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MR Urography- Technique, Applications and Pitfalls

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ABSTRACT

Clinical urography requires anatomical and functional data about the entire urinary system. Different techniques had been portrayed till now to give this data of urinary tract. Nonetheless, just CT Urography and MR Urography has capacity to depict whole urinary framework alongside encompassing structures. There are a few articles demonstrating the method and clinical uses of MRI urography, still right now MRU is definitely not a routinely advised test. Two systems of MR Urography have been depicted in this article: static and excretory. Static-fluid MRU is performed utilizing heavily T2-weighted sequences. Excretory MRU is performed with quick T1-weighted sequences following iv gadolinium. In this investigation we will depict these procedures, the imaging protocol of our institute and give the data of its applications.

Keywords: MR Urography, Static MRU, Excretory MRU, Urolithiasis

INTRODUCTION

Since years, numerous procedures have been created for imaging of the urinary framework. Out of these strategies, Computed Tomographic (CT) urography and Magnetic Resonance (MR) Urography are fundamentally used to oblige supreme evaluation of the urinary framework, renal parenchyma, and encompassing structures. MR urography can possibly noninvasively give the most particular imaging examination available for some urinary tract variations without the utilization of ionizing radiation[1,2]. Despite the fact that couple of impressive impediments and difficulties stay for MR urography, including recognition of small renal calculi, long imaging time and affectability to movement.

MR urography has been utilized to examine the urinary system since the investigation of Hennig et al[3] on heavily T2 weighted sequences in 1987. In the years that took after, significant advancements were expert in MR urography because of new sequences. System to show the urinary tract by MR urography is separated into two kinds: static-fluid MR urography and excretory MR urography. Static-fluid MR urography makes utilization of heavily T2-weighted sequences to demonstrate the urinary tract as a static accumulation of liquid. This T2WI can be rehashed consecutively (cine MR urography) to all the more likely exhibit whole bilateral ureters which is important to confirm stenosis. This arrangement is best in patients with dilated or obstructed urinary system. Contrast material i.e. iv Gadolinium is useful in excretory MR urography[4]. These two techniques utilized as a part of an integrative design as well as freely, on different events, have supplemented each other. Because of these advancements, MR urography started to be utilized as a part of obstructive uropathy patients for different indications[3].

We audit the most widely recognized MR imaging systems used to demonstrate the urinary tract and discuss about extraordinary contemplations (pediatric

patients, pregnant patients, renal deficiency) identified with MR urography. What's more, we examine and show potential clinical utilizations of MR urography as for urolithiasis, urinary tract obstruction unrelated to urolithiasis, hematuria, congenital anomalies, and pre- and postoperative assessment.

INDICATIONS OF MR UROGRAPHY[1,5]: -

1. Pregnant patients with clinical features of obstructive uropathy
2. Children with clinical features of obstructive uropathy
3. Hematuria
4. Urothelial carcinomas
5. Urinary tract infections
6. Congenital anomalies
7. Ca cervix
8. To look for integrity of urinary tract post trauma

CONTR-INDICATIONS OF MR UROGRAPHY: -

1. Patients with a cardiac pacemaker
2. MRI non compatible stents and implants
3. Claustrophobic patients

PATIENT PREPARATION: - The patient must be informed regarding the procedure of the examination. Written consent must be taken before procedure. Advice patient to void before procedure. For Adult patients, 500cc NS bolus was given immediately before scan. For Paediatric patients, weight based IVF: 4ml/kg/hr 1st 10 kg, 2ml/kg/hr next 10 kg and 1ml/kg/hr for each kg above 20 kg was given. Position of the patient is supine with the arms behind the head to avoid artefact.

TECHNIQUE OF MR UROGRAPHY: -

The most common MR urographic techniques used to display the urinary tract can be divided into two categories:

(a) Static-fluid MR urography
(b) Excretory MR urography

Static-Fluid MR Urography

Static fluid MR urography is performed using T2 sequences which uses long relaxation time of urine. Urine act as column of static fluid in these sequences which allows us to image the urinary tract as a static column of liquid.[5,6] These sequences of MRU can be repeated to assess the ureters in their entire length which helps to detect stenosis. Contrast are not required in these sequences of MR Urography; thus it is useful in patients with raised creatinine value as well as pregnant patients.[7] Hydration, the use of diuretics and compression can improve the quality of the images in patients with non-dilated collecting systems.[8]

Following sequences are taken,

- Localizer -Abdomen & Pelvis
- Coronal SSFSE -Abdomen & Pelvis
- Axial T2 Fat Sat-Respiratory Triggered-Abdomen & Pelvis
- Axial T2 Fat Sat-Breath Hold-Abdomen & Pelvis
- Coronal 3D MRCP Thick of Kidneys

Excretory MR Urography

Excretory MR Urography are contrast enhanced T1 images. This technique is performed after administration of intravenous contrast and is depends on the renal function of the patient. So, the patient must have enough renal function for the uniform distribution and excretion of the contrast medium. [3,5,8] This technique of MR Urography is usually performed to collect information about the renal parenchyma, ureters, bladder, any mass lesion and its extensions.

To start, pre-contrast images are taken to evaluate the renal parenchyma and to assess the enhancement of the walls of urinary system and any mass lesion if present. The sequences used in this technique are echo gradient in 3D with fat suppression.

After the administration of intravenous contrast medium, echo gradient 3D with fat suppression images are taken during the excretory phase. The presence of paramagnetic contrast medium in urine shortens the relaxation time of it in the T1 sequences, which allows viewing it as a high signal. All the sequences must be taken in fat suppression coronal and axial dimensions with patient in breath-hold position[9]. The recommended dose of intravenous gadolinium is of 0.1 mmol/kg for this technique [3,5]. In non-dilated collecting system, diuretics can be used to improve the excretion of contrast medium[8].

Following sequences are taken,

PRE Contrast sequences

- **Ureters and Bladder Thick slab MR Urographic coronal**

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Post contrast sequences

- **3D Fat Sat GRADIENT Dynamic Axial** (pre contrast-during the time of contrast-20 sec and 45 sec acquisitions
- **3D Fat Sat GRADIENT Axial**-Abdomen & Pelvis (Excretory phase)
- **3D Fat Sat GRADIENT Coronal**-abdomen & Pelvis (Excretory phase)

MR Urography sequences used in GE 1.5 Tesla 16 channel- MRI machine

SEQUENCES	TE (msec)	TR (msec)	Slice Thick. (mm)	No. of slices	Flip Angle (^{0})	FOV	Acquisition time
COR T2 FSE	90	min	6	15	-	34-36	22 sec.
AX T2 FSE RSEP. TRIG.	80-110	-	5-7	To cover anatomy	-	40	5-7 min.
AX T2 FSE BREATH HOLD	90-100	2000-2500	5-7	To cover anatomy	-	40	20sec/ 9 slice
COR MRCP	800-1000	Min.	40-50	Cover KUB	-	32-36	3 sec/ slice
AX 3D LAVA PRE	2.2	Min.	4-5	50	12-15	44-48	21 sec.
AX 3D LAVA DYNAMIC	2.2	Min.	4-5	50	12-15	40	22 sec. x 3
COR 3D LAVA POST	2.2	Min.	4-5	50	12-15	44-48	21 sec.

APPLICATIONS

Urolithiasis: - Calculus in urinary tract appear as signal voids when surrounded by urine or contrast material on both static and excretory MR Urography (Figure 1 & 2). They are better visualized in axial images, instead of MIP images, the source images must always be reviewed because small defects may be obscured by the surrounding urine on MIP projections[6,7]. However, low-signal-intensity filling defects within the urinary tract are not specific for calculi. Blood clots are seen as single or multiple filling defects that may cause temporary ureteral obstruction, but can be distinguished since they typically exhibit high-signal-intensity elements on unenhanced T1-weighted images and be- come much smaller or disappear within several weeks. Neoplasm can also show filling defects but can be distinguished since typically enhance after intravenous contrast material administration. Some authors such as Karabacakoglu et al. reported a better sensitivity founding collecting system calculi with diuretic-augmented excretory MR urography[10].

Urinary tract obstruction except calculus: - Though calculus remains major cause of Urinary tract obstruction, multiple other causes includes blood clots, papillary necrosis, tumour, infection diseases, post-surgery/instrumentation trauma, lesions after radiotherapy, ureterocele, megaureter retroperitoneal fibrosis, invasion or compression by extrinsic malignancy, lymphadenopathy.[6] Conventional MRI pulse sequences along with MR Urography sequences determine cause of urinary tract obstruction along with renal functions. MR urography along with angiography provides vascular information making it complete solution of problem. Most of these lesions appear hypointense on T1WI and hyperintense on T2WI. Infection shows post contrast enhancement.

Hematuria: - Renal calculus, neoplasms of urinary system and trauma are most common causes of hematuria. MR urography is useful in detection of renal parenchymal and vascular lesions as well as urothelial abnormalities. Detection and Staging of neoplasm is superior with MRU as compared to other imaging modalities. Routine abdominal imaging sequences along with 3D urography sequences is helpful in providing information about lesion as well as renal functions. Renal neoplasm appears hypointense on unenhanced T1WI and hyperintense on T2WI. Most of the neoplasm shows moderate gadolinium enhancement of such tumours on axial T1-weighgted spin-echo images. Pulse sequences

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provides infiltration of lesion in surrounding structures, also distinguish intrinsic lesion from secondary invasion from surrounding lesions [11,12].

Figure :1 A case of partially obstructing left ureteric calculus.MRI Sag. T2WI shows dilated left sided ureter with signal void in mid one third of Ureter-partially obstructing Calculus.

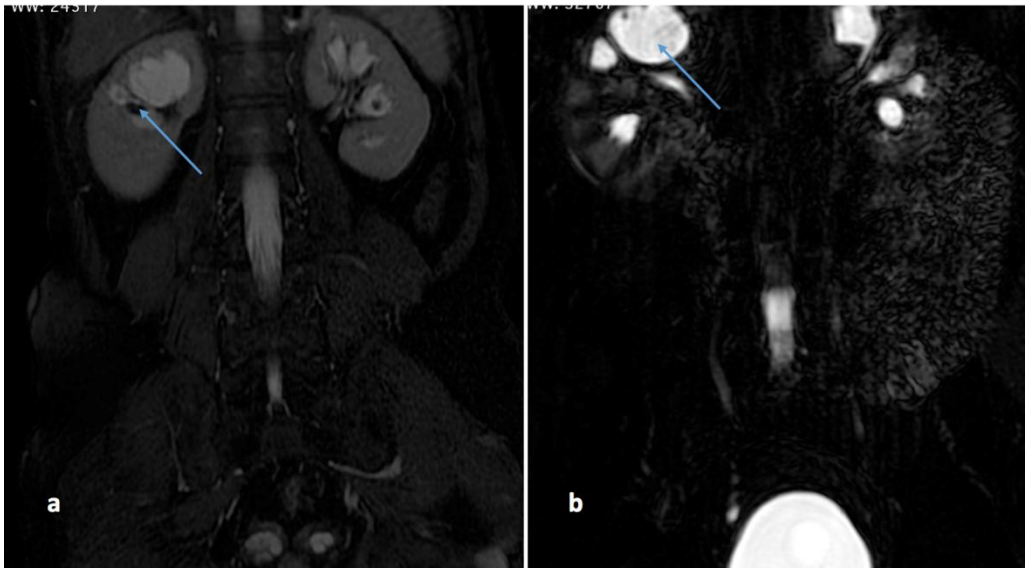

Figure :2 A case of right renal case.MRI COR. T2WI (A)shows calculus seen as signal void in PUJ and upper pole of Right Kidney. 3D urogram (B) showing Right sided hydronephrosis.

Congenital Anomalies: - Complete picture of entire urinary system can be excellently viewed on MR Urography. Multiple congenital anomalies of the kidney and urinary tract is present including absence of one of kidney, increase in number of Kidney, abnormal position of kidney, asymptomatic malformations such as a double ureter or minimal ureteral pelvic obstructions to severe, life-threatening pathologies. Most of these renal abnormalities are part of a syndrome or sequence that can be confirmed and sometimes treated by a proper approach including USG, MRI and vesico-amniotic shunt placement to relieve obstruction, molecular analysis, and pathologic examination after birth. Characteristic features of incomplete to complete fusion, duplication of urinary system are best visualised on MR Urography (Figure 3). Most of the anomalies are nicely seen on static

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MR Urography while to detect full spectrum of complications excretory MR Urography is useful. Absence of ionising radiations and iodinated contrast media makes MR Urography is choice of diagnostic modality in paediatric age group to look for congenital anomalies [5,11].

Figure :3 A case of duplex collecting system. 3D urogram showing two separate ureters on left side emptying separately in urinary bladder.

Pre and post-operative assessment: - The role of MR Urography in patients undergoing urinary diversion or Pre-Post transplantation assessment is emerging now-a-days. MRU provides excellent visualization of anastomoses, associated complications such as strictures, ureteral compression, haematoma, urine leaks, fistulae[6] (Figure 4). Generally, conventional MRI sequences along with Angiography and Urography sequences are taken for renal transplant patients. Low level of nephrotoxicity of Gadolinium allows its use in excretory urography in those with increased level of creatinine (level of serum creatinine < 4 mg/dl).

Foetus and pregnant women[13]: -

All the MR Urography procedures in foetus and pregnant women are performed using only static urography sequences. The main focus in these patients is to differentiate physiological dilation from the pathological. It is considered that physiological dilation occurs in the third trimester of gestation due to compression between the psoas and the gravid uterus. It is viewed as physiological if there is pressure of a large portion of the ureter with continuous decline towards the edge of the pelvis, with no filling imperfection, with irregular filling. If entire column of urine is seen in ureter, then one must look for pathological dilatation. Filling defects or any external lesion causing compression of ureter must be checked.

Gd passes the placental hindrance and enters fetal flow, where it is filtrated by the kidneys and discharged to the amniotic fluid. Here the Gd particles stay and remain for an undetermined sum and time, before being reabsorbed and abstained from. The more drawn out the Gd iota remains chelated, there is a higher probability that there is a conceivably deadly partition of the molecule of the chelated atom. High and repetitive doses of Gadolinium (Gd) is considered to cause teratogenic effect by some report, however it is considered as a class C medication according to the FDA. Currently it is not used in maternal pathologies. Hence lack of radiations and iodinated contrast make MR Urography useful in evaluating maternal and foetal pathologies.

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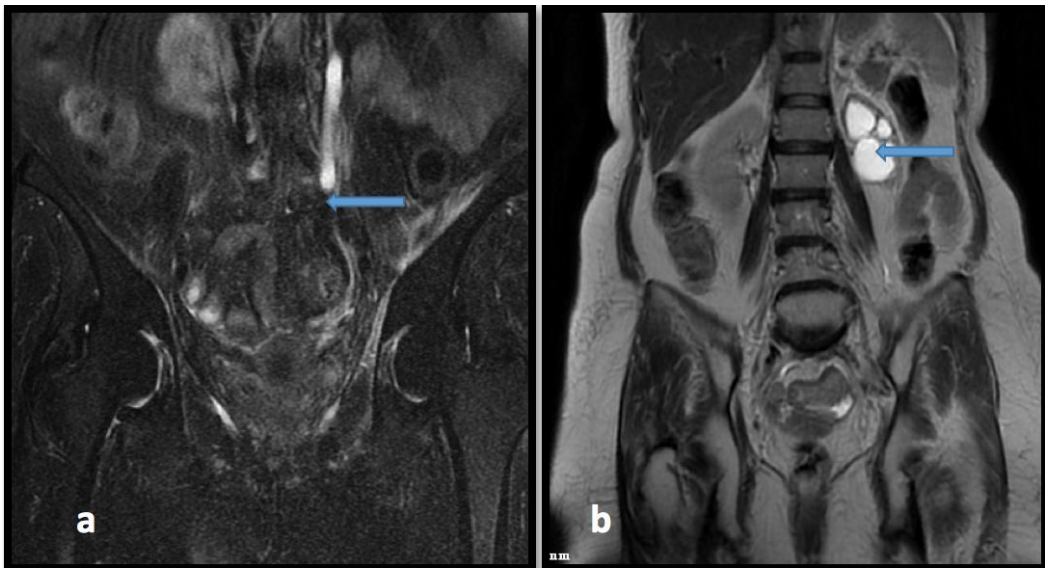

Figure:4 A case of Post Radiotherapy Fibrosis. MRI COR T2WI (a) showing soft tissue along the left pre and paravertebral region at the level of L5 vertebral body extending within the left psoas muscle with encasement of lower end of visualized Left Ureter. MRI COR FIESTA (b) showing resultant upstream dilation of Left Ureter extending upto Left pelvicalyceal system, likely to represent Post Radiotherapy Fibrosis.

CLINICAL APPLICATIONS OF MR UROGRAPHY

	Static Fluid MRU	Excretory MRU
Pediatric patients	Detection of congenital urinary tract anomalies, stenosis, cystic renal diseases.	Demonstrate diverticula, tiny lesions
Obstetric	Differentiate physiological from pathological hydronephrosis.	
Pre/post-operative assessment	Strictures, leaks and fistulas, hematomas	
Urology	Urolithiasis, Determine other causes of obstruction	To asses kidney function
Oncology	Location and characterization of tumors	Relation with adjacent structures

LIMITATIONS

While reporting MR Urography, one must be aware of following pitfalls [14,15] of technique

- Tiny calculi may be obscured by hyperintense urine on maximum-intensity projection images in both urography sequences, hence it is important to check original source images to make it sure those small calculi are not obscured by surrounding urine.
- The filling defect may be similar in appearance to a blood clot, subtle urothelial lesions or a metal clip. So, source images should be checked always.
- Ghost artifacts are encountered on 3D Urographic images due to ureteral peristalsis.
- Diagnostic or therapeutic procedures, post-surgery or some infections may produce intraluminal gas bubbles which appears as single or multiple filling defects within column of urine within ureter.
- Hemorrhage appears as hyperintense on T1-weighted images and may be obscured in post contrast study. It may also result in decrease in signal intensity of urine in static fluid urography.

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- Artefacts from metals may mimic stricture in ureter, so this susceptibility artifact should be correctly determined on other sequences**.**

CONCLUSIONS

The two techniques of MR Urography i.e. static and excretory, provides superior anatomical and functional information about the urinary system with some advantages over IVU, CT and ultrasound. Absence of ionizing radiation and iodinated contrast medium make it investigation of choice in patients with transplanted kidneys, children and pregnant women. Additionally, it has the capacity to provide a complete diagnostic evaluation of entire urinary tract in a single session.

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