



Radiology Rounds

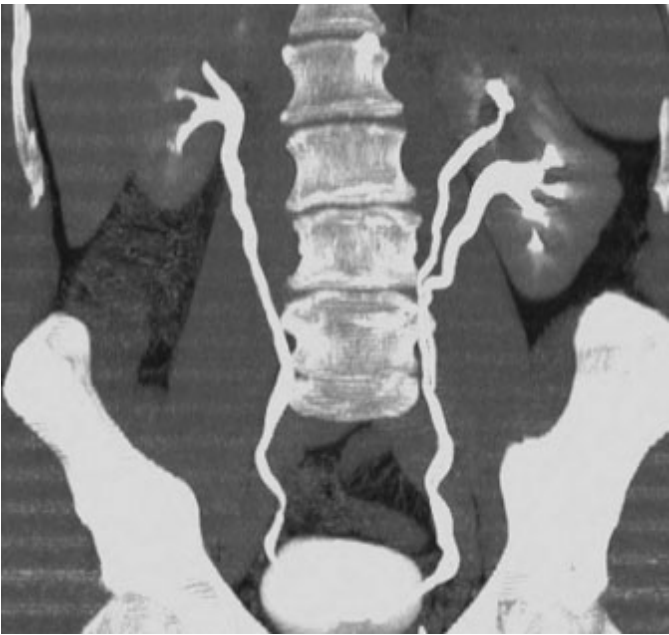
A Newsletter for Referring Physicians
Massachusetts General Hospital
Department of Radiology



Urinary Tract Imaging

The advantages of multidetector CT urography over conventional plain film excretory urography (also known as IV pyelography and IV urography) and ultrasound for the evaluation of the urinary tract are numerous. Dedicated CT protocols have been developed for these new high speed machines for different clinical indications including "stone protocol" for the evaluation of urinary tract calculi, CT urography for the evaluation of patients with hematuria and "renal mass protocol" for the characterization of known renal masses. Multidetector CT scanning is fast, taking around 15 seconds for image acquisition from the kidneys to the bladder during a single breath-hold. The images have good spatial resolution, little mis-registration due to respiratory movement, and the acquisition of multiple thin slices allows excellent two- and three-dimensional reconstructions of the abdominal anatomy, making it possible to detect pathologies outside the urinary tract as well those within. Iodinated contrast agents are not usually required for the detection of renal stones, thus avoiding the risk of adverse reactions to these agents, but are routinely used in CT urography and the renal mass protocol.

In comparison to CT, plain film excretory urography offers excellent delineation of calyceal and papillary anatomy, the ureters and bladder, but it is inferior to multi detector CT for imaging of the kidney parenchyma. Both CT and plain film excretory urography are associated with a substantial radiation dose. Ultrasound is good for imaging the kidney parenchyma and for detecting hydronephrosis, does not require the administration of iodinated contrast, and avoids radiation exposure. However, ultrasound is



Three dimensional coronal reconstruction of CT urography image, showing contrast-enhanced renal collecting system, ureters, and bladder. Note duplicated system on left side.

not good for detecting urinary tract calculi, and does not adequately image the renal collecting system or ureters. For these reasons, multidetector CT imaging has become the gold standard for the diagnosis of urinary tract calculi, the investigation of hematuria, and the characterization of renal masses and has largely replaced both plain film excretory urography and ultrasound examinations for these purposes.

Urinary Tract Imaging Protocols	
<p>Stone Protocol For detection of renal, ureteral, or bladder stones</p>	<p>Non-contrast CT imaging from kidney to bladder. (May be necessary infrequently to use iodinated contrast agent to distinguish between ureteral stones and phleboliths)</p> <p>Follow-up imaging with non-contrast plain film radiography</p>
<p>CT Urography (Hematuria Protocol) For evaluation for common causes of persistent hematuria, i.e. stones, urothelial tumors, renal tumors</p>	<p>Non-contrast followed by contrast CT imaging from kidney to bladder</p>
<p>Renal Mass Protocol For characterization of renal masses detected by other imaging studies, e.g. ultrasound, MRI</p>	<p>Non-contrast followed by contrast CT imaging of kidneys only</p>



Axial image from "stone protocol" CT showing left ureteral stone.

Urolithiasis and Nephrolithiasis

Almost all ureteral and renal stones, including those containing uric acid, can be detected by non-contrast CT imaging. The accuracy of the technique in diagnosing urolithiasis in patients presenting with acute flank pain has been determined to be as high as 97%, with a sensitivity of 95% and specificity of 98%. This compares to sensitivities in the range of 45-58% for non-contrast plain film radiography and 64-87% for plain film excretory urography.

However, it is occasionally difficult to distinguish between non-obstructing distal ureteral calculi and pelvic phleboliths on non-contrast CT images. In these cases, it may be necessary to use intravenous contrast agent, so that the relationship of the calculus to the opacified ureter can be determined. Another situation in which intravenous contrast can be helpful is in the detection of stones in HIV positive patients on protease inhibitors such as Indinavir. These calculi are typically non-radio opaque and may go undetected on stone protocol CT scans. The use of 3-D reconstruction techniques of contrast-enhanced pyelographic phase images can be helpful in all of these situations.

The disadvantage of "stone protocol" CT is that the radiation dose is high (about 500 mrem) compared to than that needed for plain film excretory urography (about 150-350 mrem) and non-contrast plain film radiography (about 13 mrem). This exposure is a significant concern, especially as urinary stones frequently affect young people. For this reason, it is better to avoid CT for follow up studies wherever possible and to use non-contrast plain film radiography instead. The initial CT scan and reconstruction images can be used to aid subsequent detection of stones on follow-up plain film radiographic images since the detection rate of stones increases from 45% identified on non-contrast radiographic films alone to 78% on films viewed together with 3-D reconstructions of the initial diagnostic CT images.

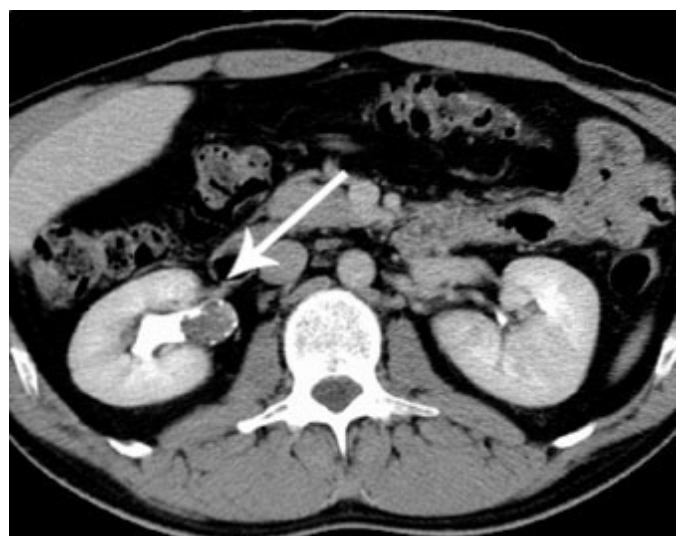
Pregnant patients should be evaluated initially with ultrasound imaging, to avoid exposure to any unnecessary radiation, and MR urography is an alternative imaging technique for evaluating the renal system in pregnant women, children, and patients with contraindications to contrast agents.

Hematuria

The main causes of hematuria are urinary tract calculi, renal tumors, urothelial tumors, and infection. CT urography is the best single diagnostic examination for diagnosing all of these pathologies, with the exception of infection, which is effectively diagnosed in most cases by microbiological analysis of the urine.

CT urography requires the use of contrast agent to opacify the collecting system, the ureters, and the bladder. In addition to optimal opacification, distension appears to be an important requirement for thorough evaluation of the renal collecting system and ureter. For this reason, intravenous saline is given at the same time as the contrast material to aid in the detection of subtle filling defects and the discrimination between urothelial neoplasms and other filling defects. Image reconstruction techniques are used to create images of the entire length of the urinary system from the kidneys to the bladder. Multi planar 3-D reconstruction can provide the anatomic detail required to correlate the finding with retrograde ureterography or to perform an endoscopic evaluation. CT has been shown to detect parenchymal masses in the kidney with a sensitivity of 94%, compared to 67% for plain film excretory urography and 79% for ultrasound.

Another potential advantage of CT is that reconstructed images can show tumors in a filled bladder opacified with contrast agent ("virtual cystoscopy"). However, conventional cystoscopy remains the gold standard for the detection of tumors of the bladder, as it will detect early color-changing mucosal lesions that do not deform the contour of the bladder wall. In addition, cystoscopy has the added capability of biopsy of suspicious lesions.



Axial CT urography image showing a filling defect in the right renal pelvis consistent with a large urothelial tumor.

Renal masses

Many renal lesions are incidentally detected on a variety of imaging tests, but cannot usually be characterized at the time of detection. Currently, at this institution "renal-mass protocol" CT is the gold standard for the characterization of renal masses. This protocol acquires thin section images of the kidneys before and after intravenous contrast administration to evaluate the important characteristic of solid lesions, the unequivocal demonstration of lesion enhancement post contrast. Lesions that demonstrate unequivocal enhancement require histologic diagnosis either by image-guided biopsy or by surgical resection.

Scheduling

CT imaging of the urinary system has essentially replaced conventional plain film excretory urography at MGH. CT scanning for stones, hematuria, or for evaluating renal masses are performed at Mass General West Imaging in Waltham, Mass General Imaging in Chelsea, or the main MGH campus. The appropriate CT protocol will be selected by the radiologist based on the clinical history of the patient. CT imaging studies can be ordered by calling 4-XRAY (617-724-9729). Results are made available to physicians online within 24-48 hours.

Further Information

For further questions on CT urography, contact [Dr. Michael Maher](#), MGH Department of Radiology, 617-726-8396.

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[Janet Cochrane Miller, D. Phil., Author](#)
[Susanna I. Lee, M.D., Ph.D., Editor](#)