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CT urography

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Abstract With the advent of multidetector row CT scanners, evaluation of the urothelium of the entire urinary tract with high-resolution thin sections during a single breath-hold has become a reality. Multidetector CT urography (MDCTU) is a single examination that allows evaluation of potential urinary tract calculi, renal parenchymal masses, and both benign and malignant urothelial lesions. Initial results with this new technique are encouraging. Current investigations of MDCTU focus on methods to improve opacification and distension of the upper urinary tract-the collecting systems, pelvis, and ureters. The role of abdominal compression, infusion of saline and/or furosemide, and optimal time delay of excretory phase imaging is being explored. Upper tract urothelial malignancies, including small lesions less the 5 mm in diameter, can be detected with high sensitivity. Methods to reduce radiation exposure are being explored, including split-bolus contrast injection techniques that combine nephrographic and excretory phases into a single phase. It is likely that in the near future, radiological evaluation of significant unexplained hematuria or of known or prior urothelial malignancy will consist of a single examination – MDCTU.

Keywords Urography · Multi-detector CT · MDCT urography

Introduction

CT urography is a term that refers to the use of CT in the complete evaluation of the urinary tract. It is well known that CT is more accurate than excretory urography (EU) in the detection of renal and ureteral calculi [1]. It is also more accurate in the detection and characterization of renal masses [2–4] and is also the preferred imaging method for assessing renal trauma and infection. Only the concern about small urothelial lesions, especially transitional cell carcinoma (TCC), has prevented CT from completely replacing EU for the imaging evaluation of the urinary tract in the assessment of significant or persistent hematuria or in follow-up assessment of known TCC.

CT urography initially referred to a combined (hybrid) examination using CT evaluation of the renal parenchyma, supplemented by a different method to evaluate the collecting systems and ureters, either digital CT radiograph or a full or partial set of EU radiographs. With the introduction of multidetector CT (MDCT), the term CT urography now usually refers to the entire examination performed on a single CT examination (MDCTU). Single detector CTU was limited in its ability to detect small urothelial lesions and to complete the examination in a single breath-hold, but the improved resolution and speed of MDCT technology has resulted in remarkable axial and 3-D reconstructions that now challenge or even surpass the quality of EU images of the urothelium [5, 6].

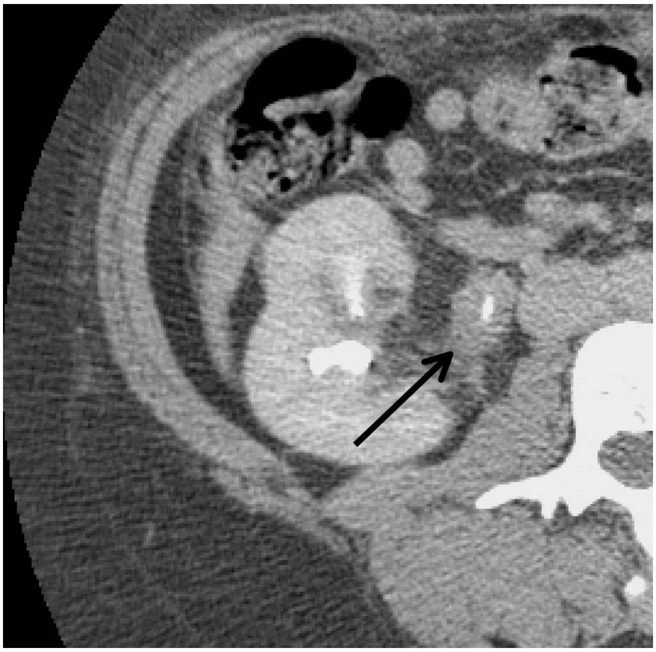

Fig. 1 TCC of proximal right ureter. Thin section (1.25 mm) axial-enhanced CT shows circumferential wall thickening of the proximal right ureter (*arrow*)

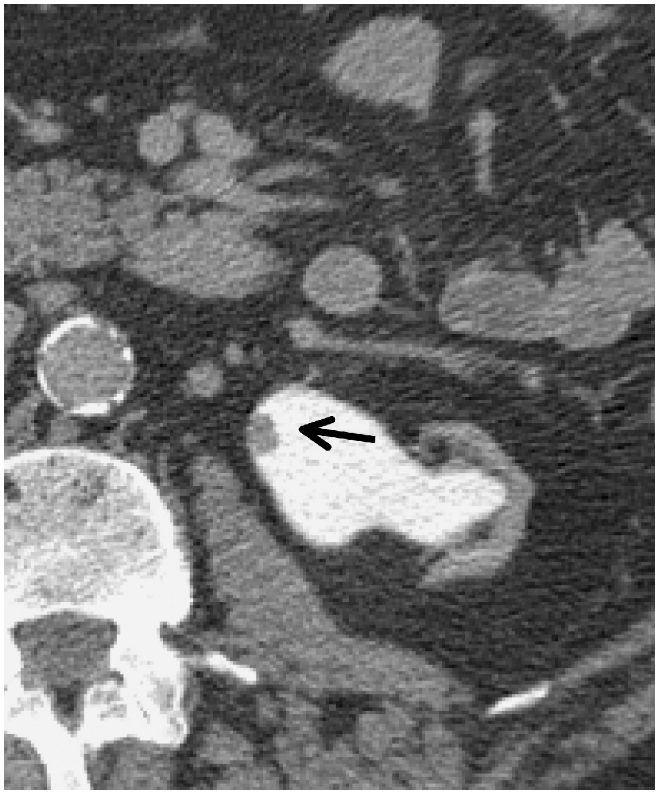

Fig. 2 TCC of left renal pelvis. Thin section (1.25 mm) axial-enhanced CT shows a 3-mm filling defect in the left renal pelvis

Techniques and protocols

A variety of techniques and protocols for MDCTU are currently in use, and there is no single method that has gained widespread acceptance. Most protocols have used a three phase examination. Unenhanced CT from the kidneys through the bladder is used to detect urinary tract calculi and as a baseline for characterization of renal parenchymal masses. Nephrographic phase-enhanced CT through the kidneys, obtained about 100 s after IV contrast injection, is used to detect and characterize renal parenchymal masses. Excretory phase CT, obtained anywhere from 3–10 min after injection, is used to detect urothelial lesions on the thinnest axial sections available (1.25 mm on the 16-detector row scanner) and to be the source data for 3-D reconstructions, usually displayed as coronal or coronal oblique images. A variety of 3-D rendered techniques have been employed.

Using the principles long accepted for EU, many investigators are evaluating methods to optimize both distension and opacification of the urinary tract lumen during MDCTU. Among those methods are abdominal compression, IV saline infusion, prone vs. supine patient positions, and delay in image acquisition [7–10]. It is difficult to compare the results of these studies, because the methodology is so different for each study. A result common to all studies has been a disconcerting number of distal ureteral segments that remained unopacified using any technique. Based on the results from our own department, we have discarded the use of abdominal compression, and now use IV saline infusion and delayed excretory phase imaging of 600 s. Recent abstracts suggest that IV furosemide may be superior to saline for improving opacification and distension of the urinary tract [11].

Several investigators have modified the standard three-phase protocol discussed above. Using a method described by Chow et al. [6], a split bolus of IV contrast is used which results in simultaneous nephrographic and excretory phase images of the urinary tract (Figs. 1, 2).

Results

We have examined more than 1,500 patients with MDCTU, and the results are encouraging. The results in our first 65 patients showed that a wide variety of urinary tract abnormalities were detected, including benign abnormalities of the urothelium, such as renal tubular ectasia, papillary necrosis, and congenital abnormalities [5]. It has been our subjective impression that the depiction of renal tubular ectasia in the pyramids is sufficient in our 16-row MDCT scanners to rival the quality of its appearance on EU images. A recent abstract [12] described significant upscale improvement in calyceal detail with increasing detector rows from single- to 16-row MDCT scanners. With the 16-row MDCT scanners, the characteristic discrete linear structures of tubular ectasia have been clearly depicted on both the thin axial images and the 3-D coronal reconstructions, but they are best visualized using wide (bone) window settings rather than standard soft tissue windows.

MDCTU can readily detect urothelial malignancies of the bladder and the upper urinary tract. The sensitivity of MDCTU for malignancies of the upper tract is of particular interest, because cystoscopy is universally obtained in patients with unexplained gross or significant microscopic hematuria, and in those with current or prior urothelial neoplasms. Ureteroscopy or retrograde pyelography, however, is typically reserved for only a small subset of these patients.

Of the initial 370 patients referred for MDCTU in our department between April 2000 and April 2002, there were 18 with 27 histologically proven upper tract (intrarenal collecting system or ureteral) urothelial malignancies. Twenty-four of these 27 neoplasms were detected on MDCTU, 18 prospectively, and the other 6 retrospectively [13]. There were three distinct CT appearances: (1) circumferential urothelial wall thickening (n=14), (2) small masses (≤5 mm in maximal diameter (n=5)), and (3) large masses (>5 mm in diameter (n=5)). Twenty of the 24 neoplasms could be seen on the axial images when standard soft-tissue windowing was used, but four small masses were visible only when viewed with wide windows. Only six of the 24 lesions could be detected on the 3-D reconstructed images using the rendering methods employed at that time.

We previously created MIP- and AIP-rendered 3-D reconstructions by selecting a large slice thickness (usually exceeding 50 mm) that included the kidneys and the ureters. More recently, we have added small slice-thickness (1.25 mm) AIP coronal reconstructions and found sensitivity for urothelial malignancies to be similar to that with axial views, despite fewer images and shorter review time (Feng et al., Society of Uroradiology, 2005). It is possible that review of thin-section coronal reformatted images may be able to replace the more cumbersome and time-consuming axial source images in MDCTU.

Radiation dose

Concern has been raised in recent years about the radiation dose from CT examinations in general, and specifically multidetector CT scans. The concern is even greater for examinations like MDCTU, where three separate acquisitions are often obtained. A recent publication comparing a three-phase acquisition MDCTU to EU with multiple nephrotomograms reported the effective dose of CTU was about 1.5 times that of EU [14]. If the split-bolus technique of contrast injection discussed above is used, significant dose reduction can be achieved. Tailoring the protocol to specific indications can also be used to eliminate one of the phases in some patients. Technical innovations, such as automatic tube current modulation, are also being introduced and evaluated, which allows constant CT image quality with lower radiation exposure [15].

References

1. Dalrymple NC, Verga M, Anderson KR, et al. (1998) The value of unenhanced helical computerized tomography in the management of acute flank pain. J Urol 159:735–740
2. Jamis-Dow CA, Choyke PL, Jennings SB, et al. (1996) Small (< 3-cm) renal masses: detection with CT versus US and pathologic correlation. Radiology 198:785–788
3. Bosniak MA (1991) The small (less than or equal to 3.0 cm)renal parenchymal tumor: detection, diagnosis, and controversies Radiology 179:307–317
4. Bosniak MA (1986) The current radiologic approach to renal cysts. Radiology 158:1–10
5. Caoili EM, Cohan RH, Korobkin M, Platt JF, Francis IR, Faerber GJ, Montie JE, Ellis JH (2002) Urinary tract abnormalities: initial experience with multi-detector row CT urography. Radiology 222:353–360
6. Chow LC, Sommer FG (2001) Multidector CT urography with abdominal compression and three-dimensional reconstruction. AJR 177:849–855
7. McNicholas MM, Raptopoulos VD, Schwartz RK, et al. (1998) Excretory phase CT urography for opacification of the urinary collecting system. AJR 170:1261–1267
8. Heneghan JP, Kim DH, Leder RA, DeLong D, Nelson RC (2001) Compression CT urography: a comparison with IVU in the opacification of the collecting system and ureters. J Comput Assist Tomogr 25:343–347
9. McTavish JD, Jinzaki M, Zou KH, Nawfel RD, Silverman SG (2002) Multi-detector row CT urography: comparison of strategies for depicting the normal urinary collecting system. Radiology 225:783–790
10. Caoili EM, Cohan RH, Korobkin M, Platt JF, Francis IR, Gebremariam A, Ellis JH (2001) Effectiveness of abdominal compression during helical renal CT. Acad Radiol 8:1100–1106
11. Kemper J, Nolte-Ernsting C, Regier M, Begemann P, Stork A, Adam G (2004) Multislice-CT urography: experimental comparison of different preparation strategies for improved depiction of the urinary tract (Abstr). Radiology 233(P):386–387
12. Raptopoulos V, McNamara A, Siewert B, Preis O, Sheiman R, Kruskal J (2004) Refinement of CT urography with 16-row multidetector CT and split-bolus single scanning (Abstr.) Radiology 233(P):387
13. Caoili EM, Inampudi P, Cohan RC, Ellis JH (2005) Multidetector CT urography of upper tract urothelial neoplasms. AJR (In Press)
14. Nawfel RD, Judy PF, Schleipman RA, Silverman SG (2004) Patient radiation dose at CT urography and conventional urography. Radiology 232:126–132
15. Kalra MK, Maher MM, Toth TL, Schmidt B, Westerman BL, Morgan HT, Saini S (2004) Techniques and applications of automatic tube current modulation for CT. Radiology 233:649–657