CT urography: how, when, why?

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Abstract

Computed tomography urography (CTU) represents in our days the modality of choice to evaluate the urinary tract lesions, replacing the intravenous (IV) urography. The aim of this paper is to make a synthetic overview concerning the CTU techniques and its principalsindications in renourinary pathologies. We will discuss also some CTU protocols optimization in the purpose to obtain a good visualization of the middle and distal part of the ureters and to reduce the radiation dose.

Key words: Computed tomography urography (CTU), techniques, indications

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Introduction

In the years, computed tomography urography (CTU) has become the modality of choice to evaluate the urinary tract lesions, replacing theintravenous (IV) urography (1-5).The European Society of Urogenital Radiology consider CT urography as a diagnostic examination tool for the kidneys, ureters, and bladder pathologies with thin-slice CT, iv administration of nonionic iodinated contrast medium, and image acquisition in the excretory phase (2). After contrast IV injection, the number of CTU phases generally varied between oneand four (3-10). Most uroradiology departments perform CT urography in three acquisitions phases that allow complete evaluation for the most common urologic causes of hematuria, such as calculi, renal masses, and urothelial tumors: unenhanced, nephrographic, and pyelographic phases (5,6,9,10). Others indications for CTU are represented by inflammatory conditions and congenital anomalies of the kidneys and ureters (2,9).Arterial phase imaging also has been incorporated into CT urography for patients who may require surgery (2). Contraindications of CTU are generally limited to those patients who cannot receive iodinated contrast because of renal insufficiency, severe allergic reaction, or pregnancy (2,5,9).

CTU techniques.

The CTU study does not require any special preparation. Supine positioning of the patient is the standard practice for CTU (9).Noncontrast CT acquisition extend from the top of the kidneys through the bladder (9). Unenhanced CT scan is primarily used for the evaluation of stone disease, renal parenchymal calcifications, precontrast attenuation measurements of renal masses, and exclusion of hemorrhagic changes (2). These precontrast images are followed by contrast material enhanced imaging, essential to evaluate the renal parenchyma and the urinary tracts (4). After the intravenous contrast injection (1,5 ml/kg nonionic iodinated contrast), the CT acquisition start at 90- to 100-sec delay, scanning the abdomen and pelvis in the nephrographic phase. The nephrographic phase optimizes the detection of small renal mass (4). The final CT acquisition is during the excretory phase after a 10 to 15-min delay, when there is opacification and distention of the collecting systems, ureters, and urinary bladder (1,2).Optimal opacification and distention of the ureters during the excretory phase may be problematic (6,7). Suboptimal distention of the ureters and the peristaltic waves may result in limited visualization of one or more segments. The intravenous administration of furosemide significantly improved middle and distal ureteral opacification compared with the intravenous administration of saline.A variety of techniques have been proposed to improve visualization, including oral water intake, diuretic administration, use of a compression belt or prone positioning prior to the excretory acquisition (8-10, 12-16).However, many CTU methods use relatively high radiation doses that have been measured to be approximately 1.5 times the dose of standard intravenous urography (11,12). To reduce the radiation dose, a split-bolus multidetectorCTU technique has been introduced, in which two separate contrast material bolus injections resultin a combined nephro-pyelographic acquisition (8,9,17). Another split-bolus multidetector CTU approach combining arterial and nephroexcretory phases or a triple-bolus protocol (30 ml, 50 ml -after 435 sec, 65 ml-after 55 sec) designed to show all renal contrast-enhancement phases in a single acquisition (11).

Our CTU protocol is a split bolus urinary tract evaluation, consisting in an unenhanced low dose scan of the kidneys and the urinary bladder after IV furosemide administration, 10 mg for patients with a body weight less than 100 kg and before an oral questioning to eliminate anuric or declared hypersensitive patients to furosemide. Those conditions are contraindications to administering the drug. A first IV bolus injection of 90 mL (2/3) of contrast medium (300-350mgI/ml) was given at a flow rate of 2.5mL/s with the start of the acquisition at 15 seconds delay after the bolus pick detection into the abdominal aorta, to evaluate the kidneys in the corticomedullary phase and the renal pedicles (Fig. 1), followed after a pause of 360 seconds by a second bolus of 60 mL (1/3) at the same rate, with the start of thissecond CT acquisition after 90-120 seconds to obtain in the same time the nephrographic and the excretory phase (Fig. 2).

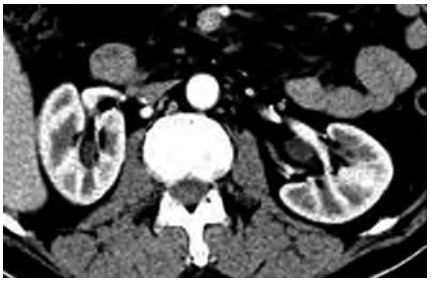


Fig. 1 Corticomedullary phase with a good evaluation of the renal pedicles.

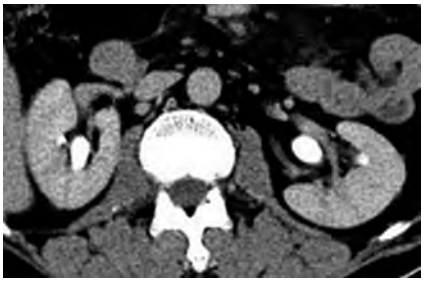


Fig. 2 Nephroexcretory phase.

Imaging reformations are done in coronal plane in MIP (Fig. 3) and tridimensional 3D VRT projections (Fig. 4).



Fig. 3 MIP (Maximum intensity projection) reconstruction in coronal plan:note the double left ureters and renal pelvis.



Fig. 4 3D VRT reconstruction

Ventral decubitus was used to better visualize the ureters and to differentiate between a small focal parietal pelvic or urinary bladdertumoral lesions and clots (Fig. 5).

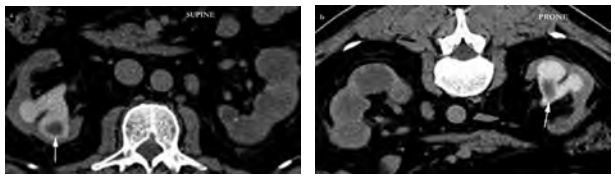


Fig. 5 Importance in some cases to do after the CT acquisitions in supine position (a) the CT acquisitions in prone position (b) to confirm the mobility or the fixated character of a filling defect (right arrow).

Images analysis.

For interpretation, all axial and reformatted images were evaluated. The use of Furosemide allows an optimal opacification of the middle and distal ureters and also reduces the parenchymal streak artifacts in the pelvicalyceal regions. Interpretation must be done systematically: describe if there are anatomical variants of the upper urinary tract (see Fig. 3 and Fig. 4); measure the kidneys and the thickness of the renal parenchyma (Fig. 6).



Fig. 6 Small left kidney with chronic inflammatory changes (arrow).

Describes the location, aspects and numbers of the renourinary stones (Fig. 7).

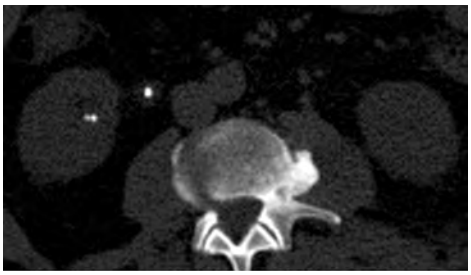


Fig. 7 Right reno-ureteral lithiasis: unenhanced low CT dose- multiple stones located into the inferior caliceal group and in the superior part of the right ureter.

Describes and measure the lacunar images suggestive of urothelial tumors (Fig. 8); describe the focal wall thickness involving the upper urinary tract or the urinary bladder and the extension into the peripelvic, periureteral fat or into the renal parenchyma using a large window.

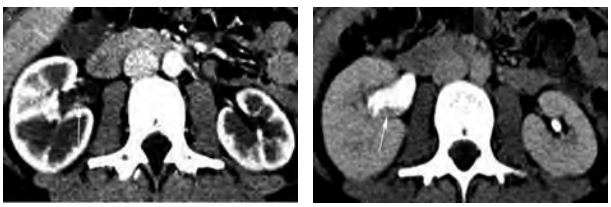


Fig. 8 Right urothelial tumor of the renal pelvis: corticomedullary phase (a) and nephroexcretory phase (b): focal thickness of the dorsal renal pelvis wall (white arrow).

Radiation dose

Dual split-bolus or triple split protocol was associated with approximately 15 to 45% reduction in radiation exposure considerably lower than that with the commonly used three-phase protocol after contrast injection (9-11).

Indications

Present-day indications for CTU include the investigation of hematuria, patients at increased risk for having

upper or lower tract urothelial neoplasms, hydronephrosis, chronic symptomatic urolithiasis, traumatic and iatrogenic ureteral injury, complex urinary tract infections (18-20). For benign indications such as variant urinary tract anatomy, ureteral pseudodiverticulosis and iatrogenic ureter trauma, single-phase CTU is sufficient, the excretory phase isrelevant. For patients with more complex benign diseases and those with chronic symptomatic urolithiasis, complex infections it is necessary to add an unenhanced phase to the excretory phase. In chronic urolithiasis without complete obstruction, furosemide-assisted CTU can demonstrate most ureteral stones within the enhanced urine (2,4,21,22).

In summary

Different approaches with different CTU techniques („1-2-3-4") are used in different patient populations for urinary tract assessment.Diureticsare used to optimize ureteric distention and to reduce the parenchymal streak artifacts in the pelvicalyceal region.CT urography is an excellent technique for the evaluation of urinary tract calculi and renal urinary tract tumors, with a high sensitivity and specificity.

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Rezumat

Urografia-CT reprezintă în zilele noastre tehnica de elecţie în evaluarea leziunilor tractului urinar superior, înlocuind urografia intravenoasă. Obiectivul acestui articol este de a face o prezentare sintetică a tehnicilor de uro-CT şi a principalelor indicaţii în patologia aparatului reno-urinar. Vom discuta de asemenea şi câteva soluţii pentru optimizarea protocoalelor de uro-CT în scopul de a obţine o bună vizualizare a ureterului distal şi de a reduce doza de iradiere.

Cuvinte cheie: urografie CT (uro-CT), technici, indicaţii