Magnetic Resonance Urography Plus, Abdominal Radiograph in Acute Calculus Ureteric Obstruction

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ABSTRACT:

BACKGROUND:
About 2-3% of the population experiences an attack of acute ureteric colic during their lifetime, and 67%-95% caused by ureteric calculi. Magnetic Resonance Imaging (MRI) can rapidly demonstrate both the presence and the level of ureteric obstruction.]

OBJECTIVE:
To study the diagnostic accuracy of MRI (alone and in combination with plain abdominal radiograph) in detecting acute ureteric calculus obstruction compared to unenhanced Computed Tomography (CT).

PATIENTS AND METHODS:
A cross sectional comparative study was conducted on a total of 48 patients suspected to have acute ureteric calculus obstruction, at the radiology department in AL-Imamain AL-Kadhemain Medical city, during the period from March to November 2015. Patients underwent MRU then unenhanced abdominal CT, and plain abdominal radiograph. The sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy of MRU findings were obtained in comparison to CT findings regarding ureteric dilatation and its level, stone detection and perirenal fluid and fat stranding.

RESULTS:
Of the 48 patients imaged with both CT and MRU, 4 of them showed no evidence of obstruction on any imaging modality, and 44 of them had a final diagnosis of acute calculus ureteric obstruction. Regarding the detection of ureteric dilatation in MRU, in comparison to CT, the sensitivity = 100%, specificity = 80%, the positive predictive value (97.72%), the negative predicative value (100%), and overall accuracy (97.9%). The detection of ureteric stone by MRU (when combined with plain abdominal radiograph) in comparison to CT, the sensitivity = 95.45%, specificity = 100%, the positive predictive value (100%), the negative predicative value (66.66%), and over all accuracy (95.8%). The detection of peri-renal fluid by MRU in comparison to CT, the sensitivity = 96.66%, specificity = 72.22%, positive predictive value (85.29%), the negative predicative value (92.85%), and overall accuracy (87.5%).

CONCLUSION:
MRI when combined with plain abdominal radiograph was nearly as accurate as unenhanced spiral CT in acute calculus ureteric obstruction. Also the MRI was more sensitive than unenhanced CT in detecting the secondary signs of upper urinary tract obstruction, as perirenal fluid.

KEY WORDS: MRU, abdominal radiograph, ureteric calculus.

INTRODUCTION:
Acute flank pain is a common clinical entity. Urinary obstruction secondary to calculi is the most common cause [1] which often causes severe pain. [2] About 1-5% of the population is affected by this condition annually. [3] Patients with acute flank pain have ureteral calculi in 67-95%. [4]

Urinary tract calculi are very common, and the incidence increases with age up to 60 years, calculi are much less common in children than adults. [5] About 50% of patients suffer at least one recurrence, and 10-20% experience three or more further episodes of urolithiasis. [6]

Most of these calculi are calcium salts, usually a mixture of oxalate and phosphate. [7] Over 90%

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of calculi are radio-opaque on plain films. The sensitivity of conventional radiography for the assessment of renal and ureteric stones is approximately 60% since it mainly relies on stone calcification for visualization [8].

CT is accurate in demonstrating kidney and ureteric calculi and. Virtually all the stones are radio-opaque on CT. [9] Unenhanced CT can provide information about the presence, size, and location of all ureteral stones. [10]. Nevertheless, one of the most important disadvantages and emerging problems in CT is the risk of radiation. [11] Stones not detected on radiography are visualized on CT. [12-15] Radiologists must ensure that all studies with ionizing radiation are indicated and integrate low-dose CT protocols into routine practice and use alternative imaging such as ultrasound and MRI where feasible [16].

The use of MRI in renal system is not new. In the past thirty years this technique has been performed as a complementary tool to evaluate urinary tract abnormalities [17]. The unique advantage of MRI is the absence of ionizing radiation. We can use routine T2WI sequences in addition to the MR Urography (MRU), which is a heavily T2-weighted turbo spin-echo sequences to obtain static-water images of the urinary tract [18]. MRI is capable of complete urinary tract imaging. Contrast resolution exceeds CTU, no ionizing radiation is required, and no intravenous contrast medium need be administered. This is beneficial in pregnant females, and patients with renal insufficiency. MRI is also very effective for imaging most pediatric lesions and anomalies [19]. Ureteric calculi seen as signal void filling defect on MRI [20]. In pregnant females, MRI appears useful for the assessment of hydronephrosis related to pregnancy and for stone detection [21]. MRI can demonstrate both the presence and level of ureteric obstruction, and the technique provides good urographic type images without risk of radiation or contrast media [22, 23].

AIM OF THE STUDY:

To study the diagnostic accuracy of MRI (alone and in combination with plain radiograph of the abdomen) in detecting acute ureteric calculus obstruction compared to unenhanced CT.

PATIENTS AND METHODS:

This cross sectional comparative study included 48 patients with age range of 18-55 years conducted in the radiology department in AL-Imamain AL-Kadhemain Medical city, during the period from March to November 2015. The 48 patients were send from the Emergency Department and Urosurgery outpatient clinic in order to perform CTU, all the patients were highly suspected of having acute calculus ureteric obstruction, with clinical evidence and presenting signs and symptoms including one or more of the following: acute flank pain, and haematuria, pallor, nausea or vomiting and/or previous history of stone passage. Exclusion criteria: patients with contraindication for MRI (ex: patients with cardiac pacemaker or with metallic shells, and claustrophobic patients, pregnants in first trimester). All the patients were examined with MRI, CT and plain abdominal radiograph (KUB). Written consent was obtained from all patients included in the study.

MRI: All MRI studies were performed with Achieva 1.5 Tesla scanner (Philips Medical system, Netherland). Examinations carried out without patient preparation, in supine position, no intravenous contrast agent given. Standard circularly-polarized body coil used. MRI protocol for abdomen and kidney used, including the following sequences: T2WI in axial and coronal imaging planes to cover both kidneys to the bladder base with the following parameters: repetition time (TR) 10 mSec, echo time (TE) 80 mSec, acquisition time of 23 sec for 19 slices. A slice thickness of 4 mm (coronal imaging), and 5mm (axial imaging) was applied with a variable field of view, 53 images were generated in each patient. HASTE-MRU was performed using a single shot technique (TR of 8000 mSec, TE 800 mSec, single excitation and a slice thickness of 10 mm), applied in the coronal plane. Coronal breath-hold scan of 13 slices was done twice to interleave slices. Acquisition time was 13 seconds for each scan. The patients were instructed to hold their breath in the same manner for each acquisition to avoid or minimize misregistration artifacts. This yielded a further 11 images per patient with a total of 64 images. A frequency selective fat suppression algorithm was used to reduce intra-abdominal fat high signal and no contrast medium was administered. The imaging time required for MRU averaged less than 5 min.

Unenhanced multidetector CT: CT examination was performed by using multi-detector row scanner (SOMATOM Definition Edge Siemens medical system, Germany). Using 5mm collimation at energy level of 100Kv and 225mA, a pitch 2:1 and a gantry rotation time of 1.9 sec. Examination carried out with no patient preparation, in supine position, and hands overhead, no intravenous contrast agent given. The examination covers both kidneys to the bladder base in single breath-hold clusters, continuous acquisition used. Slice thickness of

(5mm), with (5mm) reconstruction used. Depending on the size of the patient up to 120 images were generated per study.
KUB: Using a CR and a film size (35X43), FFD 1.4, (60-80) KV, and 20-32 mA, depends on the patient's body built, the field to be examined from symphysis pubis to the xiphsternum, with patient in supine position. All the CT and MR studies were considered technically adequate. No significant breathing or misregistration artifacts noted.
Image analysis: The MRI and CT images were evaluated by two independent radiologists to decrease inter-observer error. The KUB was correlated to the MRU. The following findings were assessed: presence or absence of perirenal stranding in CT or perirenal fluid in MR, ureteric dilatation, ureteric calculi, and level of obstruction. A ureteric calculus was diagnosed as a high attenuation ureteric filling defect on CT or as a signal void ureteric filling defect on MRU. The level of obstruction was determined to be either proximal, middle or distal ureter. Maximum dimension of the ureteric calculi measured in millimeters.
Statistical analysis: Statistical analysis was carried out using SPSS (statistical package for social sciences) version 17. Categorical variables were presented as frequencies and percentages. Continuous variables were presented as (Means ± SD).The sensitivity, specificity, positive predictive value, negative predictive value and overall accuracy of MRU findings were obtained in comparison to CT findings regarding ureteric dilatation and its level, stone detection and perirenal fluid and fat stranding.

RESULTS:

The study included 48 patients, 28 patients (58.3%) were male and 20 patients (41.7%) were female, with Male: female ratio of 7:5. Age range 18-52 years, with mean age (31.18±9.36). The final diagnoses of the 48 patients included in the study were as follow: 44 of the patients (92 %) had a final diagnosis of acute calculus ureteric obstruction and only 4 patients (8 %) showed no evidence of obstruction.
Regarding ureteric dilatation: In MRU: Ureteric dilatation seen in 44 patients (91.7%), with 4 patients (8.3%) shows no dilatation. In CT: Ureteric dilatation seen in 43 patients (89.58%), with 5 patients (10.42%) shows no dilatation. In comparison to CT, the sensitivity of MRU to detect ureteric dilatation was (100%) that mean the MRU was able to detect all patients with ureteric dilatation correctly meanwhile, its specificity was (80%) that mean the MRU was able to detect (80%) of those patients free from dilatation correctly. The positive predictive value was (97.72%) that means approximately (98%) of patients with ureteric dilatation according to MRU are more likely to have real ureteric dilatation, and the negative predicative value was (100%), which means all those free from dilatation according to MRU are really free from dilatation, as shown in table 1

Table 1: Comparison of MRU versus CT findings regarding ureteric dilatation in the 48 patients included in the study.

		CT			
		Present	Absent	Total	
MRU	Positive	43	1	44	Sensitivity = (43/43)×100 = 100% Specificity = (4/5) ×100 = 80% PPV= (43/44) ×100 = 97.72% NPV= (4/4) ×100 = 100% Accuracy=(43+4/48)×100= 7.91%
	Negative	0	4	4	
	Total	43	5	48	

Regarding ureteric stone detection: In MRU: Ureteric stone detected on MRU in 29 patients (60.41%), with 19 patients (39.58%) show no ureteric stone, while the KUB detect ureteric stone in 41 patients (85.42%), with only 7 patients (14.58%) show no stone. When the results of the MRU combined with KUB, the stone detection increases as following: 42 patients (87.5%) show ureteric stone and 6 patients (12.5%) show no ureteric stone. In CT: Ureteric stone detected in 44 patients (91.7%), with 4 patients (8.3%) show no ureteric stone. In comparison to CT, the sensitivity of MRU alone to detect stone was (65.9%), its specificity was (100%). The positive predictive value was (100%), meanwhile, the negative predicative value was (21.05%), as shown in table 2

Table 2: Comparison of MRU alone versus CT findings regarding ureteric stone detection in the 48 patients included in the study.

		CT			
		Present	Absent	Total	
MRU alone	Positive	29	0	29	Sensitivity = (29/44)×100 = 65.9% Specificity = (4/4) ×100 = 100% PPV= (29/29) ×100 = 100% NPV= (4/19) ×100 = 21.05% Accuracy=(29+4/48)×100= 68.75%
	Negative	15	4	19	
	Total	44	4	48	

In comparison to CT, the sensitivity of MRU (when combined with plain abdominal radiograph) to detect stone was (95.45%) that means it was able to detect (95%) of patients with ureteric stone correctly meanwhile, its specificity was (100%) that mean the MRU was able to detect all those persons free from stone correctly. The positive predictive value was (100%) that means all patients with ureteric stone according to MRU are more likely to have real ureteric stone, meanwhile, the negative predicative value was (66.66%), which means two third of those free from stone according to MRU are really free from stone, as shown in table 3

Table 3: Comparison of MRU combined with KUB versus CT findings regarding ureteric stone detection in the 48 patients included in the study.

		CT			
		Present	Absent	Total	
MRU + KUB	Positive	42	0	42	Sensitivity=(42/44) ×100 = 95.45% Specificity = (4/4) ×100 = 100% PPV= (42/42) ×100 = 100% NPV= (4/6) ×100 = 66.66% Accuracy=(42+4/48)×100= 95.83%
	Negative	2	4	6	
	Total	44	4	48	

Regarding peri-renal fluid and peri-renal fat stranding detection: In MRU: Peri-renal fluid seen in 34 patients (70.8%), with 14 patients (29.2%) shows no peri-renal fluid. In CT: Peri-renal fat stranding seen in 30 patients (62.5%), with 18 patients (37.5%) show no stranding. In comparison to CT, the sensitivity of MRU to detect peri-renal fluid was (96.66%) that mean the MRU was able to detect (96%) of patients with peri-renal fluid correctly meanwhile, its specificity was (72.22%) that mean the MRU was able to detect (72%) of those persons free from peri-renal fluid correctly. The positive predictive value was (85.29%) that means (85%) of patients with peri-renal fluid according to MRU are more likely to have stranding, meanwhile, the negative predicative value was (92.85%), which means approximately (93%) of those free from peri-renal fluid according to MRU are really free from that pathology, as shown in table 4.

Table 4: Comparison of perirenal fluid in MRU versus CT peri-renal fat stranding in the 48 patients included in the study.

		CT (fat stranding)			
		Present	Absent	Total	
MRU (peri-renal fluid)	Positive	29	5	34	Sensitivity=(29/30) ×100 = 96.66% Specificity=(13/18) ×100 = 72.22% PPV= (29/34) ×100 = 85.29% NPV= (13/14) ×100 = 92.85% Acuracy=(29+13/48) ×100 = 87.5%
	Negative	1	13	14	
	Total	30	18	48	

Regarding the level of Urteric obstruction: results of both procedures are completely identical regarding level of ureteric obstruction with majority (39.6%) of patients presented with middle ureteric obstruction, as shown in figure 1. Figures 2, 3 and 4 show imaging findings of some of the cases included in this study.

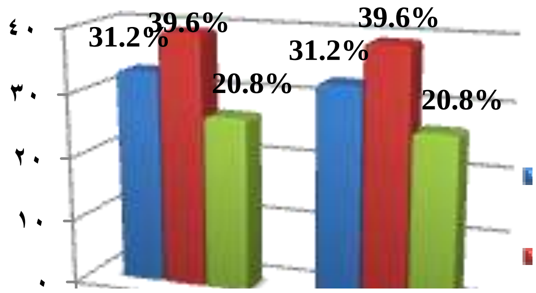

Figure 1: Comparison of CT versus the MRU regarding the level of ureteric obstruction.

Figure 2: 50 years old male with 24 hr duration of left loin pain. A: KUB showing Lt. lower ureteric radiopaque stone (arrow). B: MPR coronal abdominal CT shows lower ureteric stone (arrow). C: HASTE MRU shows dilated ureter (arrow) and dilated PCS.

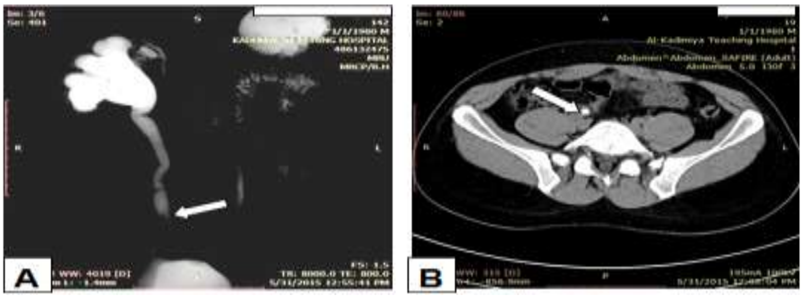

Figure 3: 35 years old male with 12 hr. duration of severe Rt. Renal colic. A: HASTE MRU showing severe hydronephrosis and hydroureter caused by lower ureteric stone (arrow). B: axial unenhanced CT showing the lower ureteric stone (arrow).

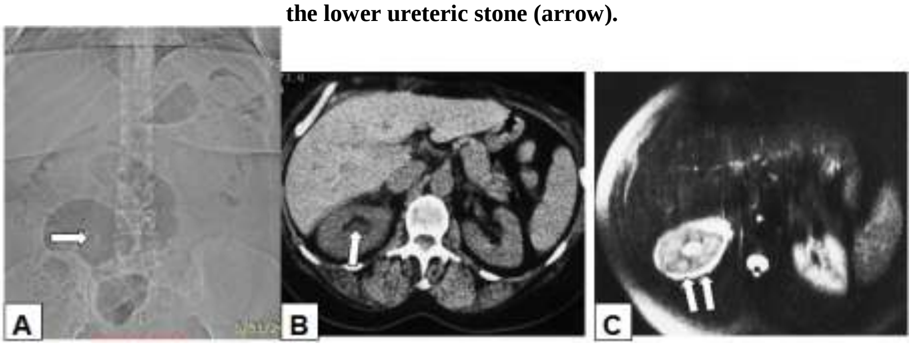

Figure 4: A 56-year-old female presented with acute right sided flank pain caused by a right middle ureteric calculus. A: KUB shows right ureteric radiopaque stone (arrow) seen over the right psoas muscle. B: Axial CT shows evidence of hydronephrosis (arrow) but with no evidence of significant stranding. C: Axial MR shows significant perirenal fluid (arrows).

DISCUSSION:

Ureteric colic is a symptom of acute urinary collecting system obstruction. The commonest cause of ureteric colic is Ureterolithiasis [24]. The ureteric colic commonly recurs, with a recurrence rate estimated to be about 40%–50% within five years, and 75% within 20–30 years from the first attack [25]. Several studies have shown that Non-contrast computed tomography (NCCT) has become the well-recognized gold standard and most clinically useful tool for diagnosis of urolithiasis [26-28]. One great advantage is its ability to detect alternative diagnoses and It can detect calculi of nearly any composition (can identify uric acid and xanthine stones that are radiolucent on plain film [29, 30]. In addition to calculi detection, CT can reveal signs associated with ureteral obstruction. These signs include renal enlargement with lower attenuation of obstructed kidney, hydronephrosis or hydroureter, and perirenal fat stranding [31, 32]. Still controversial is its role during follow-up for treated urolithiasis patients and those on observation protocol [30]. Half Fourier single shot turbo spin echo (HASTE) magnetic resonance urography (MRU) without contrast is safe, effective, comparable to CT accuracy, and now considered second-line during pregnancy when available [33, 34]. It visualizes the stone as a filling defect, evaluates secondary findings of obstruction, and also gives information about non-urologic organ systems [35].

In this cross sectional comparative study we use MRI with plain abdominal radiograph to detect the signs of acute ureteric calculus obstruction, including the ureteric dilatation, ureteric stone detection, and peri-renal fluid. We find that MRI when interpreted with a plain film of the abdomen was nearly as accurate as unenhanced spiral CT, and can detect a greater number of secondary signs of upper urinary tract obstruction, like the perirenal fluid, these results were in agreement with that of Regan et al [34] were that MRI was nearly as accurate as unenhanced spiral CT when interpreted with abdominal radiograph, and can detect greater number of secondary signs of upper urinary tract obstruction as perirenal fluid.

Perirenal and periureteric stranding can be difficult to detect on CT especially in patients with a paucity of intra abdominal fat, also the perirenal fat stranding is not specific to acute ureteric obstruction and can occur in other pathological processes such as renal infections and tumors. Also the peri ureteral vessels and lymphatics can be confused with stranding on CT. Alternatively; the MRI shows the perirenal fluid with greater sensitivity and less interobserver variability than the CT even in slim patients. These results also were in agreement with that of Regan et al [34]. The clarity with which the perirenal fluid is seen may be partly explained by the use of fat suppression and the fluid sensitive T2 weighting of the HASTE sequences. For the same reasons, MRI clearly shows the ureter and level of obstruction, increasing the confidence whereby ureteric calculi can be diagnosed on KUB [34].

CT images generated per study were about 120 axial images (compared with an average of 54 images for MRI), in addition to the reformatted CT images in the MPR, all of these images require more time for interpretation than the images of MRU. Interpretation difficulties may limit the value of CT in acute ureteral obstruction. Distal ureteric calculi may be difficult to distinguish from pelvic phleboliths or arterial calcifications. Although calculi have higher attenuation values than phleboliths, these values may be inaccurate if targeted views of the distal ureter are not obtained. Although analysis of calculi and reformatted images of obstructed ureters from data on the console is more accurate than hard copy images, this is time consuming and probably inappropriate in a busy department [34].

If we interpret the MRI alone, it fails to demonstrate many of the renal and ureteric calculi, but when interpreted in combination with a plain abdominal radiograph, a more confident diagnosis of ureteric calculus can be made, these results were in agreement with that of Semins et al [36]. While MRI/KUB misses the detection of the small calculi(less than 5 mm), these usually pass spontaneously, and do not require intervention [37].

The most important disadvantage of CT is the radiation risk. Gray [38] calculated that abdominal CT has a surprisingly substantially increased risk of carcinogenesis and death, which is comparable to that from cigarette smoking-induced malignancy (12.5 cancer deaths per 10,000 persons exposed to one examination). A conservative estimate of fatal cancers induced by CT in the United States each year is 2600 (13X10 6 examinations, 5X10 -3 Sievert, 4X10 -2 deaths per Sievert) [38].

Any assessment of the usefulness of helical CT in acute flank pain must take into account that risks increase with decreasing age [10]. In children and young adults, the probability of causing a fatal cancer cannot be regarded as negligible, as recently stressed by Brenner et al [39]. On the other hand, MRI is safe because no ionizing radiation is used. For situations in which the use of ionizing radiation is undesirable, especially in children, young adults, pregnants, and in all childbearing aged women, MRI is a reasonable imaging alternative [40]. According to Roebuck and Metreweli [41] we believe that in these groups of patients, the need to reduce the risk of radiation is more important than any financial consideration.

MRI with a HASTE sequence in patients holding their breath achieves high-quality images of the urinary tract because of the heavily T2- weighted quality and fast-acquisition time. In this study the HASTE MRU was nearly 100% accurate in revealing the presence of urinary tract dilatation and the level of obstruction, equal to that of CT. The presence of obstruction and the level of obstruction were correctly diagnosed in 100% of the patients, and these were in agreement with that of Blandino et al [10].

On the other hand, stones were identified by MRI only in 29 of 44 of our patients. The sensitivity of MRI in revealing signs of ureteral stones were similar to that of helical CT. However, MRI can demonstrate renal edema with more confidence than CT, this result was in agreement with that of Regan et al [34]. Renal edema due to urinary stasis in the renal tubules explains enlargement with lower attenuation of obstructed kidney on CT scan. On MRI, renal edema appears as a diffuse parenchymal hyperintensity. Moreover, the HASTE MRU is a fast examination, easily to be interpreted, and of low consumption of films due to the lower number of images generated for each patient, and the logistic problems related to the access to MRI are strongly reduced since MRU can be performed in few minutes [10].

CONCLUSION:

MRI when combined with plain abdominal radiograph was nearly as accurate as unenhanced spiral CT in acute calculus ureteric obstruction without the risk of radiation. The MRI was more sensitive than unenhanced CT in detecting the secondary signs of upper urinary tract obstruction, as perirenal fluid.

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