

The role of non-contrast-enhanced magnetic resonance urography in urinary tract imaging of pediatric patients

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Recurrent urinary tract infections in children are frequently associated with congenital anomalies of the kidneys and urinary tract.^[1] When inadequately treated or recurrent, these conditions pose a risk for renal scarring and long-term impairment of renal function.^[2,3] According to the ALARA (as low as reasonably achievable) principle, radiation-free imaging modalities should be prioritized in pediatric populations. Therefore, ultrasonography (US) remains the first-line imaging method; however, it has limited ability to delineate the full ureteral course and to identify complex collecting system variations.^[4,5] Although magnetic resonance urography (MRU) provides detailed anatomical evaluation of the urinary tract, its routine use in pediatric practice remains limited. In selected cases with inconclusive or discordant

Abstract

Objectives: This study aim to evaluate the indications, anatomical information, and diagnostic contribution of non-contrast-enhanced magnetic resonance urography (MRU) in pediatric patients.

Patients and methods: Thirty-three pediatric patients (17 males, 16 females; mean age: 10.6 ± 4.9 years; range, 5 to 17 years) who underwent non-contrast-enhanced MRU between January 2013 and December 2024 were retrospectively reviewed. All examinations were performed using heavily T2-weighted sequences that did not require sedation, and MRU findings were compared with concurrent ultrasonography results.

Results: Non-contrast-enhanced MRU provided excellent anatomical resolution, particularly in structural anomalies such as hydronephrosis, ureteropelvic junction and ureterovesical junction stenoses, and duplicated collecting systems. However, non-contrast-enhanced MRU did not offer direct functional assessment of the kidneys.

Conclusion: Non-contrast-enhanced MRU is a safe, reproducible, and radiation-free imaging technique for detailed evaluation of the pediatric urinary tract anatomy. It serves as a valuable second-line diagnostic modality in cases where ultrasonography yields inconclusive or limited findings.

Keywords: Ectopic ureter, hydronephrosis, non-contrast-enhanced MRU, pediatric MR urography, urinary tract anomalies.

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ultrasonography findings, non-contrast MRU may provide additional anatomical information.

For specific anatomic conditions such as ectopic ureteral insertion, MRU provides multiplanar, high-tissue-contrast evaluation and offers a distinct diagnostic advantage. Given its ability to provide detailed, radiation-free, and multiplanar anatomical evaluation, MRU has been increasingly utilized in pediatric urology.^[6,7]

This study aimed to assess the diagnostic contribution of non-contrast-enhanced MRU in pediatric patients with clinical findings that could not be fully explained by US.

PATIENTS AND METHODS

Thirty-three pediatric patients (17 males, 16 females; mean age: 10.6 ± 4.9 years; range, 5 to 17 years) who underwent non-contrast-enhanced MRU between January 2013 and December 2024 were retrospectively reviewed, along with their concurrent clinical and US findings. Inclusion criteria consisted of pediatric patients who underwent non-contrast MRU without sedation due to urinary tract-related clinical findings and who had US examinations performed within a similar time period. Patients who required sedation during MRU, those who underwent contrast-enhanced MRU, and cases with incomplete imaging or clinical data were excluded from the study. Written informed consent was obtained from the parents of all participants. The study protocol was approved by the Hatay Mustafa Kemal University Non-Interventional Clinical Research Ethics Committee (Date: 27.08.2025. Decision No: 07). The study was conducted in accordance with the principles of the Declaration of Helsinki.

All examinations were performed on a Philips Ingenia 1.5T system (Philips Healthcare, Best, the Netherlands) using a heavily T2-weighted protocol. The primary sequences included were as follows: (1) axial T2 MultiVane XD to evaluate the level

of stenosis and surrounding anatomy; (2) coronal three-dimensional heavily T2-weighted (magnetic resonance cholangiopancreatography-like) sequences to visualize the collecting system and ureters in three dimensions; (3) T2-long TE to provide additional anatomical detail in cooperative patients. All scans were acquired under free-breathing conditions without the need for breath-holding. The average total examination time was 5 to 9 min.

All patients were clinically examined by the Department of Pediatric Surgery. Magnetic resonance urography images were evaluated in consensus by two radiologists (with 15 and 7 years of experience, respectively). All datasets were transferred to a digital workstation and analyzed on high-resolution diagnostic monitors.

Statistical analysis

Statistical analysis was limited to descriptive statistics. Categorical variables were expressed as numbers and percentages, and continuous variables were summarized using ranges. No comparative or inferential statistical analyses were performed due to the descriptive and observational nature of the study.

RESULTS

Concurrent US findings were available for all patients, with two examinations performed at outside institutions. The most common indication for MRU was discordance between US findings and clinical

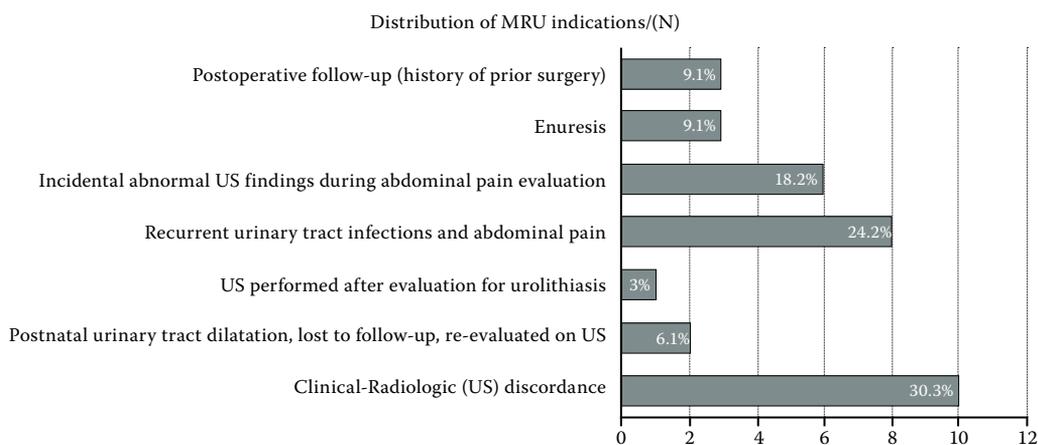


Figure 1. Distribution of magnetic resonance urography indications. MRU, magnetic resonance urography; US, ultrasonography.

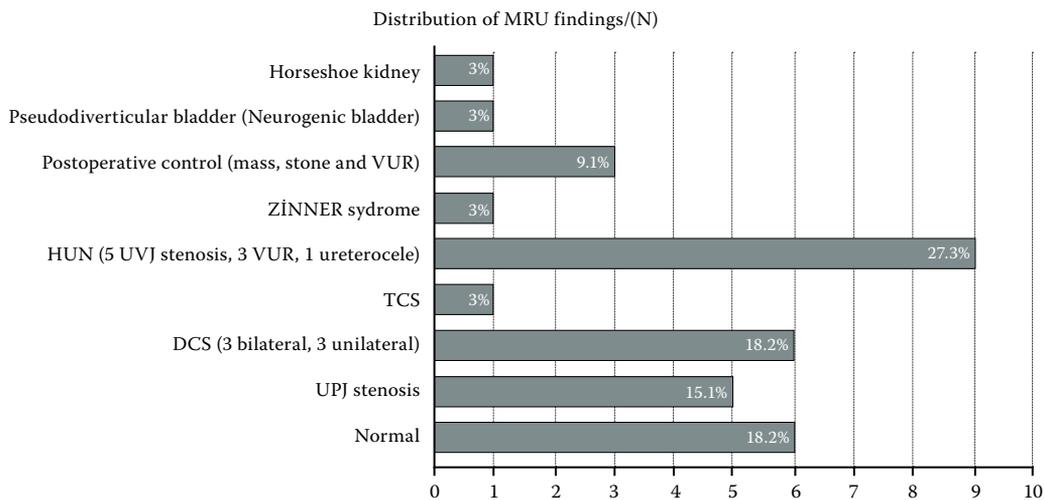


Figure 2. Distribution of MRU findings.

MRU, magnetic resonance urography; VUR, vesicoureteral reflux; HUN, hydroureteronephrosis; UVJ, ureterovesical junction; TCS, triple collecting system; DCS, duplicated collecting system; UPJ, ureteropelvic junction.

findings, reported in 10 patients. Magnetic resonance urography indications are summarized in Figure 1, and imaging findings are summarized in Figure 2.

Multiple collecting system anomalies were identified in 10 renal units. Of these, nine represented duplicated collecting systems (DCSs;

n=6; bilateral in three patients and unilateral in three) and one represented a triple collecting system (Figure 3). Ultrasonography correctly identified DCS in only one case; non-dilated or minimally dilated DCS cases could not be distinguished ultrasonographically.

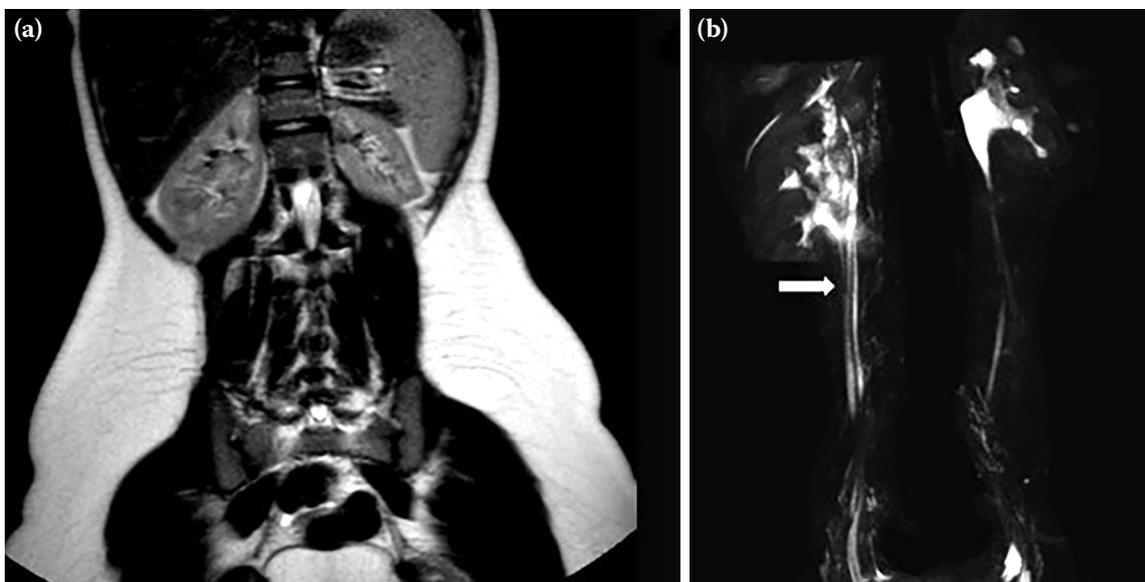


Figure 3. Right-sided triple collecting system. (a) Coronal T2-weighted MRU sequence shows only a more voluminous appearance of the right kidney compared with the contralateral side. (b) Heavily T2-weighted non-contrast-enhanced MRU sequence clearly demonstrates three distinct collecting systems (white arrow). MRU, magnetic resonance urography.

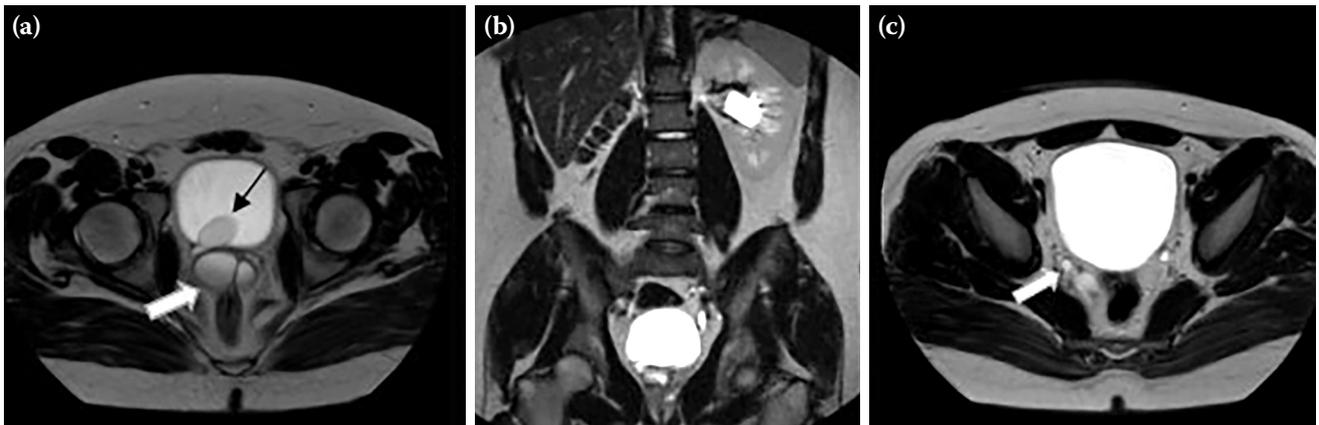


Figure 4. Zinner syndrome in a patient included in the MRU protocol. (a) Axial T2-weighted sequence at the bladder level shows a ureterocele (black arrow) and cystic dilatation of the seminal vesicle (white arrow). (b) Coronal T2-weighted sequence demonstrates absence of the right kidney. (c) Axial T2-weighted sequence at the distal ureter level reveals a rudimentary distal right ureter (white arrow).

MRU, magnetic resonance urography.

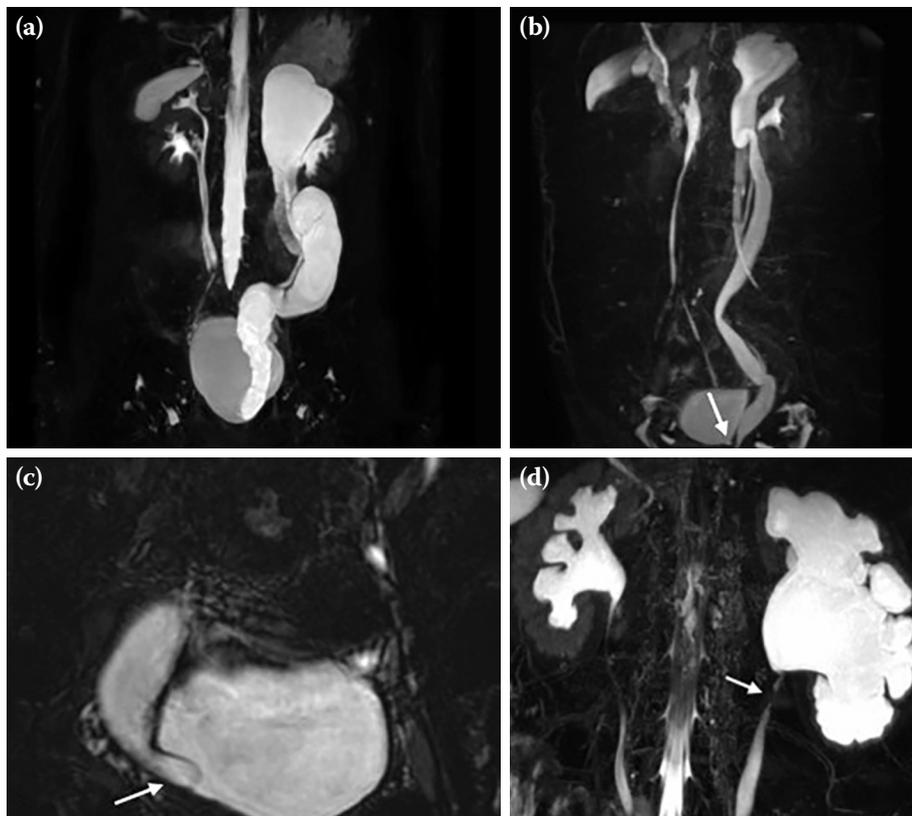


Figure 5. Heavily T2-weighted MRU sequences. (a) Bilateral DCSs with a megaureter draining the upper pole of the left kidney. (b) Left-sided DCS with ectopic insertion of the upper pole ureter (white arrow). (c) Ureterocele in a patient with right-sided hydroureteronephrosis (white arrow). (d) Left-sided hydronephrosis caused by UPJ obstruction (white arrow).

MRU, magnetic resonance urography; DCSs, duplicated collecting systems; UPJ, ureteropelvic junction.

In five patients with ureteropelvic junction stenosis, MRU clearly demonstrated both the degree of hydronephrosis and the point of abrupt ureteral tapering.

Hydroureteronephrosis was detected in nine patients; among them, five had ureterovesical junction (UVJ) stenosis, and one had a ureterocele. All diagnoses were confirmed by cystoscopy. Ultrasonography demonstrated ureteral dilatation in only three of the UVJ stenosis cases.

In one case, the right kidney was not visualized on US, and a cystic structure adjacent to the bladder was reported. Subsequent MRU revealed findings consistent with unilateral renal agenesis associated with a seminal vesicle cyst and ejaculatory duct obstruction, consistent with Zinner syndrome (Figure 4).

In another case, both US and MRU confirmed the presence of a horseshoe kidney. In a patient with neurogenic bladder, both modalities demonstrated bladder wall thickening without additional abnormalities, yielding concordant findings.

Ectopic ureter was accurately demonstrated by non-contrast-enhanced MRU in three patients, even before cystoscopy, and at the correct insertion level. In one of these cases, the initial cystoscopy revealed only a distal urethral narrowing without other abnormalities; persistent enuresis and urinary tract infection led to a repeat MRU, which demonstrated ectopic ureteral insertion at the urethral level, later confirmed at the second cystoscopy.

Overall, among 27 patients with abnormal US findings, non-contrast-enhanced MRU provided additional diagnostic information in 11 (40.7%) cases (Figure 5).

DISCUSSION

In the evaluation of urinary system pathologies in the pediatric population, the primary objective is to obtain clinically relevant anatomical information as accurately as possible while minimizing exposure to ionizing radiation.^[5,8] Therefore, US remains the first-line imaging modality due to its accessibility, ease of use, and lack of radiation.^[9] However, US demonstrates variable sensitivity in assessing the entire ureteral

course, precisely localizing the level of stenosis, and depicting complex collecting system anomalies. These limitations are largely influenced by operator experience and patient-related factors such as bowel gas.^[10,11] As demonstrated in our study, US has limited utility in cases involving nondilated DCSs, UVJ stenosis, and ectopic ureters.

Non-contrast-enhanced MRU, through its heavily T2-weighted hydrographic sequences, depicts the fluid-filled segments of the collecting system and ureters with high contrast, thereby allowing direct assessment of the anatomical level of stenosis and drainage pattern.^[4,12] Consistent with previous reports, non-contrast-enhanced MRU reliably demonstrated the configuration of duplicated systems and the affected renal parenchymal components even in minimal or nondilated DCS cases.^[13,14] This capability has direct implications for surgical planning, influencing critical decision-making steps.

In our study, the most notable contribution of non-contrast-enhanced MRU was in ureteral pathologies. In all three cases with ectopic ureters, MRU accurately demonstrated the ectopic insertion at the urethral or bladder neck level before cystoscopy, allowing subsequent cystoscopy and surgery to be performed in a targeted manner. This finding underscores MRU's role not only as an anatomical imaging tool but also as a decision-support modality capable of altering surgical strategies.

Additionally, because the examinations were performed under free-breathing conditions and required only a short acquisition time, no patient required sedation. This feature significantly enhances the clinical feasibility of non-contrast-enhanced MRU in the pediatric setting.^[15] Magnetic resonance urography in younger children (under seven years) often requires sedation to minimize motion artifacts, which may limit its routine use in this age group.^[16] In our study population, only children aged five years and older were included, as adequate image quality could be obtained without sedation in cooperative patients. In appropriately aged and cooperative children, its sedation-free, reproducible, and radiation-free nature makes non-contrast-enhanced MRU a safe and sustainable option for both diagnostic assessment and follow-up.

However, non-contrast-enhanced MRU does not provide functional assessment. Therefore, when evaluation of flow dynamics or the physiologic impact of obstruction in nondilated ureteral segments is necessary, contrast-enhanced MRU or voiding cystourethrography remains complementary.^[2,3,17] Consequently, the primary role of non-contrast-enhanced MRU lies in pediatric cases that require detailed anatomical delineation, exhibit discordant clinical and sonographic findings, or necessitate precise preoperative planning.

This study has several limitations. First, its retrospective design may be associated with inherent selection bias. Second, the sample size was relatively limited, which may restrict the generalizability of the findings. Finally, the study was conducted at a single center, which may limit the external validity of the results.

In conclusion, static fluid-based non-contrast-enhanced MRU fills an important gap in the noninvasive and radiation-free evaluation of the pediatric urinary tract. This technique allows detailed visualization of both dilated and minimally dilated segments of the collecting system, as well as congenital anatomic variations, accurately defining the anatomic level of ureteral, bladder, and collecting system pathologies. Our findings demonstrate that non-contrast-enhanced MRU provides significant additional diagnostic value in cases where US is limited. The use of rapid, free-breathing sequences shortens acquisition time and largely eliminates the need for sedation. Thus, non-contrast-enhanced MRU emerges as a safe, reproducible, and high-resolution alternative for anatomical assessment in cooperative pediatric patients, representing a reliable second-line imaging modality complementary to US for the diagnosis and preoperative planning of pediatric urinary tract pathologies. With the continued advancement and wider availability of fast imaging techniques, the clinical use of non-contrast-enhanced MRU for anatomical evaluation in pediatric practice is expected to expand further.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: I.B.S.: Conceptualization, literature review, and drafting of the manuscript; I.B.S., I.K.: Study design, data collection and processing, and analysis and interpretation; I.K., M.E.Ç.: Supervision; I.K., I.B.S., M.E.Ç.: Critical revision of the manuscript for important intellectual content. All authors approved the final version of the manuscript.

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