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# Diagnostic efficacy of magnetic resonance urography in congenital urogenital anomalies in children.

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**Abstract**

**Objective: Magnetic Resonance urography (MRU) enables one-step comprehensive morphological and functional imaging process of the urinary tract. The objective of the current study is to identify the role of static and dynamic MRU in evaluating the congenital urogenital anomalies in children.**

**Design: A randomized controlled trial.**

**Setting: Department of Pediatric and Radiology, Security Forces Hospital, Riyadh.**

**Subjects: This study was conducted on 30 cases (17 females and 13 males) with different urinary tract abnormalities. Subjects were ranging in age from newborn to 9 years with a mean age of 24 months. Intervention: All children were assessed using ultrasonography, MRU, and excretory MRU (was available for 15 patients only).**

**Main outcome measures: Static non-enhanced heavy T2W MRU was performed in 30 patients, in addition, the diuretic-enhanced excretory MRU was done for 15 patients using the same MR scanner. Results: MRU clearly afforded extra information to the results of further imaging modalities in 10 children in whom other imaging research studies were unable to provide the clear diagnosis. The confirmation supporting findings by MRU in the remaining 20 children also were beneficial in establishing the eventual diagnosis. However, the findings of MRU were unexclusive in 5 children.**

**Conclusion: MRU might turn into the favored imaging modality in duplex renal anomalies and ureteral ectopia and might be adopted to interpret any discordant outcomes of traditional imaging techniques.**

**Keywords**: Pediatric urography, Magnetic resonance, Urinary system abnormalities, Congenital genitourinary anomalies.

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## Introduction

MR urography (MRU) enables one-step comprehensive morphological and functional imaging of the urinary tract. The nonexistence of ionizing radiation supports the suitability for this method to be adopted in children. Pediatric MRU, either pre or/and post-contrast administration accompanied with subjective functional assessment is almost widespread [1].

MRU has advantage over other modalities in its generating of tissue contrast through various sources. Further to spin-echo T1 and T2 weighted images, contrast-enhanced imaging is adopted in assessing the concentration and excretory functional activities of the kidneys [2]. Two MRU techniques are used for imaging of the excretory system. The first is the static MRU that utilizes the prolonged T2 decay of water and implies fast visualization of the obstructed urinary tract independent of renal function. The second is the dynamic MRU where the signal reinforcement attained by gadolinium is utilized on T1-weighted fast spin echo (T1 FSE) images [3].

Several techniques such as Ultrasonography (US), Intravenous Urography (IVU), Voiding Cystourethrography (VCUG), and radionuclide scintigraphy are adopted in the assessment of children's urogenital anomalies. Nonetheless, it is not consistently achievable to get a clear diagnosis with a single imaging method [4]. MRU can be used in assessment of a large variety of congenital urogenital anomalies including the ureteropelvic junction obstruction, vesicoureteral junction obstruction, ureterocele, ectopic kidney, posterior urethral valve, and polycystic kidney [5]. Additionally, MRU introduces prognostic information by assessment of the quality of the renal parenchyma and the identification of the site of obstruction as well as RTT (Renal transit time) and CTT (Calyceal transit time) together with the excretory curve [6].

The purpose of this study was to spot the light on the role of static and dynamic MRU in evaluating the congenital urogenital anomalies in children as a reflection of our local experience.

## Subjects and Methods

This study was conducted on 30 cases (17 females and 13 males) with different urinary tract abnormalities. Their ages ranged from newborn to 9 years with a mean age of 24 months. They were consecutively referred to Department of Pediatric and Radiology, Security Forces Hospital, Riyadh in the period from July 2016 to December 2018. Their parents consented (written and informed) for their participation in the study and the study was ethically approved by the local bioethical committee. Patients had different clinical and radiological suspicion of urogenital anomalies. Sedative was taken for almost all children less than 3 year. All patients were subjected to placing in supine positions on the scanner bed and scout images were taken in order to locate the precise position of the kidney and bladder and to enhance as much as feasible the signal-to-noise ratio for these anatomical structures.

The children were subjected to positioning on the table with the head first and the axis of the body coincided with the isocenter of the magnet with the hands parallel to their body in order to assure an easy access when administrating the contrasting agent. Furosemide was administered (20 mg/2 mL) to 30% of patients prior to administration of the contrast agent. MAGNEVIST was used at 0.1 mmol/kg dosage. The imaging protocol consisted of 2D and 3D acquisition, scanner was a 1.5 Tesla and the chosen flip angle was 90°.

### *MR urography*

The patients were evaluated by clinical assessment that included history, general and local examination and laboratory investigations included urine analysis and serum creatinine level.

### *MR urography (MRU) techniques: Static-non-enhanced heavy T2W MRU*

Static non-enhanced heavy T2W MRU was performed in 30 patients, all the patients were examined with heavy T2 weighted fast spin echo HASTE sequence. In this study selective fat saturation pulses were used to reduce the signal from retroperitoneal fat. MRU images were acquired in coronal plane using body coil with a field of view large enough to include the entire urinary tract. MRU was performed using 1.5 Tesla superconducting unit. The two types of MRU applied were static and Diuretic-enhanced excretory.

### *Static MRU*

From the sagittal image which optimally identify the obstructed kidney or ureter, coronal slice are obtained antero-posteriorly in 2D mode. Thin slice thickness was used to include kidneys, ureter and urinary bladder in the same image. Multisection standard FSE MRU technique includes the coronal heavy T2 with the following parameters: TE: 250 msec, TR: 10.000 – 16.000 triggering, No. of excitations (NEX): 2, FOV: 200 – 400 mm, Slice thickness: 4 mm, Spacing: 1 mm. Complementary axial T2 at the level of obstruction was done with the following parameters: TE: 102, TR: 9.000 – 15.000, Band width: 83, NEX: 2, FOV: 200 – 400 mm, Slice thickness: 4 mm, Spacing: 1 mm.

### *Diuretic-enhanced excretory MRU*

The diuretic-enhanced excretory MRU was done for 15 patients using the same MR scanner. The patient was placed head first in supine position inside the bore of the magnet. The patients received an intravenous standard dose of 0.1 mmol/kg B.W. of Gd-DTPA contrast media. Thirty seconds to 1 minute before injection of Gd-DTPA, patients received 0.1 ml/kg B.W. of furosemide with a total individual dose of 5-10 mL. Pulse sequences: Images were obtained during continuous breathing in infant and young children, while imaging during breathhold was used in older cooperative children. T1-weighted, 3D, fast spoiled gradient echo (FSPGR) sequence was applied. Imaging protocol was composed of three section stacks oriented in orthogonal planes. From the coronal source images of each 3D sequence data set, the maximum intensity projection (MIP) images were post-processed parallel to the long axis of the body. The postcontrast MRU examination protocol included a set of at least two fat-suppression sequences. The first sequence was obtained 4-5 minutes after contrast material injection with a FOV including both kidneys. The second sequence was taken after 10 minutes to provide an overview of the entire collecting system. A delayed survey was obtained 15-20 minutes after injection of CM in patients with delayed excretion.

### *Post processing*

In the static MRU post processing was performed by using a maximum intensity projection algorithm and a vector of interest editing technique. It permits removal of superimposing normal or abnormal fluid filled structures. The resultant MIP images allow 3D rotations, thus the image could be viewed from different angles. In the excretory MR Urography, MIP reconstruction postprocessing included reformatting of 3D volume images using a maximum intensity projection algorithm from the original 3D data set, and, for the excretory curve, ROI was placed over the whole kidney including tissue and collecting system, which is copied automatically into every image of the sequence. Signal intensity versus time curve was obtained for each kidney. The postprocessing time ranged from 10-15 minutes.

## Results

This study included 30 patients with different congenital urinary tract abnormalities referred from pediatric department to radiology department. The male subjects represented 13 cases (43.3%) of the study while female subjects represented 17 cases (56.6%). The most represented age group was in the range between 0-2 years (33.3%).

MRU images were diagnostically sufficient in all patients. A total of 60 kidneys, 60 collecting systems and 30 bladders in 30 patients were examined. The presenting symptoms and investigations showed follow diagnoses in our patients: Antenatal hydronephrosis in 10 patients, Palpable abdominal mass in 8 patients, recurrent urinary tract infection in 3 patients, voiding dysfunction in 3 patients, flank pain in two patients, failure to thrive in two patients, total incontinence was seen in one patients, and ambiguous genitalia was seen in one patients.

Table 1 showing the Comparison of image quality (motion artifacts) between different MRU sequences used. The image quality of the static MRI sequence (done for 30 cases) was satisfactory in 2 cases (7%), and, excellent in 28 cases (93%). The image quality of dynamic sequence (done for 15 cases) was satisfactory in 2 cases (13 %), and, excellent in 13 cases (87%).

Table 2 showing the Comparison of the degree of visualization of the ureter comparing static MRU and excretory MRU. In this study the most common indication for MRU was hydronephrosis preliminarily detected by ultrasound. 33 renal units were confirmed to have hydronephrosis. Hydronephrosis was bilateral in 7 cases and unilateral in 19 cases. MRU identified UPJ obstruction as a cause of hydronephrosis in 11 renal units. 7 renal units were due to intrinsic UPJ stenosis, one renal unit was due to aberrant renal artery that was suspected by the presence of abnormal signal void across the UPJ and was confirmed by Doppler US and three renal units were due to high insertion of the ureter in Horseshoe kidney. In the other 22 renal units MRU demonstrated that hydronephrosis was due to multicystic dysplastic kidney (hydronephrotic type) in one renal unit and ureteral and ureterovesical junction pathology in the remaining renal units.

## Discussion

The comprehensive morphological and functional analysis of all parts of urinary tract, from kidneys to bladder, obtained via MRU, offers an opportunity to study congenital malformations of the urinary tract in vivo with the increased anatomic resolution [1]. Magnetic resonance urography (MRU) has the favor that in a single research study, 3D imaging of the full urinary tract as well as assessing of renal functions and urinary drainage might be done. It does not depend on employing ionizing radiation [7]. The results of MR urography is of desired diagnostic value in virtually all types of urinary tract disorders in pediatric patients, minimizing the need of exposing to radiation and invasive procedures in diagnostic imaging of urinary tract [8].

In this study we had different 60 renal units with different congenital anomalies of the urinary tract that were identified by static MRU in case of dilated system, and diuretic excretory MRU in case of dilated and non-dilated system. MRU could depict the urinary tract anatomy with high sensitivity and overall accuracy 90% allowing the assessment and location of the stenotic segment in all cases in our study with congenital UPJO (100%). This is in agreement with some studies who reported that diuretic enhanced MRU can provide both anatomic and functional data about obstructed renal units without exposure of ionizing radiation especially in children [2].

Grattan-Smith et al. [9] and Payabvash et al. [10] previously documented the superior anatomic imaging of the urinary tract with MR urography compared with different imaging modalities. In our study in all cases the anatomic imaging of the urinary tract was considered superior with MR urography when compared to ultrasound. MR urography demonstrated greater spatial and contrast resolution and the MIP images demonstrated the anatomy of the collecting systems and ureters [9,10].

Static fluid T2 weighted images in MRU are exceptionally beneficial to show huge fluid-filled compartments as in UPJO, cystic renal disease, complex duplex renal anomalies that include non-functional moieties, large ureteroceles, and ectopic ureters [11]. Static fluid MRU doesn't need any contrast. Contrast-enhanced T1 images of (excretory) MRU lay out subtle anomalies such as non-dilated duplex kidneys, and small ureterocoeles [12]. Very clear images of the urinary tract might be gained by maximum intensity projection (MIP) on heavily T2 weighted images. MRU has about 95% sensitivity and about 90% specificity for the diagnosis of duplex renal system [13].

In the present study 60% of the ureters were completely visualized with excretory MRU T1FSE. In a study done by Borthne et al., 56% of the ureters were completely visualized with excretory MRU [14]. Excretory MRU is dependent on preserved renal function. In addition, the image quality is reduced in case of marked ureteral obstruction, due to the hampered excretion of contrast. In such cases static MRU is the alternative of choice. This was in total agreement with the findings of Payabvash et al. [10]. In the existence of functionally poor renal moieties, MRU is more fruitful compared to IVU and computerized tomographic urography (CTU) in the demonstration of the anatomy of complex duplex anomalies [4] Single system ectopic ureter has been argued to be less frequent than ectopic ureters in association with duplex kidneys and needs additional confirmation. MRU is presently in consideration as an ideal for assessing of ectopic ureters, complicated duplex systems or when other complex abnormal anatomy of the urinary tract under suspicion [12].

MRU shows a developing role in the assessment of ureteral

***Table 1.*** *Comparison of image quality (motion artifacts) between different MRU sequences used, data shown are frequencies; n (%).*

| Image source | Excellent | Satisfactory | Poor | Total n |
|---|---|---|---|---|
| Static MRU | 28 (93%) | 2 (7%) | 0 (0) | 30 |
| Dynamic MRU | 13 (87%) | 2 (13%) | 0 (0) | 15 |

***Table 2.*** *Comparison of the degree of visualization of the ureter comparing static MRU and excretory MRU, data shown are frequencies; n (%).*

| Degree of visualization | Excellent | Good | Poor | Total n |
|---|---|---|---|---|
| Static | 22 (37%) | 11 (18%) | 27 (45%) | 60 |
| Excretory | 18 (60%) | 4 (13%) | 8 (27%) | 30 |

ectopia [15]. On the basis of the past experiences by Avni et al. [11] As soon as abnormal duplex kidney with ectopic ureteric insertion is suspected, the anomaly shall be confirmed by MRU [15]. This had been supported by the previous results of Perez-Brayfield et al. [16] who had confirmed that in conditions such as non-function upper poles of duplex systems, which do not introduce any contrasting uptake, scintigraphy is worthless.

MCDKs are diagnosed in general by US, the main considerations in the differential diagnosis of a MCDK is a UPJO [17,18]. In a research study conducted by McMann et al. [18], the four patients identified to have MCDK on MRU were basically suspected to be having hydronephrosis on US. In this study, MRU was able to differentiate between MCDK and UPJO. The costs and access barriers are further drawbacks of MRI. However, the total cost of traditional techniques normally is exceeding the cost of MRU due to the need of more than one imaging modality for diagnostic purposes. In addition, MRU considered the exclusive diagnostic method in specific pathologies such as complex congenital anomalies [6]. With expanding availability of MRU in various centers, it might develop to be the preferred imaging modality after an Ultrasonography in duplex renal anomalies and ureteral ectopia. MRU may also be adopted to interpret any discordant findings of traditional imaging techniques [19,20].

## Conclusion

MRU might turn into the favored imaging modality in duplex renal anomalies and ureteral ectopia and might be adopted to interpret any discordant outcomes of traditional imaging techniques.

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## Conflict of Interest Statement

The author has nothing to disclose.

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