Original Article

Magnetic Resonance Urography (MRU) Versus Intravenous Urography (IVU) in Obstructive Uropathy: A Prospective Study of 30 Cases

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Abstract

Aim : Intravenous Urography (IVU) as a diagnostic modality has limitations in patients of obstructive uropathy with impaired renal function. Our aim was to study the technique and diagnostic accuracy of Magnetic Resonance Urography (MRU) in obstructive uropathy and to correlate the findings with IVU.

Methodology : Forty-eight patients, selected over a six-month period, based on mild to severe pelvicalyceal dilatation on screening ultrasonography, underwent an IVU; those having non-obstructive dilatation were excluded (18 patients). Thirty patients (age range 10 to 75 years) with definite obstructive dilatation underwent MRU. These were obtained using an open MRI unit (Siemens Magnetom Open Viva) with low-dose gadolinium-DTPA (0.01 mmol / kg body weight) using various MRI sequences. MRU studies were classified as 'excellent' or 'diagnostic' and data generated was compared with that of IVU.

Results : MRU studies were 'excellent' in twelve and 'diagnostic' in eighteen patients. Of the sixty pelvicalyceal systems (PCS) evaluated in thirty patients, there were thirty-seven calculi, nine pelvi-ureteric junction (PUJ) obstructions, six with impaired renal function, four malrotated kidneys and one each of horseshoe kidney, pancake kidney, pelvic mass (endometriomas), duplex moieties, ureterocele and vesico-ureteric reflux. MRU better depicted moderate-severe PCS dilatation, staghorn and urethral calculi, impaired renal function, extrinsic ureteric and PUJ obstruction. IVU better depicted small calculi and mild PCS dilatation.

Conclusions : In these thirty patients of obstructive uropathy, low magnetic field, open MRI units and low-dose Gd-DTPA provided cost-effective MRU studies with excellent diagnostic utility. MRU scored over IVU in patients with moderate-severe dilatation, staghorn and urethral calculi, impaired renal function, extrinsic ureteric and PUJ obstruction. ©

INTRODUCTION

Obstructive uropathy presents to medical wards with symptoms of renal colic, fever, hematuria, pyuria or even lithuria. Occasionally, a uremic patient admitted for management of renal failure, on investigation, is found to have pelvicalyceal system (PCS) and ureteric dilatation, thinned-out parenchyma and enlarged kidneys with or without the etiology of obstruction being evident. Often, investigating and treating such a patient lies in the domain of medicine and definitive surgical intervention is attempted only when the patient is medically stabilized.

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Intravenous urography (IVU) and ultrasonography (US) have, thus far, formed the mainstay in the investigation of obstructive uropathy. IVU helps to evaluate renal function well; US is adequate only for the evaluation of upper genitourinary pathoanatomy, leaving much of the ureters un-imaged. IVU however, is inappropriate for pregnant and young patients due to the high doses of radiation, can precipitate contrast nephrotoxicity in dehydrated diabetics and myeloma patients and has a potential for hypersensitivity reactions. These concerns have engendered the development of Magnetic Resonance Urography (MRU): static fluid imaging wherein static or slow-flowing fluids in the body are imaged as high-signal-intensity, high-contrast, bright structures against a dark background with very low signal intensity, referred to by some researchers as 'hydrographic contrast'.[1]

MRU as a technique for assessment of the urinary tract was first described by Henning *et al*[2] in 1987. The earlier studies described the utility of the T2-weighted

Rapid Acquisition with Relaxation Enhancement (T2W RARE) sequence, which was originally described by Henning and Friedberg. Subsequently, the T2W Half-Fourier Acquisition Single Shot Turbo Spin Echo (HASTE) sequence was used which afforded a better visualization of the renal parenchyma and other intra-abdominal structures. Nolte-Ernsting *et al*,[3] used a T1-weighted contrast (Gadolinium-DTPA or Gd-DTPA) enhanced dynamic MRU sequence, which attempted to simulate IVU in that it was able to provide functional information as well.

A comparison between MRU and IVU has been made by a few researchers; however, this was with the more expensive, high-strength magnets, in a closed MRI unit and at a conventional IV contrast dose of 0.1 mmol / kg.[4-7] Low magnetic field open MRI units have been employed for MRU of children with spinal dysraphism and spinal deformities, with the advantages of easy accessibility, greater comfort in terms of patient positioning and less claustrophobia.[8] Szopinski K *et al*[9] have successfully used low-dose gadolinium-DTPA (0.01 mmol / kg body weight) in MRU sequences with advantages of cost-effectiveness and superior T2W image quality (less T2* effects).[9] Ours is the first such study in the country, wherein we have compared the efficacy of MRU versus IVU, utilizing a low-magnetic-field open MRI scanner with low-dose gadolinium-DTPA (0.01 mmol / kg body weight).

Subjects And Methods

Patients with symptoms of renal colic, hematuria, fever with dysuria or pyuria and lithuria who had evidence of mild to severe dilatation of the PCS on the basis of a screening US were selected (48 patients) over a six month period (January to July 2002). These 48 patients underwent an IVU as a primary diagnostic modality. Patients with non-obstructive lesions viz. non-obstructing calculi (six patients), renal abscesses (five patients), masses (four patients), tuberculosis (two patients) and medullary sponge kidney (MSK, one patient) were excluded from the study. The remaining 30 patients with obstructive uropathy on IVU underwent MRU after obtaining permission of the ethics committee of our institution. Of the 30 patients, 23 were males and seven were females. The average age was 34 years (range 10 to 75 years). Sixteen patients were examined on an outpatient basis, while 14 were inpatients. Seven patients presented to the emergency department, while 23 were routine patients.

The principal presenting symptoms of these 30 patients were: dull or colicky pain (23, 76.6%), burning micturition (12, 40%), hematuria (five, 16.6%), dysuria (four, 13.3%), increased frequency (three, 10%), and nocturia (two, 6.6%), lump in abdomen or flank (two, 6.6%), lithuria (two, 6.6%), pyuria (two, 6.6%), fever with (two, 6.6%) or without (one, 3.3%) chills, retention and decreased urinary output (one, 3.3%), dysmenorrhea, anorexia and weight loss (one, 3.3%).

A written, informed consent was obtained for all patients in the study group. Ultrasonography was performed for all patients on the Corevision Color Doppler machine (Toshiba, Japan). IVU was performed on the Multix I with a Tridoros 6R generator (Siemens, Germany). For the purpose of diagnostic uniformity, strict protocol was adhered to for all patients included in the study group. Blood urea nitrogen (BUN), serum creatinine levels and a routine urine examination were obtained before and after each IVU procedure. All IVUs were performed after adequate bowel preparation. An antecubital vein was cannulated and an injection of 60cc of non-ionic iodinated contrast media, iohexol (non-ionic monomer, Omnipaque 300, Nycomed, Cork, Ireland) was made over one minute. Plain and 1, 7, 15, 20 and 25 minute films were obtained followed by post-evacuation and full bladder films. IVU of patients with findings of pyonephrosis on US was deferred, during which time the patient was put on antibiotics, until urine culture was normal for at least 6 weeks. In patients with serum creatinine >2mg%, IVU was deferred until renal chemistry remained normal for at least 3 to 6 weeks (serum creatinine ≤ 1.5mg%).

MRU studies were carried out at a private MRI center, as part of a joint research project. Indoor patients were transported by hospital ambulance facilities with an accompanying resident doctor. The MRU study, inclusive of the contrast agent was provided free of cost to all patients. MRU was performed on a 0.2T (Tesla) Open MR System (Magnetom, Open Viva, Siemens Medical Systems, Erlangen, Germany) using a standard body coil, with low-dose gadopentate dimeglumine (Gadolinium-DTPA, Magnevist, Schering, Germany), 0.01 mmol / kg body weight. Patients were well hydrated before the study and were asked not to fast.

A combination of non-enhanced, heavily T2-weighted (the heavier the T2-weighting, the brighter is the appearance of water) RARE (Fig. 1) and plain and contrast (gadolinium) enhanced T1-weighted (to opacify blood vessels and the urinary collecting system) FLASH (Fast Low Angle Shot) sequences were obtained. Though furosemide reduces T2* (T2-star) effects, we refrained from its use since low-dose contrast confers the same advantage. The sequence protocol used was:

- Localizer to select the area of interest,
- RARE sequence - 40mm thick slab - TR / TE - 10ms / 1100ms (TR: Time to Repeat; TE: Time to Echo)
- Plain T1W 2D FLASH coronal - TR / TE 160ms / 6.6ms
- Intravenous contrast - 0.01 mmol / kg
- Post-contrast T1W 2D FLASH coronal sequence obtained every 2-3 minutes for 10-15 minutes, after contrast injection, until contrast was visualized in the PCS.

Fig. 1 : Ballooning of pelvis with dilated calyces (bright; arrow) in a case of left-sided pelvi-ureteric junction obstruction: Heavily T2W RARE MR Urography.

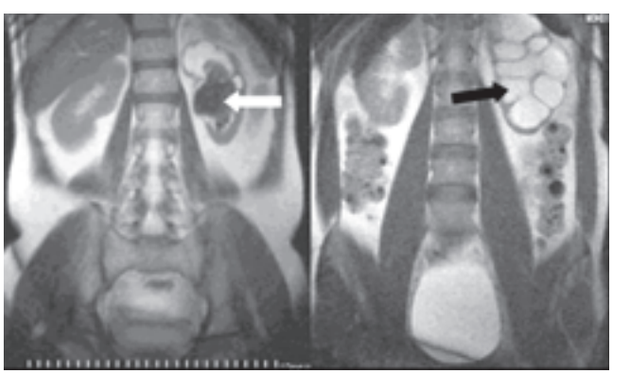

Fig. 2 : T2W TSE coronal images: The image on the left depicts a prominent left staghorn calculus, seen as a large pelvic signal void (dark; white arrow). The image on the right depicts a severely dilated PCS (bright; black arrow).

- RARE coronal thick-slab
- T2 TSE (Turbo Spin Echo, Fig. 2) coronal LOTA (Long-Term Averaging) - TR / TE (4200ms / 106ms)
- 3D T2 FISP (Fast Imaging in Steady-State Precession) - TR / TE (14.5ms / 7ms)
- Trufisp coronal - TR / TE (7.31ms / 3.52ms)
- Other sequences e.g. CISS (Constructive Interference in Steady State)
- Phase-shift (in- and opposed-phase 2D FLASH) imaging techniques were employed (Figs. 3 and 4).

Hard-copy source images and maximum intensity projections (MIPs) and IVUs were interpreted separately by two experienced radiologists who were blinded to each other's results.

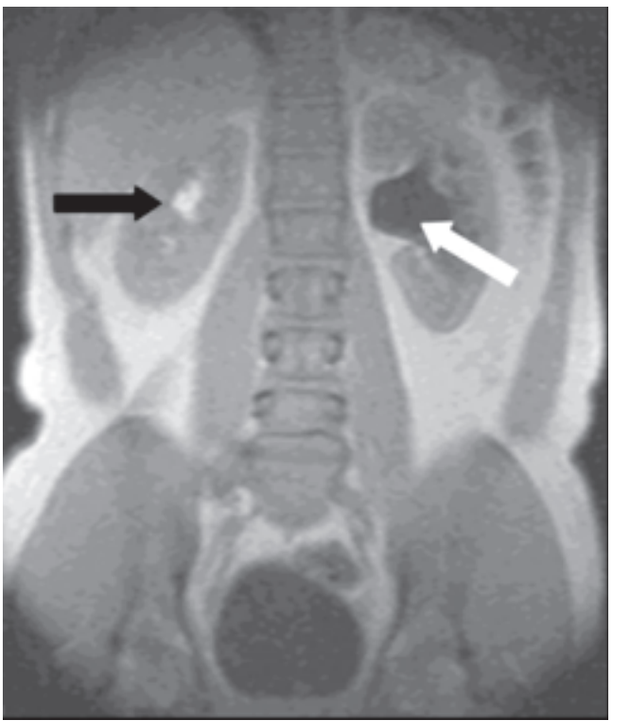

Fig. 3 : 2D FLASH post-contrast 5minutes, in-phase. In-phase images afford superior functional evaluation. Here the left kidney shows delayed function with a staghorn calculus in the PCS (oblique white arrow). Compare the right PCS filled with contrast (bright; right-pointing arrow) with that on the left (dark).

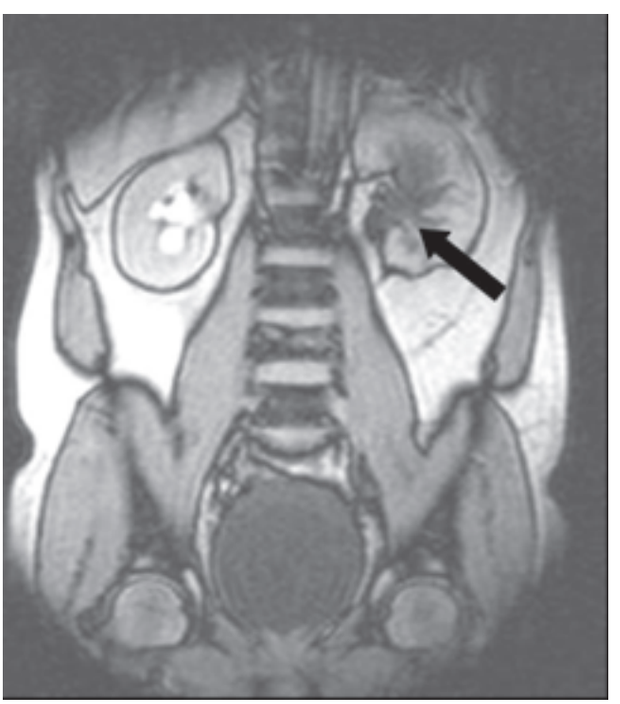

Fig. 4 : 2D FLASH post-contrast, out-of-phase. Affords superior morphological evaluation. Same patient as figure 3, depicting delayed function in the left kidney (arrow).

MRU studies were graded into excellent and diagnostic, based on final image quality and information

Table 1 : MRU findings with corresponding MRU quality grades

MRU Quality Grade	'n'	Information Yield								
		Dilated PCS			Calculi (including post-ESWL steinstrasse)	Poor Renal Function	PUJ obstruction		Pelvic masses - extrinsic obstruction	'Horseshoe' and 'Pancake' Kidney.
		mild*	moderate	severe			developing**	developed		
Excellent	12	1	5	6	10	5	2	5	1	1 (Horseshoe)
Diagnostic	18	3	12	1	16	1	1			1 (Pancake)

* Two mildly dilated PCS were evident only on IVU; ** One developing PUJ was evident only on IVU.

yield. A total of 31 MRU studies were done in 30 patients (one patient underwent a post-ESWL [Extracorporeal Shock Wave Lithotripsy] MRU as well).

Statistical analyses of the results were obtained. The sensitivity, specificity, positive and negative predictive values and false positive and negative error rates were obtained for both, MRU and IVU. In addition, data were analyzed using the Kappa Analysis, Wilcoxon's Signed Rank Test, and the McNemar's Test.

RESULTS

A total of 60 pelvicalyceal units were evaluated in 30 patients (two per patient). The duration of symptoms ranged from three days to four years.

The clinical examination was normal in 23 (76.6%) patients; two (6.6%) had palpable, ballotable lumps in the epigastrium and right flank; two had facial puffiness and pedal edema; one patient had phimosis, another with grade V vesico-ureteric reflux had a doughy, distended abdomen; one patient with endometriomas had right iliac fossa tenderness, with a firm, immobile and tender mass in the right fornix on per vaginal (PV) and bimanual examinations. One elderly male had grade II prostatomegaly on per rectal (PR) examination.

The mean BUN and serum creatinine values were 15.5 mg% (range: 8 to 90.4 mg%) and 1.1 mg % (range: 0.7 to 4.3 mg %), respectively. Urine examination was normal in 17 patients, revealed red blood cells in eight patients and pus cells in three patients. Urine proteins were found in one patient. Growth on urine culture was seen in one patient (*E. coli* > 10^5).

Intrinsic obstruction was found in 31 units (calculi [22], pelvi-ureteric junction [PUJ] obstruction [7], posterior urethral valves [1], large ureteroceles [1]), while extrinsic obstruction was found in 9 units (benign prostatic hyperplasia [2], horseshoe [1] or pancake kidney [1], endometrioma [1], inflammatory strictures [1], obstructing abscess [1], pyonephrosis [1], fungal ball [1]). One patient had 'steinstrasse' (German for a 'stony path'- a linear arrangement of calculus fragments along the ureter after ESWL, Fig. 5).

Eighteen patients had evidence of unilateral obstruction (one collecting system; 11 on the left, seven on the right), while 12 patients had evidence of bilateral obstruction (both collecting systems involved).

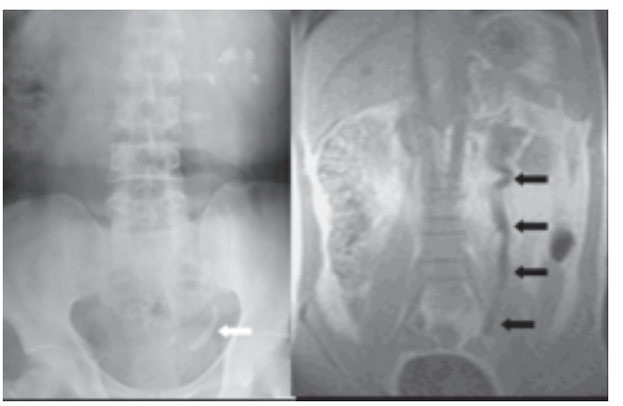

Fig. 5 : Post-ESWL 'Steinstrasse'. The image on the left is a plain radiograph of the abdomen, depicting a linear arrangement of calculus fragments along the lower left ureter (single white arrow). The image on the right is a 2D FLASH in-phase MRU showing multiple signal voids along the entire extent of the left ureter (multiple black arrows).

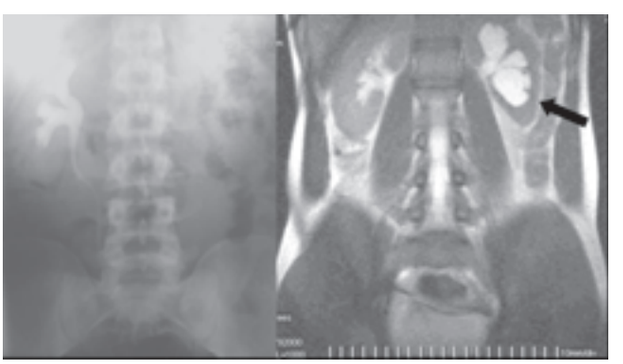

Fig. 6 : The 'trump card' of MRU: The delayed IVU image on the left depicts a normal right kidney but a non-visualized left kidney. This showed up on a T2W Trufisp coronal MRU image (arrow). On post-contrast 2D FLASH images (not shown), no contrast excretion was seen in the left PCS, suggesting poor function.

Table 1 gives a summary of MRU findings with the assigned MRU quality grades. It is evident that MRU is best suited for patients with moderate to severe dilatation of the PCS. In addition, staghorn and larger calculi, urethral calculi, extrinsic obstruction such as pelvic masses and PUJ obstruction were well visualized. Noteworthy here is the fact that kidneys with poor excretory function which were not visualized on IVU were well delineated on MRU (Fig. 6). Thus MRU is best

Table 2 : Comparison of MRU and IVU as regards features of obstruction

Findings	Present on both studies	Only on MRU	Only on IVU	Total
Dilated PCS:				30 (n)
* Mild	3	1	2	6
* Moderate	17			17
* Severe	7			7
Calculi:				37
* PCS	12		9	21
* Ureter	10		2	12
* Bladder	1			1
* Urethra	2	1 (posterior urethra)		3
Pelvi-ureteric Junction Obstruction	7	1	1	9
Pancake Kidney	1			1
Horseshoe Kidney	1			1
Pelvic Mass (Endometrioma)		1 (excellent characterization)		1
Malrotation of Kidney:				4
* Under-rotation			2	2
* Over-rotation	2			2
Duplex moieties (Two PCS per kidney)	1			1
Ureterocele	1			1
Vesico-ureteric Reflux			1	1
Decreased Renal Function (Late PCS opacification)	3	3		6
Others:				11
* Renal scarring		1	1	
* Renal cysts		2	1	2
* Polycystic Kidney disease	1			1
* Abnormalities of renal ascent		1		1
* Incidental abscesses		2		2
* Fungal ball	1			1
* Prominent Pyramids	1			1

Table 3 : Statistical Analysis of MRU and IVU findings

Test*	MRU	IVU
Sensitivity	81.5% (84 true-positives)	87.2% (88 true-positives)
Specificity	90.0% (18 true-negatives)	85.0% (17 true-negatives)
False-negative error rate	18.5% (19 false-negatives)	12.8% (13 false-negatives)
False-positive error rate	10.0% (2 false-positives)	15.0% (3 false-positives)
Positive predictive value	97.6%	96.7%
Negative predictive value	48.6%	56.6%

Test	Results & Inferences
Kappa Analysis	84%; excellent interobserver agreement which was due to observation rather than chance.
Wilcoxon's Signed Rank Test	$p<0.05$; etiology-specific differences between MRU & IVU not statistically significant.
McNemar's Test	Statistically significant increase ($p<0.05$) in information yield after addition of phase-shift imaging techniques for MRU.

* All findings on MRU / IVU were used to generate the respective statistical data.

suited for patients with moderate to severe PCS dilatation.

The comparative findings of MRU and IVU in these 30 patients are given in Table 2.

MRU scored over IVU in the outlining of the PCS despite poor kidney function, in detection and characterization of pelvic masses and other extrinsic ureteric obstruction (endometriomas in our study), for moderate to severe PUJ obstruction, in the characterization of obstructed horseshoe and pancake kidneys, in the detection of lower urinary tract (urethral) calculi, for abnormalities of ascent and parenchymal lesions (such as incidental renal abscesses). IVU, on the other hand, performed better in the detection of smaller PCS calculi, ureteric calculi, other small obstructive lesions, mild collecting system dilatation, mild PUJ obstruction, inflammatory strictures, post-ESWL 'steinstrasse' and some cases of malrotation.

Table 3 outlines the statistical analysis of MRU and IVU findings. The data has been generated from observations made from 60 pelvicalyceal units (30

Table 4 : Comparison of other features of MRU and IVU

Sr. No.	MR Urography	Intravenous Urography
1	No Radiation involved.	Radiation involved.
2	Renal and surrounding anatomy demonstrated. Renal parenchyma visible.	Only PCS outlined. Details of renal parenchyma and surrounding structures not provided.
3	Function assessed using IV Gadolinium 0.01 to 0.1 mmol/kg body weight, expensive.	Function assessed using IV ionic / non-ionic iodinated contrast medium, inexpensive.
4	Can be performed even if renal function is impaired, safer.	Impaired renal function is an absolute contraindication to the use of iodinated CM**, more allergic reactions.
5	Bowel preparation not essential and patient need not be NBM* but should be well hydrated.	Bowel preparation necessary. Patient must be NBM and at the same time well hydrated
6	Patients with paramagnetic or metallic objects cannot undergo the examination.	No such contraindication.
7	Morphological & Functional study. T1W and T2W sequences can delineate parenchyma as well as dilated PCS and ureters.	Mainly a functional study. No such sequences, poor delineation ofparenchyma, good delineation of dilated PCS and ureters.
8	Normal ureters not always well demonstrated.	Almost always well demonstrated.

* Nil by mouth, **Contrast media

patients), 40 of which were found to be dilated.

Thus, as a newer investigative modality, MRU has a slightly better specificity and a lesser false-positive error rate compared to IVU. The lower sensitivity (81.5% versus 87.2%) is due to limitations in detecting very small calculi and mildly dilated pelvicalyceal systems.

Twenty-three patients were treated surgically as follows: nephrolithotomy, pyelolithotomy - 15, pyeloplasty - five, bilateral ureteric reimplantation with DJ stents for hydronephrotic pancake kidney - one, Politano Lead-Better surgery for right duplex kidney with ureterocele and bilateral vesico-ureteric reflux - one, laparotomy and excision of endometriomas - one. Three patients were treated by instrumentation as follows: Extracorporeal Shock Wave Lithotripsy - ESWL - with ureterorenoscopy [followed by a post-ESWL MRU and IVU, Fig. 5] - one, Percutaneous Nephrolithostomy - PCNL - with DJ stenting and bilateral ESWL - one, ureterorenoscopy with lithotrity - one.

Imaging diagnoses corresponded with the intraoperative and instrumentation findings in 21 of 23 surgically treated patients and all three treated by instrumentation. This is attributable to the lack of both, IVU and MRU, to exactly quantify calculi in terms of numbers, especially when many calculi obstruct a collecting system.

Both, pre and immediate post-MRU BUN and serum creatinine levels remained unchanged in all of our patients (normal or otherwise).

The use of phase-shift imaging techniques (Figs. 3 and 4) and various supplementary sequences, served to enhance study quality.

Discussion

Our cohort comprising 30 selected patients of obstructive uropathy underwent both IVU followed by MRU using a low magnetic field MRI unit and low-dose Gd-DTPA. Our study illustrates that a combination of heavily T2W sequences with contrast-enhanced T1W sequences using a low-dose gadolinium protocol with additional phase-shift techniques generates reliable studies on a 0.2T open MR system. Although such an MR system affords a relatively lower spatial resolution than its higher field-strength counterparts, the resolution is dependent on the matrix size (the number of picture elements ['pixels'] - the smallest units of the image - on the 'x' and 'y' axes). We utilized a matrix of 256 x 256 pixels. With a 0.2T system, it takes longer to achieve the same resolution than with a higher field-strength system. However, we found advantages in patient positioning and IV contrast administration; additionally, children were more comfortable and consequently more compliant. These advantages would also prove beneficial to pregnant patients presenting with symptoms of obstructive uropathy. Conventional MRI systems with their closed, deep gantries induce claustrophobia and restrict patient positioning. The low magnetic field-strength MRI units are far less expensive than their higher magnetic-field strength counterparts. This coupled with the fact that low-dose gadolinium (an expensive contrast medium) was used, makes the MRU cost-effective. To our knowledge, this is the first such study in the country successfully employing a 0.2T Open MR system.

Our study agreed with that of Szopinski K *et al*[9] who, in a study of 91 patients conclude that low-dose gadolinium provides effective enhancement without the attendant T2* effects (artefacts which result from hypercoagulated gadolinium chelates). A study on similar lines as ours, of 14 children with spinal dysraphism, has found MRU to be effective when compared with IVU and recommends the use of low-field open MR scanners, as these scanners afford greater patient comfort and less claustrophobia.[8] Research on the use of negative oral contrast agents like blueberry juice which suppresses signals from bowel gas (due to its high manganese content), have further refined MRU

techniques in children.[10,11] Modifications in technique like combining T2W and FLASH sequences serve to further enhance image quality and diagnostic efficacy, even with low-field MR scanners. The presence of perirenal or periureteric fluid differentiates acute from chronic obstruction on MRU.[12,13]

In cases of compromised renal function such as chronic renal failure, dynamic contrast-enhanced MRU is shown to be effective because it is highly sensitive to even small amounts of gadolinium in the collecting system.[14] Besides, gadolinium-DTPA complex is safe in such patients as its in-vivo tolerance correlates with its high hydrophilicity.[15] There was no change in BUN and serum creatinine levels in any of our patients after MRU. Thus, we were able to image CRF patients without fear of further deranging these parameters, a major advantage of MRU over IVU.

In all cases of obstructive uropathy, the main reason for failure of IVU to diagnose upper tract pathology is the absence of contrast medium excretion.[16] Further, MRU is significantly superior to IVU in the evaluation of moderate-severely dilated ureters and bladder, both intrinsically and extrinsically.[3] This is where MRU and especially T2W techniques scores over IVU. A recent study has concluded that MRU properly depicts anatomy and allows assessment of urinary tract obstruction better than US and IVU in infants and neonates. It additionally provides functional information and therefore has the potential to replace IVU.[17]

Our study of 30 patients of obstructive uropathy, successfully combines the protocols and recommendations of the studies by Szopinski K. *et al*[9] (91 patients, low-dose Gd-DTPA) and Maher M.M. *et al*[8] (14 patients, comparison of MRU with IVU, recommend Open MRI units). We were also able to reproduce the results of Jung P. *et al*,[16] who have compared MRU and IVU in 82 patients and have found that T2W sequences depicted the anatomy while T1W sequences depicted poor function in kidneys that were not visualized at all on IVU. We also found MRU to be an especially valuable tool for the excellent characterization of pelvic masses that cause urinary tract obstruction. One such patient was diagnosed on MRU as having endometriomas due to the heterogeneous appearance of the pelvic masses which suggested blood products in varying stages of degradation. MRU also performed well in the delineation of obstructed horseshoe and pancake kidneys.

MRU is a sensitive and specific modality for the detection and diagnosis especially of non-calculus obstructive uropathy from lesions such as PUJ obstruction (moderate to severe), endometriomas, and horseshoe / pancake kidneys, as seen from our study. Low-dose Gd-DTPA MRU without diuretics or compression has been found to be useful for obstructive renal tumors.[9] The sensitivity of the modality falls with smaller intrapelvic and ureteric causes of obstruction and reduces as these lesions keep getting smaller.

Calculi, on MRU, are seen as signal voids. Hence, smaller calculi may be difficult to detect. MRU images are essentially obtained in multiple successive coronal slices or planes, the information from which must be assimilated and interpreted as a whole. Consequently, a small PCS dilatation or a small obstructing lesion will get segmented and hence, may be difficult to detect. IVU, however, generates a single, composite coronal image with high spatial resolution, adequate to depict smaller obstructing lesions (e.g. calculi) and mild PCS dilatation. The other comparative features of MRU versus IVU are summarized in Table 4.

To conclude, MRU utilizing low magnetic field, open MRI units and low-dose Gd-DTPA has excellent diagnostic utility in patients of obstructive uropathy, is advantageous in children and outlines the dilated PCS even in the presence of poor renal function, detects lower urinary calculi and depicts PUJ and extrinsic obstructions better than IVU.

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