Acute Renal Colic: Value of Unenhanced Spiral Computed Tomography Compared with Intravenous Urography

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Abstract

***Objective**: The objective of this study was to compare the efficacy of plain spiral computed tomographic (CT) scan with intravenous urography (IVU) in the evaluation of patients with suspected urinary calculi/obstruction. **Materials and Methods**: Twenty consecutive patients with acute signs of renal colic were prospectively examined with unenhanced spiral CT followed by an IVU within the same day. The CT scans were reviewed jointly by 2 radiologists blinded to the IVU and a consensus was reached for each finding. The IVU was similarly reviewed by another 2 separate radiologists. **Results**: Eleven of the 20 patients had signs of urinary obstruction on CT and IVU. Of these 11 patients, 7 had a ureteric calculus that was demonstrated on CT and IVU and 4 had a calculus that was demonstrated on CT only. Two patients had a urinary calculus seen on CT and IVU with no signs of urinary obstruction. One patient had a calculus seen on CT alone with no urinary obstruction. Two patients only had signs of urinary obstruction on CT. The remaining 4 cases had normal findings on CT and IVU. **Conclusion**: Unenhanced CT is more effective than IVU in identifying ureteric calculi and is equally effective in detecting urinary obstruction. CT is also useful in detecting secondary signs of obstruction even in the absence of any calculus.*

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Key words: Calculus, Fat stranding, Obstruction, Periureteric, Ureteric

Introduction

The typical ureteric calculus presents with an acute onset of flank pain which may radiate to the groin. Intravenous urography (IVU) has classically been the gold standard for the diagnosis of urinary calculi. However, it can be an uncomfortable procedure requiring intravenous injection of contrast and abdominal compression.

A pioneering study by Smith et al[1] indicated that non-contrast computed tomography (CT) was superior to IVU in the diagnosis of ureteric calculi. In our hospital, IVU is still the modality of choice for the radiographic evaluation of patients suspected of having a ureteric calculus. IVU is able to demonstrate the excretory function of the kidneys and the presence of any obstruction. However, the site and size of the calculus, especially if it is radiolucent, may occasionally be difficult to visualise.

CT scan is usually reserved for patients with previous allergy to contrast, patients with abnormal creatinine function or patients who potentially have a higher risk of an adverse reaction to intravenous contrast (such as asthmatics or patients with multiple drug allergies). However, it has excellent soft tissue contrast compared to radiographs and can provide direct demonstration of a calculus within the ureter. Its cross-sectional imaging of the urinary system also allows for precise determination of the location and size of the calculus.

This prospective study was undertaken to assess its accuracy and feasibility in the local context, as the technique is relatively new in our hospital.

Materials and Methods

Study Group

Approval for this study was obtained from the ethics committee at our hospital. Twenty consecutive outpatients who presented to the urology outpatient clinic with acute flank pain, above 16 years of age and in whom IVU was scheduled as part of their diagnostic evaluation were recruited for the study. Females between the

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ages of 16 to 50 years were included if pregnancy was excluded.

Informed consent was obtained from all patients before they underwent IVU or CT. All patients underwent a plain spiral CT (with no intravenous or oral contrast) followed by an IVU within the same day. The CT scans were performed by acquiring axial spiral images from the top of the kidneys to the symphysis pubis in 5-mm thick sections with a pitch of 1.5. Only supine scans were done in our study. The IVU was performed in a standard technique using a plain control kidney, ureter and bladder (KUB) radiograph followed by an intravenous injection of 50 mL of non-ionic contrast medium (Omnipaque 350). Radiographs were then performed at 1, 10 and 20 minutes followed by a post micturation film. Only the 1-minute film is a tomogram. If there were signs of obstruction or delayed excretion of contrast, additional films will be taken to determine the level and extent of the obstruction.

Reading Method

In concordance with the radiologic criteria described by Smith et al,[1] CT criteria for urolithiasis were defined by the presence of a high density structure within the ureteric lumen or at the anatomic site of the ureterovesical junction. If a ureteric calculus was depicted, its location was specified as the proximal, middle, or distal third of the ureter or at the ureterovesical junction. The size of the calculus was also measured. Urinary obstruction was considered whenever the ureter was unilaterally dilated above a certain level, below which the caliber was normal. Secondary signs of calculus disease were also evaluated for every case. These included unilateral nephromegaly, dilatation of the intrarenal collecting system, perinephric and periureteric fat stranding.

The IVU criteria for urolithiasis were the presence of a calculus within the ureter with or without dilatation of the proximal ureter. As for CT, the location of the ureteric calculus was similarly recorded. Ureteral obstruction was defined as a unilateral delay of excreted contrast medium into the collecting system or dilatation of the ureter to a specific level. In addition, the time of completion of both CT and IVU examinations were recorded for comparison.

All the CT examinations were reviewed jointly by 2 radiologists who were blinded to the IVU results. A consensus was reached for each finding and recorded in a standardised score-sheet. The IVU radiographs were similarly reviewed by another 2 radiologists without the corresponding CT scans.

Differences in sensitivity between non-contrast enhanced CT and IVU in the depiction of ureteric calculus and urinary obstruction were compared by using the McNemar test.

Results

CT Findings

A ureteric calculus was demonstrated in 14 of the 20 patients (Table I). Of these 14, ureteric obstruction was depicted in 11 cases. In another 2 cases, the CT showed only ureteric obstruction but a calculus could not be identified. The remaining 4 cases were normal.

Of the secondary signs of calculus disease, periureteric fat stranding was most commonly visualised (Table II). Twelve out of 14 cases (85.7%) with demonstrable ureteric calculus had 2 or more secondary signs of calculus disease. Of the remaining 6 cases without calculus, 2 had secondary signs of calculus disease.

TABLE I: CT FINDINGS IN 14 PATIENTS WITH URETERIC CALCULI

Patient no.	Nephromegaly	HN	HU	Perinephric fat stranding	Periureteric fat stranding	Tissue rim sign	Location within ureter	IVU time (min)
1	-	-	-	-	Y	Y	Proximal	50
2	-	Y	Y	Y	Y	Y	Proximal	48
3	-	-	-	-	-	-	UVJ	47
4	-	-	Y	Y	Y	-	UVJ	123
5	Y	-	-	Y	-	-	UVJ	67
6	-	-	Y	-	Y	-	UVJ	48
7	-	Y	Y	-	Y	Y	Mid	62
8	Y	Y	Y	Y	Y	Y	Distal	39
9	-	Y	Y	Y	Y	Y	Proximal	91
10	-	Y	-	Y	Y	-	UVJ	87
11	-	Y	Y	-	Y	Y	Mid	74
12	-	Y	Y	Y	Y	Y	Mid	45
13	Y	Y	Y	-	Y	Y	Mid	42
14	-	Y	Y	Y	Y	Y	Mid	56

CT: computed tomography; HN: hydronephrosis; HU: hydroureter; IVU: intravenous urogram; Y: positive; UVJ: uretero-vesical junction

TABLE II: FREQUENCY OF SECONDARY SIGNS OF CALCULUS DISEASE

Secondary signs	Number of patients	
	Calculus present	Calculus absent
Nephromegaly	3	1
Perinephric fat stranding	8	1
Periureteric fat stranding	12	1
Hydronephrosis	9	1
Hydroureter	10	2

IVU Findings

In 7 patients, a calculus was depicted as the cause of urinary obstruction. In one of these patients, the collecting system did not fill with contrast medium even at the termination of the study. In 4 patients, urinary obstruction was depicted on IVU radiographs but a calculus could not be identified. Another 2 patients had a calculus depicted but no evidence of urinary obstruction. The collecting system was normal in the remaining 7 patients.

The time taken to complete the study varied from 39 to 123 minutes, with a mean of 60.5 minutes.

Comparison of Non-contrast Enhanced CT and IVU

There were 14 out of 20 patients with ureteric calculus that was depicted on non-contrast enhanced CT. Of these cases, IVU depicted a calculus in only 9 cases (Fig. 1). There was no patient in whom a ureteric calculus was demonstrated on IVU radiographs but was not seen on CT scan. Using the McNemar's test, the *P* value was 0.025 and this was statistically significant. Of the remaining 6, CT showed perinephric/periureteric fat stranding with unilateral hydronephrosis in one case and unilateral hydroureter in another case. The IVU was normal in these 2 cases.

Eleven patients had urinary obstruction seen on both CT and IVU. Two patients had signs of obstruction only on CT scans while 7 patients had no obstruction on CT or IVU. Using McNemar's test, the *P* value was 0.157 and this was statistically insignificant.

Each patient's preference was also documented at the end of the study. Seventeen patients preferred CT scan, 2 preferred IVU while 1 patient had no preference. The reasons given for having a CT in favour of IVU were a shorter examination (11 respondents), no abdominal compression (6 respondents) and no injection of contrast media (8 respondents). Of the 2 who preferred IVU, 1 was claustrophobic while in the CT gantry while the other patient felt that IVU was a "better" examination.

Discussion

Unenhanced helical CT has been reported to be highly sensitive for the detection of ureterolithiasis in patients with acute flank pain.[1,2] It has also been reported that both CT and IVU are equivalent in the detection of urinary obstruction.[1] Our study confirmed that unenhanced CT is more sensitive than IVU in the detection of ureteric calculus and equally effective in the detection of urinary obstruction.

There are two main reasons why CT is superior to IVU. The cross-sectional imaging ability of CT provides direct demonstration, precise localisation and measurement of a calculus within the lumen of the ureter, eliminating the overlapping bowel shadows present in IVU. The superior soft tissue resolution of CT also ensure that calculi will always have a higher attenuation value (200-600 HU) than surrounding soft tissue regardless of composition.[3-5] CT scan may also help to identify alternative pathology-like ovarian cyst, colitis or mesenteric adenitis as the cause of the acute flank pain.

In addition, there are other advantages to using unenhanced CT in place of IVU. As no intravenous contrast is required, there is no risk of contrast medium reaction or extravasation. It is also more comfortable as no abdominal compression is required. The study can be completed within 5 to 10 minutes compared to IVU, which took a mean of 60.5 minutes in our study. These 3 factors are well highlighted in our patient survey where 17 of the 20 patients preferred CT to IVU, citing either one or more of the above reasons.

The value of secondary signs of ureteral calculus disease on CT is well documented.[6,7] They include nephromegaly, hydronephrosis, hydroureter, perinephric and periureteric fat stranding (Fig. 2). These signs are helpful to the radiologist as it may indicate the recent passage of a calculus by revealing the secondary signs of ureteral obstruction. It is also useful to confirm if an indeterminate but suspicious calcification is a ureterolithiasis. In our series, 85.7% of those with calculus disease had at least 2 of the above signs. In 2 patients, secondary signs were present although no calculus was elicited. We attributed that to recent passage of calculus. The combination of unilateral dilatation and unilateral perinephric fat stranding was found to have the best positive predictive value for stone disease.[6]

The absence of secondary signs, however, cannot exclude recent passage of calculus.[8] We had 1 patient who had a 2-mm calculus lodged in the left uretero-vesical (UV) junction with absence of any secondary signs. This is likely to be due to partial or low grade obstruction.

Potential pitfalls can occur in the interpretation of non-contrast enhanced CT. The ureteric calculi detected in our study ranged in size from 1 to 6 mm. Diminished conspicuity of a calculus may occur due to volume averaging. This can be reduced by using 5-mm thick sections to image the urinary tract. Helical data acquisition also helps to reduce

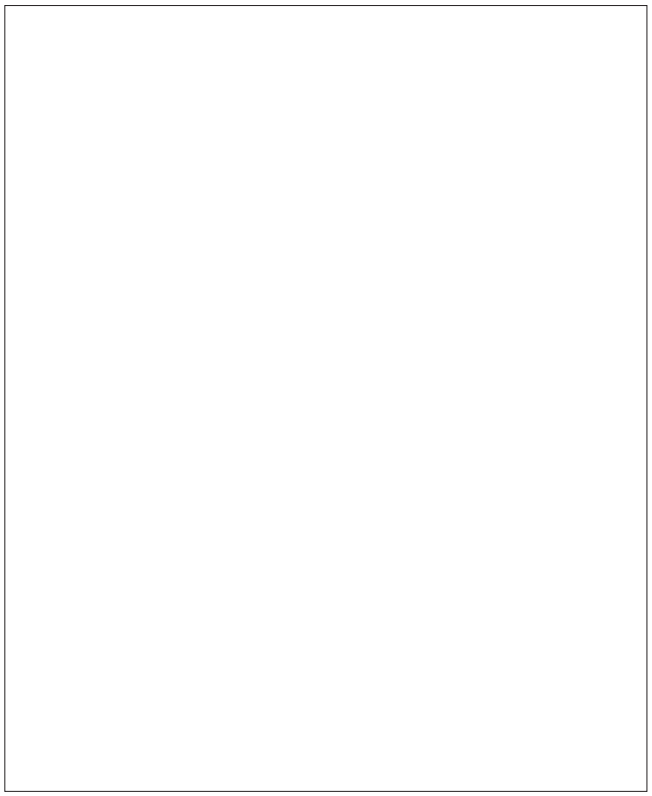

Fig. 1a. IVU showing a mildly dilated right collecting system. No calculus was demonstrated.

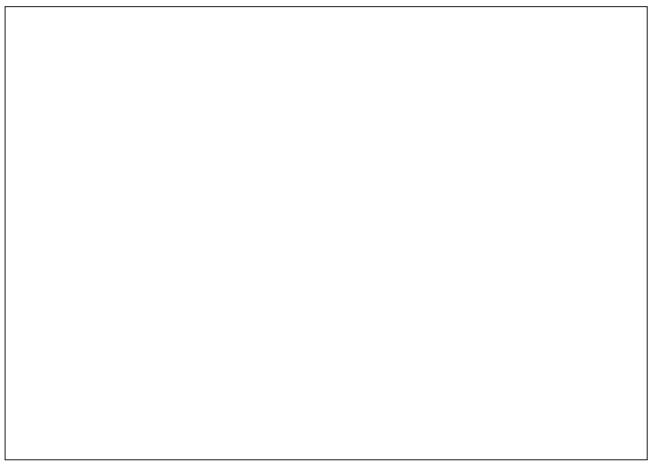

Fig.1b. CT scan showing a calculus in the right mid ureter.

the volume averaging effects as images can be reconstructed at different intervals.

Vascular calcifications along the course of the ureter can occasionally be confused with a calculus within the ureter. In this instance, the course of the ureter has to be trace over serial sections to ascertain if the ureter is dilated to the level of the suspicious area of high attenuation. The presence of a tissue rim sign (thought to represent the oedematous wall of the ureter) is specific for the diagnosis of ureterolithiasis. However, a negative tissue rim sign does not preclude such a diagnosis. Calculus with a tissue

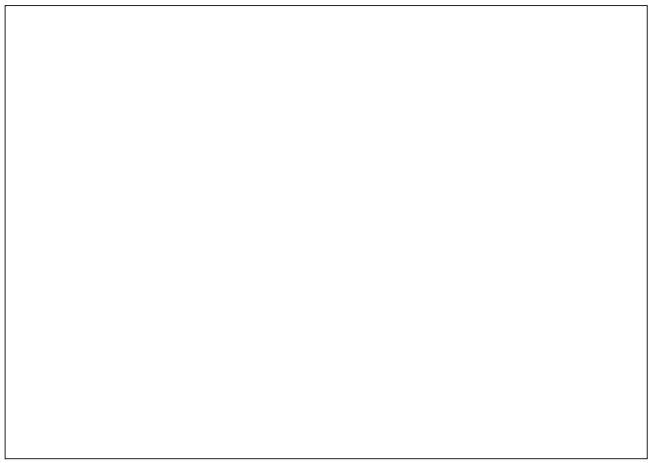

Fig. 2a. CT scan showing a mildly dilated intrarenal collecting system with perinephric fat stranding.

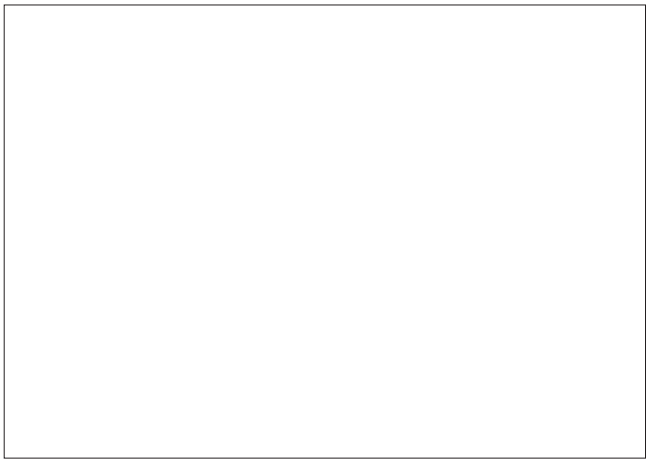

Fig. 2b. CT scan showing a calculus in the proximal left ureter associated with periureteric fat stranding.
Fig.2. Secondary signs of calculus disease.

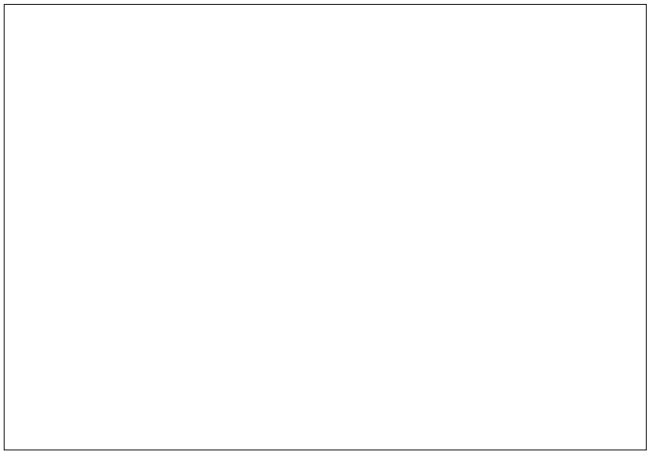

Fig. 3. A pelvic phlebolith related to the non-calcified portion of the pelvic vein giving the "comet sign".

rim sign is reported to be smaller (averaging 1 to 6 mm) compared to those with a negative sign (averaging between 4 to 10 mm).[9,10] A possible reason is that the ureteric wall may be stretched by a large calculus and become too thin

to be identified on CT. This is, however, not a significant clinical problem as smaller calculi are often the ones that are missed or create diagnostic confusion as they may be less conspicuous or less likely to be associated with secondary signs of stone disease. We were not able to verify this finding as the tissue rim sign was noted in all our patients.

Difficulties can also arise with a calculus lodged in the UV junction. This is especially so if the uterus is abutting the posterior wall of the bladder. In this instance, the understanding of the anatomic location of the UV junction (at the posterior lateral aspect of the bladder) and the ability to trace the ureter to the bladder will help to distinguish this from a phlebolith. Other CT findings to differentiate a calculus from a phlebolith have been reported.[11,12] Among phleboliths, the mean attenuation is less than 278 HU and a visible central lucency may be present. A "comet sign" (Fig. 3) (which represent adjacent eccentric, tapering soft-tissue mass corresponding to the non-calcified portion of a pelvic vein) may be seen and there may be a bifid peak at profile analysis.

A potential weakness of this study is the small number of patients that underwent unenhanced CT and IVU. However, we were still able to demonstrate the apparent superior ability of unenhanced CT over IVU to depict a calculus within the ureter in patients with acute renal colic. The effective radiation dose of an IVU varies from 2.5 to 5.0 mSv, while that of a body CT varies from 5.0 to 15.0 mSv.[13] The increase in radiation dose is partly offset by the risks of contrast media reaction in IVU and may also be justified if additional information obtained from CT helps to alter subsequent patient management.[14]

In conclusion, we would recommend an unenhanced CT for patients presenting initially with acute flank pain with suspected ureteric calculus and who would otherwise be referred for an IVU. Our study has shown that CT is more effective in precisely identifying ureteric calculus and equally effective in diagnosing ureteric obstruction.

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