Ultrasound and Intravenous- urography for Detecting Urolithiasis with Non-enhanced Computed Tomography as a Reference Standard

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Abstract

Objective: To determine the sensitivity and specificity of combined Ultrasonography (US) and Intravenous-urography (IVU) compared with non- enhanced Computed Tomography (CT) as a reference standard for the depiction of urolithiasis.

Materials and Methods: during 10 months, 55 patients (mean age 42 years) prospectively underwent both US, IVU and non- enhanced CT referred from emergency department for evaluation of renal colic. The findings on the US, IVU were compared with those of Ct for the presence or absence of stone disease.

Results: thirty three stones detected by CT. US depicted 24 and IVU 30 of 33 calculi identified at CT. in comparing US techniques for depicting any relevant abnormality (unilateral hydronephrosis and presence or absence of a ureteral jet in patients with obstructing calculus), improve detection of stone disease.

Conclusion: US and IVU have a limited value for detecting urolithiasis.

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Introduction

Non- enhanced helical Computed Tomography (CT) has become the primary imaging modality for the evaluation of acute flank pain and suspected renal stone disease. The high sensitivity (96%) of helical (CT) for depicting renal calculi has been established. [1] CT is of a particular value for detecting ureteral calculi, which often are not visualized with other imaging modalities.

The sensitivity of Ultrasonography (US) compared with non- enhanced Computed Tomography (CT) as a reference standard for the depiction of urolithiasis is unclear. Establishing the sensitivity of US for renal calculi will allow informed decision regarding which type of imaging examination to performed for a given clinical situation.

IVU has the advantage of telling whether the calculus is within the genitourinary tract and the level and degree of obstruction.

A non- enhanced CT is the exam of choice for suspected renal colic. The only reason to obtain a plain film is to characterize the stone markup.

Materials & Methods

During 10 months, 55 patients referred from the emergency department for evaluation of renal colic prospectively underwent none- enhanced CT, IVU and US of the kidneys and ureters. Of the 55 patients, 22 were women, and 33 were men. The main patient age was 42 years (range, 20- 64), and the main patient weight was 62.5 kg (range, 45- 80 kg). Patients were selected from those undergoing a standardized CT protocol for suspected urolithiasis who also underwent US, IVU within 10 hours preceding or following CT.

Non- enhanced CT was performed by using scanner (Siemens) and a dedicated protocol with 5.0- mm collimation and a pitch of 1.5: 1. Images were obtained by using (120- 140 kVp, 120- 140 mAs). Scanning was performed from the upper abdomen through the pubis. US was performed by using (Agilent Technologies) curved transducers (2.5-5 MHZ) and consisted of either dedicated renal or abdominal imaging. US included evaluation of the kidneys and ureters in multiple anatomic planes. Intravenous urography protocol starts with (KUB). Imaging

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should encompass the area from the suprarenal region to the level below the symphysis pubis. Nephrotomography is performed 1-3 minutes following the bolus administration. A (KUB) radiograph 5- 10- 15 minutes post contrast administration. Delayed images should be obtained until opacification to the level of obstruction is identified. Full bladder view followed by empty large film should be obtained.

US, IVU and CT examination were reviewed in a blinded retrospectively manner by two staff radiologists who specialize in body imaging. The reviewing radiologists worked as a team and provided a consensus interpretation for each image. For each patient, the US, IVU images were reviewed prior the CT examination. The team relies on direct signs as focal high- attenuating opacities at CT or secondary signs of urolithiasis as perinephric fat standing or rim of soft tissue surrounding the stone (Fig 1). In inderminated cases, contrast was given to differentiate stone from phlebolith. At US direct sign as echogenic shadowing or ancillary signs hydronephrosis or ureteral jet, but in IVU hold up the contrast at the level of obstruction, filling defect in radiolucent stone or delay in contrast excretion. The calculi size (long axis) and number were recorded for the US, IVU and CT examination and considered positive or negative exams regardless the number of stones. The location of esach calculus was recorded as being in either the right or the left kidney.

The agreement of US and IVU for calculi in the renal parenchyma or ureter was calculated by using CT as a reference. The agreement for the presence or absence of any urolithiasis for each patient was also calculated for comparison with the original US and IVU interpretation at the time the study was performed. Calculi were classified according to the size in groups of 0.0- 0.5 mm, 0.5- 0.8 mm, and greater than 8.0 mm, since calculi size affects patients' therapy. [5]

Results

During 10 months, 55 patients referred from our emergency department for evaluation of renal colic were prospectively enrolled. There were 22 women and 33 men with a mean age of 42 years (range, 20- 64), and the main patient weight was 62.5 kg (range, 45- 80 kg). Of the 55 patients, 33 were found to have renal or ureteral calculi. These patients form the basis of this report. In the remaining patients, the following was found: one patient had renal cell carcinoma, ureteropelvic junction obstruction, and renal hematoma. Only one patient had a non- urologic (acute appendicitis) which caused flank pain identified at imaging (Fig 2). Additional findings include one patient with renal artery calcification (Fig 3), and cholithiasis and adrenal myelolipoma. Of the remaining 15 patients in whom no abnormalities were identified at CT and US, final clinical diagnosis included musculoskeletal or disc- related pain (n= 5), gastroenteritis (n= 2), urinary tract infection or pelvic inflammatory disease (n= 3), nephritic syndrome (n= 2), recent ureteric calculus passage (n= 2), prostititis (n=1). A total of 33 calculi were detected on CT, 10 in the pelvocaliceal system and 23 in the ureters. The uteteral calculi were located as follows: nine (27%) were located in the proximal ureter or ureteropelvic junction, six (18%) were located in the distal ureter and eight (24%) were located at the ureterovesical junction. The mean size of the renal calculi was 12 mm (range, 4- 20 mm) and the mean size of the ureteral calculi was 4.4 mm (range, 2-15 mm). Seven (21%) were larger than 2.5 mm and five (15%) had multiple calculi on CT scan. Twenty five of 33 calculi in the right depicted by CT, leaving 8 stones for the left side.

By consensus, US detected 24 and IVU 30 of 33 calculi identified at CT. In comparing US techniques for depicting any relevant abnormality (unilateral hydronephrosis and presence or absence of a ureteral jet in patients with obstructing calculus), the level of agreement with CT will increase. In three of nine missed calculi at US, no ancillary signs of acute obstruction (i. e. hydronephrosis or unilateral abnormal ureteric jet) was depicted but the three calculi missed by IVU were too small in renal parenchyma and another 2 mm in the middle part of the ureter. Of 33 patients with documented calculi, 25 (76%) had associated unilateral hydronephrosis. Ureteric jet analysis was performed in 29 of 33 patients with documented calculi. No false positive findings would have resulted from the analysis of ureteric jet. However, in six cases with documented calculi, the ureteric jet was normal.

Figure 1 a: CT image shows a small pelvic calcification (arrow) within a linear soft tissue density representing an unopacified pelvic vein (comet tail sign) indicative phlepolith.

Figure 1 b: CT image shows urethral stone and a thin rind of soft tissue (arrows) surrounding the stone (soft tissue rim sign) indicative of an edematous urethral wall.

Figure 1 c: Transverse US shows an echogenic Focus (arrow) medial to the middle of the right kidney.

Figure 1 d: Non-enhanced transverse CT image also well depicts the obstructing calculus (arrow) with a adjacent periure- teral stranding.

Figure 2: Non-enhanced CT scan shows a dialated appendix (arrow) with periappendicular stranding consistent with appendicitis.

Figure 3 a: Vascular calcification in the patient was misinterpreted as a renal pelvic calculus at US. (a) Longitudinal US image of the kidney demonstrates a shadowing echogenic focus in the renal pelvic that suggests a calculus.

Figure 3 b: Transverse non-enhanced CT image reveals atherosclerosis calcification (arrow) of the segmental renal arteries.

Figure 4 a: Axial CT scan of the kidney shows dilatation of the right renal collecting system, as well as mild stranding of the perinephric fat medical to the lower pole of the right kidney.

Figure 4 b: A more inferior image shows dilatation of the right ureter (arrow).

Figure 4 c: Another more inferior scan shows that the right ureter remains dilated to the ureterovesical junction (arrow). No calcification was identified.

Discussion

Historical, suspected nephrolithiasis has been evaluated with intravenous urography. Recently, however, many practices have adopted non- enhanced helical CT as the imaging modality of choice for the detection of ureteric calculi and associated renal obstruction. [1- 4] Compared with those of intravenous urography, the benefits of non-enhanced CT include the following: no requirement for intravenously administered contrast material, high sensitivity for calculus detection, and the ability to depict non- urinary causes of acute flank pain.

In our study, the sensitivity of US and IVU compared with CT as a standard for direct depiction of ureteric calculi is (73%) and (90%), respectively; these findings approximate sensitivities reported in the literature. [4, 5, 7-9] The greatest weakness of US, is its inability to depict the entire ureteric course. Bowel gas and large patients habitus contribute to poor ureteric depiction. Some authors [17-19] have advocated the use of transperineal US for improved calculus detection. While this approach is intuitive in the examination of women, it changes a relatively short examination into a longer, more expensive, and personally invasive procedure for the patient.

The exact sensitivity of intravenous urography for calculus detection is uncertain. However, in one study. 1 of the patients with obstruction documented at intravenous urography compared with that documented at non-enhanced CT, 58% of calculi were not depicted. By comparison, the sensitivity for non- enhanced CT reaches nearly 100%. [4, 5] In addition to correctly depicting ureteric calculi, non- enhanced CT depicts extra urinary abnormalities in 10% - 16% of cases. [3, 5] Accordingly, many centers now routinely use CT to screen patients who have acute flank pain or hematuria. Prior to the acceptance of helical CT, several investigators [6, 13, 14] hailed US as a good alternative to intravenous urography, with sensitivities of 95%- 100% for detection of urinary tract obstruction. However, other findings [7-9] suggest more modest US sensitivities of 37%- 64% for calculus detection, with sensitivities of 74%- 85% for the detection of acute obstruction.

In a study conducted by Faye C, et al to determine the role of US versus excretory urography in acute flake pain concluded that US was not as sensitive as excretory urography for diagnosis hydronephrosis, for detecting ureteral or renal calcification, or for diagnosis forniceal rupture. [10]

Despite likely having a lower sensitivity for calculus detection than CT, US require no ionizing radiation and are the study of choice in pregnant patients. [15] Given the ready availability of US units in emergency departments, the emergency medicine literature, [11, 12] also advocated the use of US as a screening examination in the initial assessment of renal colic. Henderson and colleagues [12] reported that US performed by an emergency department physician is 97% sensitive for the detection of "pathology consistent with nephro- ureterolithiasis," when compared with intravenous urography. Rosen et al [11] reported that bedside US evaluation performed by the emergency department physician to evaluate hydronephrosis is 72% sensitive and 73% specific for the prediction of nephrolithiasis, compared with intravenous urography or CT. To our knowledge, in only one article [16] in the radiology literature was the effectiveness of US compared with that of Ct for the detection of upper urinary tract calculi and hydronephrosis.

Another approach to improving US sensitivity is the use of color flow analysis of ureteric jets. [20] However, a unilaterally abnormal uretric jet can usually be suggestive of a uretric calculus, but US cannot definitively depict the location of the obstructing lesion. Further, the finding of normal ureteral jets cannot be used to exclude a diagnosis of ureterolithiasis, since seven (30%) of 23 of our patients with documented calculi had normal ureteric jets.

Our study did not include routine evaluation of renal resistive indexes. In the patients without hydronephrosis or calculi identified at US, asymmetric changes in the resistive indexes might have been suggestive of early obstruction, improving overall sensitivity. [20-22]

Although virtually all stones previously considered radiolucent on plain radiographs, such as uric acid stones, are readily identified on CT scans, the recent use of protease inhibitors to treat Human Immunodeficiency Viral (HIV) disease has led to an increasing prevalence of urinary tract obstruction caused by deposition of crystals that are nonopaque on CT scans (Fig 4). [23] The presence of secondary signs of obstruction on the symptomatic side in the absence of an identifiable calculus typically prompt a differential diagnosis of a passed stone, pyelonephritis, or obstruction unrelated to stone disease. However, in patients undergoing therapy with the protease inhibitor indinavir (Crixivan; Merck, Rahway. NJ), the same constellation of findings should suggest the diagnosis of indinavir crystal deposition. Because demonstration of indinavir crystals requires gas chromatography, which is not available in most hospital laboratories, intravenous urography or retrograde urography should be used as they provide a rapid way to confirm the diagnosis of crystal deposition disease suspected on the basis of CT findings and clinical history.

In conclusion, US fared quite well vis- a- vis CT in the detection of stone disease in patients with renal colic. Therefore, if a physician is in a situation where CT is unavailable, US is probably the technology of choice. Plain films are usually non helpful and an IVU is time consuming.

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