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The value of unenhanced multi-detector computed tomography versus three-dimensional ultrasound in evaluating patients with impaired renal function and hematuria

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KEYWORDS
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Abstract
Introduction: Unenhanced computed tomography (CT) is used to detect urinary tract calculi with high accuracy. The development of multi-detector CT (MDCT) allows reconstructions in coronal, sagittal and oblique directions.
Objective: To compare MDCT with three-dimensional (3D) ultrasound (US) imaging in evaluating patients with impaired renal function and hematuria.
Patients and methods: A total of 55 patients with hematuria and impaired renal function were examined with unenhanced MDCT and 3D US imaging at Al-Fayoum University Hospital between March 2008 and April 2010.
Results: The diagnosis on unenhanced MDCT was urolithiasis in 25 patients, psoas abscess with perinephritis in 2, chronic cystitis in 3, prostatic enlargement in 4, renal mass lesions in 3, vesical masses in 4, renal trauma in 2, adult polycystic kidney disease in 1, renal vein thrombosis in 1 and no specific abnormality in 10 patients. In diagnosing the cause of hematuria, the sensitivity was 82% for CT versus 73% for US. This can be attributed to the high sensitivity of CT (100%) in the diagnosis of urolithiasis, which is a common cause of hematuria. In the diagnosis of other causes of hematuria the sensitivity was 66% for CT versus 77% for US. The combination of MDCT and US increased the sensitivity to 87%.

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Conclusion: The combination of unenhanced MDCT and US is highly valuable in evaluating patients with impaired renal function and hematuria. Further studies comparing the sensitivity of these techniques with magnetic resonance urography are indicated.

Introduction

Hematuria is the presence of blood in the urine, which can be microscopic or macroscopic. Causes of hematuria include blood diseases, urinary tract infection, urinary tract neoplasms, calculi, trauma, glomerulonephritis, billharziasis, benign prostatic hyperplasia, prostatitis, pelviureteric junction obstruction and adult polycystic kidney disease [1]. Other less common causes include left renal vein hypertension (nutcracker phenomenon) [2], urinary tract allergy [3], bladder wall varices, sequelae of inferior vena cava thrombosis [4], march hematuria and endometriosis of the bladder [1].

The investigation of hematuria includes medical history, certain blood tests, radiological imaging of the urinary tract, guided biopsies, cystoscopy and urine cytology. Imaging of urinary tract includes plain X-ray, excretory urography (EUG), ultrasonography (US), computed tomography (CT) and magnetic resonance urography (MRU). The sensitivity of EUG in the detection of urinary tract calculi is around 65%, which means it misses around 35% of calculi. The sensitivity of abdominal US combined with plain X-ray in the detection of urinary calculi is around 70%. MRU fails to detect calculi and calcifications. Unenhanced CT has high accuracy in the detection of urinary tract calculi [5,6].

Multi-detector CT (MDCT) obtains thin collimated data of the urinary tract during single breath hold and provides higher spatial resolution compared with single detector CT. Its ability to provide reconstructions in the coronal, sagittal and oblique planes makes it accurate in the localization of calculi and various urinary tract pathologies. It provides accurate anatomical detail of vital structures, providing valuable data for management decisions [7].

The true frequency of contrast nephropathy is difficult to establish because there are no standard diagnostic criteria, but the primary risk factor in using intravenous contrast media is impairment of renal function (serum creatinine >1.4 mg/dl) especially if coexistent with diabetes mellitus [8–10].

The aim of this study was to compare unenhanced MDCT scan with US in the evaluation of patients with hematuria and impaired renal function where intravenous contrast is contra-indicated.

Subjects and methods

A total of 55 patients with hematuria and impaired renal function (serum creatinine >1.4 mg/dl) attended Fayoum University Hospital between March 2008 and April 2010. The mean patient age was 30 years (range 10–65 years). The causes of impaired renal function included bilateral obstructive uropathy, hypertensive nephropathy, diabetic nephropathy and glomerulonephritis. Apart from a full medical history and clinical examination, all patients underwent three-dimensional (3D) US imaging of the abdomen and pelvis with multi-planar image analysis, volume rendering and 3D extended imaging, including the multi-slice view which transforms 3D volume data obtained from a regular US scan into a series of sequential images captured in segments of 0.5–5 mm. The oblique view enables 3D volume data imaging in various planes. A 2–6 MHz 3D volume probe (SONOACE X8 US machine, Medison, Korea) was used.

Unenhanced CT imaging was performed using a 4-slice Toshiba MDCT scanner (Asteion). Patients were asked to drink 1 Liter of water an hour prior to examination and were not allowed to empty the bladder. No oral or intravenous contrast was given. Single breath hold scanning from the level of the suprarenal glands to the infravesical level was performed with 2.5 mm slice thickness. Coronal, sagittal, oblique and, if indicated, 3D reconstructions were performed. The final diagnosis was based on correlation with other imaging modalities, surgical findings and pathology reports.

Results

Unenhanced MDCT showed urinary tract calculi in 25 (45.5%) patients (Table 1). Thirteen patients had multiple calculi, while 12 had a solitary stone. The sites of the calculi are shown in Tables (2 and 3) and Fig. 1. Secondary signs of ureteric obstruction observed on unenhanced CT are shown in Table 4.

Table 1 Unenhanced CT diagnosis.

Unenhanced CT diagnosis	Number	%
Urinary tract calculi	25	45.5
Psoas muscle abscess + perinephritis	2	3.6
Renal trauma	2	3.6
Renal soft tissue mass	3	5.5
Post-bilharzia chronic cystitis	3	5.5
Prostatic enlargement	4	7.3
Vesical mass	4	7.3
Renal vein thrombosis and inferior vena cava thrombosis	1	1.8
Adult polycystic kidney disease	1	1.8
Normal study	10	18.1
Total	55	100

Table 2 Sites of urinary tract calculi.

Sites of urinary tract calculi	Number	%
Unilateral renal	2	8
Bilateral renal	4	16
Unilateral ureteric	9	36
Bilateral ureteric	8	32
Vesical	2	8
Total	25	100

Table 3 Sites of ureteric calculi.

Sites of ureteric calculi	Number	%
Proximal lumbar	6	24
Distal lumbar	6	24
Pelvic	8	32
Intramural	5	20
Total	25	100

Fig. 1 Unenhanced CT with coronal reconstruction showing stone in pelvic course of left ureter.

The unenhanced CT diagnosis in the 30 patients without urolithiasis (Table 1) included 2 patients with psoas muscle abscesses and perinephritis (Fig. 2), 2 with renal trauma (Fig. 3), 3 with renal mass lesions which proved to be neoplasms (Figs. 4 and 5), 4 with prostatic enlargement (Fig. 6) and 4 with vesical mass lesions which proved to be neoplasms (Fig. 7).

Among 10 patients with hematuria who were subjected to further investigations, the final diagnosis was post-bilharzia vesical wall ulcers in 3, small transitional cell renal neoplasms in 2, a small vesical neoplasm in 1, vesico-uterine fistula in 1, and unknown etiology in 3.

Table 4 Secondary signs of ureteric calculi on unenhanced CT.

Secondary signs of ureteric calculi	Number	%
Back pressure changes	20	80
Tissue rim sign	8	32
Renal enlargement	10	40
Decreased renal density	4	16
Perinephric edema	5	20
Periureteric edema	6	24
Total	25	100

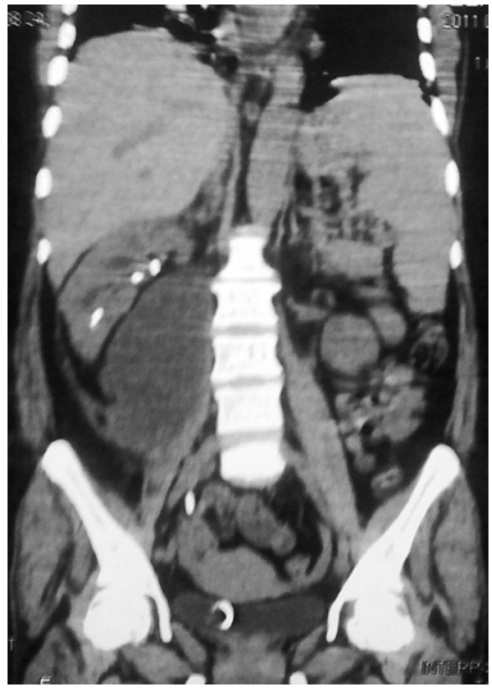

Fig. 2 Unenhanced CT coronal view showing right psoas muscle absces.

On comparing the results of MDCT to 3D US in the detection of renal calculi, US had 100% sensitivity, but MDCT was more accurate in counting the number of calculi and in differentiating staghorn stones from multiple stones. The sensitivity of US in detecting ureteric stones was 100% for upper lumbar, 33% for distal lumbar, 50% for pelvic and 100% for intramural ureteric stones (Fig. 8). US was highly sensitive in detecting vesical stones and neoplasms (Fig. 9) and in demonstrating vesical wall infiltration. In the patients with post-bilharzia chronic cystitis, unenhanced CT was superior to US in detecting bladder wall calcifications. The renal masses shown on unenhanced MDCT were clearly demonstrated using US with power Doppler technique which provided more accurate staging with regard to perinephric fat and renal vein involvement. Two cases with small renal transitional cell neoplasms were not suspected on unenhanced MDCT, of which one was detected with US. CT showed the presence of perinephritis associated with psoas abscess better than US. In patients with renal trauma, color duplex sonography

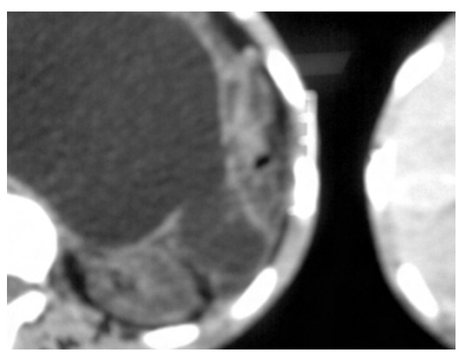

Fig. 3 Renal trauma with enlarged hypodense left kidney (arrow) and large pancreatic pseudocyst.

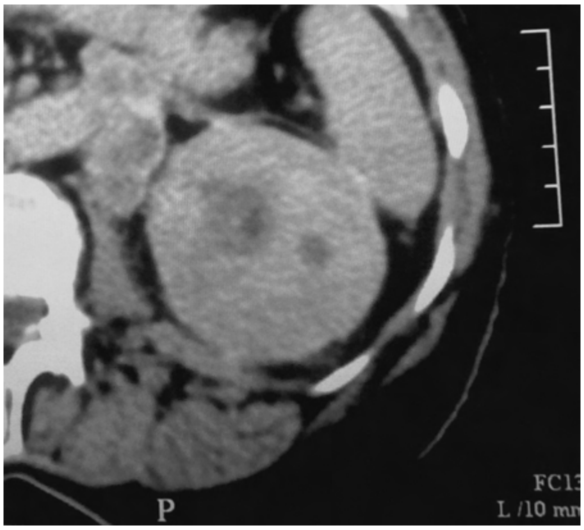

Fig. 4 Hypodense focal lesion in left kidney with enlarged hilar lymph node and left renal vein thrombosis.

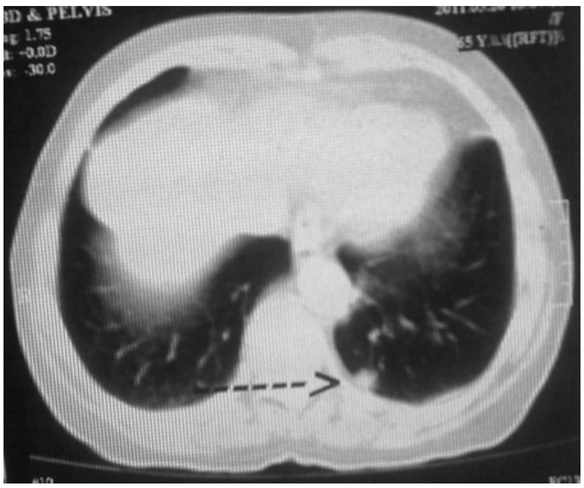

Fig. 5 Chest CT showing small metastasis in left lung base (same patient as in Fig. 6).

was useful in diagnosing vascular occlusion, perinephric fluid collections and renal lacerations. Adult polycystic renal disease was easily diagnosed with US. Table 5 compares the sensitivity of unenhanced CT versus US in the diagnosis of hematuria causes.

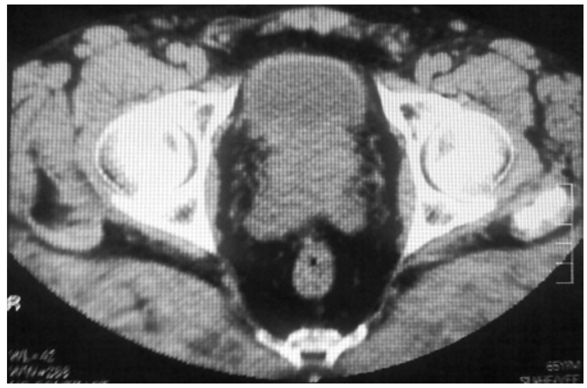

Fig. 6 Unenhanced axial CT showing prostatic enlargement.

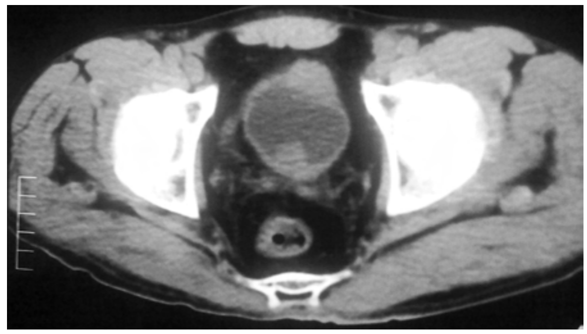

Fig. 7 Axial unenhanced CT showing two vesical neoplasms.

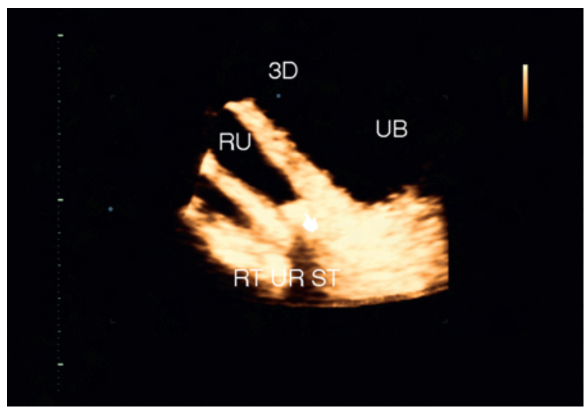

Fig. 8 3D US with volume rendering showing stone in distal course of right ureter.

Discussion

Urolithiasis is the most common cause of hematuria. Unenhanced CT shows high accuracy in the detection of urinary tract calculi and calcifications [7]. MDCT with coronal, sagittal and oblique reconstruction allows exact localization, measurement and counting of calculi [11–14]. MDCT allows the detection of secondary signs which support the diagnosis of urolithiasis if there is difficulty in visualizing stones [15,16].

Table 5 Sensitivity of unenhanced computed tomography vs. ultrasound in diagnosing the cause of hematuria.

Causes of hematuria	Unenhanced CT sensitivity	Ultrasound sensitivity	Combined CT and US sensitivity
Urinary tract calculi	100	68	100
Other pathologies	66	77	77
All cases	82	73	87

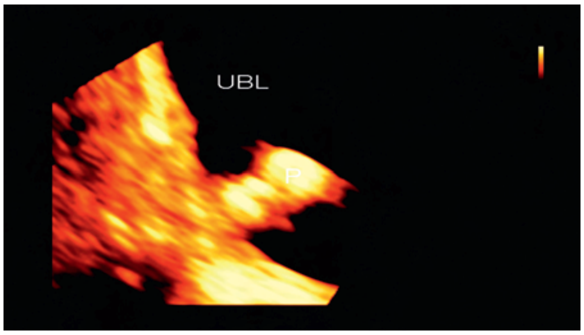

Fig. 9 3D US volume rendering of small vesical wall polyp.

The commonest signs of ureteric obstruction are proximal back-pressure changes seen in 80% of our cases and in 69–83% of cases in other reports [16–18]. In our study the tissue rim sign was seen in 32% of cases, similar to the 34% reported by Strouse et al. [19]. In our cases perinephric edema was seen in 20% and periureteral edema in 24%, compared with 47% and 59%, respectively, reported by Ege et al. [16]. Renal enlargement was detected in 40% of our cases, compared with 36–71% in other reports [15,16,19]. Such differences are related to the degree of calcular obstruction and the presence of secondary infection.

US was less sensitive than CT in detecting ureteric calculi, especially in the lumbar and upper pelvic ureter, and was less accurate in evaluating the number and morphology of calculi. Previous studies showed that MDCT urography was more sensitive than US and EUG in the detection of renal masses [20–23]. Caoili et al. [24] stated that uro-epithelial neoplasms can be detected accurately. Chow and Sommer [25] reported that many benign abnormalities of the upper urinary tract can be easily identified using coronal and 3D reconstructions, but all previous studies used contrast enhanced CT to distinguish between benign and malignant urinary tract pathology.

In the current study unenhanced CT was more sensitive than US in the diagnosis of hematuria causes (Table 5). This can be attributed to the high sensitivity of CT in the diagnosis of calculi, which represent a common cause of hematuria. However US was more sensitive than unenhanced CT in the diagnosis of other causes of hematuria. The combination of unenhanced MDCT and US increased the sensitivity in diagnosing the cause of hematuria (Table 5).

Conclusion

The combination of unenhanced MDCT and US is very useful in evaluating patients with hematuria and impaired renal function. Further studies comparing the sensitivity of these techniques with that of MRU are indicated.

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