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Original Research Article

Comparison of USG KUB Findings with MR Urography (fluid static) in Patients with Obstructive Uropathy- A Cross Sectional Study

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Abstract

Introduction- Obstructive uropathy is one of the most urgent clinical entities that has to be diagnosed and treated on time. Ultrasonography [USG] is cheap and easily accessible for determining the cause of obstructive uropathy. Magnetic Resonance Urography [MRU] has the potential to provide an excellent noninvasive examination of a wide range of urinary tract disorders, congenital anomalies and neoplasms without contrast administration.
Aims- To assess the role of USG in obstructive uropathy patients and compare its finding with MRU static fluid.
Design- Cross sectional study
Materials & methods- This study was conducted on all patients referred to the Radio-Diagnosis department with any clinically suspicious obstructive uropathy symptoms. They underwent USG KUB and those with confirmed obstructive uropathy, underwent static fluid MR urography.
Results- The study was conducted in 74 patients; 59.4% patients were males. Hydroureteronephrosis was the most common finding. MRU was superior to USG for diagnosis of stricture ureter and calculus in patients with obstructive uropathy. USG and MRI for diagnosis of VUJ, vesical, renal and pelvis calculus showed perfect agreement ($\kappa=1$; $p=0.01$); moderate for ureteric calculus (0.60-0.79; $p<0.05$) and minimal for ureteric stricture (0.21-0.39; $p<0.05$). MRU was superior in detailing PUJ obstruction as partial and complete.
Conclusions- Ultrasound as an initial investigation helped in finding the level and severity of urinary obstruction. However, MRU performed better, in whom ultrasound showed inadequate results. In case of malignant obstruction, it gave precise soft tissue details. MRU appears as a better tool in diagnosing both extrinsic and intrinsic causes of obstructive uropathy.

Keywords: Obstructive uropathy, Ultrasonography KUB, MR Urography Static fluid.

1. Introduction

Obstructive uropathy is one of the most urgent clinical entities that has to be diagnosed and treated on time [1,2]. If untreated, it results in acute or chronic end stage renal failure [3]. If renal function is normal, Intravenous urography [IVU] & Computed Tomography [CT] urography remains the best investigations of choice. If renal function is impaired, X-ray, ultrasonography [USG], non-contrast CT, and magnetic resonance urography [MRU] are preferred.

Several issues like reaching a consensus on the best modality for accurate diagnosis still remains. Because of its higher soft-tissue resolution, MRU is an essential modality in diagnosing and planning management approaches in obstructive uropathy patients.

2. Material and Method

The present study was to assess the role of USG in patients with obstructive uropathy and compare its finding with that of fluid static MRU. This study was conducted as a facility based cross sectional study during the study period of November 2019 to August 2021. All patients referred to the Department of Radio-Diagnosis with any clinically suspicious obstructive uropathy symptoms with any contraindications to Contrast agent (i.e., patients with Metformin use; decreased kidney function; allergy to iodine; toxic

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goiter of the thyroid, complications after the previous administration of a contrast medium; hepatic and renal failure; acute and chronic circulatory and respiratory failure; asthma and pulmonary edema were included. However, patients with acute abdominal trauma; history of metallic implant, foreign body, pacemaker, aneurysm clip, cochlear implant, any electric stimulator recently implanted prosthetic valve; and history of claustrophobia were excluded from the study. After obtaining ethical clearance from Institute's ethical committee, all the patients fulfilling the above-mentioned inclusion criteria were enrolled. Written consent was obtained after explaining the complete details about this study via consent form. An informed written consent form in local language containing all information about this study was given to the patient to read and sign. They were ensured that confidentiality will be maintained in every manner and options to withdraw from study were always kept open.

Socio-demographic details such as age, gender, socioeconomic status was obtained from all the study participants and entered in questionnaire. Detailed history regarding their illness, its duration, family history, past history and examination details was obtained. All patients underwent Kidney-Ureter-Bladder [KUB] study in Color Doppler USG machine present in the department. All patients were positioned supine on table with required table height and KUB study was done. Patients were carefully examined in both transverse and axial planes using low frequency & high frequency probes. Both kidneys including collecting system, ureters and urinary bladder were studied. Those patients with USG KUB confirmed obstructive uropathy, were subjected for the non-contrast MRU [static fluid].

2.1 MRI technique for urography evaluation

Patients were initially screened for any metallic objects, foreign bodies, neurosurgical clips, neuroelectric stimulator, pacemaker, dental implants, intraocular foreign bodies. Patients underwent MRI in 1.5 TESLA MRI machine present in department. A body surface coil was used and T2W-MRU was performed in addition to axial and oblique coronal sequences along the course of the urinary tract using respiratory-gated acquisitions. The patient was positioned in supine posture with arms extended above the head. Elastic tapes and supports were used adequately to prevent patient's movement. Typical scan time was 15-20 minutes. The images obtained were transferred to a dedicated workstation for post-processing. The two-dimensional series served to prove detailed anatomical data and reference scans. Maximum intensity projection – MIP techniques & volume rendered techniques were used for 3D heavy T2 weighted static fluid sequences for obtaining images of the renal collecting systems, ureters and the urinary bladder. To exclude unwanted structures like gall bladder & fluid filled bowel loops, manual volume editing was used when required. The following sequences were used to obtain MRI images as required (Table 1).

The morphology of the kidneys, collecting system, ureters and urinary bladder seen, from the obtained images were noted. The hydronephrosis as graded as mild, moderate and severe based on the imaging findings. It was named as mild, when there was pelvicalyceal dilatation, with normal cortical and medullary thickness; moderate when there was pelvicalyceal dilatation with thinned out medulla, normal cortex and normal cortico-medullary differentiation; severe when there was pelvicalyceal dilatation with cortico-medullary differentiation loss & thinned out renal cortical parenchyma. The reporting for Static fluid MR Urography done as per format.

2.2 Statistical analysis

Data was compiled using Microsoft Word and Excel and analyzed using Statistical Package for Social Sciences (IBM SPSS Complex Samples) Version 2.0 for windows. Categorical data was expressed as frequency and proportions whereas continuous data was expressed as mean and standard deviation. Chi square test without or with Yates correction (where value in any cell was less than 5) or Fischer Exact test (in case of any cell with 0 value in 2*2 table) was applied. Kappa statistics was applied and then the P value was considered statistically significant.

3. Results

The present study was conducted on total of 74 patients clinically suspected of obstructive uropathy referred to our department for USG KUB. Mean age of the subjects was 30.85 years and slight male preponderance with a male: female ratio of 1.4:1 was observed for obstructive uropathy. About 59.4 % patients in present study were males whereas remaining 40.6% were females.

On USG and MRI assessment, hydroureteronephrosis is the most common obstructive finding, seen in 52 patients (70.3%), of whom 12 patients [16.2%] had hydroureteronephrosis on right side, 11 patients [14.8%] had hydroureteronephrosis on left side and 29 patients [39.2%] had bilateral hydroureteronephrosis. Out of the 19 hydronephrosis [25.6%] patient, two patients (2.8%) had pyonephrosis on right side, one patient [1.4%] had pyonephrosis on left side and one patient [1.4%] had bilateral pyonephrosis.

Out of 51 patients [68.9%] with right sided pelvicalyceal dilatation on USG & MRI assessment, 21 patients [28.4%] had mild hydronephrosis, 23 patients [31.0%] had moderate hydronephrosis and seven patients [9.5%] had gross hydronephrosis. Out of 56 patients [75.7%] with left sided pelvicalyceal dilatation on USG & MRI assessment, 17 patients [22.9%] had mild hydronephrosis, 27 patients [36.5%] had moderate hydronephrosis and 12 patients [16.2%] had gross hydronephrosis (Table 3).

Table -1. Showing the sequences used to obtain images in Static Fluid MR Urography protocol

SEQUENCE	ORIENTA TION	TR/ TE	FLIP ANGLE	ACQUISITI ON MATRIX	SLICE THICKNES S [mm]	FOV [mm]
T2- TSE fat Sat	Axial	5/2	60	320x256	4.0	350-400 [Fit to patient]
T2- HASTE	Axial	1500/100	150	320x320	4.0	400-450 [Fit to patient]
T1- fat sat	Coronal	5/3	12	320x256	2.0	350-400 [Fit to patient]
T2- HASTE	Coronal	1500/100	150	320x256	3.0	400-450 [Fit to patient]
T2- HASTE [Thick] Breath hold single slice	Coronal oblique	1500/100	150	320-256	60.0	400-450 [Fit to patient]
T2- HASTE [Thick] Breath hold single slice	Sagittal oblique	1500/100	150	320-256	60.0	400-450 [Fit to patient]

Table - 2. Interpretation of Cohen's Kappa

Value of Kappa	Level of Agreement	% of data that are reliable
0-.20	None	0-4%
.21-.39	Minimal	4-15%
.40-.59	Weak	15-35%
.60-.79	Moderate	35-63%
.80-.90	Strong	64-81%
Above .90	Almost perfect	82-100%

Table -3. Distribution according to obstructive features in USG & MRI

		Right		Left		Bilateral	
		n	%	n	%	n	%
Pelvicalyceal system	Hydro- ureteronephrosis	12	16.2	11	14.8	29	39.2
	Isolated Hydroureter	0	0	0	0	1	1.4
	Others	2*	2.7				
Pyonephrosis	Present	2	2.8	1	1.4	1	1.4
Dilated pelvicalyceal system	Mild	21	28.4	17	22.9		
	Moderate	23	31.0	27	36.5		
	Gross	7	9.5	12	16.2		
	Absent	23	31.0	18	24.3		

*Combination of HUN on one side and HN on other side.

Table – 4. Comparison of USG and MRI findings of calculus

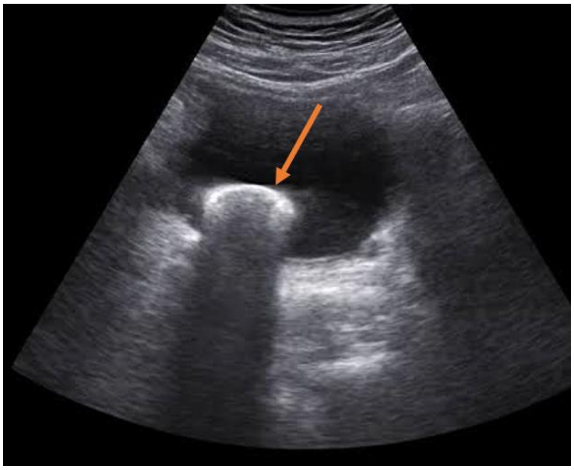
Findings			USG KUB N = 74	MR Urography N=74	κ	P -value
Calculus	Renal	Right	8	8	1	0.001
		Left	13	13	1	0.001
	Pelvis	Right	7	7	1	0.001
		Left	2	2	1	0.001
	Ureter	Right	4	7	0.717	0.001
		Left	3	6	0.657	0.001
	VUJ	Right	0	0	1	0.001
		Left	1	1	1	0.001
	Vesical		8	8	1	0.001

Table- 5: Comparison of other findings between USG and MR Urography

		USG				MR Urography				Cohen's kappa κ	P value
		Right		Left		Right		Left			
		n	%	n	%	N	%	n	%		
PUJ obstruction	Present	4	5.4	11	14.9	3*	4.0	9*	12.1		
		-	-	-	-	1**	1.4	2**	2.7		
Ureter Stricture	Present	1	1.4	1	1.4	5	6.7	8	10.8	0.24	0.007

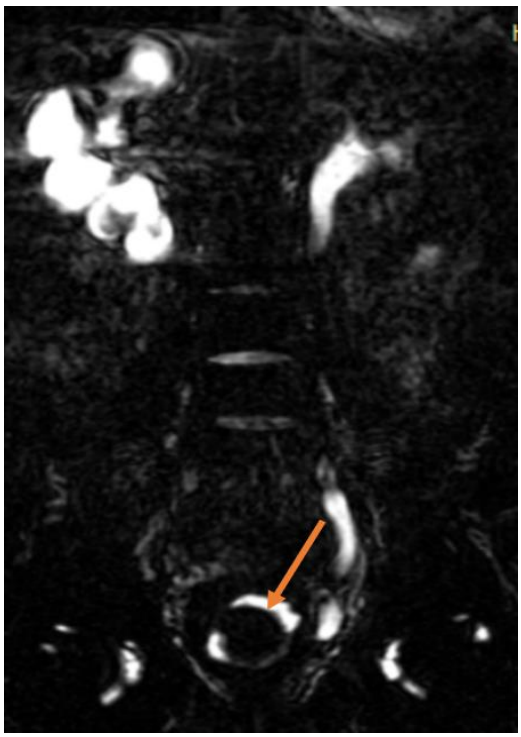
*- partial, **- complete

Both USG and MR Urography detected renal calculus in 21 occasions, pelvic calculus in nine, VUJ calculus in one and vesical calculus in eight patients. (Figure -1)

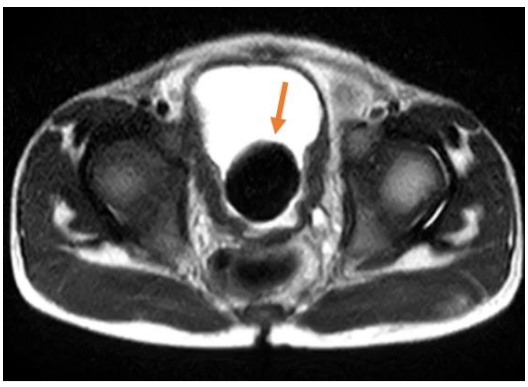


A

Figure 1 (A) Grey scale ultrasound shows vesical calculus in a patient with supra pubic pain.



B



C

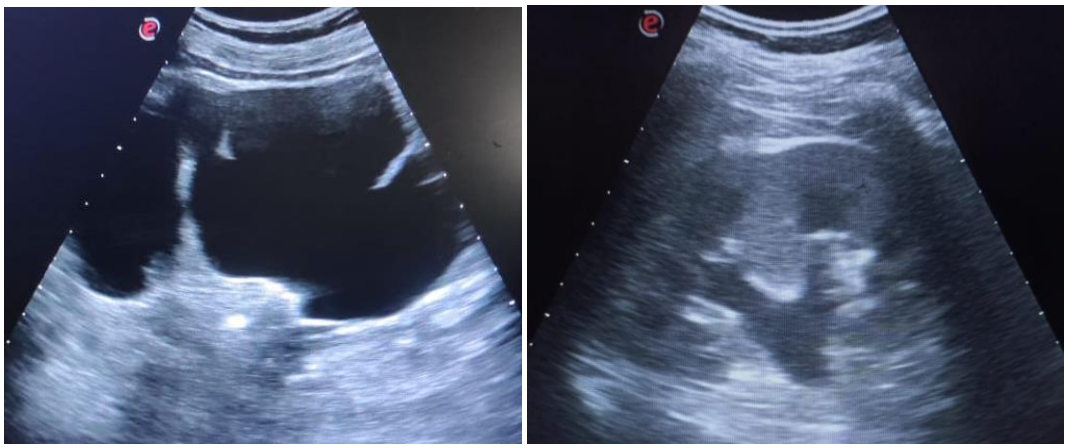
Figure 1 (B), (C) In the same patient on MRI, coronal and axial T2 shows vesical calculus with chronic cystitis and right hydronephrosis.

Three patients in whom USG could not detect right ureteric calculus (false negative), were found to have ureteric calculus in subsequent MR Urography. Thus, USG detected four true positive ureteric calculus on right side, three false negative, 0 false positive and 141 true negative ureteric calculus. Three patients in whom USG could not detect left ureteric calculus (false negative), were found to have ureteric calculus in subsequent MR Urography. Thus, USG detected three true positive ureteric calculus on left side, three false negative, 0 false positive and 142 true negative ureteric calculus.

A perfect agreement was observed between MRI and USG for diagnosis of calculus of VUJ, vesical, renal and pelvis ($\kappa=1$; $p=0.01$) whereas for diagnosis of calculus of ureter, the level of agreement was moderate (0.60-0.79; $p<0.05$).

Thus, MRI was superior to USG for diagnosis of ureter calculus in patients with obstructive uropathy (Table- 4).

On comparison of USG and MRI findings, it is found that both USG and MR urography is equally potential in detecting PUJ obstruction [5.4% on right side and 14.9% on left side]. However, MR Urography has an edge over USG in classifying the complete and partial PUJ obstruction [one out of four patients on right side and two out of 11 patients on left side were found to have complete obstruction] (Figure- 2).



A B

Figure- 2 (A), (B) Grey scale ultrasound image shows ballooning of right renal pelvis & right moderate hydronephrosis and mild left hydronephrosis.

Figure- 2. (C) MRI-3D Urogram shows bilateral partial PUJ obstruction (right > left).

On USG, ureteric stricture was detected in two patients, out of which one was on right and one was on left. Eleven patients in whom USG could not detect ureteric stricture (false negative), were found to have ureteric stricture in subsequent MR Urography [four on right side and seven on left side] (Figure 3).

Figure- 3. Ultrasound images depicting hydronephrosis [A] and dilated left proximal ureter [B] with non-visualization of mid and distal ureter due to bowel gases [arrow]. MR 3D Urogram (C) showing left mid ureteric stricture [arrow] in the same patient.

Thus, USG detected two true positive. Kappa statistics was used to assess the level of agreement between USG and MRI. For diagnosis of ureteric stricture, the level of agreement was minimal (0.21-0.39; $p<0.05$). Thus, MRI was superior to USG for diagnosis of stricture ureter in patients with obstructive uropathy (Table - 5).

Other findings include chronic cystitis, seen in 18 patients [24.3%], posterior urethral valve in two patients [2.7%], vesico ureteric reflux in five patients [6.7%] including bilateral VUR in three patients [4.0%] and unilateral VUR in two patients [2.7%]. Horshoe kidney was seen in one patient [1.4%], calcified putty kidney in one patient [1.4%], cystic dysplasia of kidney in one patient [1.4 %]. Renal cysts were seen in 11 patients [14.8%], including unilateral in five patients [6.7%] and bilateral in six patients [8.1%].

4. Discussion

In present study, we compared ultrasound KUB findings with MR urography findings. All statistical calculations were done by SPSS software applying kappa statistics and then p value was calculated & considered statistically significant. In the duration of this study, total of 74 patients with obstructive uropathy were evaluated by both ultrasound and MR Urography.

Age- The present analysis showed that mean age was 30.85years; this nearly correlated with the study conducted by Irshad Ahmed et al [4] which showed mean age group as 37, Bansal et al [5] whose mean age group was 39.17 and Dipali Kadam et al [6] which showed common age group as between 31-40.

Gender- Out of the total cases, 40.5% were female & 59.4% were males. This study showed that obstructive uropathy was common in both sexes with male predominance, which corresponds to the studies by Bansal et al [5], Dipali Kadam et al. [6] and Nuraj et al. [7].

Obstructive features - Most common obstructive finding was hydroureteronephrosis [HUN], seen in 52

patients (70.3%), hydronephrosis [HN] was the second most frequent obstructive finding seen in 19 patients (25.6%). Bilateral hydroureter was noted in one patient [1.4%]. Two patients [2.7%] had combination of hydronephrosis on one side and hydroureteronephrosis on the other side.

Forty patients [54%] had unilateral urinary obstruction [including 23 patients with unilateral HUN and 17 patients with unilateral HN]. Thirty-four patients [45.9%] had bilateral urinary obstruction [including 29 patients with HUN, two patients with HN, one patient with bilateral hydroureter and two patients with bilateral mixed dilatation].

In present study, urinary obstruction was most commonly unilateral than bilateral. This correlates with studies conducted by Bansal et al [5] and Sharma et al [8]. USG and sMRU showed similar obstructive finding including HN, HUN and hydroureter, showing 100% agreement.

In the study conducted by Irshad Ahmed et al [4], MRU revealed urinary tract dilatation in 55 of 55 individuals (sensitivity of 100 percent for detection of obstruction). In their study, Muthusami et al. [9] observed comparable results, stating that MRU's overall sensitivity and specificity for detecting hydronephrosis were 95 percent and 100 percent, respectively. In a research, O'Malley et al. [10] found that MR urography was very accurate in detecting renal pelvicalyceal and ureteric dilatation, with a sensitivity of 100 percent and a specificity of 96 percent. In a 2002 study, Zielonko et al. [11] found that sMRU had a 100 percent sensitivity and specificity for detecting urinary tract dilatation. The sensitivity of MRU to correctly diagnose dilated urinary tracts was 100 percent in a study by Karabacakoglu et al. [12] in 2003. Sudah et al [13] also found that MRU had 100 percent sensitivity, specificity, and accuracy in diagnosing blockage. Left sided pelvicalyceal dilatation was slightly more common [75.7%] than the right side [68.9%]. On both the sides moderate grade dilatation was most commonly seen [31% on right side & 36.5% on left side], followed by mild pelvicalyceal dilatation [28.4% on right side and 22.9% on left side]. This finding was consistent with study conducted by Irshad Ahmed et al [4].

Urolithiasis was the most common cause of obstructive features including hydronephrosis, hydroureteronephrosis and hydroureter as it was seen in 52 occasions. This correlated with study by Nuraj et al. [7], Sen KK et al. [14], Dipali Kadam et al [6] and Sharma et al [8]. However, the incidence is high as compared to other studies by Wang et al. [15] and Organ M et al. [16]. Ultrasound revealed renal calculi in 21 patients 28.4%, [eight on right side and 13 on left side], renal pelvis calculi in nine patients 12.2% [seven on right side and two on left side], ureteric calculi in seven patients 9.4% [four on right side and three on left side], left VUJ calculus in one patient and vesical calculi in eight patients (10.8%). Both USG and MR Urography detected renal calculus in 21 occasions, pelvic calculus in nine, VUJ calculus in one and vesical calculus in eight patients, showing 100% agreement. MRI was significant in detecting ureteric calculi as it additionally detected ureteric calculi in six patients [three on either side].

Ureteric calculi were missed in ultrasound in these six patients, as they were located in the mid and lower ureter. The smaller size of calculus, excessive abdominal fat in obese patients and the presence of bowel gases made visualization difficult & resulted in the fallacy. However, ultrasound helped in grading the obstructive features including hydronephrosis very precisely in all the cases.

Thus, present study showed that MRI is superior to USG for diagnosis of ureter calculus in patients with obstructive uropathy. However, in the study by Dipali Kadam et al [6], MR urography diagnosed only 77% of total ureteric calculi. In another study by Zielonko et al. [11] the diagnosis of calculi group by MRU correlated with other modalities in 85% of cases. Unlike our study, both these studies compared MRU findings with, not just USG but with other investigations as well.

USG revealed PUJ obstruction in 15 patients [20.3%], including four patients [5.4%] on right side and in 11 patients [14.9%] on left side. MR Urography detected PUJ obstruction in all 15 patients showing 100% correlation. This finding correlated with study conducted by Zielonko et al. [11], which also showed similar results including right sided PUJ obstruction in four patients [5.4%], of which three patients [4.0%] had partial PUJ obstruction and one patient [1.4%] had complete PUJ obstruction. MRI also revealed left sided PUJ obstruction in 11 patients [14.8%], of which nine patients [12.1 %] had partial PUJ obstruction and two patients [2.7%] had complete PUJ obstruction.

In our study, the PUJ obstruction was noted in the 15 patients [20.2% of total 74 patients]. This finding was consistent with study by Khanna et al [17] which showed PUJ obstruction in 22.5% of study patients. A study by Riccabona et al. [18] found PUJ obstruction in 48% of patients. However, Sen et al. [14] found PUJ obstruction in 12% of patients.

The study depicted that MRI was superior to USG for diagnosis of stricture ureter in patients with obstructive uropathy. The study by Arlen AM et al. [19], showed that MR Urography was excellent in depicting anatomic and functional details of the collecting system, thereby promising diagnosis of ureteral stricture.

On USG assessment, obstructive uropathy features due to pelvic lesions were noted in 19 patients [25.7%], including nine female pelvic pathologies [12.2%], seven male pelvic pathologies [9.5%] and three patients [4.0%] with urinary bladder pathologies.MR Urography was able to detect all the lesions detected in USG.

On both USG and MRI assessment, out of nine patients with female pelvic pathologies as cause for obstructive uropathy, cervical carcinoma and cervical stump/vault carcinoma were seen in two patients [2.7%] each. Ovarian carcinoma, hydrometrocolpos due to imperforate hymen, multiple fibroids with sarcomatous degeneration, rhabdomyosarcoma of abdomino pelvic cavity and metastasis from soft tissue

sarcoma was seen in one patient each [1.4%]. USG and MRI both were able to detect bladder carcinoma in two patients [2.7%], with MRI providing more anatomical details of the invasive lesions.

In present study, neoplastic lesions were the cause of obstruction in 14.8%, as compared to eight percent seen in study conducted by El Imam M et al. [20] in Soudan. The difference could be due to the fact that our study was done in a tertiary referral hospital where patients with malignancy in the region are usually referred late. Cervical carcinoma in women & prostatic carcinoma in men were the leading malignancy in our study. Due to the proximity of the cervix to the bladder, obstruction can be seen in 30% of cervical cancers according to study by Lau MW et al. [21]. In spite of advances in early diagnosis of prostate cancer, ten percent of patients with locally advanced prostate cancer showed urinary tract obstruction as their main symptoms as per study by Anast JW et al. [22].

MR Urography depicted better anatomical details of extrinsic causes of obstruction, by its coronal and axial sections which show abdominal and pelvic diseases producing ureteric compression. This is consistent with studies by Aerts et al. [23], Shokeir AA et al. [24] and Szopiński et al. [25].

The present study has some limitations that the obstructive uropathy patients with pacemakers, foreign body and aneurismal clips could not undergo MR Urography. MR Urography was difficult in uncooperative patients. However, sedation and usage of adhesive tapes and belt, were useful in some patients. The study was a single-center study conducted at a referral tertiary care hospital with diverse patients, the results may not be generalizable to the general population.

Conclusion

Ultrasound as an initial investigation helped in finding the level and severity of urinary obstruction. It helped in grading the obstructive features very precisely in all the cases. However static fluid MR Urography performed better, in whom ultrasound showed inadequate results due to the presence of bowel gases and excessive abdominal fat in obese patients. It was superior in classifying the PUJ obstruction as partial and complete. It detected more cases of ureteric calculi and ureteric strictures. In case of neoplastic urinary obstruction, in addition to the level of obstruction, it gave a precise local/diffuse extension of lesion, surrounding soft tissue/ organ invasion and additional lymph nodes. As compared to Ultrasound, the static fluid MR urography appears as a better tool in diagnosing both extrinsic and intrinsic causes of obstructive uropathy.

Competing interest

The authors declare that there are no conflicts of interest.

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