NON-CONTRAST MAGNETIC RESONANCE UROGRAPHY

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ABSTRACT

BACKGROUND AND PURPOSE

Magnetic Resonance (MR) urography with its optimal contrast resolution and lack of ionizing radiation provides a comprehensive examination of the entire urinary tract noninvasively. MR urography is clinically useful in the evaluation of suspected urinary tract obstruction, haematuria, congenital anomalies, and surgically altered anatomy. It is particularly useful in cases of where there is contraindication of ionizing radiation and in paediatric and pregnant patients.

The common MR urographic techniques are: Static-fluid MR urography and excretory MR urography. Static-fluid MR urography uses of heavily T2-weighted sequences to image the urinary tract as a static collection of fluid, can be repeated sequentially (Cine MR urography) to better demonstrate the ureters in their entirety and to confirm the presence of fixed stenoses. Excretory MR urography is performed during the excretory phase of enhancement after the intravenous administration of gadolinium-based contrast material; thus, the patient must have sufficient renal function to allow the excretion. Static-fluid and excretory MR urography can be combined with conventional MR imaging for comprehensive evaluation of the urinary tract. The limitations are limited availability, high cost, relatively long examination time, low spatial resolution compared to IVU (Intravenous Urogram) and CT Urography; sensitivity to motion (breathing and ureteral peristalsis) inherent contraindications like patients with pacemakers, claustrophobia, and relative insensitivity for calcification and ureteric calculi.

In this article, an attempt has been made to demonstrate the potential of static-fluid MRU to demonstrate a spectrum of urologic pathology involving the kidneys, ureters, and bladder while discussing the limitations.

METHODS

Thirty patients with urinary tract abnormalities were evaluated with MR urography performed between May 2014 to April 2016 using routine MR sequences and additional heavily T2 weighted sequence on a 1.5 Tesla MRI machine. Images were post processed using MIP algorithm. Both, the reconstructed and source images were evaluated.

RESULTS

Static-fluid MR urography correctly depicted the presence of urinary tract dilatation and level of obstruction. It also succeeded in depicting the cause of obstruction.

CONCLUSION

MR urography allows comprehensive imaging of the urinary tract abnormalities non-invasively without using ionizing radiation.

PURPOSE

To study the efficacy of static MR urography in comparison with conventional urography. To study the levels and causes of obstruction of urinary tract by MR urography and compare them with other investigation procedures.

KEYWORDS

Non-contrast MR urography, Calculous, Stricture, Hydroureteronephrosis.

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INTRODUCTION: Iodinated contrast agents that were excreted by kidney and could be administered intravenously were developed in 1920s. The key element iodine set the stage for all future developments in contrast material for radiographic imaging. From this stage, extensive development of the quality of contrast medium has grown immensely to the present stage of non-ionic contrast media, which are considered to be safe. New generation of contrast media for radiographic visualization appears to be peaked, unlikely to be surpassed in the near future. For a long time, IVU has been gold standard for the detection of dilatation of urinary tract. Over the years, the use of IVU has become somewhat less due to the advent of cross-sectional imaging, but nevertheless remained in general use because of its low

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cost. IVU has the disadvantage of using ionizing radiation and iodinated contrast media, both of which contribute to some extent to morbidity and mortality.[1] The use of ionizing radiation may also be an issue, particularly in children, young adults and during pregnancy. However, above-mentioned non-ionic contrast media cannot be administered in patients with poor renal function. Ultrasonogram has significantly reduced the referrals for IVU as it is safe, non-invasive method of assessment of urinary tract dilatation, but visualization of non-dilated collecting system needs contrast opacification.[2]

MRU is becoming an integral part of recently emerging advances that involve clinical radiourology. The advantages of MRU are that it is a non-invasive technique, allows multiplanar imaging, good soft tissue contrast and resolution, and no need for contrast agents. So, it is useful for imaging of non-functioning kidneys. There is lack of ionizing radiation with this procedure, so it is useful in children during pregnancy[3] and those who require repeated examination of urinary tract.

In the present study, 3-dimensional FSE sequences are employed. This article is an attempt to study the diagnostic capability of urography and its efficacy in the visualization of urinary collecting system.

MATERIALS AND METHODS:

Patients: We prospectively reviewed the MRU examinations of 30 patients (17 men and 13 women; age range, 24-70 years; mean age, 35 years), performed between May 2014 to April 2016 at Department of Radiodiagnosis, SRMC, Nandyal. Patients with complaints of ureteric colic, polyuria, dysuria, haematuria, and fever were selected. Patients with cardiac pacemakers, severely obese, and claustrophobic patients were excluded from the study. In accordance with the guidelines of our institutional review board for prospective studies, informed consent and formal approval were obtained.

Examination Technique: MRU was performed on Signa HD 1.5 Tesla MRI, GE Healthcare (Milwaukee, USA). A body coil and commercially available software were used. Before performing MR urography, 3 plane localizer obtained in three planes used to confirm optimum patient positioning; axial and coronal T2 weighted single shot FSE sequences of KUB region were taken. (TR 1615 msec, TE 88 msec, FOV 38 x 38, Matrix 256 x 256, NEX 0.56, TA 49 sec).

Static-fluid MR urography treats urinary tract as static column of fluid. MRU sequences are very heavily T2WI and closely resembles those used for T2W MRCP. 3-dimensional respiratory triggered sequences can be used to obtain thin section data sets that can be post processed to create VR/MIP images of entire urinary tract.[4,5] FRFSE (Fast recovery fast spin echo)[6] provides high signal intensity of fluid even with short repetition time and can be used for short breath hold techniques or respiratory gating. It also has advantage for volumetric imaging. Fat saturation pulse to reduce high signal intensities from retroperitoneal fat. Breath holding in major source of phase related artefact that degrades the quality of abdominal MR image. Respiratory triggering (RTr) can be used to decrease respiratory artifacts by synchronizing image data collection with respiratory cycle. Sensitivity encoding parallel imaging techniques ASSET (Array Spatial Sensitivity Encoding Technique) reduced imaging time and potential for respiratory motion artefacts.

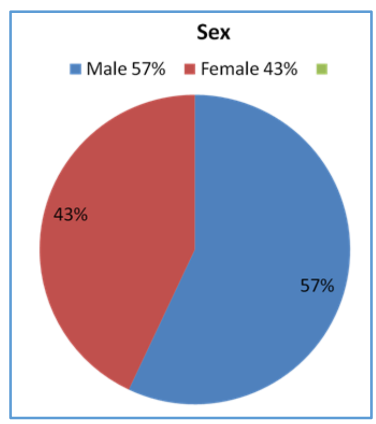
MRI renal standard acquisition includes T1 dual echo-gradient sequence within and opposed phase echo-times, and T2 weighted images in all planes (Axial, sagittal, and coronal), and in addition fat suppressed techniques.

These sequences give valuable information about:

1. Renal anatomy and anatomic abnormalities or variants.
2. Relation with adjacent structures as vascular impressions.
3. Findings in abdominal or retroperitoneal spaces.
4. Information of the lesions depending on their signal.

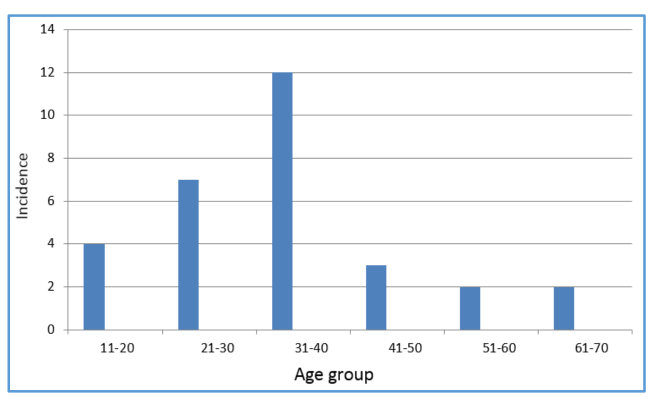
T2 weighted images with fat suppressed techniques are helpful to demonstrate the presence of inflammation and/or oedema (perinephritic, parapyelic, or periureteral) in cases of renal obstruction; whereas the sequences in phase and out of phase are useful to show the presence of intracellular lipids.

OBSERVATIONS AND RESULTS:



Graph 1: Sex Distribution

Out of 30 patients, who underwent MR urography, 17 were male and 13 were females.



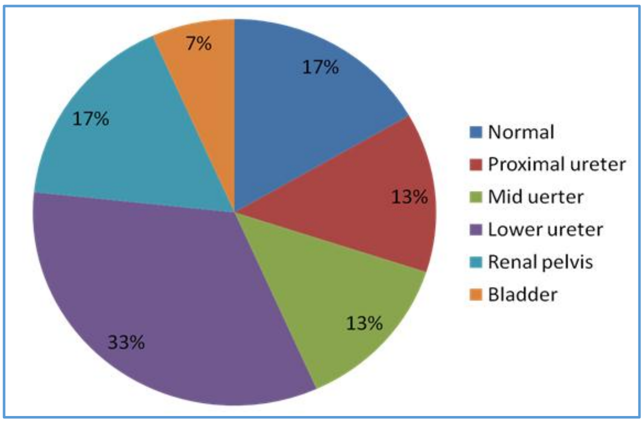
Graph 2: Age Incidence

Most common age group 3rd decade followed by 2nd decade.

Sl. No.	Clinical Features	No. of patients
1.	Pain	28
2.	Dysuria	20
3.	Haematuria	16
4.	Fever	14

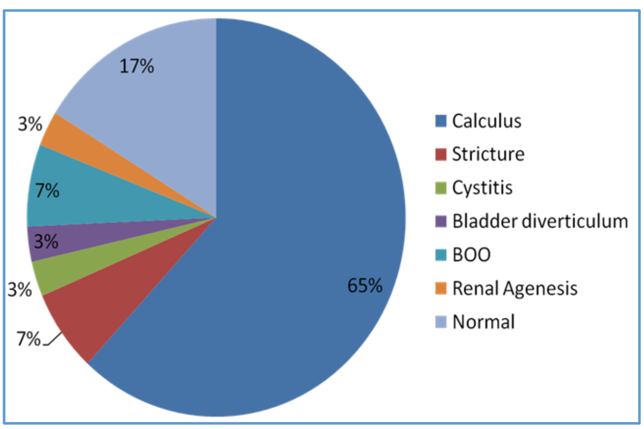
Table 1: Clinical Features

Most common presentation was pain followed by dysuria.



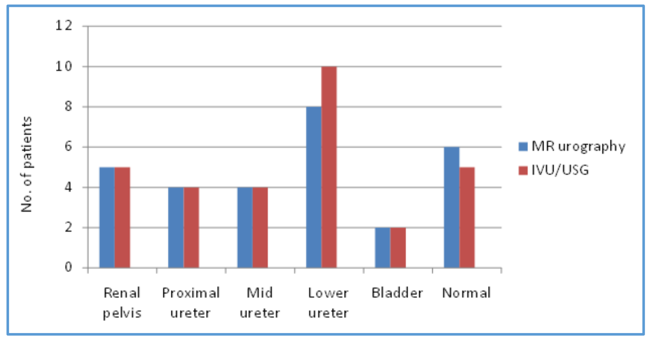
Graph 3: Site of Obstruction

Most common clinical presentation was pain followed by dysuria.



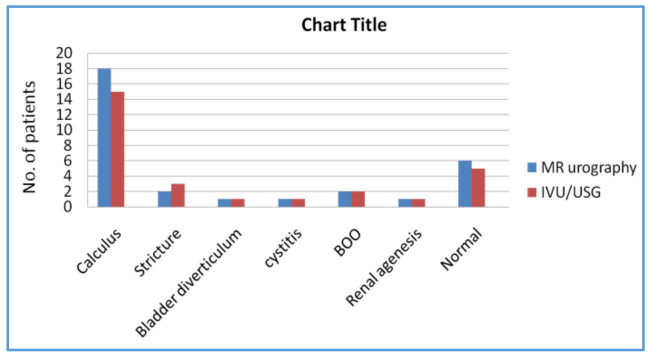
Graph 4: Pathological Findings

The commonest site of obstruction in this study was lower ureter followed by renal pelvis.



Graph 5: MR Urography Correlation with Site of Findings

The most common pathological finding was calculus.



Graph 6: MR Urography Correlation for Pathological Findings

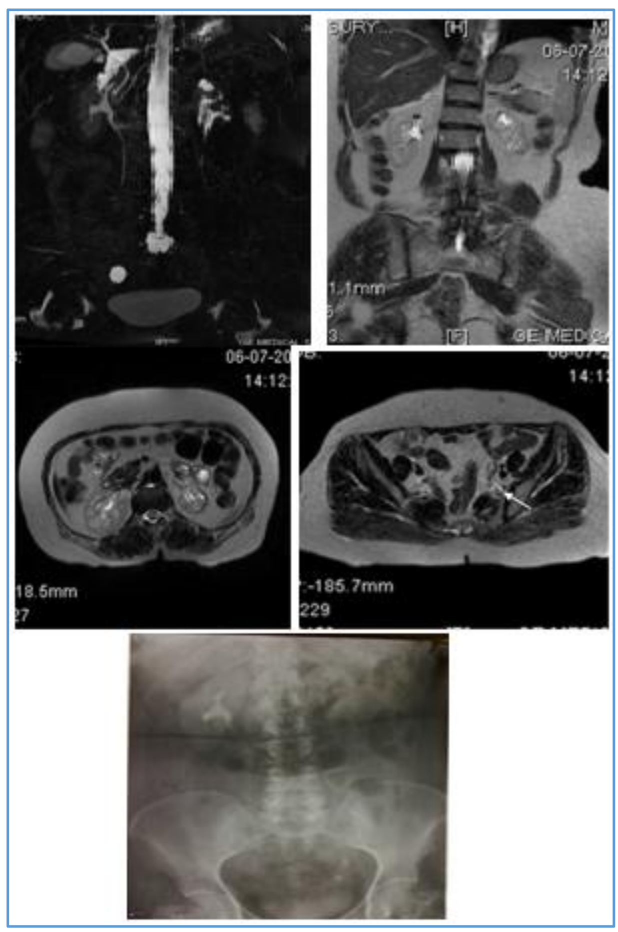


Fig. 1a, b, c, d, e: MRU

Right Kidney: Size, shape, site are normal. Ureter and collection system are normal.

Left Kidney: Small in size with parenchymal atrophy.
Hypointense filling defect noted in lower ureter level suggestive of calculus.
Axial images localize the filling defect better.

IVU: Normal excreting right kidney. Non-excreting kidney on left side with calculus noted in lower ureter.

Diagnosis: Small left kidney with lower left ureteric calculus.

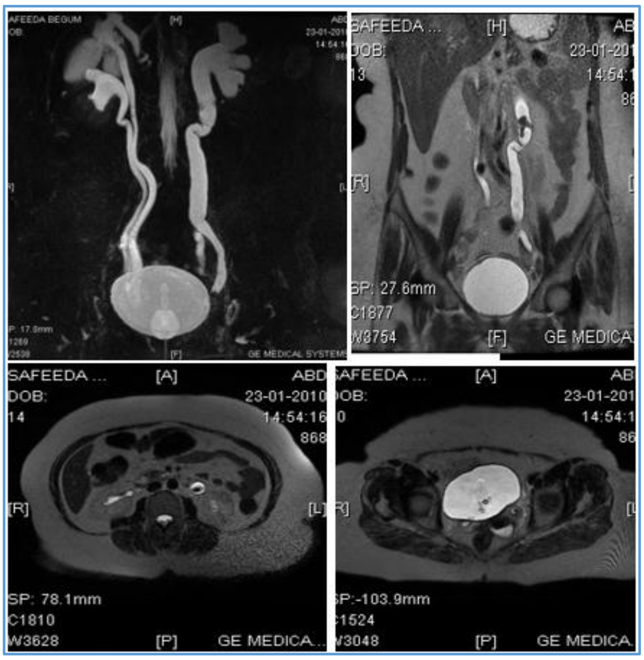


Fig. 2a, b, c, d: MRU

Right Kidney: Size, shape, site are normal. Duplex collecting system detected on right side.

Left Kidney: Left moderate hydroureteronephrosis with hypointense filling noted at multiple levels in ureter (proximal and distal ureter) – suggestive of calculi.

Diagnosis: Duplex collecting system on right side. Left moderate hydroureteronephrosis with multiple calculi in ureter.

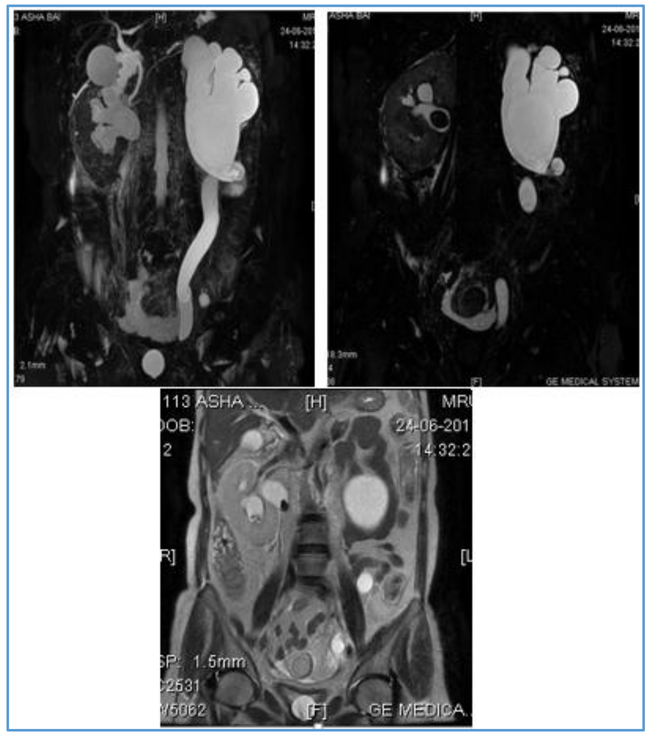


Fig. 3a, b, c: MRU

Right Kidney: Obstructing right renal calculi (pelvis) with right moderate hydronephrosis. Incidentally detected renal cortical cyst in upper pole of right kidney.

Left kidney: Left gross hydroureteronephrosis. Smooth tapering distal ureter - ? Stricture.

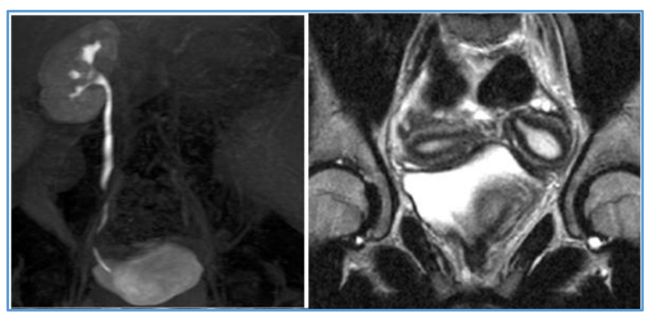


Fig. 4a, b: MRU

Right Kidney: Site, size, shape - normal. Collecting system, ureter normal.

Left Kidney: Not visualised.
Uterus - didelphic uterus. Detected as an incidental finding.
Bladder - Normal

Diagnosis: Left renal agenesis with Mullerian duct anomaly - didelphic uterus.

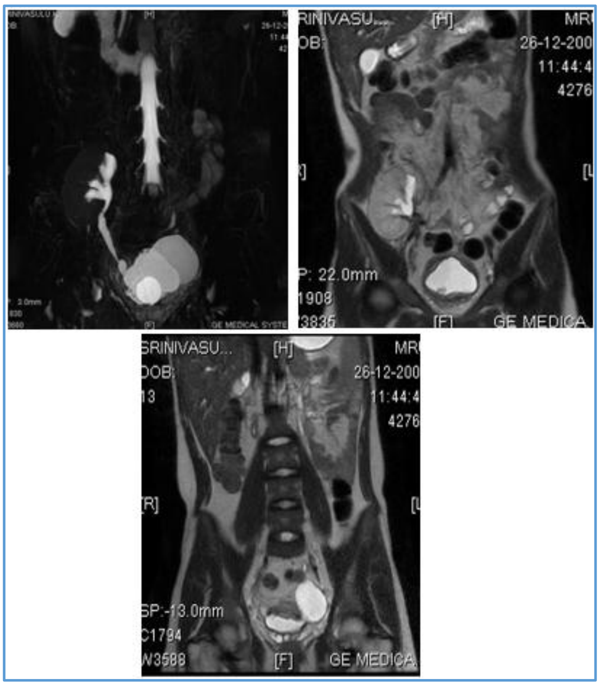


Fig. 5a, b, c: MRU

Transplant Kidney: Size normal. Collecting system and ureter normal. No evidence of perirenal collections.

Bladder: Diverticulum was detected.

Diagnosis: Transplant kidney with urinary bladder diverticulum.

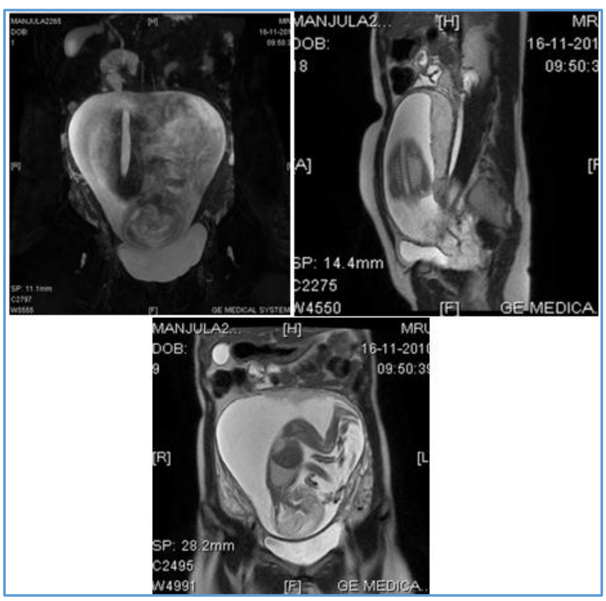


Fig. 6a, b, c: MRU

Both kidneys are normal in size, shape, and site. Dilated right pelvicalyceal up to mid ureteric level with tapering at the pelvic brim and no visible filling defect.

Diagnosis: Physiological hydronephrosis.

DISCUSSION: Hydroureteronephrosis is a frequent urological problem with multiple aetiologies. In routine practice, USG and IVU are frequently used to diagnose hydronephrosis. For a long time, IVU has been the only technique used in evaluating possible ureterohydronephrosis, but requires ionizing radiation, iodinated contrast media, and most important of all the functioning kidney. Ultrasound was shown to be quite effective in diagnosis with a reported sensitivity of 98%.[1]

However, the specificity is very low especially in depicting ureter.[2] MRU can be used to evaluate urinary tract without ionizing radiation and iodinated contrast material.[3,7] In the past, most authors used RARE (Rapid Acquisition Relaxation Enhancement), first described by Hennig et al, 1986.[8,9] Heavily T2 weighted turbo spin echo pulse sequences were used to obtain water images of urinary tract. However, these techniques were time consuming and spatial resolution was poor. Moreover, only urinary tract was seen, but renal parenchyma was poorly visualised/absent.

HASTE (Half-Fourier Acquisition Single-Shot Turbo Spin-Echo) (Siemens; Erlangen, Germany) on SS FSE (Single-shot Fast Spin-Echo) (GE Health Systems) is a susceptibility insensitive single shot sequence allowing ultrafast acquisition of T2 weighted high resolution images.[10,11] Only half of the K Space is measured, other half constructed by Half-Fourier. This sequence has the advantage of visualization of urinary tract and renal parenchyma and can be obtained in a few seconds thus reducing motion artefacts. In our study, 3D respiratory triggered sequences 3D FR FSE (Fast Recovery Fast Spin Echo) sequence was used. It provides high signal intensity of fluid even with short repetition time. Frequency selective fat saturation pulses was used to reduce signal from retroperitoneal fat. During a period from May 2014 to April 2016, a total of 30 patients formed the study group. This included 13 females (43%) and 17 males (57%). Most patients in this study group belonged to the 3rd decade. Commonest complaint in this study was pain followed by dysuria. MR Urography images were of relatively good quality. Distension of urinary bladder aided in better visualization of upper urinary tract.[12,13] We had considerable difficulty in removal of overlying bowel from images of few patients. Renal sizes could be easily measured, renal contours were normal, no masses and other parenchymal abnormalities were seen. Calyceal, forniceal, and infundibular anatomy was not seen with the same detail as with an IVU and CT urography.[12] Anatomy of retroperitoneal and adjacent organs were reasonably seen.

Sl. No.	Study	Sensitivity	Specificity
1.	Catherine Roy et al[4]	100%	100%
2.	Fintan Regan et al[14]	100%	100%
3.	Martin O'Malley et al[5]	100%	100%
4.	Current Study MRU with T1, T2	100%	100%

Table 2: Comparison with Other Studies Demonstrating Urinary Tract Dilatation

MR urography findings were correlated with findings of IVU/USG and final diagnosis obtained in 28 patients. Follow up could not be obtained in 2 patients. The accuracy of MRI was good in identifying level of obstruction. USG has high sensitivity of detecting obstruction. Its specificity is reported to be as low as 26%[15] due to obscuration of ureter by overlying bowel gas. Proximal ureteric obstruction identified by MR urography in 4 patients was confirmed in all patients on further follow up (100% accuracy). Mid ureteric obstruction was diagnosed in all 4 patients by MR urography. One patient had a 3 mm calculus in lower end of ureter as shown by USG was missed by MR urography. MR urography showed calculi in 18 patients. Correlation was obtained in 15 out of 18 patients (83%). Accuracy on further follow up. This correlates with study of Martin et al, 1997, who found 70-83% accuracy in diagnosing urolithiasis.

Sl. No.	Study	Accuracy
1.	Catherine Roy et al[4]	100%
2.	Yi Tang et al[16]	100%
3.	Current study MRU with T1 and T2	93%

Table 3: MRU Showed Correlation to Level of Obstruction in 26 Out of 28 Patients (93% Accuracy)

MR urography accurately diagnosed strictures in 2 cases[7,17] 83% to 89% accuracy. MR urography diagnosed a case of left renal agenesis, which was associated with Mullerian duct anomaly - didelphic uterus. MRU showed transplant kidney[18] with clear demonstration of pelvicalyceal system and ureter where calculus obstruction was suspected. Incidental renal cortical cysts were detected in two patients.

MR urography demonstrates renal calculi as filling defects. It was difficult to differentiate the blood clots and tumours for which T1 weighted images and contrast were necessary.[19]

MRU performed in a pregnant woman[7,20,21] in the second trimester showed compression of mid ureter with tapering at the pelvic brim. Ureter below this level of compression is relatively collapsed.

MRU clearly demonstrates congenital anomalies in a patient with renal duplication,[22] where IVU could not be done, hydronephrotic upper moiety, and site of ectopic ureteral insertion were clearly demonstrated.[19]

SUMMARY AND CONCLUSION: A total of 30 patients were subjected to MR urography examination. This included 17 male (57%) and 13 female (43%). Patients in 3rd decades were mostly affected. Pain was the commonest symptom followed by dysuria. The lower part of ureter showed the maximum findings in this study. Calculus disease was the most common MRU finding. Regarding the presence of urinary tract dilatation and site of obstruction, MRU was accurate in 100% and 93% of cases respectively. 3D respiratory triggered sequence, 3D FRFSE was used along with fat saturation was the technique used. MRU was optimum for patients with renal failure and those allergic to iodinated contrast agents. It is safe as it involves non-ionizing radiation, a feature especially useful in children, pregnant women, and those requiring repeated imaging evaluation of the urinary tract. Usually, no patient preparation is required. It is operator independent unlike ultrasonography, independent of renal function. It is useful for assessment of congenital anomalies, renal donors, and complication post-transplant. In acute urolithiasis, MR urography is not very relevant compared to other modalities like CT. But, in chronic stone disease, it can provide valuable information about urinary tract anatomy.

In our study, there were certain limitations, limited availability, high cost, relatively long examination time, low spatial resolution compared to IVU and CTU; sensitivity to motion (breathing and ureteral peristalsis) inherent contraindications like patients with pacemakers, claustrophobia, relative insensitivity for calcification, and ureteric calculi. It relies on detecting secondary signs like ureteral dilatation and perinephric fluid. Superimposed abdominal fluid collections obscure segments of urinary tract. MR urography cannot differentiate dilatation between obstructive hydroureteronephrosis and dilatation due to vesicoureteric reflux. Static MRU provides no functional information. This should be complimented with contrast/excretory MRU. In conclusion, MR urography provides high quality imaging of urinary tract and is an accurate and safe diagnostic alternative to other urological procedures. This when combined with excretory MRU, conventional MR images and MRA in a single session can yield a rapid and complete diagnostic evaluation of urinary tract and have the potential to provide the same information as can be obtained with multiple separate diagnostic studies.

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