Original Research Article

Static MR urography in obstructive uropathy and congenital anomalies in adults and paediatric age

Avinash Bansal[1*], Sanjay M Khaladkar[2], Vaishnavi Thakker[1] Nagi Reddy Bethireddy[1]

[1]Junior Resident, Department of Radiodiagnosis, Dr. D.Y Patil Medical College & Research Centre, Dr. D. Y. Patil Vidyapeeth, Pimpri, Maharashtra, India

[2]Professor, Department of Radiodiagnosis, Dr. D.Y Patil Medical College & Research Centre, Dr. D. Y. Patil Vidyapeeth, Pimpri, Maharashtra, India

Received: 14-10-2020 / Revised: 17-11-2020 / Accepted: 08-12-2020

Abstract

Background: Magnetic Resonance Urography (MRU) provides anatomical imaging of the renal system and urinary tract and is useful in both adults and paediatric patients. Functional MR urography enables differential renal function to be determined and allows the measurement of renal excretion into the collecting systems. The utility of MRU in adult patients who had obstructive uropathy was evaluated in this study to determine the extent and cause of obstruction. Paediatric patients were assessed for anatomical imaging and obstruction thresholds for possible congenital abnormalities.**Method:** This was a prospective, observational study conducted at a tertiary centre for over a period of 2 years. Total of 62 cases, both adult and paediatric patients were examined under Siemens Avanto Magnetic Resonance Imaging (1.5 Tesla). Data was collected on a pretested proforma, entered in excel sheet and quantitative data was summarised with MEAN and SD.**Results:** Age: Mean age of the subjects was 39.17. The majority were males at 59.67% (37) and females constituted 40.33% (25). The mean duration of symptoms was 16.52 days. Flank pain was most common presenting complaint in 53.23%. 32.26% of the lesions were observed in kidney, 12.90% in renal pelvis, 6.45% each in upper and mid ureter, 16.13% in distal ureter, 19.35% at PUJ, 4.84% in urinary bladder, 9.68% in urethra. 5 patients had bilateral lesions, 38 had right sided involvement and 13 had left sided involvement. Significant number of paediatric patients had congenital lesions and lesser number of acquired lesions when compared to adults with a P value of 0.000249.**Conclusion:** Static MR-Urography was useful in detecting the exact aetiology of obstructing lesions presenting in varied aged groups including congenital and acquired lesions. Most common reasons for obstructive uropathy was noted to be lesions in kidney followed by those in pelvis and the ureters. Significant number of paediatric patients presented with congenital lesions compared to the adults who had higher number of acquired lesions. We suggest static MR-Urography is one of the ideal diagnostic tests in diagnosis of cases with obstructive uropathy.

Keywords: static,MR-Urography,congenital malformations,obstructive uropathy,kidney.

Introduction

Magnetic Resonance Urography (MRU) is used in major multispecialty institutes, the literature has identified more and more applications in the paediatric setting. MRU is a quantitative imaging approach that blends excellent anatomical data with functional details which are in the part accessible via renal scintigraphy to assess various paediatric urological conditions[1].It provides anatomical imaging of the renal system and urinary tract, but more generally pertains to anatomical imaging in conjunction with functional imaging, the latter requiring use of IV gadolinium-based contrast. Anatomical imaging of the abdomen and pelvis is performed, while using sequences which concentrate on the renal architecture (T1 and T2 weighted sequences) and urinary tract. Urinary tract sequences

**Correspondence*

Dr. Avinash Bansal

Junior Resident, Department of Radiodiagnosis, Dr. D.Y Patil Medical College & Research Centre, Dr. D. Y. Patil Vidyapeeth, Pimpri, Maharashtra, India.

E-mail: avinah2102@gmail.com

provide high-resolution 2D and 3D T2WI, which allow multiplanar reformatting when obtained in a 3D fashion and can be used to make a variety of reconstructions. Functional MR urography enables differential renal function to be determined and allows the measurement of renal excretion into the collecting systems. Excretion of the intravenously administered contrast occurs after absorption through the renal parenchyma and subsequently quantified using post-processing techniques by imaging several times over 15 minutes. This makes it possible to calculate functioning of the renal system (based on renal volumes or glomerular filtration) and the washout/ excretion curves of time vs. signal strength[2].

Usual signs for paediatric MRU include examination of anatomy and functioning of the renal system and the urinary tract, possible obstruction of the urinary tract, surgical preparation, post-operative complications. In general, patients commonly undergo imaging tests such as Ultrasound, Voiding Cystourethrogram, and/or renal scintigraphy. Conventionally, MR Urography is used as a tool for solving problems posed by indefinite evaluation using other modalities or surgical preparation. Even without the presence of any dilatation of the collecting system, MR Urography can be used to accurately delineate anatomy, which is usually a limiting factor in evaluation using Ultrasound. In addition, MRU can image ureter along its entire extent and recognise anomalous insertions, locations and possible obstruction or narrowing, including the detection of ureteropelvic junction obstruction as due to crossing vessels. MRU can provide vivid 3D anatomical reconstruction of the renal collecting system and its urinary tract while preparing for surgery or assessing post-surgical changes[1].

The utility of MRU in adult patients who had unilateral/bilateral obstructive uropathy was evaluated in this study to determine the extent and cause of obstruction. In addition, paediatric patients were assessed for anatomical imaging and obstruction thresholds for possible congenital abnormalities.

Materials & Methods

This was a prospective, observational study conducted at a tertiary centre for over a period of 2 years from September 2018 to August 2020. A total of 62 cases comprising both adult and paediatric patients were included in the study. Examination was done under Siemens Avanto Magnetic Resonance Imaging (1.5 Tesla). Proper safety measures were taken. The inclusion criteria for adult patients comprised of all patients with hydronephrosis, hydroureter, calculus, PUJ block, ureteric stricture, Transitional Cell Carcinoma causing hydronephrosis and hydroureter, extrinsic mass causing obstruction to the urinary tract, CA cervix involving urinary bladder and/or lower ureter, large fibroid and retroperitoneal masses suspected clinically and/or detected on USG/Computed Tomography/IVU. The inclusion criteria for paediatric patients included suspected PUJ block, Double Ureter, Megaureter, vesicoureteral reflux, Posterior Urethral Valves, Ectopic Ureterocoele suspected clinically or detected on USG. Patients with Postoperative presence of MR incompatible orthopaedic hardware, cardiac pacemakers, metallic foreign bodies or cochlear implants in-situ, postoperative/post radiation therapy patients and those who were unwilling to give a valid consent and participate were not included in the study. Institutional Ethical Committee (IEC) clearance was obtained before conducting the study. Informed consent was obtained from all the patients. For children, consent was obtained from parents/guardians.

MRI scan technique Patients positioned supine with head pointing towards the magnet and placed over spine coil with body coils over pelvis & abdomen. Body coil was tightened using straps to prevent respiratory artifacts. A pillow was placed under the head and cushions under the legs. Laser beam was centred over iliac crest. Planes and sequences used were T2 Haste, Axial, Coronal and Sagittal planes; T2 Weighted (T2WI) in Sagittal plane; T2 TSE 3D – Coronal, Rest; T2 Haste FS – Axial, Coronal and Sagittal planes; Diffusion Weighted B-Value 1 - 50 s/mm; Diffusion Weighted B- Value 2 – 800 s/mm, with a slice thickness of 3.5mm.

Data Collection method and Statistical Analysis Data was collected from the subjects on a pretested proforma. Data was entered in excel sheet. Quantitative data was summarised with MEAN and SD. The data was as well expressed in form of proportions and percentages.

Results

Demographics:Age: Mean age of the subjects in the study was 39.17 (SD:23.21). The median age was 45 years with an age range of 10 days to 77 years. Paediatric: The youngest patient in our study was 10 days old. Age distribution was noted and it was observed that there were Infants numbering 6 (9.67%), 2-10 years at 7 (11.29%) and 4 (6.45%) between 11-20 years. Adults: The majority of the patients were between 41-50 years at 15 (24.19%), followed by 61-70 years at 10 (16.10%), 51-60 years at 9 (14.5%), 3 each (4.83%) between 21-30 and 71-80 years.Gender: The majority of the subjects were males at 59.67% (37)

and females constituted 40.33% (25).Of the 17 paediatric patients, 9 were males and 8 were females.

Diagnosis:Acute PUJ obstruction [Image1]was the most common diagnosis as observed in 13 patients, followed by hydronephrosis and hydroureter in 10 patients, proximal ureteric calculus in 7 patients, urethral stricture and vesicoureteral reflux in 5 each, TCC, nephrolithiasis and mid ureteric calculus in 3 each, bifid pelvicalyceal system[Fig 2], RCC [Fig 3], duplex kidney, UVJ obstruction in 2 each, 1 patient each had ectopic ureter, vesicovaginal fistula, ectopic kidney, congenital PUJ stenosis, horse shoe shaped kidney, congenital megaureter, dysplastic kidney, pyelonephritis, peripelvic cyst and retrocaval ureter[Fig 4].Evaluation of symptoms: The mean duration of symptoms was 16.52 days with a SD of 28.20.Flank pain was most common presenting complaint in 53.23% followed by hematuria in 29.03%, oliguria in 11.29%, increased frequency of micturition in 9.68%, other GI symptoms in 6.45%, mass/swelling per abdomen and fever in 3.23% each and burning micturition and anuria in 1.61% each.

Site and side of lesion [Table 1]: 32.26% of the lesions were observed in kidney, 12.90% in renal pelvis, 6.45% each in upper and mid ureter, 16.13% in distal ureter, 19.35% at PUJ, 4.84% in urinary bladder, 9.68% in urethra. 5 patients had bilateral lesions, 38 had right sided involvement and 13 had left sided involvement. 6 had urinary bladder or urethral involvement hence not classified based on side.

Congenital and acquired lesions[Table 1]: Significant number of paediatric patients had congenital lesions and lesser number of acquired lesions when compared to adults with a P value of 0.000249. There were 41.17% (7/17) of congenital lesions compared to 4.44% (2/45) in adult age group. Acquired lesions were 58.83% (10/17) in paediatric age group compared to 95.56% in adults (43/45).

Table 1: Comparative analysis of the patients

Parameter	Paediatric		Adult		Note
	Congenital	Acquired	Congenital	Acquired	
No of subjects	7	10	2	43	
Gender					
Male	4	5	2	26	
Female	3	5	0	17	
Site of lesion					Some patients had more than one site involvement hence the total sites will be more than number of subjects
Kidney	6	7	1	6	
Renal pelvis	Nil	Nil	2	6	
Upper ureter	Nil	1	1	2	
Mid Ureter	Nil	Nil	Nil	4	
Distal ureter	3	Nil	Nil	7	
PUJ	Nil	1	Nil	11	
Urinary Bladder	Nil	Nil	Nil	3	
Urethra	Nil	1	Nil	5	
Side of lesion					Patients with sole urinary bladder or urethral could not classified based on side.
Right	5	5	1	27	
Left	2	2	1	8	
Bilateral	2	2	Nil	1	
Malignancies					
TCC	Nil	Nil	Nil	3	
RCC	Nil	Nil	Nil	2	

Table 2: Comparative analysis with confirmatory investigation

Age group		Site	Diagnosis	Confirmatory test
Paediatric patients	Congenital	Kidney	Horse shoe shaped kidney with congenital PUJ stenosis	CT scan
			Duplex kidney	CT scan
			Ectopic kidney	CT scan
		Pelvis	Bifid pelvicalyceal system	CT scan
		PUJ	Horse shoe shaped kidney with congenital PUJ stenosis	CT scan
		Ureter	Ectopic ureter	CT scan
			Vesicoureteral reflux	MCU
		Bladder	Vesicovaginal fistula	CT scan/IVU
	Acquired	Kidney	Multi-cystic dysplastic kidney	USG, CT scan
			Posttraumatic infundibular stenosis in the right upper pole.	CT scan
			Nephrolithiasis	Ultrasonography/ CT scan
			Pyelonephritis	CT scan
		PUJ	Urolithiasis	Ultrasonography/ CT scan
		Urethra	Stricture	MCU
Adult patients	Congenital	Kidney	Ectopic kidney	CT scan
		Pelvis	Bifid pelvicalyceal system with duplex ureter	IVU, CT scan
		Ureter	Bifid pelvicalyceal system with Duplex ureter	IVU, CT scan
	Acquired	Kidney	RCC	CT scan
			Nephrolithiasis	Ultrasonography/ CT scan
			Hydronephrosis	Ultrasonography
			Pyelonephritis	Ultrasonography
		PUJ	Urolithiasis	Ultrasonography/ CT scan
		Ureter	Ureteric calculus	Ultrasonography
			Retrocaval ureter	CT scan
			Vesicoureteral reflux	MCU
			Hydroureter	Ultrasonography
		Bladder	TCC	CT scan
		Urethra	Stricture	MCU

As observed from Table 2; congenital anomalies were commonly observed in the paediatric age group. These included horseshoes shaped kidney, ectopic ureters, ectopic kidney, duplex kidney, congenital PUJ stenosis, bifid pelvicalyceal system and vesicovaginal fistula. For most of these congenital anomalies CT scan was the other confirmatory diagnostic test performed. Acquired lesions in paediatric age group included dysplastic kidney, post traumatic infundibular stenosis in the right upper pole, pyelonephritis, nephrolithiasis, urolithiasis and urethral stricture. Ultrasonography was able to detect nephrolithiasis and urolithiasis along with multicystic dysplastic kidneys whereas other acquired lesions were confirmed by CT scan. There were no malignant lesions detected.In adults only two congenital lesions were noted which included ectopic kidney detected on CT scan and Bifid pelvicalyceal system with Duplex ureter which was subsequently confirmed on IVU and CT scan. Acquired lesions were predominately cases of nephrolithiasis and urolithiasis mostly confirmed by ultrasonography and in some cases detected by CT scan. RCC and TCC were confirmed by CT scan findings. Hydroureter and hydronephrosis mostly were detected clearly upon ultrasonography and in some cases by CT-scan.

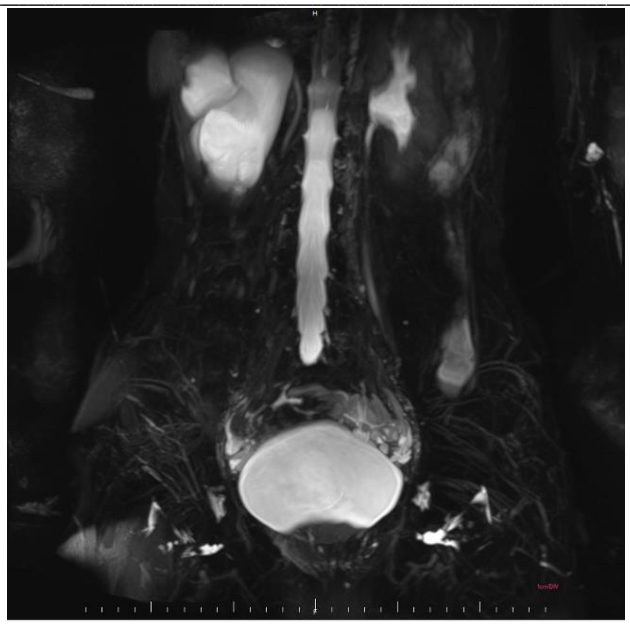

Fig 1: Right PUJ obstruction. MRI COR. T2WI. Right sided moderate to gross hydronephrosis

Fig 2: Right hydronephrosis with bifid ureter.MRI COR. T2WI. Right kidney is enlarged with dilated and bifid renal collecting system.

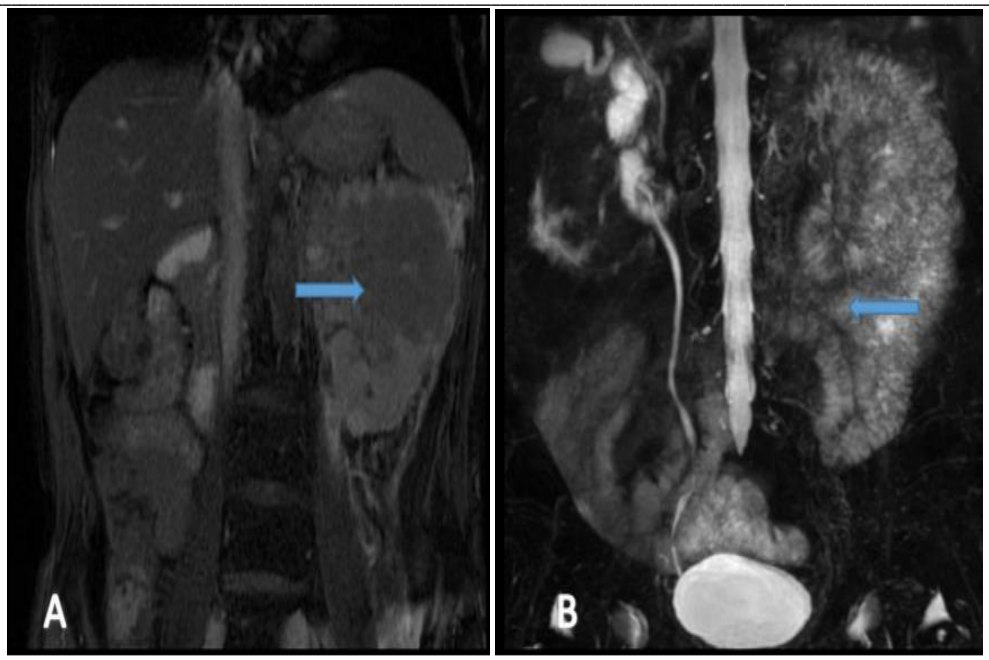

Fig 3: Renal cell carcinoma on the left side. MRI Coronal T2WI (A) Left kidney shows lobulated mass involving its upper and mid pole. 3D urogram (B) Absence of left-sided urogram, suggestive of non-functioning left kidney

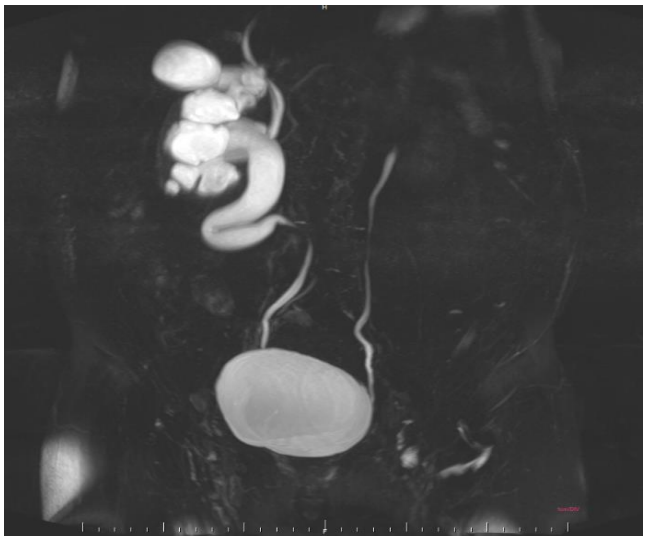

Fig 4: Type I retrocaval ureter.MRI COR. T2WI. Enlarged right kidney due to marked hydronephrosis and upper hydroureter. Dilated and tortuous right ureter in its upper one third part which is then deviated medially and posteriorly to inferior vena cava at the level of upper margin of L4 vertebra giving fish hook appearance/reverse J appearance

Discussion

The current study was a prospective observational study with a total of 62 cases comprising both adult and paediatric patients. Our study was conducted with an aim of evaluating the utility of static MR-urography in obstructive uropathy in adults and in paediatric age groups.We further evaluated whether the lesion was unilateral or bilateral and the level and cause of

obstruction. In addition, congenital anomalies were studied in detail.[Table 1]Magnetic resonance urography(MRU) is relatively new and budding technique [3]. MRU has been shown to be time saving, safe, and a technique that is not invasive for reliable assessment of urinary system[4].MRU employing heavily T2-weighted turbo spin echo (TSE) sequences such as rapid acquisition with relaxation enhancement and half-Fourier acquisition single shot turbo spin echo (HASTE) sequences has been described as static MRU in patients with urinary symptoms[5].Payabvash S et al. [6] noted one of the important applications of static MR-Urography is in diagnosis of the congenital lesions in children. Adeb M et al. [7] found a good utility of static MR-urography in detecting duplicated renal collecting systems which are on the common congenital anomalies observed in children. Ramravi KP [8] evaluated patients presenting with suspected urinary tract abnormalities using plain radiography, ultrasonography, and static MR urography. A total of n=60 patients were included. The most common age group involved was 42- 50 years with n=14(23.3%) and 31 – 40 years with n=13(21.7%) of patients. In this study (55%) were male and (45%) were females. The findings corroborated with our study.Ahmad I et al. [9] evaluated role of MRU in obstructive uropathy. A total of 55 patients between 14 to 70 years (mean age 37 years) of these 34.5% were females and 65.5% were males were included. In study by Ramravi KP [8] the most common presentation was the presence of loin pain in n=32(47.70%) followed by nausea and vomiting in n=10(14.90%) patients. The findings corroborated to our study.Ahmad I et al. [9] noted Urinary obstruction was caused by PUJ narrowing[Fig 1] in 49 renal units, ureteral strictures in 6 (one stricture each in upper and mid-ureter, 4 strictures at vesico-ureteric junction [VUJ], circumcaval ureter in 1 unit, carcinoma cervix with urinary bladder outlet obstruction in 1 unit, ureterocoele in 1 and compression of lower ureter by crossing of iliac vessels in one patient. The cause of ureteral strictures was urinary tuberculosis (1 renal unit) of mid-ureter, prior abdominal surgery/urological procedures in 2 renal units (upper ureter and VUJ), history of the passage of documented VUJ stone in the past (1), primary VUJ obstruction (2).Congenital primary megaureter [Table 2]: There was one case of left congenital primary megaureter noted in 1month old male child. MRU depicted left megaureter, with sudden narrowing of ureter around UV junction.Duplex kidney: Right duplex kidney was noted in 6 years old female child. Static MR urography showed 2 right-sided collecting systems along with ureters, right lower moiety mild pelvicaliectasis (“drooping lily” appearance) due to VUR, and extensive scarring in the right kidney lower moiety parenchyma. Another 10-day old child had left duplex kidney with similar static urography findings on the left side.Horse shoe Kidney with congenital UPJ stenosis: Right horseshoe shared kidney with congenital UPJ stenosis was noted in 7-year-old child. Static MRU showed a dilated collecting system till the level of the UPJ.Bifid Pelvicalyceal system[Fig 2], Duplex ureter: Bifid pelvicalyceal system was noted in a 13 years old female patient and 28-year-old male patient. The male patient also additionally showed a duplex ureter. Static MR urogram shows right renal collecting system is dilated and appears bifid with single dilated ureter in female patient and double ureter in male patient.Bilateral vesicoureteral reflux with ectopic left ureter, vesicovaginal fistula: This was noted in a 0.5 years old male patient. Static MR urogram shows right hydronephrosis with mild VUR; left hydronephrosis with marked VUR - with ectopic insertion of lower end of left ureter. In reanother female child there was presence of vesicovaginal fistula MR urogram shows bilateral hydronephrosis and hydroureter with normal opening in urinary bladder; Thin linear blind ending hyperintense sinus tract coursing from the posterior aspect of proximal urethra was observed. Another male child aged 6 months had an ectopic ureter with similar static MR-urography findings.Ectopic left kidney with trifid pelvis: This was observed in a 50 years old male patient. Static MR image shows mild narrowing at pelvi-ureteric junction – likely due to partial PUJ obstruction; The unascended left kidney is seen in left lower lumbar and iliac region and appears enlarged. It shows moderate hydronephrosis with trifid renal pelvis. However, late presentation is a rarity rather than a rule.

MRU is being used to evaluate patients with absence of kidneys, kidneys in rotated or abnormal position, kidney duplication, kidney dysplasia, presence of ectopic ureter, retrocaval ureter[Fig 4], primary megaureter, UPJ obstruction, etc. [10-15].Complicated kidney duplication along with congenital UPJ obstruction are the 2 most important indications. Renal duplication can be of two types, complete or partial. In partial duplication, the ureters are seen joining above the urinary bladder. Complete renal duplication has a female predilection, and MR Urography has been shown to be more accurate as compared to IVU and ultrasonography for anatomical assessment of the complete duplex kidney[10-11,16].The upper pole ureter inserts inferior-medially to the lower pole ureter, in complete duplication, hence is more prone to obstruction. The upper pole ureter inserts either

ectopically, with development of a ureterocoele or it may insert at another site apart from urinary bladder. Renal excretory function is not a rate limiting factor in the diagnosis of an ectopic ureter, since static-fluid MR urographic is deemed sufficient. [10, 12-14]

Transitional cell carcinoma of urinary bladder[Table 2]: This was observed in three patients aged 50, 67 and 72 years. Haematuria was presenting complaint in two patients whereas another patient had lower abdominal pain. Static MRU shows nondependent solid polypoidal lesions at different sites of the urinary bladder. Renal cell carcinoma[Fig 3]: This was observed in 2 patients aged 47 and 77 years. Weight loss was noted in both the patients, one had haematuria whereas another had loss of appetite. Static MR image showed large exophytic renal mass that distorted renal outline.Malignant obstruction of the urinary tract system can be due to either benign or malignant causes. Benign urothelial tumours such as fibro-epithelial polyps appear as filling defects at MRU. [15]Most malignancies of the urinary tract epithelial layer are TCCs which appear as sessile filling defects or wall thickening [17]. As with other forms of urography, the "goblet" sign can occasionally be seen at MRU in the setting of TCC of the ureter[18].

Urothelial malignancies usually have an intermediate signal intensity at MR imaging and demonstrate enhancement that is not seen in case of calculus or clots[15].

MR imaging cannot currently match the spatial resolution of CT, although it is excellent for the detection, characterization, and staging of renal neoplasms[19-23].

Conclusion

Static MR-Urography was useful in detecting the exact aetiology of obstructing lesions presenting in varied aged groups including congenital and acquired lesions. As noted from our study, majority of the patients were between 41-50 years of age with a male preponderance in obstructive type of lesions. The presentation was most common for flank pain followed by haematuria. Most common diagnosis was acute PUJ obstruction and lesions being unilateral. Most common reasons for obstructive uropathy were noted to be lesions in kidney followed by those in pelvis and the ureters. It was also noted that significant number of paediatric patients presented with congenital lesions compared to the adults who had higher number of acquired lesions. We further suggest, conducting similar studies with a higher patient sample size and do a cost-effective analysis of the study for a wider use and acceptability in cases presenting with obstructive uropathy. We suggest static MR-Urography is one of the ideal diagnostic tests in diagnosis of cases with obstructive uropathy.

References

1. Morin CE, McBee MP, Trout AT, Reddy PP, Dillman JR. Use of MR urography in pediatric patients. Current urology reports. 2018; 19(11):93.
2. Dickerson EC, Dillman JR, Smith EA, DiPietro MA, Lebowitz RL, Darge K. Pediatric MR urography: indications, techniques, and approach to review. Radiographics. 2015;35(4):1208-30.
3. Leyendecker JR, Barnes CE, Zagoria RJ. MR urography: techniques and clinical applications. Radiographics. 2008 ;28(1):23-46.
4. Sudah M, Vanninen R, Partanen K, Heino A, Vainio P, Ala-Opas M. MR urography in evaluation of acute flank pain: T2-weighted sequences and gadolinium-enhanced three-dimensional FLASH compared with urography. American Journal of Roentgenology. 2001 ; 176 (1):105-12.
5. Roy C, Saussine C, Jacqmin D. Magnetic resonance urography. BJU international. 2000 ;86:42-7.
6. 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. Pediatric surgery international. 2008 1;24(9):979.
7. Adeb M, Darge K, Dillman JR, Carr M, Epelman M. Magnetic resonance urography in evaluation of duplicated renal collecting systems. Magnetic Resonance Imaging Clinics. 2013 ;21(4):717-30.
8. Ramravi KP. A comparative study of plain Radiography, Ultrasound and static MR Urography in evaluation of Urinary Tract Pathologies. J Cont Med A Dent. 2020; 8(1):16-20.
9. Ahmad I, Ilyas M, Khan I, Robbani I, Wazir BS. Magnetic resonance urography in the evaluation of obstructive uropathy. Advances in Human Biology. 2018;8(2):91.
10. Avni FE, Nicaise N, Hall M, Janssens F, Collier F, Matos C, Metens T. The role of MR imaging for the assessment of complicated duplex kidneys in children: preliminary report. Pediatric radiology. 2001;31(4):215-23.
11. Borthne A, Nordshus T, Reiseter T, Geitung JT, Gjesdal KI, Babovic A, Bjerre A, Loe B. MR

urography: the future gold standard in paediatric urogenital imaging?. Pediatric radiology. 1999 ;29(9):694-701.
12. Grattan-Smith JD, Jones RA. MR urography in children. Pediatric radiology. 2006 1;36(11):1119-32.
13. Riccabona M. Pediatric MRU—its potential and its role in the diagnostic work-up of upper urinary tract dilatation in infants and children. World journal of urology. 2004 ;22(2):79-87.
14. Riccabona M, Simbrunner J, Ring E, Ruppert-Kohlmayr A, Ebner F, Fotter R. Feasibility of MR urography in neonates and infants with anomalies of the upper urinary tract. European radiology. 2002 ;12(6):1442-50
15. Blandino A, Gaeta M, Minutoli F, Salamone I, Magno C, Scribano E, Pandolfo I. MR urography of the ureter. American Journal of Roentgenology. 2002 ;179(5):1307-14.
16. O'malley ME, Soto JA, Yucel EK, Hussain S. MR urography: evaluation of a three-dimensional fast spin-echo technique in patients with hydro-nephrosis. AJR. American journal of roent-genology. 1997; 168(2):387-92.
17. Browne RF, Meehan CP, Colville J, Power R, Torreggiani WC. Transitional cell carcinoma of the upper urinary tract: spectrum of imaging findings. Radiographics. 2005;25(6):1609-27.
18. Nolte-Ernsting CC, Adam GB, Günther RW. MR urography: examination techniques and clinical applications. European Radiology. 2001; 11(3) :355-72.
19. Renken NS, Krestin GP. Magnetic resonance imaging of the kidney. InSeminars in Ultrasound, CT and MRI 2005 ; 26(3): 153-161WB Saunders.
20. Yoshimitsu K, Irie H, Tajima T, Nishie A, Asayama Y, Hirakawa M, Nakayama T, Kakihara D, Honda H. MR imaging of renal cell carcinoma: its role in determining cell type. Radiation Medicine-Medical Imaging and Radiation Oncology. 2004;22(6):371-6.
21. Ho VB, Choyke PL. MR evaluation of solid renal masses. Magnetic Resonance Imaging Clinics. 2004 ;12(3):413-27.
22. Roy C, Sauer B, Lindner V, Lang H, Saussine C, Jacqmin D. MR imaging of papillary renal neoplasms: potential application for characteri zation of small renal masses. European radiology. 2007;17(1):193-200.
23. Hallscheidt PJ, Bock M, Riedasch G, Zuna I, Schoenberg SO, Autschbach F, Soder M, Noeldge G. Diagnostic accuracy of staging renal cell carcinomas using multidetector-row computed tomography and magnetic resonance imaging: a prospective study with histopathologic correlation. Journal of computer assisted tomography. 2004 ;28(3):333-9.

Conflict of Interest: Nil
Source of support:Nil