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The role of ultrasound and intravenous urography in evaluating patients with hematuria

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Abstract

Background and objective: Intravenous urography is a radiographic examination in which anatomic and physiologic abnormalities of the urinary tract are detected by obtaining a timed series of imaging of the abdomen and pelvis after the injection of intravenous "IV" iodinated contrast media. This study aimed to measure the diagnostic validity of ultrasound and intravenous urography in the hope of omitting unnecessary intravenous urography and to determine whether ultrasound could help to replace the intravenous urography in the diagnosis of hematuria.

Patients and methods: A prospective hospital based study was performed from 15th April 2015 to 15th April 2016 on 100 patients presenting to Rizgary Teaching Hospital with hematuria, all patients underwent a real time ultrasound examination of the urinary tract followed by an intravenous urography. The diagnostic validities were recorded and compared for each modality.

Results: Ultrasound had higher sensitivity than intravenous urography for diagnosis of kidney calculi, lower ureteric calculi, and urologic neoplasms, but in calculi of the middle and upper ureter, there was no difference between ultrasound and intravenous urography.

Conclusion: Our results are in favor of using ultrasound in the initial evaluation of hematuria. However, we must choose our diagnostic tool according to the patient's condition and suspected disorders causing hematuria, as ultrasound can be safely done and hence minimizing the exposure of the patient and medical staff to excessive radiation.

Keywords: Hematuria; Ultrasonography; Intravenous urography; Urologic neoplasm; Urinary calculi.

Introduction

The kidneys are bilaterally paired reddish brown organs. Typically each kidney weighs about 150 gm in the male and 135 gm in the female. The kidneys generally measure 10 to 12 cm vertically, 5 to 7 cm transversely, and 3 cm in the anteroposterior dimension.[1] In healthy young adults, parenchymal thickness is of the order of 2.5-3 cm at the poles and 1.5-2 cm elsewhere.[2] The ureters are bilateral tubular structures responsible for transporting urine from the renal pelvis to the bladder. They are generally 22 - 30 cm in length with a wall composed of multiple layers.[1,4] The urinary bladder is a pyramidal muscular organ when empty. It has a triangular shaped base posteriorly.[3] Hematuria is defined as the presence of red blood cells in the urine.When visible to the patient it is termed gross hemturia. Microscopic hematuria is that detected by the dipstick or microscopic examination of the urinary sediment. The more common cause of hematuria includes urinary tract infection, urolithiasis, trauma, renal parenchymal disease, and malignancy. Urinary tract malignancy is four times more common in patient with macroscopic hematuria than microscopic hematuria.[5,6] The KUB radiograph is of limited value in the assessment of hematuria.However, it does play a role in the diagnosis of urinary stones, which may cause hematuria.[7]

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Ultrasound plays a central role in the assessment of hematuria. It is a readily available, risk-free and inexpensive imaging technique. It is a useful modality for the detection of urinary tract calculi. In addition, ultrasound has been shown to be more sensitive than intravenous urography (IVU) in diagnosing urological malignancy. The mass could be detected by ultrasound if it is more than 0.5cm.[8] IVU was one of the first contrast based radiological investigations. It can provide information about the existence, etiology, location, and severity of obstruction. IVU may fail to detect radiolucent stone, small stone size (less than 5 mm), or poor opacification of the renal collecting system due to severe obstruction.[9-11] Another disadvantage is that IVU may be protracted in patients with obstruction, when delayed images may be required several hours after injection of contrast for complete assessment.[12] IVU involve the use of ionizing radiation and an intravenous contrast medium (CM).[13,14] Non-ionic and low osmolar contrast medium, e.g., iohexol (ominipaque) have been shown to cause fewer serious side effects than ionic medium, e.g., diatrizoate (urographin). The quantity of CM administered to the patient by IV injection should be related to the weight of the patient (300mg/kg body weight).[15] Although IVU is still the in the nonglomerular hematuria, some clinicians use ultrasound in practice. We performed this study to compare the diagnostic value of ultrasound and IVU as the initial evaluation method in patients with hematuria. This study aimed to evaluate the feasibility of replacing IVU with ultrasound as the first line diagnostic modality for cases of patient with hematuria in our hospitals. The main objectives were to measure the diagnostic validity of ultrasound and IVU in the hope of omitting unnecessary and time consuming IVU and to determine whether ultrasound could help to replace the IVU in the diagnosis of patients with hematuria. ultrasound could help to replace the IVU in the diagnosis of patients with hematuria.

Methods

Patient Selection: This is a prospective hospital based study included a convenience sample of hundred patients with hematuria, who were referred for IVU in the radiology department of Rizgary Teaching Hospital; all patients underwent a urinary tract ultrasound and IVU examination. Patients with impaired renal function and history of allergy to iodinated contrast media were excluded.

Methods: All patients underwent a preliminary ultrasound examination of the urinary tract using an ultrasound machine 3.5MHz convex array transducer manufactured by Philips; Origin: Bothell, WA USA; Model No. HDXE version 2010. All patients were thoroughly examined in multiple planes (longitudinal, transverse and oblique axis) in both supine left and right lateral position. The urinary bladder was examined when adequately full. A report was provided at the completion of ultrasound examination. After the ultrasound the patient underwent an IVU examination using an x-ray machine with the fluoroscope (iconos) with control, 500 mAs, manufactured by Siemens; origin Germany; Model 2005, the choice of film sequence was determined by the radiologist supervising the procedure. The contrast media used was water soluble iodinated low osmolar non-ionic contrast. 1ml/kg body weight of iohexol (ominipaque 350) was manually injected intravenously via a median antecubital vein cannula.

Image Analysis

The analysis of IVU: All IVU images were analyzed for renal size, shape, and position, pelvicalyceal system and ureters for any features of dilatation or obstructive hydronephrosis(distension and dilation of the renal pelvis and calyces) or Hydroureter (dilatation of the ureter more than 3 mm), filling defects or compression by space occupying lesion and for detection of urinary calculi.

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Ultrasound results analysis: the Urinary system was evaluated for urinary calculi, obstructive changes or other urinary tract causes of renal pain (e.g., space occupying lesions) or nonurinary tract alternate findings (e.g., pathologies related to the surrounding organs and structures like acute appendicitis, cholecystitis, and ovarian cyst). What is relevant for our study was the detection of urinary calculi, urinary system masses, their sites and presence of associated obstructive changes and the degree of obstruction.

Ethical considerations: Regarding ethical consideration, informed consent to participate in the study was obtained from all patients to obtain their agreement. The nature and the aim of the study explained to all participants through a direct interview, and verbal consent was taken from them beforehand.

Statistical analysis: The statistical analyses were carried out with the statistical package for the social sciences (version 19.0 for Windows). Descriptive analysis, including mean and standard deviation for quantitative variables and frequency, were performed, McNemar test was used and a *P* value less than 0.05 was considered statistically significant. Each entry was double checked to avoid any possible mistakes.

Results

A total of 100 participants were enrolled in the study with the mean age of 37.6 years ranging from 5 to 73 years. In terms of age, 32% of the study sample were less than 30 years, while 28% of them were in their fifth decade. Male participants constituted 52% of the sample and 48% were female. The male to female ratio was 1.08:1. Most participants had sedentary jobs (43%). Hematuria was associated with colic (58%) and with equal sites of renal colic (24%) for both right and left kidneys (Table 1).

Table 1: Age, sex, occupation, hematuria and site of renal colic of participants.

Variables	Categories	No.	%
Gender	Male	52	52
	Female	48	48
Age(years)	≤30	32	32
	30 – 39	24	24
	40 – 49	28	28
	50 – 59	6	6
	≥60	10	10
Occupation	Manual worker	25	25
	Sedentary job	43	43
	House worker	32	32
Hematuria	Renal colic	58	58
	Vague pain	37	37
	Painless	5	5
Total		100	100

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The findings of Table 2 reveal that 52 participants were diagnosed with renal stone by using ultrasound. In contrast, only 24 cases were diagnosed by IVU. The results of Table 3 indicate that among the different degrees of 27 hydronephrosis; IVU diagnosed 17 as mild, nine as moderate while one as severe hydronephrosis. In contrast, nine patients were diagnosed as mild, 17 as moderate and one as severe hydronephrosis by ultrasound.

Table 2: Diagnosis of renal stone by ultrasound and IVU.

Ultrasound	IVU		Total	*P* value (McNemar test)
	Yes	No		
Yes	24	28	52	<0.001
	100%	36.8%	52%	
No	0	48	48	
	0%	63.2%	48%	
Total	24	76	100	
	100%	100%	100%	

Table 3: Comparison between ultrasound and IVU in detecting degrees of 27 hydronephrosis cases.

Ultrasound	IVU			Total	*P* value (McNemar test)
	Mild	Moderate	Severe		
Mild	9	0	0	9	0.001
Moderate	8	9	0	17	
Severe	0	0	1	1	
Total	17	9	1	27	

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Table 4 shows that among the 100 patients, the ultrasound could detect 18 of them with ureteric stone which was more than the IVU of only 14 though the finding was not significant by the McNemar test. Ultrasound had higher ability (79%) in detecting hydronephrosis than IVU (27%). Both ultrasound and IVU had similar capabilities in diagnosing urinary bladder stones (6 cases for each) and renal masses (4 for each). McNemar test was not significant. The findings also reveal that ultrasound was superior in the diagnosis of bladder masses (10 cases) in comparison to IVU (3 patients only).

Discussion

Different imaging methods can be used for a patient with hematuria, each with its capabilities and disadvantages, hematuria either gross or microscopic, may be indicative of serious disease of the genitourinary tract, our study showed that hematuria is more frequent in men than in women. A systemic approach is required to choose diagnostic tools in hematuria cases. A comparison of ultrasound and IVU in our series was in favor of ultrasound for both urinary tract calculi and tumors. IVU lacks a high sensitivity in the diagnosis of renal tumors, particularly the small ones in the anterior or posterior lobe that have not impacted the anatomy of the collecting system. Also, if the patient is sensitive to contrast media or has a poor kidney function, IVU is contraindicated. On the other hand, given its low cost and noninvasive nature, ultrasound can be suggested as an alternative, regarding its accuracy in differentiating solid from cystic masses.[16] Rafique and Javed studied the diagnostic accuracy of IVU and the

Table 4: Comparison between ultrasound and IVU in detection of different parameters.

	IVU			
US	**Yes**	**No**	**Total**	**P-value (McNemar test)**
		Ureteric stone		
Yes	14	4	18	0.133
No	0	82	82	
Total	14	86	100	
		Hydronephrosis		
Yes	27	52	79	
No	0	21	21	< 0.001
Total	27	73	100	
		Urinary bladder stones		
Yes	6	0	6	
No	0	94	94	1.00
Total	6	94	100	
		Renal mass		
Yes	4	0	4	
No	0	96	96	1.00
Total	4	96	100	
		Bladder mass		
Yes	3	7	10	
No	0	90	90	0.023
Total	3	97	100	

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transabdominal ultrasound in 100 patients with bladder carcinoma. They demonstrated that ultrasound is significantly more sensitive than IVU (96% versus 87%; *P* <0.01). Also, ultrasound could determine the pathology of the upper urinary tract such as ureteral obstruction secondary to bladder cancer when IVU failed due to a poor kidney function. They suggested that ultrasound be used as a cost-effective method in cases of suspected bladder tumor.[17] Moreover, Hoenig and coworkers have shown the value of ultrasound in 5 boys aged 11 to 18 years with transitional cell carcinoma.[18] Ultrasound in the diagnosis of hematuria causes is able to show mucosal lesions greater than 4 mm to 5 mm when the bladder is full, while IVU could not show tumors smaller than 1.5 cm. In 2005, Palmer and colleagues performed a study to determine the accuracy of ultrasound and CT scan without contrast in the diagnosis of urinary tract calculi in 75 children. Symptoms including flank pain and/or hematuria were present in 72% of the patients. They found that ultrasound could not detect the calculus in 41% of symptomatic patients, while CT scan was unable to show the calculus in 5%.[19] The Middleton and colleagues have shown a 91% sensitivity for ultrasound in the assessment of calculi remnants after percutaneous nephrolithotomy or shock wave lithotripsy.[20] Marumo and coworkers have studied the hyperechoic spots accidentally found in the kidneys on ultrasound, They followed up 195 patients for 1 to 161 months and performed ultrasound on a yearly basis. Thirty-nine patients had hyperechoic spots while no calculi were detected on radiography. They underwent spiral CT scan with 3-mm cuts and calculi were seen in 31 (79.5%). The authors reported that ultrasound is an effective diagnostic tool for finding calculi of patients with asymptomatic hematuria.[21] Yilmaz and colleagues have studied 112 adult patients with renal colic, and a diagnosis of ureteral calculus was made by ultrasound, IVU, and CT scan. The sensitivity and specificity were 19% and 97% for ultrasound, 52% and 94% for IVU, and 94% and 97% for CT scan, respectively.[22] Although Doppler ultrasound with the measurement of the resistive index and ureteral jet can increase the diagnostic value of ultrasound, ureteral calculi may not be detected when hydronephrosis and ureteral dilatation is not present, or when the patient is obese or has abdominal distention. We considered cases of pathologic hydronephrosis on ultrasound when a definite diagnosis was also calculi, as positive for ureteral calculi and also there were many cases of calculi proximate to the bladder. This can explain the high accuracy of ultrasound that we have found. IVU results were normal for hydronephrosis in these patients. Such cases warrant supplemental diagnostic measures. The results of ultrasound for lower ureteral calculi were superior to IVU; however, it is not a good diagnostic tool if hydronephrosis is absent and the calculus is not near to the ureterovesical junction. Complementary imaging may help us achieve a better result with ultrasound. For instance, using ultrasound and plain abdominal radiography as the first step. Henderson and colleagues reported a 97.1% sensitivity, higher than that of IVU, for urinary calculi in patients with hematuria and flank pain.[23] They found that the likelihood of detecting a disease responsible for hematuria is higher when investigated by ultrasound compared with IVU (sensitivities, 85% versus 62.5%). Mokulis and coworkers performed a study to assess patients with microscopic hematuria by ultrasound when the IVU results are normal; they found that 20% of 101 patients with a normal IVU result had abnormal findings on ultrasound. The authors concluded that ultrasound is necessary for patients with microscopic hematuria when IVU result is normal.[24] A case-control study was done in Italy to compare the results of ultrasound in 516

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patients with hematuria and with those in 1788 controls. They reported a sensitivity of 93% and a specificity of 100% for the diagnosis of hematuria causes.[25]

Conclusion

Ultrasound is operator dependent, compared to IVU. However, many clinicians rely on ultrasound for the evaluation of patients with hematuria, especially when uremia, pregnancy, and other such conditions make IVU contraindicated. In the presence of less-invasive techniques such as shock wave lithotripsy, transurethral resection, transureteral lithotripsy, ureteroscopy, and cystoscopy, ultrasound findings may sometimes be stuffiest to make therapeutic decisions. However, we must decide to choose our diagnostic tool according to the patient's condition and the most suspected disorders causing hematuria. Raising awareness among physicians and urologist in our locality about the high accuracy of ultrasound in diagnosing hematuria and IVU should be preserved only for equivocal cases or when a detailed map of the pelvic-calyceal system is required.

Competing interests

The authors declare that they have no competing interests.

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