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A comparison of non-contrast CT and intravenous urography in the diagnosis of urolithiasis and obstruction

N. Khan^a, Z. Anwar^a, A.M. Zafar^b, F. Ahmed^a, M.H. Ather^{c,*}

^a Department of Radiology, Aga Khan Medical University, Karachi, Pakistan

^b Rhode Island Hospital, Brown University, Providence, RI 02912, USA

^c Department of Surgery, Aga Khan Medical University, Karachi, Pakistan

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KEYWORDS

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Abstract

Objectives: To compare the diagnostic accuracy of non-contrast-enhanced computed tomography (NCCT) and intravenous urography (IVU) performed in the same patient in the diagnosis of urolithiasis and ureteric obstruction.

Subjects and methods: This is a retrospective review of radiological and clinical data of patients with suspected urolithiasis or ureteric obstruction who had both NCCT and IVU performed within 30 days of each other. The data were analyzed using the statistical packages EpidataTM and SPSSTM. The number of calculi, presence of hydronephrosis and hydroureter, cysts and ureteric wall thickening were evaluated in both NCCT and IVU. Additionally, perinephric stranding in NCCT and delayed excretion in IVU were also evaluated.

Results: Of the 139 patients (87 male and 52 female), 102 patients (73.4%) had positive findings on NCCT and 71 (51.1%) on IVU. On NCCT 133 stones were detected in 80 patients (57.6%), 67 (48.2%) in the kidney, 63 (45.2%) in the ureter and 3 (2.2%) in the bladder. The findings on NCCT were hydronephrosis in 43 (31%), hydroureter in 34 (24.5%), perinephric stranding in 7 (5%), ureteric wall thickening in 4 (2.8%), renal mass and renal cyst in 1 (0.7%) each. On IVU 86 stones were detected in 46 patients (33.1%), 53

* Corresponding author. Tel.: +92 2134864778; fax: +92 2134934294.

E-mail address: hammad.ather@aku.edu (M.H. Ather).

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(38.1%) in the kidney, 31 (22.3%) in the ureter and 1 (1.4%) in the bladder. The findings on IVU were hydronephrosis in 31 (22.3%), hydroureter in 18 (13%), delayed excretion in 5 (3.6%), renal cyst and ureteric wall thickening in 1 (0.7%) each. Incidental findings were more common on NCCT (23/139, 16.6%) than IVU (2/139, 1.4%).

Conclusions: NCCT compared with IVU had a higher detection rate for ureterolithiasis, especially for stones in the distal ureter. An added benefit of NCCT was the detection of significant additional findings.

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Introduction

Over the past two decades, the choice of imaging in the evaluation of urolithiasis and ureteric obstruction has seen a paradigm shift. In pediatric patients, intravenous urography (IVU) still comprises the greater proportion of uro-radiological investigations [1]. The excellent spatial resolution provided by multislice non-contrast-enhanced computed tomography (NCCT) has made it the imaging modality of choice for the diagnosis and follow-up of urolithiasis [2]. An added advantage of CT over IVU is its ability to diagnose other causes of flank pain, such as appendicitis or acute gynecological conditions.

Radiation dose is currently one of the major disadvantages of CT [3]. Ferrandino et al. [4] have noted that about 20% of patients received potentially significant radiation doses during short-term follow-up of an acute stone event. Although the threshold level for radiation-induced malignancies is debated, urologists must remain vigilant in minimizing radiation exposure.

The major disadvantage of IVU is the risk of allergic reactions or impaired renal function due to intravenous (IV) contrast. NCCT in the evaluation of suspected urolithiasis has the potential to diagnose other causes of flank pain such as solid organ malignancies [5].

Ureteric colic accounts for approximately 1% of all hospital admissions. IVU has been the standard imaging modality for suspected urolithiasis for over 75 years. However, more recently it has been superseded by NCCT. Whereas IVU is specific for the collecting system, NCCT gives a more global picture of the whole abdomen. Wong et al. [6] in a small comparative study demonstrated superiority of NCCT over IVU in the diagnosis of ureteric stones. CT has the additional advantage of identifying ureteric obstruction in the absence of stones by showing secondary signs of obstruction [6]. Smith et al. [2] found that NCCT is more effective than IVU in identifying ureteric stones and equally effective in the determination of ureteric obstruction. The drawbacks of CT include a significantly higher radiation dose (up to 3 times that of a standard IVU) and the fact that it can miss ureteropelvic junction obstruction associated with urolithiasis.

The aim of this study was to determine whether NCCT or IVU is the best imaging modality in patients with suspected urolithiasis.

Subjects and methods

The radiology database for January 2002–December 2007 was accessed to identify patients who presented with ureteric colic indicating urolithiasis or ureteric obstruction and had both NCCT and IVU within a period of 30 days.

NCCT was performed with a multidetector helical scanner (Aquilion 64, Toshiba™) from the level of the kidneys to the pubic symphysis in breath-hold status, with the following parameters: beam collimation 5 mm × 1.25 mm; pitch 6; scan time about 20 s. Subsequent curved three-dimensional multiplanar reconstruction (MPR) focusing on the ureter of the symptomatic side was performed on a compatible workstation by an experienced CT technologist. By manually selecting a point within the center of the ureteric lumen on sequential axial images, the renal collecting system could be demonstrated completely from the level of the renal pelvis to the urinary bladder.

IVU was performed by taking a plain abdominal film prior to IV administration of 50 mL non-ionic contrast medium, followed by an anteroposterior view at 5 min, anteroposterior and bilateral oblique views at 15 min, anteroposterior view at 30 min, and a post-voiding view. Further delayed images were taken if necessary.

In patients with renal colic and a high suspicion for urolithiasis, both procedures were performed at the discretion of the referring physician and after informed consent had been obtained. During the study period, a total of 11,245 uro-radiological examinations were performed using either IVU ($n = 4915$, 43.7%) or NCCT ($n = 6330$, 56.3%). Most procedures were performed in adults ($n = 10,741$, 95.5%) as compared to children ($n = 504$, 4.5%). In total, 139 patients had both an IVU and NCCT performed within 30 days of each other.

The number of calculi, presence of hydronephrosis and hydroureter, cysts and ureteric wall thickening were evaluated in both NCCT and IVU. Perinephric stranding in NCCT and delayed excretion in IVU were also evaluated. The stone size (in mm) was determined in the largest single dimension. The data were analyzed using commercially available statistical packages (Epidata™ and SPSS™).

Results

The mean age of the 139 patients (87 male and 52 female) was 29.5 years (range 16–84 years). In the NCCT group 102 patients (73.4%) had findings of stone, ureteric obstruction or other abnormalities and in the IVU group 71 (51.1%) had a finding (Table 1).

Incidental findings were more common on NCCT (23/139, 16.6%) than IVU (2/139, 1.4%). CT identified more ureteric stones than IVU at all locations, especially in the distal ureter and ureterovesical junction (Table 2). The mean stone size was 5.3 mm for stones identified on CT, 6.4 mm for those identified on IVU and 5.9 mm for those missed on IVU.

Table 1 Findings on NCCT and IVU.

Finding	NCCT		IVU	
	n	%	n	%
Stones present	80/139	57.6	46/139	33.1
Number of stones	133	–	86	–
Stones/patient	1.7	–	1.9	–
Stone in kidney or at PUJ	67	48.2	53	38.1
Stone in ureter	63	45.2	31	22.3
Stone in bladder	3	2.2	2	1.4
Presence of mass	1	0.7	–	–
Hydronephrosis	43	31	31	22.3
Hydroureter	34	24.5	18	13
Cysts	1	0.7	1	0.7
Ureteric wall thickening	4	2.8	1	0.7
Perinephric stranding	7	5.0	–	–
Delayed excretion	–	–	5	3.6

PUJ – pelvi-ureteric junction; UVJ – ureterovesical junction.

Discussion

Imaging of the urinary tract is pivotal in the diagnosis, management, and follow-up of patients with urolithiasis. Historically, urologists have used a variety of imaging modalities, including plain radiography of the kidneys, ureters and bladder (KUB), IVU, ultrasound (US), magnetic resonance urography (MRU) and computed tomography (CT), each with its advantages and limitations. Until recently, IVU was considered the gold standard for diagnosing renal calculi, but this modality has largely been replaced by NCCT, due to its high sensitivity and specificity and the ease of performing the study.

In less developed countries, a significant percentage of patients with urolithiasis have renal failure, which is a contra-indication for the use of IV contrast [2,7]. Traditionally, plain KUB and US have been used in patients with renal failure. In a study comparing US and NCCT in patients with renal failure, Ather et al. [8] reported sensitivity and specificity of 81% and 100%, respectively, for renal stones, and 93% and 100% for hydronephrosis. They noted that US was poor in the diagnosis of ureteric stones (46%) and hydroureter (50%) and that the addition of plain KUB to the protocol increased the diagnostic ability for ureteric stone to 77% [8].

A significant drawback of IVU is its failure to differentiate between acute obstruction and residual changes due to previous obstruction. CT has the advantage that it can be used to determine the renal parenchymal attenuation to differentiate between acute and chronic obstruction. Erbaş et al. [9] noted a significant difference in the mean parenchymal attenuation value on the acutely obstructed side versus the unobstructed or chronically obstructed side.

Table 2 Ureteric stones identified on NCCT and IVU.

Stone location in ureter	NCCT		IVU		p-Value
	n	%	n	%	
Upper ureter	7	11	5	16	0.04
Middle ureter	7	11	3	10	0.5
Distal ureter excluding UVJ	30	47	18	58	0.004
UVJ	19	31	5	16	0.002
Overall	63	–	31	–	<0.004

UVJ – ureterovesical junction.

Over diagnosis of insignificant pathology is a concern with NCCT, which often identifies non-obstructing renal stones in patients presenting with acute pain [10]. These stones may not be the cause of discomfort, but they result in multiple clinical and radiologic evaluations.

Imaging has an important role in follow-up of patients treated for urolithiasis. Most series on ureteroscopy for urolithiasis use post-operative KUB or IVU to determine outcomes. These radiological studies are not very sensitive and often underestimate the residual fragment rates. NCCT has the potential to improve the detection of residual fragments, albeit with higher radiation exposure. A recent study reported that the stone-free rate following ureteroscopy is overestimated when KUB and US only are used [11].

Identification of ureteric stones is difficult in patients presenting with acute colic caused by radiolucent or partially mineralized stones with minimal or no obstruction. In defense of IVU, Saeed et al. [12] noted that the addition of erect radiography facilitates the diagnosis of nephroptosis as well as differentiation between phleboliths and small distal ureteric stones.

In this study, NCCT compared with IVU had a higher detection rate for ureterolithiasis, especially for stones in the distal ureter (Table 1). NCCT compared with IVU also identified more stones in the kidney. Some of these stones may not merit active intervention at the time of diagnosis, but require active surveillance.

NCCT compared with IVU demonstrated a higher detection rate for the number of calculi and related obstruction. The increased number of incidental findings also makes CT more useful. One major advantage of IVU is the evaluation of delayed excretion, which cannot be evaluated by NCCT.

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