Urinary Tract Obstruction and Infection

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Urinary Tract Obstruction

In most patients, ureteral obstruction results from an acute process with associated symptoms. Some controversy exists as to which imaging studies are best for investigating suspected ureteral obstruction. In most hospitals in the United States, non-contrast helical computed tomography (CT) is preferred because it is safe and extremely rapid, and the accuracy rate for detecting ureteral stones, the most common cause of ureteral obstruction, exceeds that of other imaging studies. Other causes of acute abdominal pain, such as appendicitis, leaking aortic aneurysm, and diverticulitis, can also be readily diagnosed and occur in 13-19% of cases. Non-contrast helical CT has an overall accuracy of 97% for diagnosing ureteral stone disease [1-8]. This far exceeds the accuracy of intravenous urography (IVU) or ultrasonography (US) (See Table 1). Regardless of composition, virtually all ureteral stones have high attenuation values, making them readily detectable with CT. Nonmineralized matrix stones and some drug-related stones (due, for example, to protease inhibitors) may not be visible on CT images, but are rarely encountered.

The proper technique for performing noncontrast helical CT to detect ureteral stone disease using a helical scanner includes 5 mm collimation scanning from the top of the kidneys to the base of the bladder without intravenous or oral contrast material. Scans should be obtained during a single breath hold or in clusters. A pitch of 1-1.5 is preferable. Using a 16 slice MDCT, collimation of 1.5 mm is appropriate. In order to reduce radiation dose, a variable mA is used for each slice, based on beam attenuation. For the obese patient, a fixed mA equal to his/her weight in pounds will usually suffice. The expected dose is 30-40 mSv. Review of the images in cine mode on a workstation facilitates continuous identification of the ureter and workflow. Three-dimensional (3D) reconstructions are usually not necessary.

In addition to direct visualization of the ureteral stone, secondary signs of ureteral obstruction include unilateral nephromegaly, perinephric stranding, hydronephrosis, and periureteral stranding. The combination of perinephric stranding and unilateral hydronephrosis has a positive predictive value of 96% for the presence of stone disease. The absence of both of these signs has a negative predictive value of 93% for excluding stone disease. CT also gives information that determines therapy. Stones that are 5 mm or less in size, of smooth shape, and located within the distal third of the ureter are likely to pass spontaneously [9].

The major pitfall of noncontrast helical CT evaluation of the urinary tract for stone disease is the difficulty in distinguishing pelvic phleboliths from ureteral calculi. The presence of a tissue ‘rim’ sign usually indicates that the calcification is a stone rather than a phlebolith. Alternatively, the absence of the tissue rim sign, or pres-

Table 1. Diagnostic performance for CT, US, and IVU for detection of ureteral stones

<table>
<thead>
<tr>
<th>Lead author</th>
<th>Year of publication</th>
<th>N</th>
<th>Stone +</th>
<th>Test</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalano</td>
<td>2002</td>
<td>181</td>
<td>82</td>
<td>CT</td>
<td>.92</td>
<td>.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>US/plain radiography</td>
<td>.77</td>
<td>.96</td>
</tr>
<tr>
<td>Boulay</td>
<td>1999</td>
<td>51</td>
<td>49</td>
<td>CT</td>
<td>1.0</td>
<td>96</td>
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<tr>
<td>Sheley</td>
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<td>180</td>
<td>87</td>
<td>CT</td>
<td>.86</td>
<td>91</td>
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<td>Sourtzis</td>
<td>1999</td>
<td>36</td>
<td>36</td>
<td>CT</td>
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<td>1.0</td>
</tr>
<tr>
<td>Yilmaz</td>
<td>1998</td>
<td>97</td>
<td>64</td>
<td>IVU</td>
<td>.66</td>
<td>97</td>
</tr>
<tr>
<td>Smith</td>
<td>1996</td>
<td>210</td>
<td>100</td>
<td>CT</td>
<td>.97</td>
<td>96</td>
</tr>
</tbody>
</table>

N, Number of subjects; Stone +, Number of subjects with ureteral stone
ence of a ‘comet tail’ sign strongly suggests that the calcification is a phlebolith rather than a stone. In practice, the presence of two or more secondary signs of obstruction, even without clear visualization of a calcification within the ureter, indicates obstruction. If there is no history of recent stone passage, a cistoscopcy and contrast-enhanced study of the upper tracts may be needed to exclude neoplasm.

Intravenous urography is an alternative technique for the detection of urinary tract obstruction [10]. It is safe, relatively inexpensive, and allows evaluation of the entire urinary tract with some functional information. Abnormalities may be subtle during the earliest phases of obstruction. Dilatation of the urinary tract may be minimal or even absent. Delayed opacification of the collecting system, asymmetric persistent nephrograms, and columnization of the ureteral contrast material down to the level of obstruction, indicate ongoing obstruction. Delayed films may be necessary to delineate the level of obstruction using IVU. The accuracy of IVU in diagnosing ureteral obstruction is unknown, but small studies suggest that it is significantly lower than the accuracy derived by noncontrast helical CT studies. Extraradicular causes of acute abdominal pain are not usually detectable with intravenous urography.

US, usually combined with a plain film, is an alternative method for evaluating the obstructed or dilated urinary tract. Although US allows for excellent evaluation of the renal parenchyma and the collecting system to the ureteropelvic junction, it is limited in the evaluation of the ureter and of soft-tissue lesions within the collecting system. The use of renal US in the evaluation of suspected acute ureteral obstruction is limited because dilatation often does not develop for hours, or even days. In these cases, US findings are normal in up to 50% of patients. The use of US Doppler-derived resistive indices may be helpful in detecting acute obstruction before dilatation develops. The usefulness of this finding is controversial [11-14]. Identification of jets at the ureterovesical junction indicates obstruction is incomplete and may be used to guide therapy [15].

In diuresis renography, radionuclides are injected to evaluate the urinary tract for obstruction. Considerably less anatomic detail is available with this test than with other radiographic examinations, so it is less useful in the acute setting than for follow-up or evaluation of chronic urinary tract obstruction. Diuresis renography does have the advantage of yielding objective data regarding the significance of hydronephrosis and also allows for evaluation of the function of each kidney. Administration of a diuretic, usually furosemide, augments the standard renogram and is useful in evaluating dilated urinary systems.

Magnetic resonance urography (MRU), using rapid scanning techniques such as HASTE or single-shot fast spin echo sequences, is beginning to be used for evaluation of the urinary tract [16, 17]. The kidneys and dilated ureters are very bright on T2-weighted images and their stable position allows for clear imaging of the level of obstruction. Unfortunately, stones appear as signal voids and can be difficult to identify and measure.

Most stones are radiodense, meaning that confirmation of stone location during conservative therapy is best performed using plain films [18]. US is useful in identifying persistent hydronephrosis or cortical atrophy.

In dealing with the pregnant patient with flank pain, fetal age and estimated radiation dose is of paramount importance. Right hydronephrosis is commonly encountered as the enlarging uterus turns slightly to the right, compressing the ureter. When an obstructing stone is suspected in either the right or left system, ultrasound should first be performed. Some urologists will place a stent based on clinical findings and severe hydronephrosis. If more imaging information is needed, a limited IVU using a plain scout film followed by a 10 minute post infusion delayed film yields the least radiation in the first trimester patient. After 20-24 weeks, IVU becomes difficult to interpret because of the enlarging uterus, and CT should be considered [19]. The expected fetal dose is approximately 16 mSv, well below that expected to cause anomalies.

### Urinary Tract Infection

#### Acute Pyelonephritis

Acute pyelonephritis is usually an ascending infection spread from the bladder, and is seen predominately in females. Rarely, the source of infection is hematogenous bacteremia. Diagnosis is usually made on clinical grounds and with urine analysis. Imaging may be needed to detect complications or sequelae of pyelonephritis. When clinical pyelonephritis persists for greater than three days after antibiotic therapy has been initiated, then imaging is recommended. CT is the imaging technique of choice to evaluate the kidneys for possible complications of pyelonephritis, such as abscess or obstruction. CT is the most sensitive and specific test for detecting the changes of acute pyelonephritis and its complications. Typical CT findings of pyelonephritis include unilateral nephromegaly, renal striations, wedge-shaped defects, and perinephric inflammatory changes [20]. Areas of liquefaction within the renal parenchyma indicate the development of a renal abscess. CT is more sensitive for the detection of renal abscess than other techniques, such as IVU or US.

In males with a urinary tract infection (UTI) and/or suspected pyelonephritis, US is valuable to identify common causes of UTI such as epididymitis, orchitis and prostatitis. Patients with a neurogenic bladder secondary to a spinal cord injury pose a difficult problem as the urine is usually colonized. Development of systemic symptoms should prompt rapid imaging as these patients may not be sensate to pain and a devastating abscess can develop quickly [21]. Finally, in order to diminish radiation dose to pregnant patients, US with power Doppler may be at-