Unenhanced CT Scanning in Acute Flank Pain: Value of Secondary Signs of Ureteral Obstruction

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ABSTRACT:

BACKGROUND:

To determine the value of secondary signs of ureteral obstruction on helical unenhanced CT in diagnosing or excluding ureteral stone disease.

METHODS:

Over a period of 15 months, we prospectively analysed the CT scans of 283 patients with acute flank pain for the presence of ureteral stones & associated signs of ureteral obstruction. 105 patients had no confirmatory imaging studies or surgery & were unable to be contacted for follow up .These were excluded from the study. In the remaining 178 patients confirmatory data were availabe & thus were included in the study. Ureteral stone disease was confirmed to be present in 114 patients & absent in 64 patients. For each patient, we determined the presence or absence of ureteral stone, ureteral or collecting system dilatation, perinephric stranding, &renal parenchymal thickening. We also noted the presence or absence of the (" tissue rim" sign) surrounding ureteral stones & extraurinary calcifications.

RESULTS:

Hydroureter was the sign with the highest sensitivity (92 %) & highest specificity (92%), While hydroureter had the highest specificity (95 %) & highest PPV (97%). The combination of unilateral hydroureter & unilateral perinephric stranding had both the highest PPV (98 %) & NPV (91 %) compared with any individual sign alone . The tissue rim sign was present in (57 %) of urteral stones & in none of the extraurinary calcifications.

CONCLUSION:

In patients having acute flank pain with suspected ureteral stone disease imaged with unenhanced CT , secondary signs including hydroureter , hydronephrosis , perinephric fat stranding , & renal parenchymal thickening are very common & provides supportive evidence that an acute obstructive process is present & that the urinary tract is likely responsible for the patients' complaints even when the ureteral stone itself could not be identified on CT .

KEY WORDS: flank pain, unenhanced ct, ureteral onstruction .

INTRODUCTION:

Abdominal & pelvic pain is often nonspecific Suspected renal colic, most often presenting as flank pain that may radiate to the groin, is an example .Ureteral stone disease is the prime consideration in patients presenting with acute flank pain . However, there are many noncalculus urinary tract causes of flank pain [(1)] . Besides , there are many conditions that arise outside the urinary tract which may cause urinary tract obstruction [(2,3)]. Furthermore, there are many other nonurinary tract conditions that may present with flank pain other than those causing urinary tract obstruction [(2,3)]. Therefore, it is important to have a safe & accurate diagnostic test to determine whether there is obstructive uropathy , & to determine whether the obstruction is due to stone disease . Compared to excretory urography , unenhanced CT avoids the use of , & possible complications , of intravenous contrast material .

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It can be performed without patient preparation , offering a more rapid alternative diagnostic tool in patients with suspected renal colic [(4)] . The urinary tract opposite the side with a suspected calculus serves as an intrinsic control. Recent studies comparing conventional radiography & CT scanning showed that only about half of urinary tract calculi are in fact visible on plain abdominal radiographs & excretory urography . [5,6] .Unenhanced CT , on the other hand , allows direct visualization of virtually all stones within the lumen of the ureter , whatever their composition , size , or locatrion . The only known exception is stones consisting entirely of protease inhibitors such as indinavir [7] . In addition , unenhanced helical CT could be performed with approximately the same or reduced radiation dose compared with standard excretory urography [(5 , 8 , 9 , 10)] . Furthermore , CT scanning may provide an alternative diagnosis in patient who present with acute flank pain who are found not to have urinary tract obstruction on imaging .

The hallmark CT finding of acute ureteral obstruction caused by ureterolithiasis is the direct visualization of a stone within the lumen of the ureter . When the ureter is dilated & can be followed to the level of the stone, the diagnosis is straight forward. However , in some cases the diagnosis on unenhanced CT is less straight forward . An example are patients who have recently passed a stone . Besides , unenhanced CT has some limitations : in some patients with ureterolithiasis a stone may not be readily visible because of volume averaging , small size of the stone , low stone attenuation , or respiratory variation between data acquisition . Another limitation is that difficulty may be encountered in differentiating ureteral calculi from phleboliths along the course of the ureter & other extraurinary calcifications . Furthermore, in patients with little retroperitoneal fat the ureter may not be so easily followed especially when not dilated . Conversely , normal periureteric blood vessels , especially the gonadal veins , can sometimes be confused with a dilated ureter . In addition to direct stone visualization , secondary CT signs of ureteral obstruction have been previously described [11,12,13]. These secondary signs may be the only clue to obstruction when a stone is not readily identified . Likewise , the absence of these secondary signs might be helpful in excluding stone disease when suspicious calcifications are present along the course of the ureters.These secondary signs include : hydronephrosis , hydroureter , perinephric fat stranding , nephromegaly , & the " tissue rim" sign (a circumferential rim or halo of soft tissue attenuation surrounding a calculus on unenhanced axial CT) . This has been reported to be useful in differentiating ureteral calculi from extraurinary calcifications [11]. However, the prevalence of this sign has been reported in only few studies [8, 11].

PATIENTS AND METHODS:

Over a period of 15 months, the CT scans of 283 patients with acute flank pain were prospectively analysed for the presence of ureteral stones & associated signs of ureteral obstruction. In 105 patients , no other imaging investigations were available & follow up was not possible so these were excluded from the study . In the remaining 178 patients confirmatory data were available . These 178 patients formed the basis of this study . This group included 74 men & 104 women with an age range of 16- 68 years. CT scaning was performed using a single helical acquisition , from the top of T12 vertebral body to the base of the urinary bladder , using a collimation of 8 mm ,& a pitch of 1.6 . For each patient, the following information was recorded on both the RT & LT side:

1. Location of ureteral stone (in the proximal ureter , mid ureter , distal ureter , or ureterovesical junction)

2. Stone size (maximum dimention measured in the axial plane)

3. The presence or absence of:

hydronephrosis(defined as dilatation of the collecting system) , hydroureter (defined as dilatation of the ureter distal to the pelviureteric junction) , perinephric fat stranding (was defined as increased density of ,or the presence of linear soft tissue densities within the perinephric fat), & renal cortical thickening (was subjectively assessed by comparing sections at the central portions of the two kidneys) . These findings were assessed subjectively using the contralateral side (without a ureteral stone) as a control in accordance with prior publications [11, 13, 14, 15].

The sensitivity , specificity , positive & negative predictive values , & accuracy were calculated for each of the secondary signs of ureteral obstruction . For purposes of computing these values, we counted each sign as present only when it was unilateral or asymmetric . When bilateral & symmetric , the sign was counted as absent . For patients with stones in the proximal, mid, & distal ureter ; we noted the presence or absence of the (" tissue rim" sign) surrounding each stone . We also noted the presence or absence of this sign surrounding 192 extraurinary calcifications found in 91 patients . A positive tissue rim sign was defined as a 1-2 mm rim of soft tissue attenuation (20-40 HU) surrounding the intraureteral calculus [11]. The presence or absence of the tissue rim sign could be determined only when we saw a clear fat plane around a stone or calcification . Thus, we couldn't estimate the presence or absence of this sign around stones at the ureterovesical junction. We used the Studen't two- tailed *t* test to evaluate the relationship of the presence or absence of the tissue rim sign to stone size.

RESULTS:

Of the 178 patients who were included in the study , ureteral stone disease was determined to be present in 114 patients .Ureteral stones were identified on CT in 108 patients .

In the other 6 patients no stones were identified on CT but one or more of the secondary signs of ureteral obstruction were identified.

These 6 patients were quite sure of having passed stones prior to the CT examination & thus the final diagnosis was considered as ureteral stone disease in them.

In 76 of these 114 patients the presence of ureteral stones was proved by confirmatory or follow up imaging studies (excretory urography in 31 patients , contrast enhanced CT in 23 patients , stone movement seen on follow up plain radiographs in 17 patients & follow up unenhanced CT scans in 5 patients) . Of the remaining 38 patients who did not have confirmatory imaging studies, intervention was successfuly done in 27 patients & a stone was recovered in the remaining 11 patients (after the CT examination in 5 patients in whom the stones were identified on CT & prior to the CT examination in 6 patients in whom no stones were identified on CT but secondary signs of obstruction were present). The CT scans of 64 patients were reported to be negative for ureteral stone disease .Of these 64 patients , alternative diagnoses unrelated to ureterolitiasis were found on CT in 23 patients : 14 patients had conditions unrelated to the urinary tract (appendicitis in 7 patients , proved later surgically ; common bile duct stones in 6 patients , proved by surgery in 4 patients & by enoscopic retrograde pancreato-cholangiography in 2 patients ; & complicated liver hydatid cyst in one patient , proved surgically) . The other 9 patients with alternative diagnoses detected on CT , had conditions related to the urinary tract but unrelated to ureteral stones (pyelonephritis in 7 patients ; hypernephroma in one patient , proved surgically ; & haemorrhagic renal cyst in one patient) . The remaining 41 patients whoes CT scans were negative for ureteral stone disease, no alternative diagnoses were recorded on CT. On clinical follow up in these 41 patients: 24 patients were successfuly treated for urinary tract infection, 7 patients were diagnosed as having pelvic inflammatory disease, & spontaneously subsiding flank pain in the other 10 patients. Non of the 64 patients whose CT scans were interpreted as negative for ureteral stone disease, recoved a stone on clinical follow up nor a stone was discovered on further imaging studies .Table 1 shows the frequencies of the secondary signs of ureteral stones in patients with & without ureterolithiasis & table 2 shows the sensitivity, specificity, PPV, NPV, & accuracy of these signs.

Table 1: Frequency of secondary signs of obstruction in 114 patients with ureterolithiasis & 64 patients without ureterolithiasis .

Secondary sign detected at CT	Patients with ureteral stones (n = 114)	Patients without ureteral stones (n = 64)
Hydroyreter		
Unilateral	105	5
Absent	9	59
Bilateral symmetric	0	0
Hydronephrosis		
Unilateral	93	3
Absent	21	61
Bilateral symmetric	0	0
Perinephric fat stranding		
Unilateral	79	4
Absent	31	55
Bilateral symmetric	1	2
Bilateral asymmetric	3	3
Renal parenchymal thickness		
Asymmetric	62	7
Symmetric	52	57

Table 2: the sensitivity, specificity, PPV, NPV, & accuracy for each of the secondary signs of obstruction.

Secondary Sign	Sensitivity	Specificity	PPV	NPV	Accuracy
Hydroureter	92 %	92 %	95 %	87 %	92 %
Hydronephrosis	82 %	95 %	97 %	74 %	87 %
Perinephric fat stranding	72 %	89 %	92 %	64 %	78 %
Renal parenchymal thickening	54 %	89 %	90 %	52 %	67 %

Unilateral hydroutreter was the most sensitive sign (92 %) . It was found in 105 of 114 patients with proved ureterolithiasis . However, this sign was absent in 9 patients with ureterolithiasis , 4 of whom had no other secondary sign . Unilateral hydroureter had also a high specificity (92 %) , being present on CT in only 5 of the 64 patients without ureteral stones . Each of these 5 patients had an abnormality that could explain their unilateral ureteral dilatation: 3 patients had appendicitis correctly diagnosed on CT that could explain their unilateral hydroureter, & the other 2 patients had pyelonephritis . None of these 2 patients recovered a stone prior to the CT scan. Unilateral hydroureter also had high PPV , NPV , & accuracy (95 % , 87 % , & 92 % respectively) . Unilateral hydronephrosis was of high specificity (95 %) , being absent in 61 of 64 patients without ureterolithiasis . Hydronephrosis was also one of the signs with high PPV (97 %). However, it was a sign of relatively low sensitivity (82 %), being absent in 21 of 114 patients with proved ureterolithiasis .Similarly, perinephric fat stranding had a high specificity (89%), but low sensitivity (72%) perinephric stranding was absent in 31 patients with ureterolithiasis & bilateral symmetrical in one patient. On the other hand, perinephric stranding was unilateral or bilaterally asymmetrical in 7 of the 64 patients without ureterolithiasis . Five of these 7 patients had pyelonephritis & 2 had appendicitis. The combination of unilateral hydroureter & unilateral (or asymmetric bilateral) perinrphric fat sranding was present in 80 of the 114 patients with proved ureterolithiasis . Furthermore, only two patients without ureterolithiasis had both unilateral hydroureter & unilateral perinephric stranding (both these patients were found to have appendicitis correctly diagnosed on CT scanning) . Thus, the combination of unilateral hydroureter & unilateral (or bilateral asymmetric) perinephric stranding was found in 82 patients (80 patients with , & 2 patients without ureteral stones) yeilding a PPVof 98 % (80 of 82 patients). This value was higher than the PPV of any individual secondary sign. Furthermore, unilateral hydroureter & perinephric stranding were both absent in 52 of 64 patients without ureterolithiasis . However, 5 patients with proved ureterolithiasis had neither hydroureter nor perinephric stranding. Thus, the combination of both hydroureter & perinephric stranding was absent in 57 patients (52 patients without, & 5 patients with ureteral stones) yeilding a NPV of 91 % (52 of 57 patients). This was much higher than the NPV of any individual sign alone. Of 114 patients with ureteral stones visible on CT , 32 were in the proximal ureter , 26 within the midureter , 31 within the distal ureter , & 25 within the pelviureteric junction . Of the 89 stones within the proximal , mid , & distal ureter ; 58 were surrounded by a circumferential rim of soft tissue attenuation (tissue rim sign) .We couldint estimate the presence or absence of this sign around the 25 stones at the ureterovesical junction . On the other hand, of the 178 patients included in this study, 192 extraurinary calcifications were present in 91 patients. None of these 192 extraurinary calcifications was surrounded by a rim of soft tissue attenuation (table3).

Table 3: Frequency of the tissue rim sign in 89 ureteral stones & 192 extraurinary calcification .

Type of calcific density	Tissue rim sign (No. & %)		Total
	Positive	Negative	
Calculi			
Proximal	19 (59 %)	13 (41 %)	32
Mid	18 (69 %)	8 (31 %)	26
Distal	21 (68 %)	10 (32 %)	31
Total	58 (65 %)	31 (35 %)	89
Extraurinary calcification	0	192 (100 %)	192

DISCUSSION:

Several secondary signs of obstructive urolithiasis have been proposed as having value to resolve the issue of recent stone passage, as well as the issue of lack of visualization of a stone due to small size, low attenuation , respiratory movement , & volume averaging .

The role of these signs is to help diagnose patients with acute flank pain with incoclusive evidence of ureteral stone. These signs , however are not universally present & may vary in degree of severity from patient to patient [16]

The current study showed that secondary signs of ureteral obstruction were very common in patients with ureteral stones . In almost all of our 114 patients with proved ureterolithiasis , at least one secondary finding was present . only 4 of the 114 patients lacked all the secondary findings . Hydroureter was the most sensitive sign (92 %) . It was found in 108 patients with ureteral stones identified on CT & in 6 patients with no identifiable stones on CT. However the presence of hydroureter in these 6 patients raised the possibility of stone passage prior to the examination. A possibility which was ascertained by the patients . Hydroureter was also found in 5 patients without ureterolithiasis , all of whom had abnormalities which explained the presence of hydroureter . Thus the presence of hydroureter in these patients with flank pain with no identifiable ureteral stones on CT have drown the attention of the interpreter to the possibility of the presence extraurinry conditions causing ureteral obstruction or the possibility of stone passage prior to the examination . Hydronephrosis had relatively low sensitivity (82 %) . Because the ureter & the renal collecting system are continuous , it might be expected that collecting system dilatation would parallel ureteral dilatation . However , collecting system dilatation develops more slowly than ureteral dilatation , & therefore, its frequency is strongly determined by the time delay between the onset of pain & the time of performing the CT examination . Perinephric fat stranding is thought to be due to thickening of the perinephric lymphatics in an attempt to drain excess fluid that accumulates within the renal interstitium as a result of obstruction [17] . Renal lymphatics are present in a subcapsular location & deep within the renal parenchyma . Intrarenal communication exists between the deep & the subcapsular lymphatics , with preferential flow directed via valves from the deep to the subcapsular system .

In addition , lymphatics in the perinephric space freely communicate with the subcapsular lymphatics .

These perinephric lymphatics eventually drain to the paraaortic lymph nodes . Two studies [17,18] postulate that , if obstruction is complete or high grade , there will be diversion of lymph flow to the subcapsular & perinephric lymphatics which will become thickened & hence seen on CT images as linear or curvilinear stranding . If the obstruction is partial or intermittent , on the other hand , there may not be a significant diversion of renal lymphatic drainage to the subcapsular & perinephric lymphatics [18,20] .

The lack of universal presence of perinephric stranding in this study likely reflects those patients with mild or intermittent obstruction in whom lymphatic drainage is predominantly toward the renal hilum . Renal oedema results in enlargement of the obstructed kidney & thickening of it's parenchyma . In a study by Varanelli et al [16] , the sensitivity of renal enlargement was found to reach a peak of 65 % at 5-6 hours from the onset of pain , then this sensitivity dropped over time in some patients . They attributed this drop in renal enlargement to the decrease in renal blood flow & increased lymphatic drainage. Most of our patients with flank pain can only obtain the apportunity to perform a CT scan at our busy depatrments much after this time window. This probably explains the lower sensitivity of this sign in this study compared with other studies [1 , 16] This study suggests that the tissue rim sign on CT is specific for the diagnosis of ureterolithiasis as this sign was present in 57% of patients with ureterolithiasis & in non of those with extraurinary calcifications . On the other hand, the absence of this sign doesn't preclude the diagnosis of ureterolithiasis because it was absent in 43 % of patients with ureterolithiasis .

We also found that large stones lodged in the ureter tend not to produce a positive tissue rim sign probably because large stones strech the ureteral wall which becomes too thin to be detected on axial CT images. Although 7 of 64 patients without ureteral stones had one or more of the secondary signs , the presence of these signs proved helpful in raising the possibility of an extraurinry pathology causing ureteral obstruction , or the possibility of passing stones prior to the CT examination & hence that the urinary tract was likely responsible for the patients' complaints . A limitation of this study is that not all patients had confirmatory imaging studies or surgery. We had to rely on whether a stone was recovered by the patient in 11 of the 114 cases with ureteral stone disease& & in 41 of the 64 cases in which CT scans showed no stones & no alternative diagnosis which might explain the patients' complaints. If we assume that not all patients meticuluosly strained their urine & that small stones could have been overlooked , then this means of confirmation will have underestimated the false negative rate & overestimated the false positive rate . However , recent studies consider the unequivocal stone identification within the ureteral lumen by CT as a sufficient evidence of ureterolithiasis that may be adopted as a gold standard of disease . [16,19,20, 21] .

CONCLUSION:

That associated findings of hydroureter, hydronephrosis, perinephric fat stranding , & renal parenchymal thickening are very common in patients with ureteral stones & might prove helpful in confirming that the urinary tract is likely responsible for the patients' complaints ; a confirmation which is especially useful in cases when no stone could be identified on CT to explain the patients' condition . A positive tissue rim sign is specific for the diagnosis of ureterolithiasis while a negative tissue rim sign doesn't preclude the diagnosis.

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