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ORIGINAL ARTICLE

Static fluid magnetic resonance urography in evaluation of ureteral ectopia: Experience in 10 pediatric cases

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KEYWORDS

Magnetic resonance urography;
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Ureteric insertion anomalies

Abstract *Introduction:* Ectopic ureters are often very difficult to diagnose with conventional imaging modalities especially in children. Magnetic resonance urography (MRU) has been recently investigated as a problem-solving tool for the evaluation of various congenital urogenital anomalies with favorable results.
Aim of the work: To assess the value of static fluid MRU in diagnosing ectopic ureters in childhood.
Patients and methods: Ten out of 14 pediatric patients with suspected ureteral ectopia (as suggested by clinical or conventional imaging techniques) were included in this study and prospectively studied by MRU aiming to confirm the suspected diagnosis. The examinations were done on 1.5T machines using static fluid T2W-MRU sequences. Ultrasound examinations were done for all patients. Voiding cystourethrogram (VCUG) was done for 8 patients to exclude vesico-ureteric reflux or urethral anomalies.
Results: All studied patients had dilated collecting systems. Static fluid MRU was able to detect the site of ectopic ureteric insertion in all 10 patients. It was superior to ultrasound in evaluation of 8 cases with complex duplex systems. In one patient with multiple congenital anomalies, MRU clearly demonstrated the urinary and extra-urinary anomalies. The final diagnosis was confirmed by surgical or endoscopic data in all patients.

Abbreviations: MRU, magnetic resonance urography; VCUG, voiding cystourethrogram

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Conclusions: In dilated collecting systems, static fluid MRU can provide detailed assessment of the collecting systems and ureters as well as adequately detect ureteral ectopia. MRU should be recommended whenever a ureteric insertion anomaly is suspected.

1. Introduction

Ureteral ectopia is defined as a ureter that terminates into an abnormal location.[1] Caudal ectopia, also known as medial ectopia, refers to a ureter whose orifice is located beyond the proximal lip of the bladder neck. Generally, ureteral ectopia is more common in females.[2]

Ectopic ureters can drain a single kidney, however it is usually associated with complete ureteral duplication in about 70% of cases. According to the Weigert-Meyer rule; the ureteral orifice of the upper-pole moiety inserts into the bladder inferomedial to both its normal location and the orifice of the ureter draining the lower renal segment. The ureter draining the upper-pole moiety frequently ends in an ureterocele or has an ectopic insertion, whereas reflux into the lower moiety often occurs.[3]

Ectopic insertion of the ureter is embryologically derived from abnormal ureteral bud migration which usually results in caudal ectopia.[4] In females, an ectopic ureter can insert into the lower bladder, urethra, vestibule, or vagina. In males, it usually empties into the lower bladder, posterior urethra, seminal vesicle, vas deferens, or ejaculatory duct. In very rare instances, it may empty into the rectum.[4,5]

The fundamental difference between a male and female ureteral ectopia is that in the latter, ectopic ureters can terminate at a level distal to the continence mechanisms of the bladder neck and external sphincter and thus may be associated with incontinence. This presents with a classic history of continuous dribbling incontinence despite what appears to be a normal voiding pattern in approximately one-half of patients with ectopic ureters.[4,6]

When ureteric insertion anomalies are suspected, the classic radiologic work-up usually includes ultrasound (US), voiding cystourethrography (VCUG), intravenous urography (IVU) and computed tomography (CT). Despite the widespread use of these modalities, they all have inherent shortcomings making it difficult to reach a definite diagnosis with a single imaging method. Combination of many of these tools is frequently needed to adequately depict the underlying congenital abnormalities.[7]

Magnetic resonance imaging (MRI) is known for its superb spatial and temporal resolutions. It provides good anatomic visualization and multiplanar three-dimensional reconstruction capability. MRI notably avoids exposure to ionizing radiation and may be performed in patients with renal impairment or allergy to iodine-based contrast agents.[8] This makes it more suitable for evaluation of patients in the pediatric age group.

MRI techniques used to display the urinary tract can be separated into two categories: (a) static fluid MR urography; also known as T2-weighted MR urography (T2W-MRU), and (b) contrast enhanced excretory MR urography (CE-MRU); also known as T1-weighted MR urography.[9]

Static fluid T2W-MRU treats the urinary tract as a static column of fluid, using one of a variety of T2-weighted sequences that exploit the long T2 relaxation time of urine. It does not require the excretion of contrast material and is therefore useful for demonstrating the collecting system of an obstructed or poorly excreting kidney.[10,11] For patients with non-dilated systems, the use of hydration and diuretics may enhance the quality of MR urography.[12]

CE-MRU is roughly analogous to CT urography and conventional IVU. It is dependent on the excretory power of the kidneys[13] and is used mainly for functional rather than morphological evaluation.[8]

MRU has been investigated in the past decade as a problem-solving tool for evaluation of various congenital urogenital anomalies with favorable results.[7,8,14] Recent technological advances have expanded the diagnostic capabilities

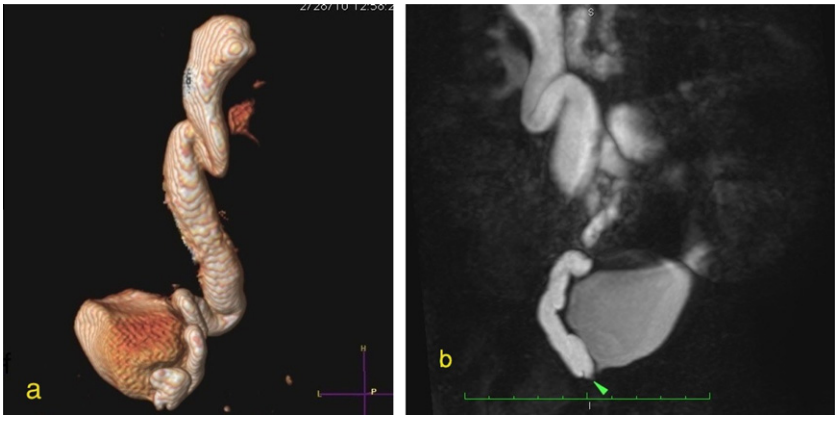

Figure 1 A 1.8 years old male patient with right sided complete duplex system. The upper moiety is markedly dilated showing ectopic ureteric insertion at the prostate. The lower moiety showed normal appearance. (a)Volume rendered 3D image showing posterior projection of the duplex collecting system, urinary bladder and ectopic ureteral insertion. (b) MRU image using thin slab MIP anteroposterior projections of the right ureter showing ectopic insertion below the bladder neck into the urethra.

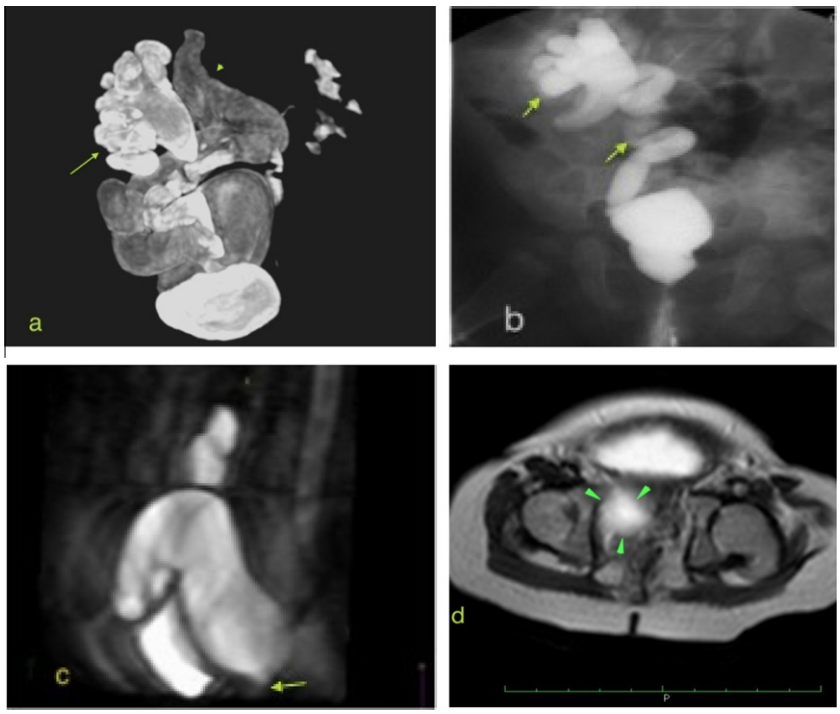

Figure 2 A 2 years old male patient with right sided complete duplex system. The upper moiety is markedly dilated showing ectopic ureteric insertion at the prostate. The lower moiety showed VUR with milder dilatation. (a) MRU image using thick slab MIP anteroposterior projection of the urinary tracts showing dilated right lower moiety (arrow) and tortuous upper moiety ureter (arrowhead). (b) VCUG showing reflux in the lower moiety (arrow). (c) Sagittal MIP projection showing upper moiety low ectopic ureteric insertion (arrow). (d) Axial T2W image showing upper moiety dilated ureter with ectopic low insertion into the prostate (arrowheads).

of MRI. These advances included faster image acquisition, enhanced resolution, reduced motion artifact and improved signal-to-noise ratio.[15] Introducing these enhancements to MRI besides being a radiation-free diagnostic tool makes it potentially the most suitable diagnostic modality for evaluation of pediatric patients with suspected urogenital anomalies. Its role in the evaluation of specific problems as ureteral ectopia needs further scrutiny to assess its diagnostic performance. The aim of this study was to report our initial experience using T2W-MRU in the evaluation of ureteral ectopia.

2. Methods

2.1. Study population

Between October 2010 and December 2011, patients who presented to the Pediatric Genitourinary Surgery Unit in the Alexandria Main University Hospital with suspected ureteric insertion anomalies were referred to the Radiodiagnosis Department and prospectively assessed. The presence of an end-ureteric anomaly (including ectopic ureters) had been suggested by either clinical or imaging abnormalities. The presence of a duplicated system by US, and inadequate visualization of the terminal ureteric segment in the setting of hydro-uretero-nephrosis raised the possibility of ureteral ectopia. Those suspected to have an ectopic ureter by clinical or US findings were further evaluated with SF-MRU.

Out of a total of 14 children with clinical or imaging suspicion of the ectopic ureteric insertion, 10 patients (6 girls and 4 boys) with proved ectopia were included in this study, aged 2 months to 2.5 years (median age 16 months).Antenatal US showing hydro-uretero-nephrosis was the cause for referral in two patients, abnormal US during the work-up of a urinary tract infection (UTI) in four, clinical presentation of urinary dribbling in three patients and as part of a work-up for multiple congenital anomalies in one patient. The final diagnosis was confirmed during surgery in 4 patients and endoscopically in 6.

VCUG was also performed in 8/10 patients to exclude bladder and urethral anomalies as well as to assess for vesico-ureteral reflux. IVU was done for 3/10 cases.

2.2. Imaging techniques

US examinations included detailed evaluation of the entire urinary tract (kidneys, ureters and bladder) and were done using a sector or linear transducer. The equipment was adjusted to operate at the highest clinically appropriate frequency.

VCUG was performed through retrograde filling of the catheterized bladder by a contrast medium. VUR was graded using the international grading system (grades I–V).[16] AP film of the abdomen with low volume filled bladder was taken. Lateral urethra voiding shot in males; AP urethra voiding shot in females as well as post void films were taken. IVU was performed in only 3 patients using non-ionic contrast.

2.3. MRI imaging

All patients in our study population required sedation or anesthesia. Pre-scanning preparation included 3 h fasting with adequate hydration; referably using intravenous fluids (normal

Table 1 Patient demographic data, mode of presentation and imaging findings.

Case No.	Sex	Age	Mode of presentation	US findings	VCUG	MRU findings
1	M	2 years	UTI	Right hydro-uretero-nephrosis, duplex	Right grade IV reflux	Right duplex, obstructed UP with EI, VUR G-IV LP
2	M	1.8 years	UTI	Right duplex, dilated UP	−ve	Right duplex, obstructed UP with EI
3	M	2 months	ANU	Left hydro-uretero-nephrosis, duplex	N/A	Left duplex, obstructed UP with EI
4	F	1.8 years	Dribbling	Left hydro-uretero-nephrosis, duplex	−ve	Left duplex, obstructed UP with EI
5	F	2 months	ANU	Bilateral hydro-uretero-nephrosis	Bilateral grade IV reflux	Right G-IV reflux. Left duplex, obstructed UP with EI, VUR G-IV LP
6	F	2.5 years	Dribbling	Left hydro-uretero-nephrosis, duplex	Left grade IV reflux	Left duplex, obstructed UP with EI, reflux G-IV LP
7	M	2 years	UTI	Right duplex, hydro-uretero-nephrosis UP	N/A	Right duplex, obstructed UP with EU. Left bifid pelvis
8	F	1.5 years	UTI	Right UP cysts, LP mild hydro-nephrosis	−ve	Right duplex, multicystic dysplastic UP with EU, mild hydro-nephrosis LP
9	F	2 years	Multiple congenital anomalies	Right hydro-ureter, left mild hydro-nephrosis	−ve	Horse-shoe kidneys, right EI, left megaureter. spinal and anorectal anomalies
10	F	2 years	Dribbling	Right mild hydro-uretero-nephrosis	−ve	Right ureter EI

ANU, antenatal ultrasound; EI, ectopic insertion; EU, ectopic ureterocele; LP, lower-pole; N/A, not available; UP, upper-pole; UTI, urinary tract infection.

saline or lactated ringer) as calculated by the anesthesiologist. This ensures adequate distension of the urinary tract while limiting the artifacts from fluid filled bowel loops.

All patients in this study were imaged using 1.5T superconducting magnet MRI machines; Philips Gyroscan Intera version 12.1.1.2 (Best, The Netherlands) and Siemens Magnetom Avanto (Erlangen, Germany). T2W-MRU was performed in addition to axial and oblique coronal sequences along the course of the urinary tract.

The patient was placed in supine position; arms extended above head. A body surface coil was used. Respiratory-gated acquisitions were used. Elastic tapes and supports were used to prevent patient's movement. Typical scan time was 15 min.

2.4. Scanning parameters

Localizing T1-W gradient echo sequences were used. Axial 2D T2-W turbo spin echo (HASTE/TSE) sequence from the level of upper renal poles to lower border of the pelvis was TR2500, TE100, flip angle 90, matrix size 256, FOV 200×160 mm, number of slices 30–40 and slice thickness 4 mm. Fat saturation was applied in some cases. Additional high resolution T2W thin axial sections were obtained at the pelvis for assessment of the ureteric insertions. Oblique coronal 2D T2W turbo spin echo (HASTE/TSE) sequence parallel to long axis of kidneys was TR3500, TE90, flip angle 90, matrix size 256, FOV 220×200, number of slices 30, and slice thickness 3 mm. Fat saturation was applied in some cases. Coronal 3D heavy T2W-MRU sequence in oblique coronal plane parallel to long axis of kidneys, was TR2000, TE700, flip angle 90, matrix size 256, FOV 220×200 mm, number of slices 60–70, and slice thickness 2 mm.

2.5. Post processing and interpretation

The source images were transferred to a dedicated workstation for post-processing. The two dimensional series served to prove detailed anatomical data and reference scans. Maximum intensity projection (MIP) techniques and volume rendered techniques (VRT) were used for 3D heavy T2W static fluid sequences for generating images of the collecting systems, ureters and urinary bladder. Manual volume editing was used when needed to exclude unwanted structures, including fluid filled bowel loops, the gall bladder and the CSF filled thecal sac. In all kidney-ureter units, the morphologic findings of MR urography were documented and correlated with the results of conventional imaging and ultrasound. The final diagnosis was confirmed by surgical or endoscopic data in all patients.

3. Results

MRU showed detailed structural abnormalities in the studied group of 10 patients. The modes of presentation and imaging data are demonstrated in Table 1. Eight patients had complete duplex systems associated with ectopic insertion of the ureter corresponding to the upper moiety (Table 1; Cases 1–8). One patient had horse-shoe kidney with ectopic right ureteric insertion and was associated with spinal and anorectal anomalies (Table 1; Case 9). Another patient had an isolated ureteric

ectopia of a single collecting system with normal kidney (Table 1; Case 10).

Regarding the site of ectopia; 3 patients had the ectopic ureteric insertion in the prostate (Figs. 1 and 2), 4 patients in the vagina (Fig. 3), 2 patients had ectopic ureterocele inserting near the urethral orifice (Fig. 4) and one had isolated ectopic sphincteric insertion.

US failed to diagnose duplex kidneys demonstrated by MRU in 2/8 cases (Table 1). Marked bilateral dilatation of the collecting systems associated with thinned parenchyma hindered accurate visualization in one case. As for the other case, associated segmental multicystic dysplasia in the upper-pole of the kidney prevented detection of a duplex kidney. Regarding the inferior ureteric insertion, US failed to identify any of the extravesical ectopic ureteric insertions. In 2 patients with ureteroceles, US was able to diagnose the presence of ureteroceles however the exact site of ureteric termination could not be reliably identified by ultrasound.

In 8 patients with documented duplex systems, MRU was able to differentiate well between the upper and lower-poles, demonstrating the related parenchyma changes and separable pelvicalyceal system. This allowed identification of the affected pole which eventually required surgical correction. Also, the ectopic inferior insertion of the ureter in relation to the abnormal pole was correctly assessed by MRU.

In the patient with associated multiple congenital anomalies (urinary, anorectal and spinal anomalies), MRU clearly demonstrated the renal and extra-renal anomalies in addition to localization of the ureteral ectopic insertion site. US failed to identify extra-renal anomalies as well as the horse-shoe anomaly due to a limited field of view caused by supra-pubic cystostomy and transverse colostomy (Fig. 3).

VCUG was performed in 8/10 patients. It showed grade IV reflux in 3 patients with duplex systems and was negative in the other 5 patients, serving to exclude the presence of VUR as well as the bladder outlet and urethral anomalies. VCUG failed to detect ectopic ureteric insertion in all cases due to non-opacified upper moiety ectopic ureters. IVU was only performed in 3 patients and was not conclusive in any of them. The other patients did not undergo IVU studies, because of visualized significant dilatation on ultrasonography that precluded the use of contrast based studies due to expected poor opacification of grossly dilated ureters.

4. Discussion

Congenital urogenital anomalies form one of the common indications for imaging in the pediatric age group. The referring physician and radiologist usually face the problem of selecting the best imaging modality that can reliably identify the suspected anomaly and possible associated anomalies. The ultimate goal is to reliably identify the anomaly and distinguish between congenital urinary system anomalies that would require intervention and those that do not.[17]

Ectopic ureters are one of the most difficult diagnoses to make, both clinically and on imaging. A multimodality imaging approach often has to be used yet not always yielding satisfactory results. Ectopic ureters are often associated with complex duplex systems. The ureter related to the upper-pole may have ectopic insertion or may be coupled with an ectopic ureterocele. Reflux commonly occurs into the lower-pole as well. Furthermore, ectopic ureteric insertion may occur with single collecting system kidneys. The mode and time of presentation vary greatly. Some cases are diagnosed antenatally while others

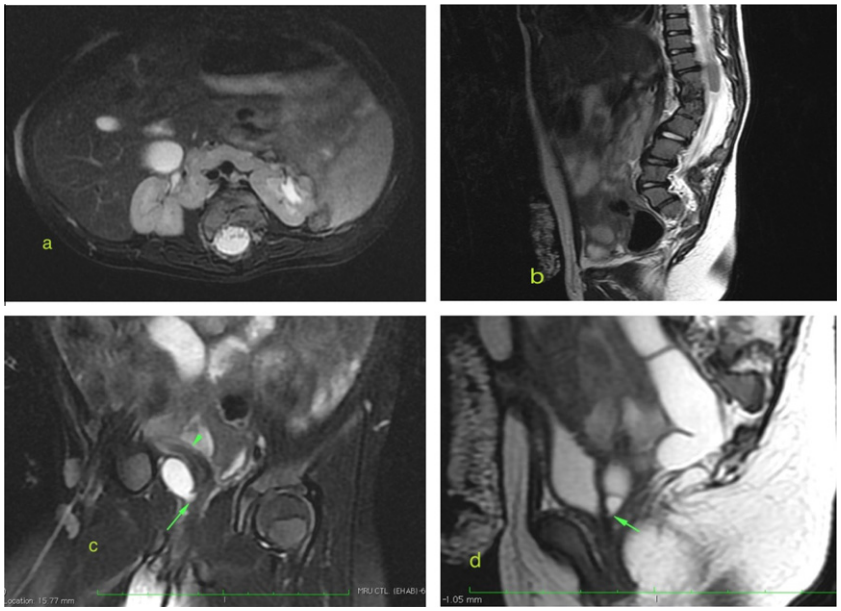

Figure 3 A 2 year old female patient with multiple congenital anomalies and imperforate anus. Suprapubic cystostomy and transverse colostomy were done. MRU showed horse-shoe kidneys with right ectopic ureter inserting at the vaginal dome, spinal anomalies and high anorectal anomaly. (a) Axial T2W image showing HSK with fused lower-poles at the midline. (b) Sagittal coronal T2W images showing caudal regression, segmentation anomalies and kyphoscoliosis. High anorectal anomaly also noted. (c) Oblique coronal T2W images of the pelvis showing right ectopic vaginal ureteric insertion (arrow) just inferior to the uterus (arrowhead). (d) Sagittal T2W image showing site of ectopic vaginal ureteric insertion (arrow).

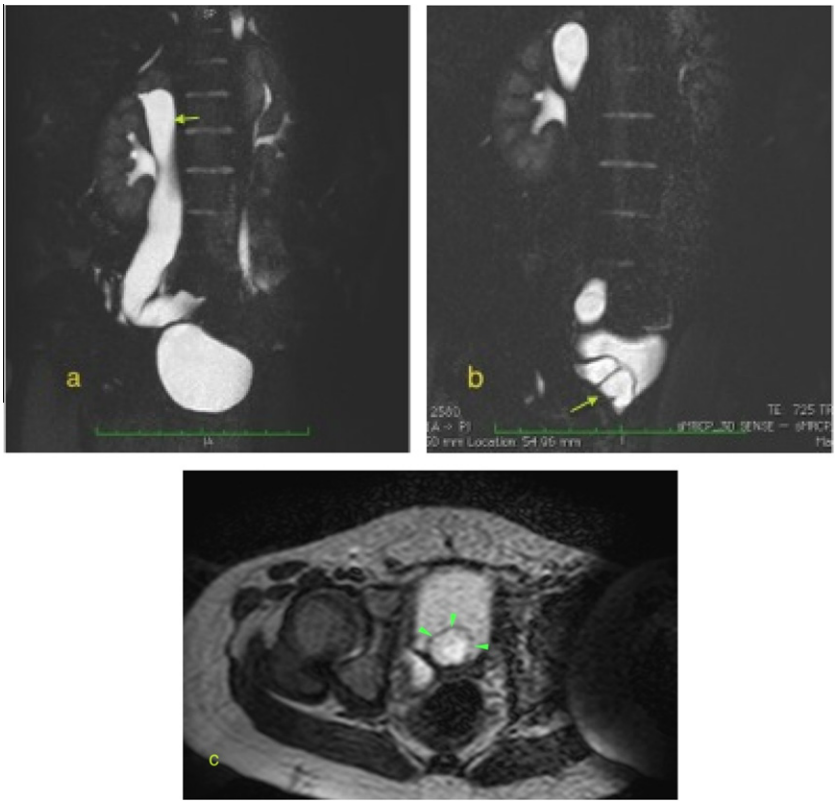

Figure 4 A 2 years old male patient with right sided complete duplex system. The upper moiety is markedly dilated showing ectopic ureterocele inserting near the urethral orifice. The lower moiety is normal. Bifid left renal pelvis is noted (a) thick slab MIP anteroposterior projection of the urinary tracts bilaterally showing dilated right upper moiety (arrow). (b)Thin section MRU image in oblique coronal plane posteriorly, showing ectopic ureterocele inserting near the urethral orifice (arrow). (c) Axial T2W image showing ectopic ureterocele with low insertion below the trigone.

are diagnosed after urinary tract infection or dribbling in young girls.[18]

The classic work-up of such an anomaly includes US and VCUG performed as early as possible. IVU used to be included in the systematic work-up, but is now less commonly performed because the dilated systems often show a reduced excretory function and poorly opacify on IVU. Nevertheless, an accurate diagnosis is important for making the correct management decision, which may vary from endoscopic incision of ureteroceles to the upper-pole heminephrectomy in cases with grossly dilated non-functioning duplex systems.[18,19]

In this study T2W-MRU was superior to US in the evaluation of cases with complex duplex systems and ectopic ureters. It adequately displayed dilated collecting systems and ureteric insertions, including the ectopic insertion or ureterocele. Associated extra-renal anomalies can be readily discovered as well. Usually, US easily displays an ectopic ureterocele, yet in our series it failed to demonstrate the exact site of insertion of the two low-positioned ectopic ureteroceles and the accurate evaluation was achieved by MRU. Recent studies by Riccabona et al,[20] Payabvash et al[21] and Grattan-Smith et al[22] indicated the value of MRU in the assessment of dilated collecting systems and its ability to provide a global view of the malformation. However, we should also highlight that it may be difficult to demonstrate non-dilated ureters by T2W-MRU like US. If necessary, the performance of MRI can be improved by the injection of furosemide in order to distend non-dilated collecting systems and ureters better.

Our results were in accordance with the previous multiple reports. Avni et al.[18] found that MRU differentiated well between the upper and the lower-poles of the kidneys and correctly diagnosed the presence of a duplex kidney, the presence of an abnormality that may require surgery and indicated the type of the inferior ureteric insertion in 100% of patients. Other studies by Avni et al,[23] Staatz et al[24] and Krishnan et al[25] highlighted the value of MRU in the evaluation of ureteral ectopia. Many other studies also highlighted the role of MRU in the evaluation of various ureteral insertion anomalies including ureteroceles and megaureters.[3,7,8,26,27]

Based on our experience and previous reports, we can state that heavy T2W-MRU has clear advantages over US and other conventional imaging techniques; a reasonable scan time, high diagnostic accuracy, no operator dependency and overall safe procedure with no radiation exposure. Once an abnormal duplex kidney with ectopic ureteric insertion is suspected, MRI should follow the US examination. VCUG may be performed if VUR is suspected. This would provide an imaging algorithm with a high diagnostic yield. MRU will demonstrate the duplex collecting system and the ureteric insertion in addition to any other associated anomalies.

5. Conclusion

In dilated collecting systems, static fluid T2W-MRU can provide detailed structural assessment of the collecting systems and ureters. It can adequately detect the ureteral ectopia and complications associated with duplex collecting systems. MRU should be performed whenever a ureteric insertion anomaly is suspected.

References

1. Glassberg KI, Braren V, Duckett JW, Jacobs EC, King LR, Lebowitz RL. Suggested terminology for duplex systems, ectopic ureters and ureteroceles. *J Urol* 1984;**132**(6):1153–4.
2. P Gearhart J, Rink RC. *Mouriquand PDE. Pediatric urology*. 2nd ed. Philadelphia, PA, London: Saunders; 2010.
3. Berrocal T, Lopez-Pereira P, Arjonilla A, Gutierrez J. Anomalies of the distal ureter, bladder, and urethra in children: embryologic, radiologic, and pathologic features. *Radiographics* 2002;**22**(5): 1139–64.
4. Fernbach SK, Feinstein KA, Spencer K, Lindstrom CA. Ureteral duplication and its complications. *Radiographics* 1997;**17**(1): 109–27.
5. Gharagozloo AM, Lebowitz RL. Detection of a poorly functioning malpositioned kidney with single ectopic ureter in girls with urinary dribbling: imaging evaluation in five patients. *AJR Am J Roentgenol* 1995;**164**(4):957–61.
6. Ahmed S, Barker A. Single-system ectopic ureters: a review of 12 cases. *J Pediatr Surg* 1992;**27**(4):491–6.
7. Borthne A, Pierre-Jerome C, Nordshus T, Reiseter T. MR urography in children: current status and future development. *Eur Radiol* 2000;**10**(3):503–11.
8. Leyendecker JR, Barnes CE, Zagoria RJ. MR urography: techniques and clinical applications. *Radiographics* 2008;**28**(1): 23–46.
9. Borthne AS, Pierre-Jerome C, Gjesdal KI, Storaas T, Courivaud M, Eriksen M. Pediatric excretory MR urography: comparative study of enhanced and non-enhanced techniques. *Eur Radiol* 2003;**13**(6):1423–7.
10. Tang Y, Yamashita Y, Namimoto T, Abe Y, Nishiharu T, Sumi S, et al. The value of MR urography that uses HASTE sequences to reveal urinary tract disorders. *AJR Am J Roentgenol* 1996;**167**(6):1497–502.
11. Roy C, Saussine C, Guth S, Horviller S, Tuchmann C, Vasilescu C, et al. MR urography in the evaluation of urinary tract obstruction. *Abdom Imaging* 1998;**23**(1):27–34.
12. Rothpearl A, Frager D, Subramanian A, Bashist B, Baer J, Kay C. MR urography: technique and application. *Radiology* 1995;**194**(1): 125–30.
13. Darge K, Grattan-Smith JD, Riccabona M. Pediatric uroradiology: state of the art. *Pediatr Radiol* 2011;**41**(1):82–91.
14. Kirsch AJ, Grattan-Smith JD, Molitierno Jr JA. The role of magnetic resonance imaging in pediatric urology. *Curr Opin Urol* 2006;**16**(4):283–90.
15. Jones RA, Schmotzer B, Little SB, Grattan-Smith JD. MRU post-processing. *Pediatr Radiol* 2008;**38**(Suppl 1):S18–27.
16. Lebowitz RL, Olbing H, Parkkulainen KV, Smellie JM, Tamminen-Mobius TE. International system of radiographic grading of vesicoureteric reflux. International reflux study in children. *Pediatr Radiol* 1985;**15**(2):105–9.
17. Avni EF, Bali MA, Regnault M, Damry N, Degroot F, Metens T, et al. MR urography in children. *Eur J Radiol* 2002;**43**(2):154–66.
18. Avni FE, Nicaise N, Hall M, Janssens F, Collier F, Matos C, et al. The role of MR imaging for the assessment of complicated duplex kidneys in children: preliminary report. *Pediatr Radiol* 2001;**31**(4):215–23.
19. Khanna PC, Karnik ND, Jankharia BG, Merchant SA, Joshi AR, Kukreja KU. Magnetic resonance urography (MRU) versus intravenous urography (IVU) in obstructive uropathy: a prospective study of 30 cases. *J Assoc Physicians India* 2005;**53**:527–34.
20. Riccabona M, Avni FE, Blickman JG, Dacher JN, Darge K, Lobo ML, et al. Imaging recommendations in paediatric uroradiology. Minutes of the ESPR uroradiology task force session on childhood obstructive uropathy, high-grade fetal hydronephrosis, childhood haematuria, and urolithiasis in childhood. ESPR Annual Congress, Edinburgh, UK, June 2008. *Pediatr Radiol* 2009;**39**(8):891–8.
21. Payabvash S, Kajbafzadeh AM, Saeedi P, Sadeghi Z, Elmi A, Mehdizadeh M. Application of magnetic resonance urography in diagnosis of congenital urogenital anomalies in children. *Pediatr Surg Int* 2008;**24**(9):979–86.
22. Grattan-Smith JD, Little SB, Jones RA. MR urography in children: how we do it. *Pediatr Radiol* 2008;**38**(Suppl 1):S3–S17.
23. Avni EF, Matos C, Rypens F, Schulman CC. Ectopic vaginal insertion of an upper pole ureter: demonstration by special sequences of magnetic resonance imaging. *J Urol* 1997;**158**(5):1931–2.
24. Staatz G, Rohrmann D, Nolte-Ernsting CC, Stollbrink C, Haage T, Schmidt T, et al. Magnetic resonance urography in children: evaluation of suspected ureteral ectopia in duplex systems. *J Urol* 2001;**166**(6):2346–50.
25. Krishnan A, Baskin LS. Identification of ectopic ureter in incontinent girl using magnetic resonance imaging. *J Urol* 2005;**65**(5):1002.
26. Blandino A, Gaeta M, Minutoli F, Salamone I, Magno C, Scribano E, et al. MR urography of the ureter. *AJR Am J Roentgenol* 2002;**179**(5):1307–14.
27. Grattan-Smith JD, Jones RA. MR urography in children. *Pediatr Radiol* 2006;**36**(11):1119–32, quiz 228-9.