Acute Ureteric Calculus Obstruction:
Unenhanced Spiral CT Versus MR Urography
and Abdominal Radiograph

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Abstract:

The main aim of this study was to compare the performance of unenhanced spiral CT to the combination of MR urography (MRU) and plain abdominal radiography (KUB) in patients suspected of having acute calculus ureteric obstruction. 64 patients with suspected acute calculus ureteric obstruction were evaluated. The presence of perirenal fluid, presence and level of ureteric obstruction and calculi were assessed on both techniques. 44 out of 64 (69%) patients had acute calculus ureteric obstruction based on clinical, radiographic or surgical findings. MRU showed perirenal fluid in acute ureteric obstruction (77%) with a greater sensitivity than CT showed stranding (45%). The combination of fluid and ureteric dilation on MRU showed a sensitivity of 93% (CT 80%), specificity of 95% (CT 85%), and accuracy of 94% (CT 81%).

KUB showed ureteric calculi in 21/29 (72%) of patients with calculi seen by CT. Overall, MRU/KUB revealed 2.4 abnormalities per acutely obstructed ureter compared with 1.8 abnormalities detected by CT. MRU/KUB using HASTE sequences can diagnose the presence of acute calculus ureteric obstruction with similar accuracy to spiral CT. This technique has less observer variability and is more accurate than CT in detecting evidence of obstruction such as perirenal fluid.

Introduction:

The clinical features of acute ureteric colic typically include severe flank pain radiating to the groin, microhaematuria and calculus retrieval from urine.[1]

Although the disease is usually self-limiting with the spontaneous passage of a stone, persisting pain or high grade obstruction may require hospitalization and urological intervention. As calcium, stone disease has a propensity to recur with significant associated morbidity, reliable and non-invasive imaging techniques both for initial diagnosis and in follow up of the disease are required.

Intravenous urography (IVU) has traditionally been the imaging modality of choice in evaluating patients with acute ureteric calculus disease.

Unenhanced spiral CT (CT) is accurate in demonstrating kidney and ureteric calculi and signs of acute obstruction such as perirenal stranding, and hydronephrosis.[2–4]

Alternatively, MR urography (MRU) has been slow to gain wide acceptance in evaluating patients with ureteric obstruction. This may be explained by the limited access to fast MRI techniques, and poor detection of kidney and ureteric calculi when compared with CT. MRU using HASTE (Half-Fourier single shot turbo spin-echo) sequences can however, demonstrate both the presence and level of ureteric obstruction,[5,6] and this technique provides good urographic type images without risk of radiation or contrast media.

The goal of this study was to compare spiral CT andMRU and to determine if HASTE MRU when combined with plain radiograph of the abdomen (KUB) can be diagnostic in patients with acute ureteric colic. A secondary objective of this study was to compare interobserver variability and ease of interpretation of CT compared with MRU.

Patients and methods;

A prospective evaluation of 96 patients presenting to the Emergency Department with suspected acute calculus ureteric obstruction over a 1-year period was performed.

All patients had clinical evidence of acute calculus obstruction with flank pain, haematuria and/or history of stone passage.

This was a non-consecutive group of patients as MRI was performed only during weekday hours. Additionally only those patients imaged with both CT and MRU within 6 hr of each other were included. Six claustrophobic patients refused imaging with MR and MRI was not available in a further six patients because of routine scanner maintenance. Five patients left the Emergency department before MRI could be performed and a further three patients who had received intravenous contrast agents were excluded from the study.

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64 patients were included in the final study group and all these patients were imaged with both CT and MRU.

Depending on availability at the time of referral, 42 (66%) patients underwent CT first and the remaining 22 patients underwent MRI prior to CT. KUBs were available in 45/64 (70%) patients. Informed consent was obtained in all patients.

Unenhanced spiral CT (Siemens, Iselin, NJ) was carried out through both kidneys to the bladder base in three breath-hold clusters with the following imaging parameters:

130 kV, 83 mA, gantry rotation time 1.9 s. A slice thickness of 3 mm with 3 mm reconstruction was used.

Depending on the size of the patient up to 120 images were generated per study.

Patients underwent HASTE MRI using a 1.5 Tesla Magnetom Vision scanner (Siemens, Iselin, NJ) in the axial, sagittal and coronal imaging planes to cover both kidneys to the bladder base. The following parameters were used: repetition time (TR) 11.9, echo time (TE) 95.0, acquisition time of 23 s for 19 slices. A slice thickness of either 4 mm (coronal and sagittal imaging) or 7 mm (axial imaging to cover the full abdomen) was applied with a variable field of view. 57 images (1963 planes) were generated for each patient. MRU was performed using a single shot technique (TR of 2000, TE 80, single excitation and a slice thickness of 10 mm). It yielded a further 11 images per patient with a total of 68 images. A frequency selective fat suppression algorithm was used to reduce intra-abdominal fat high signal and no contrast medium was administered.

Image analysis:
Images from both CT and MRU were read independently by three radiologists – a senior radiology resident (observer 1) and two attending radiologists experienced in abdominal imaging (observers 2 and 3). The readers were unaware of the final clinical outcome, results of other imaging modalities and of each other's findings. CTs and MRUs were presented in a random order to the radiologists for interpretation and read in three sessions.

The KUB was read in conjunction with the patient's MRU.

The following findings were assessed on both imaging techniques: presence or absence of perirenal and periureteric stranding (CT) or fluid (MR), ureteric dilatation, and level of obstruction. A level of obstruction was determined to be either proximal, middle or distal ureter. A ureteric calculus was diagnosed as a high attenuation focus on CT or as an intraluminal signal void on MR. Calculi were documented as either kidney, proximal, middle or distal ureter in location, and their maximum diameter measured in millimeters.

The ease of interpretation was graded subjectively by each observer between 1 and 5, the most difficult interpretation was assigned a grade 1 and the easiest, one grade 5. A consensus opinion was reached where there was a disagreement between observers in evaluating stranding/ fluid, ureteric dilation and level of obstruction.

Statistical analysis:
Data from the consensus opinion of the observers were used to calculate sensitivity, specificity, positive, negative predictive values and accuracy of both techniques for detection of acute calculus obstruction. Exact confidence intervals were calculated for these results. The number of findings per acutely obstructed kidney noted by each observer and by consensus was calculated for CT and MRU/KUB techniques, and a p-value of ,0.001 was considered to be significant.

Agreement between CT and MRU was measured by Kappa statistics for all three observers and for the consensus opinion. A Kappa value of 0.75 denoted excellent agreement, Kappa between 0.4 and 0.75 was good agreement, and less than 0.4 was marginal agreement.[7]

Interobserver variability regarding findings of fluid, ureteric dilation and level of obstruction and whether the right or left kidney was affected. It assessed with Kappa statistics for all possible observer combinations (observers 1 and 2, 2 and 3, and 1 and 3). The size of calculi seen on CT and KUB was compared using a two sample t-test.

A McNemar's exact test compared each finding by each observer with the presence of acute ureteric obstruction.

The ability of CT and MRU/KUB in predicting disease using the combined findings of fluid, ureteric dilation and calculi was compared using the McNemar's chi-squared test. Finally, the Wilcoxon Signed rank test was applied to measure the differences in ease of interpretation of CT and MRU/KUB for all three observers.

Results:
Out of 64 patients, images were taken with both CT and MRU. 20 (31%) showed no evidence of obstruction on any imaging modality and had a final diagnosis as follows: urinary tract infection (3), appendicitis (1), perirenal abscess (1), musculoskeletal pain (2), liver haemangioma (1), prostate carcinoma (1), prostate enlargement with urinary tract infection (1), Crohn's disease with

abscess formation (1), myeloma of kidneys (1), degenerative hip or lumbar spine disease (3). No definite diagnosis was made in a further five patients. 44 out of 64 (69%) patients had a final diagnosis of acute calculus obstruction. In addition to the findings on CT and KUB, there was additional confirmation of calculus disease as follows: imaging studies in 35 patients, including intravenous pyelography (14), retrograde pyelography (12), and documented movement of a calculus on sequential KUBs (8), surgery was performed in 11 patients, including urethroscopy and stone retrieval, and a further 10 patients reported passing calculi.

All CT and MR studies were considered technically adequate. No significant breathing or misregistration artefacts were noted. The sensitivity, specificity, and overall accuracy of fluid and ureteric dilatation to predict disease were 80%, 85%, and 81%, respectively, for CT(Figure 1), compared with 93%, 95%, and 94% for MRU. There were 61 findings of either fluid or ureteric dilatation on MRU in 44 acutely obstructed kidneys. This compared with 37 abnormalities per obstructed kidney on CT if the same parameters of fluid and dilatation were used . If fluid, dilatation and stone detection were assessed, the MRU/KUB

combination showed 66 abnormalities in 27 acutely obstructed kidneys where all imaging modalities were available for evaluation, compared with 76 in 43 abnormalities per obstructed kidney on CT .

Using consensus data, there was complete correlation between CT and MRU in 48 out of 64 (75%) patients. MR demonstrated perirenal or periureteric fluid in 14 patients not seen in CT scanning (Figure 2). There was only one patient where CT demonstrated stranding not shown by MRU. The observers missed perirenal stranding on CT in four patients who had minimal intra-abdominal fat including two patients with HIV. In five further patients with acute ureteric obstruction, proximal ureteric stranding was missed by observers 2 and 3.

In one patient with bilateral pelvic kidneys, bilateral hydronephrosis was incorrectly diagnosed in CT. The correct diagnosis of multiple parapelvic cysts, without obstruction was diagnosed by MRU. In another patient, with the benefit of coronal imaging, MR identified a distal left ureterocoele, not identified on CT. There was overall good agreement between CT and MRU regarding to the ureteric dilation , level of obstruction and which kidney was the affected one.
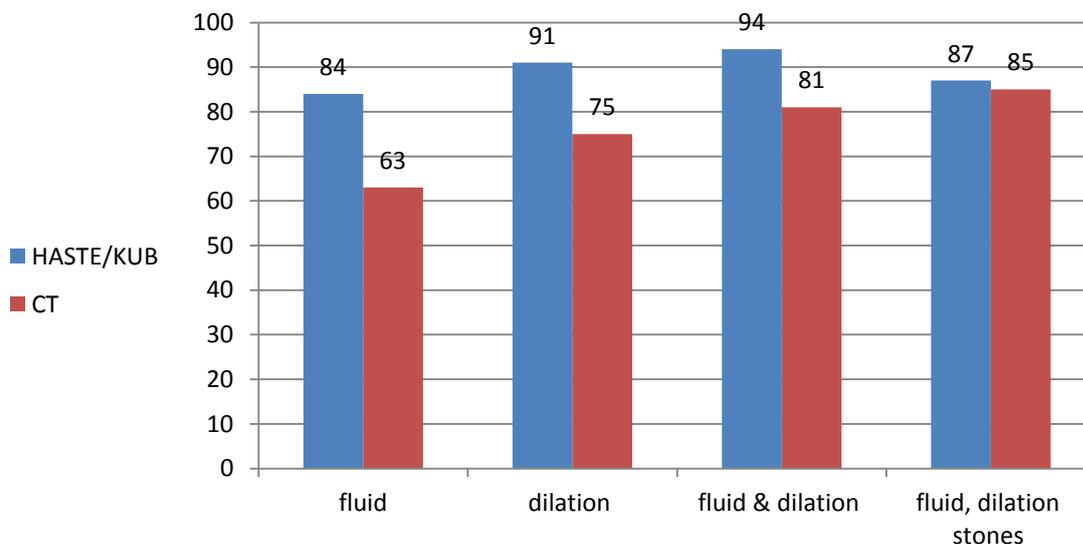

Figure 1. Accuracy of half-Fourier single shot turbo spin-echo (HASTE) MR urography/ plain abdominal radiograph (MRU/KUB) was compared with spiral CT in acute calculus ureteric obstruction.
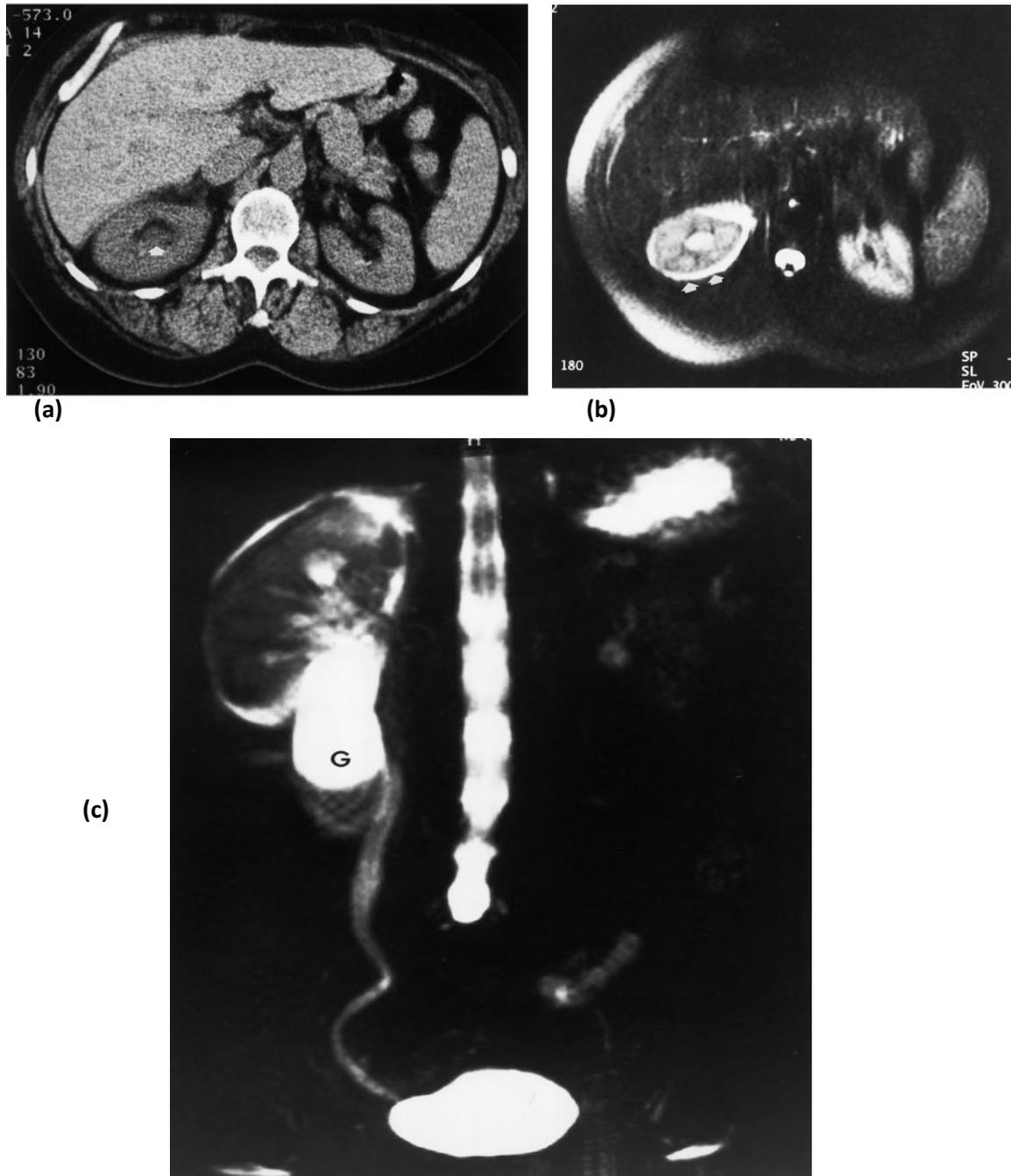
Figure 2. A 56-year-old female presented with acute rightsided flank pain caused by a right vesicoureteric junction calculus.
(a) Axial CT shows evidence of hydronephrosis with but no evidence of significant stranding. (b) Axial MR, shows significant perirenal fluid (arrows). (c) MR urogram shows a dilated ureter to the level of the bladder. Gallbladder (G).

Interobserver variability:

This case statistics demonstrated good overall concordance between the individual observers regarding to the presence or absence of the acute disease on MRU and CT. There was strong agreement between all observers as to which kidney was acutely obstructed although interobserver agreement was generally greater for MRU than for CT.

There was also good agreement between all observers in assessing the presence or absence of perirenal fluid on MRU but significant deviations occurred between all observers in assessing perirenal stranding on CT (Table 1). Similarly there was stronger, but not statistically significant, agreement between all three interobserver combinations in the depiction of the level of obstruction on MRU.

In the obstructed kidneys, a level of obstruction was suggested by the presence of dilatation or calculi on CT in 32 patients as follows: proximal ureter 9, mid ureter 2 and distal ureter 21. Similarly, MRU/KUB demonstrated a level of obstruction in 40 patients: proximal ureter 5, mid ureter 7 and distal ureter 28.

The location and the size of ureteric calculi detected by CT and KUB/MRU are shown in Table 1. CT detected 29 ureteric calculi ranging in size from 1 mm to 12 mm in length (mean 3.7 mm). Using CT as the gold standard KUB/MRU detected 21/29 (72%) ureteric calculi (size 2–14 mm) in patients with evidence of obstruction. MRU alone demonstrated calculi in only three patients, all of whom had calculi greater than 10 mm diameter in dilated systems and there was a significant difference in the mean size of calculi detected by CT (3.7 mm) and MRU/ KUB (5.1 mm).

There was no significant difference between CT and MRU in the probability of predicting acute calculus ureteric obstruction when the combination of all three parameters (fluid, dilatation and calculi) was used and the combination of fluid and ureteric dilatation on both techniques were significantly more predictive disease than the individual finding of either dilatation or fluid.

Finally, the difficulty in interpreting CT was assigned by the three radiologists having average grade of 4, 3.5, and 3.3 respectively and 4.4, 4.4 and 4.2, respectively, for MRU. All three interpreters found the median score significantly larger (i.e. easier to interpret) for MRU than CT , although the least experienced radiologist (observer 1) showed less difference in difficulty between the two imaging modalities.

Table 1a: Calculus detection and location as demonstrated by CT and MR urography/plain abdominal radiograph (MRU/ KUB). Mean stone size (mms) are in parentheses

	CT	MRU/KUB
Prox	3 (7)	3 (4.6)
Mid	4 (6.4)	3 (8.5)
Distal	22 (3.1)	15 (4.4)
Total	29a (3.7)	21a (5.1)

17 additional intra renal calculi were seen on CT and 6 on KUB. These included two bladder calculi.

Table 1b: Number of calculi detected by CT and MRU in less than 5 mm, 6–10 mm and more than 10 mm mean size groups.

	CT	MRU/KUB
Less than 5 mm	21 (72%)	13 (62%)
6–10 mm	6 (20%)	6 (29%)
More than 10 mm	2 (7%)	2 (10%)
Total	29	21

Discussion:

In this prospective study, we found that MRU when interpreted with a plain film of the abdomen (KUB) was as accurate as unenhanced spiral CT in acute calculus ureteric obstruction. MRU had better results than the acute CT in detecting the perirenal fluid as a sign of obstruction.

There have been many recent papers, which describes the utility of unenhanced CT in the acute calculus obstruction.[2–4] Small calculi can be detected and secondary signs of obstruction such as perirenal stranding can be seen without the need for administered contrast media.[7,8]

At this situation however, referring urologists were initially more comfortable at interpreting and making management decisions based on intravenous urography than CT, and 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.[8,9] This is too much time consuming and probably inappropriate in a busy department.

Signs of obstruction such as perirenal and periureteric stranding can be difficult to see on CT and this is especially true in patients with a paucity of intraabdominal fat. Perirenal stranding is not specific to acute ureteric obstruction and occurs in diseases such as renal infection and tumour and periureteral vessels and lymphatics can be confused with stranding on CT.

Numerous CT images were generated per study (up to120 axial images compared with an average of 54 images for MRU), and these were required time consuming interpretation.

Alternatively, MRU shows the effects of acute obstruction, i.e. perirenal fluid with greater sensitivity and less interobserver variability than CT shows stranding. The clarity with which this fluid is seen may be partly explained by the use of fat suppression and the fluid sensitive T2 weighting sequences. For the same reasons, MRU clearly shows the ureter and level of obstruction, increasing the confidence whereby ureteric calculi can be diagnosed on KUB.

Although MRU failed to demonstrate most kidney and ureteric calculi, if combined with a KUB, a more confident diagnosis of ureteric calculus can be made.

While MRU/KUB misses small calculi, (7 mm or less), these usually pass spontaneously [1], and do not require intervention.

our CT technique used multiple acquisitions rather than a single long spiral and a stone may be missed due to misregistration, and the tube current we employed could further reduce the stone detection rate due to beam hardening artefact.

In summary, MRU is more accurate alternative to unenhanced spiral CT in detecting signs of obstruction (perirenal fluid and ureteric dilatation) without the risk of radiation. This technique shows no statistically significant difference in predicting the presence of acute calculus obstruction, demonstrates less interobserver variability, and is easier to interpret than CT.

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