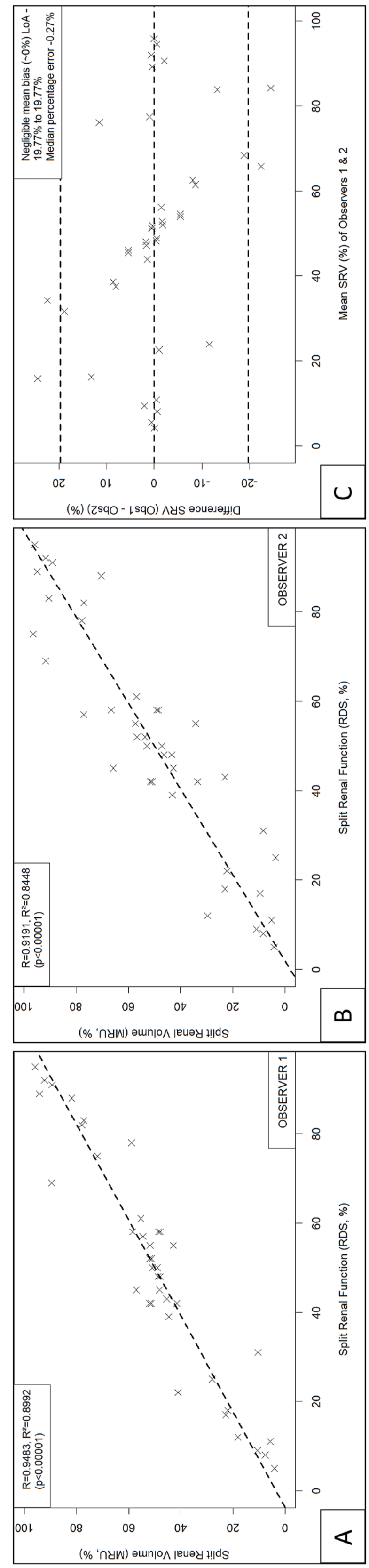

Fig. 2 Split renal volume (SRV) and split renal function (SRF) correlation for all renal units. **a and b:** Scatter plots demonstrating tight linear relationships between SRV% and SRF% for each observer; **c:** Bland–Altman analysis of interobserver agreement for SRV (%) confirming small bias and acceptable limits of agreement.

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(95% CI 0.5811 to 0.9198); $R^2 = 0.6555$; $p < 0.00001$. Interobserver ICC was 0.854 (95% CI 0.632 to 0.941), with Bland–Altman bias of 4.65% and LoA −12.49%–21.79%; the median error was 3.60% (Fig. 3a and b). These results suggest that volumetric estimates remain reliable even when the collecting system is dilated and parenchyma thinned out.

Among non-obstructed renal units (n = 19), correlations were also strong. For Observer 1, R = 0.890 (95% CI 0.7311 to 0.9572); $R^2 = 0.7918$; $p < 0.00001$ while for Observer 2, R = 0.793 (95% CI 0.5289 to 0.9168), $R^2 = 0.6283$ ($p < 0.0001$). Interobserver ICC was 0.834 (95% CI 0.565 to 0.936); Bland–Altman bias was −5.14% with LoA −22.92%–12.65%; the median error was −2.6% (Fig. 3c and d). The reproducibility in non-obstructed kidneys underscores that the volumetric estimates are reproducible even where obstruction is not established. The results of the correlation analysis performed by both observers, including subgroup analysis by obstruction status, are summarised in Table 1.

Using a prespecified exploratory threshold of 40%, MRU-derived SRV showed a sensitivity of 90.9%, specificity of 89.7%, positive predictive value of 76.9%, negative predictive value of 96.3%, and overall accuracy of 90.0% for identifying renal units with impaired function, defined as SRF <40% on RDS. Threshold-based agreement between SRV and SRF was 90.0%, with formal threshold discordance in 4/40 (10.0%) renal units. A review of the discordant cases in their clinical context showed that 3 of the 4 discordant renal units occurred in symptomatic children who

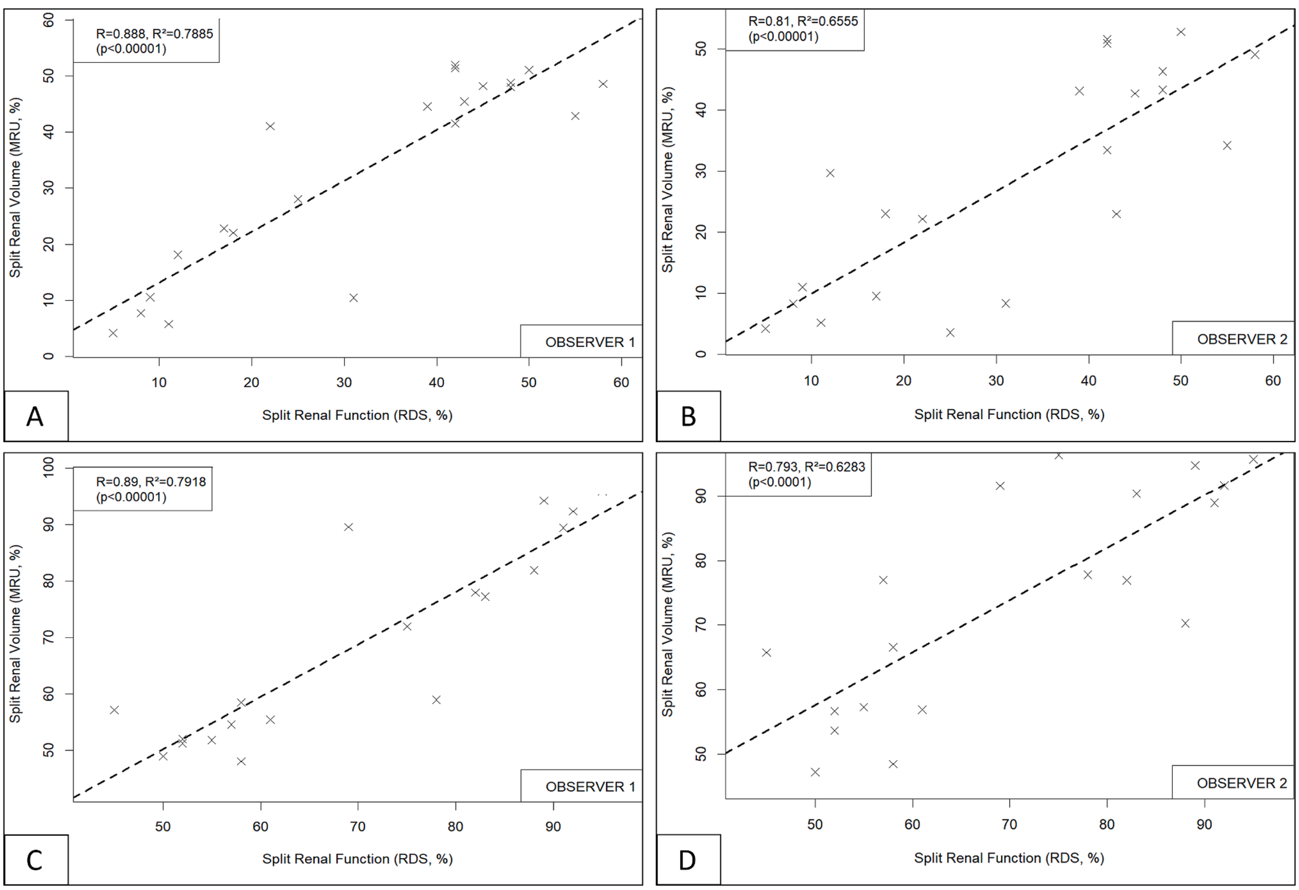

Fig. 3 Split renal volume (SRV) and split renal function (SRF) correlation for renal units based on obstruction status. **a and b:** Stratified scatter plots of SRV vs SRF for Observer 1 and 2 in obstructed renal units; **c and d:** Stratified scatter plots of SRV vs SRF for Observer 1 and 2 in non-obstructed renal units.

Table 1 Interobserver agreement, Bland–Altman for SRV (%) and robust (median) percentage error (Observer 1 vs Observer 2).

Analysis set	ICC 2,1 (95% CI)	Mean diff (Obs1–Obs2), %	95% LoA	Median % error
All kidneys	0.932 (95% CI 0.875 to 0.963)	0%	−19.77 to 19.77%	−0.27%
Obstructed	0.854 (95% CI 0.632 to 0.941)	4.65%	−12.49 to 21.79%	3.60%
Non-obstructed	0.834 (95% CI 0.565 to 0.936)	−5.14%	−22.92 to 12.65%	−2.6%

Abbreviations.
SRV- split renal volume, ICC- Intraclass Correlation, CI, confidence interval, LoA- Limits of Agreement.

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Table 2 Renal-unit level comparison of differential renal volume on MRU and differential renal function on RDS.

Patient no	Renal unit no	Side	% SRV on MRU	% SRF on RDS	Status	Presentation
1	1	Left	22.5229405	18	Obstructed	Asymptomatic
	2	Right	77.4835521	82	Non-obstructed	
2	3	Left	51.1661827	42	Obstructed	UTI
	4	Right	48.8367213	58	Obstructed	
3	5	Left	83.203783	83	Non-obstructed	Pain
	6	Right	16.800097	17	Obstructed	
4	7	Left	45.6122175	45	Obstructed	Asymptomatic
	8	Right	54.3772656	55	Non-obstructed	
5	9	Left	48.0444526	50	Non-obstructed	Asymptomatic
	10	Right	51.9629765	50	Obstructed	
6	11	Left	95.6918985	95	Non-obstructed	Lump
	12	Right	4.30728314	5	Obstructed	
7	13	Left	47.1658665	48	Obstructed	Asymptomatic
	14	Right	52.8401344	52	Non-obstructed	
8	15	Left	17.7088689	25	Obstructed	Asymptomatic
	16	Right	82.2737789	75	Non-obstructed	
9	17	Left	75.5288978	88	Non-obstructed	Asymptomatic
	18	Right	24.469086	12	Obstructed	
10	19[a]	Left	38.9654622	55	Obstructed	Pain
	20	Right	61.0286352	45	Non-obstructed	
11	21	Left	9.38722295	31	Obstructed	Asymptomatic
	22	Right	90.6179922	69	Non-obstructed	
12	23[a]	Left	37.7063572	42	Obstructed	Pain
	24	Right	62.2926337	58	Non-obstructed	
13	25	Left	5.50821713	11	Obstructed	Lump
	26	Right	94.5079681	89	Non-obstructed	
14	27	Left	10.7991434	9	Obstructed	Pain
	28	Right	89.2051398	91	Non-obstructed	
15	29	Left	91.9672918	92	Non-obstructed	Lump
	30	Right	8.0329263	8	Obstructed	
16	31	Left	33.2127976	22	Obstructed	Pain
	32	Right	66.7993552	78	Non-obstructed	
17	33[a,b]	Left	43.8631535	39	Obstructed	Asymptomatic
	34	Right	56.1347498	61	Non-obstructed	
18	35[a]	Left	35.7046242	43	Obstructed	Lump
	36	Right	64.3037278	57	Non-obstructed	
19	37	Left	45.7510818	48	Obstructed	Incidental
	38	Right	53.567069	52	Non-obstructed	
20	39	Left	48.2355908	58	Non-obstructed	Incidental
	40	Right	51.758057	42	Obstructed	

Abbreviations: SRV, split renal volume. MRU, magnetic resonance urography. DRF, differential renal function. RDS, renal dynamic scan. UTI, urinary tract infection.
[a] Threshold discordance.
[b] Clinical misclassification.

underwent surgery on clinical grounds despite SRF>40% on the affected side (Table 2). Thus, only one renal unit represented a potentially management-relevant clinical misclassification in this cohort, where %SRV and SRF were 43.9% and 39% respectively (Table 2).

Discussion

This feasibility study conducted in a prospective paediatric cohort with UPJO was undertaken to evaluate the correlation between SRF measured on RDS and SRV derived from MRU, as RDS is not only invasive and associated with radiation exposure but is also not readily or uniformly available across all centres. In contrast, NCE-MRU involves no radiation or contrast administration, and MRI is now widely available at many institutions. Also, MRU resolves anatomic questions crucial for operative planning, e.g., high ureteric insertion, crossing vessels, extrarenal pelvis, associated ureteral anomalies, potentially reducing reliance on multiple separate investigations in selected cases [3]. An additional advantage of MRU is that it does not require complex functional interpretation, such as assessment of O'Reilly curves. MRU also allows clear visualisation in cases

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that may be reported as equivocal on RDS, often due to variability in nuclear medicine protocols, including differences in diuretic use and non-uniform interpretation based on tracer clearance.

In this study, we observed a strong correlation between SRF and SRV in all renal units, and in both obstructed and non-obstructed renal units, with excellent overall agreement. Furthermore, analysis by two independent observers with differing levels of experience, a trained radiologist and a paediatric surgeon, demonstrated minimal median error and excellent interobserver agreement, underscoring that MRU-based volumetric assessment is a simpler, reproducible investigation with a relatively short learning curve. However, a broader validation across centres is still required. These results suggest that NCE-MRU may provide both detailed anatomical information and a reproducible estimate of SRF within a single examination [3]. Such a pathway is attractive to families and health systems seeking to reduce radiation dose, limit multiple visits, and streamline decision-making in UPJO [7,21].

In addition to the strong correlation analysis, our exploratory threshold-based analysis adds clinically relevant context for these findings. Using the commonly applied 40% cut-off for impaired split renal function, MRU-derived SRV demonstrated high sensitivity, specificity, and overall accuracy for identifying renal units with reduced function. Threshold-based agreement between SRV and SRF was also high, with discordance observed in only a small proportion of renal units. Importantly, review of the discordant cases showed that most occurred in symptomatic children who proceeded to surgery on clinical grounds despite SRF remaining above 40%, suggesting that formal threshold discordance does not necessarily translate into clinically misclassification.

Our results cohere with He et al., demonstrating strong agreement between NCE-MRU volumetry and RDS within a short imaging interval, while extending that work via a prospective design, explicit reporting of interobserver ICC, and a no-sedation protocol [13]. In contrast to dynamic fMRU studies that reproduce renogram curves using gadolinium, we show that simple volumetry alone already tracks SRF closely, thereby obviating contrast in many scenarios [6]. Complementary literature has also highlighted the ability of unenhanced MRI to replace certain nuclear studies such as DMSA for cortical scarring, reinforcing the wider potential of MR-based strategies to reduce radiation in children [18].

SRF is, by definition, a relative contribution of each kidney to bilateral function. Barring acute oedema or extreme dysplasia, parenchymal volume correlates with nephron mass and viable cortex, which largely determine relative excretory function; chronic obstruction, conversely, is accompanied by parenchymal thinning and reduced volume share [7]. Our consistent correlations across obstructed and non-obstructed units, and the small interobserver median error, provide empirical confirmation of this physiological coupling. Moreover, volumetry explicitly excludes the collecting system, preventing overestimation due to hydronephrotic dilatation—a key technical point in our segmentation protocol.

A key clinical challenge with reliance on RDS and SRF for decision-making arises in children with asymptomatic hydronephrosis who demonstrate an SRF greater than 40% but exhibit an obstructive drainage pattern on RDS and are therefore managed conservatively with surveillance rather than pyeloplasty [22]. In such cases, clinicians are often compelled to perform RDS investigations at regular intervals during follow-up, exposing children to serial nuclear scans with cumulative radiation exposure. These children also undergo repeated ultrasonographic evaluations, which are operator dependent and lack clearly defined anatomical thresholds to guide the timing of surgical intervention [23–25]. The renal-unit level data in our cohort also illustrate that symptoms, obstruction/drainage status, and split renal function do not always align directly, underscoring that clinical decision-making in UPJO relies on integration of anatomical, functional, and symptomatic factors rather than any single parameter in isolation. In this context, NCE-MRU may serve as a useful imaging modality by providing anatomical assessment along with an estimate of SRV as a surrogate of SRF. This potential role warrants further evaluation in future studies before incorporation into routine clinical algorithms.

In practical terms, and based on the available evidence, NCE-MRU is unlikely to replace routine RDS for all children with UPJO-type hydronephrosis. A more realistic role of NCE-MRU is in selected scenarios, such as older cooperative children with equivocal findings, cases with discordance between ultrasound and scintigraphy, or when detailed anatomical assessment is required alongside estimation of relative renal function. A high agreement of MRU-derived volumetric assessment with the commonly used 40% SRF threshold in our cohort suggests that NCE-MRU may also provide decision-relevant information in these patients. Another particularly relevant application may be in children with preserved SRF but obstructive drainage curves who are managed with surveillance, in whom NCE-MRU-based volumetry could eventually be evaluated as a radiation-free tool for serial functional follow-up. However, even in these potentially relevant indications, practical constraints related to MRI availability and resource utilisation must be acknowledged. In many health systems, MRI remains a relatively expensive and high-demand modality, which may limit the feasibility of NCE-MRU in routine practice.

The findings of this study must be interpreted within the context of certain limitations. This single-centre study was conducted in a specialized tertiary-care setting, which may limit the generalizability of the findings to less specialized centres. The study had a modest sample size, so precision around subgroup estimates is limited. It was conducted in a selected cohort of cooperative children aged 5 years and above in whom NCE-MRU could be performed without sedation. Therefore, the findings may not be directly generalizable to infants and younger children, in whom MRI often requires sedation or general anaesthesia, thereby altering the risk-benefit balance of this technique as an alternative to radionuclide imaging. Although selected infants may occasionally undergo MRI without sedation using feed-and-swaddle techniques in experienced centres [26,27], this was not evaluated in the present study. Accordingly, the current findings are most directly applicable to older cooperative children. Our volumetry was manual, which is labour-intensive and susceptible to reader fatigue; however, the strong ICC mitigates concern over

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random error. Although manual segmentation remains time-consuming and may limit immediate routine applicability, the high interobserver reproducibility observed in this study suggests that the measurement itself is robust when a standardized protocol is applied. We therefore interpret these findings as supporting feasibility and reproducibility rather than indicating that the workflow barriers to implementation have been overcome. Wider clinical translation will likely depend on semi-automated or automated segmentation workflows that reduce analysis time and operator dependence. Also, we did not include a functional MRU arm or longitudinal postoperative follow-up; therefore, the incremental value of dynamic MR parameters and the ability of MRU-derived SRV to track changes after pyeloplasty remain to be established.

Nevertheless, the current study supports the potential role of NCE-MRU as a feasible radiation-free adjunct to RDS for the assessment of renal cortical function. Key strengths of our study include a prospective design, a homogeneous UPJO cohort, imaging performed without sedation or gadolinium and dual-observer analysis with rigorous reproducibility statistics. Segmentation rules were simple and transparent, tracing parenchyma while excluding sinus and pelvicalyceal system, thus, reducing ambiguity and facilitating reproducibility. By reporting both Pearson correlations and Bland—Altman with median percentage error, we provide complementary perspectives on accuracy and bias. A further strength is that we extended the analysis beyond correlation alone by evaluating diagnostic performance at a clinically relevant SRF threshold, including sensitivity, specificity, overall accuracy, and the clinical context of discordant cases.

In future, multicentre validation with scanner-agnostic protocols is needed to ensure generalisability, including harmonisation of slice thickness, fat-saturation, and DWI parameters. Also, development of semi-automated or AI-assisted segmentation with quality-control overlays could cut analysis time and further improve reproducibility. Decision-analytic studies comparing US → RDS vs US → NCE-MRU pathways in terms of cost, turnaround time, and radiation would clarify health-system value, particularly in regions with constrained nuclear medicine capacity.

Conclusions

In this feasibility study, we demonstrated that parenchymal SRV on NCE-MRU closely mirrored SRF on RDS, with strong linear correlations and high interobserver reproducibility. In addition, MRU-derived SRV showed high agreement with the 40% SRF threshold. These results support the use of NCE-MRU as a non-invasive, radiation-free complementary modality with potential to support functional assessment in paediatric UPJO-type hydronephrosis. However, future studies with a larger sample size validating the SRF decision thresholds are required before any definite conclusions are drawn in this regard.

Ethics approval and consent to participate

Ethical approval was obtained from the institutional ethics committee (Ref no: AIIMSA3639/08.04.2025). Written informed consent was obtained from the legal guardians of all participants.

Data availability

All analyzed data has been presented in the manuscript. Additional data are available from the corresponding author upon reasonable request.

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