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Current Techniques and Clinical Applications of Computed Tomography Urography

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From conventional radiograph to magnetic resonance urography, imaging of urinary system has evolved with variety of investigations over the past several decades with each of them having advantages and limitations of their own. In the current era, computed tomography (CT) has emerged as a preferred investigations for evaluation of the urinary tract. There are various techniques involved in performing CT urography (CTU) with triple bolus technique (TB-CTU) currently drawing a special attention because of its low radiation exposure. This article aims to discuss the current techniques, indications, and clinical applications of CTU with illustrations.

Introduction

With the advent of multislice computed tomography (CT), CT urography (CTU) has replaced intravenous urography (IVU) as a primary imaging modality of urinary tract,[1] with the multiplanar reformation capability of CTU providing excellent anatomical details. There are various technique for acquisition of CTU, including conventional 3-phase and triple bolus techniques (TB-CTU). Overall, TB-CTU or dual-split bolus protocol have significantly lower radiation dose than that of conventional 3-phase CT protocol.[1-5] Using dual energy CT (DECT) in split-bolus technique reduces further radiation exposure by omitting the unenhanced phase that can be replaced with virtual unenhanced images (VNC). This article explains various current techniques of CTU with a concise illustration of various pathologies by CTU, and also discusses limitations of CTU.

Indications

Hematuria is one of the important indications of CTU.[1,6] CTU had been found to have better diagnostic yield than IVU.[7] In addition, CTU can depict the pathologies outside the urinary system. CTU is also indicated in patients with increased risk of urothelial neoplasms, in surveillance of patients with previous history of urothelial tumors, hydronephrosis or hydroureter with unknown cause, chronic symptomatic urolithiasis, complex urinary tract infections, and ureteral (traumatic or iatrogenic) injury. CTU is also indicated in any other circumstances where comprehensive evaluation of urinary tract is required.[6] Not all the patients requiring evaluation of urinary tract with CT need a 3-phase CTU. A single unenhanced CT would be appropriate in setting of flank pain with high suspicion of obstructing stone. In the evaluation of congenital anomaly or postoperative complications like urinary extravasation, excretory phase images would be sufficient.

CTU Techniques

Rationale

The CTU techniques are acquired based on the principles of different phases of renal enhancement (Fig. 1). [2,4,5,8] The initial phase of renal enhancement is described as corticomedullary phase that occurs 25-80 seconds after intravenous contrast administration. In this phase, most of the injected contrast material is seen in the vascular system, including capillaries, in addition to minimal amount of contrast in peritubular space and proximal convoluted tubules. The corticomedullary attenuation difference is accentuated in this phase owing to strong enhancement of cortex and minimal enhancement of medulla. The nephrographic phase begins about 85-120 seconds after the contrast injection, during which most of the injected contrast material seen within the loop of Henle and collecting ducts. In this phase, the renal cortex and medulla enhance more or less equally and this phase is the preferred one when evaluating the renal masses. The final excretory phase starts about 3-5 minutes after the contrast injection, in which excretion of contrast material occurs with opacification of the pelvicalyceal system and ureter, with the nephrogram remaining homogenous.

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FIG. 1. Axial CT images. Different phases of renal enhancement: (A) unenhanced study, (B) corticomedullary phase with accentuated corticomedullary differential enhancement, (C) nephrographic phase with relatively homogenous corticomedullary enhancement, and (D) excretory phase shows excreted contrast in renal pelvicalyceal system.

CTU usually requires similar preparation to contrast-enhanced abdominal CT. In most radiology departments, 3-phase acquisition is the most commonly used CTU technique to evaluate most of the commonly seen pathologies of urinary tract. The other technique is a split bolus CTU where 2 or 3 separate bolus (TB-CTU) injections of intravenous contrast are used. TB-CTU has shown promising results in evaluation of urinary tract with the benefit of low radiation dose to the patient.[2]

Three-phase acquisition (Fig. 2) usually consists of initial unenhanced set of images, followed by intravenous contrast injection and acquiring images in nephrographic and delayed phase.[6,9,10] Unenhanced images are useful for the evaluation of stones, calcifications, and also used to measure attenuation to compare with postcontrast enhancement of the lesions. Nephrographic phase images are acquired approximately after 90-100 seconds after start of injection of intravenous contrast. This helps in enhancement of kidney with evaluation of small renal masses. This is followed by image acquisition after 7-15 minutes that show excretion of contrast in pelvis and ureters. This phase is utilized for the evaluation of pelvicalyceal pathologies as they appear as filling defects within the excreted contrast column and used in 3D reformation to produce multiplanar reconstruction (MPR),

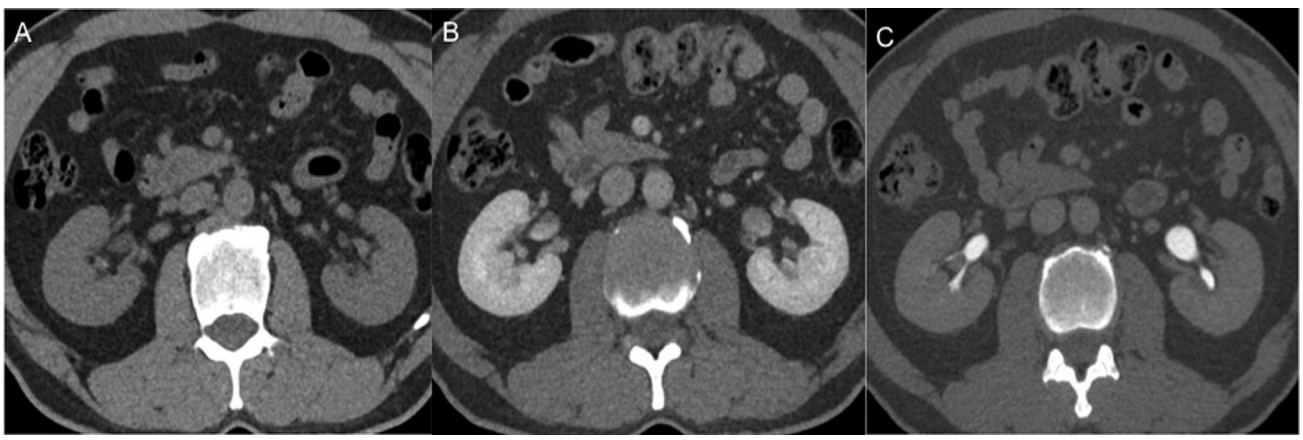

FIG. 2. Three-phase CTU axial images: unenhanced (A), nephrographic (B), and excretory (C) phase images.