Urology Journal
UNRC/IUA

Vol. 3, No. 1, 54-60 Winter 2006
Printed in IRAN

Comparison of Ultrasonography and Intravenous Urography in the Screening and Diagnosis of Hematuria Causes

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ABSTRACT

Introduction: Our aim was to compare transabdominal ultrasonography (US) and intravenous urography (IVU) in the evaluation of patients with hematuria.

Materials and Methods: Two hundred patients with hematuria were assessed by US and IVU, and if needed, by cystoscopy, ureteroscopy, and CT scan, to determine the definite cause of hematuria. The results of US and IVU were compared according to the definite diagnoses.

Results: Of 97 patients with microscopic hematuria, 44 (45%) had a documented cause for hematuria, and of 103 patients with gross hematuria, 76 (74%) had a definite disorder ($P < .001$). Urinary calculi were found in 105 patients, 93 (88.5%) and 73 (69.5%) of which were detected by US and IVU, respectively ($P < .001$). There were 3 and 6 cases of kidney and bladder neoplasms, respectively, all of which were revealed by US, but only 2 renal tumors were detectable on IVU. Ultrasonography had a higher sensitivity than IVU for diagnoses of kidney calculi, lower ureteral calculi, and urologic neoplasms (95.3% versus 65.1% for kidney calculi, $P = .039$; 89.7% versus 69.2% for lower ureteral calculi, $P < .001$; and 100% versus 22.3% for urologic neoplasms, $P < .001$), but in calculi of the middle and upper ureter and of the whole ureter, there were no differences between US and IVU.

Conclusion: Our results are in favor of using US in the initial evaluation of hematuria. However, we must choose our diagnostic tool according to the patient's condition and suspected disorders causing hematuria.

KEY WORDS: hematuria, ultrasonography, intravenous urography, urologic neoplasms, urinary calculi

Introduction

Hematuria is a common complaint among people who refer to urology clinics. In addition, defined as more than 3 red blood cells per high-power microscopic field (HPF), it is generally the most common finding in urinalysis.(1) It has been shown that 2.5% of men aging 28 to 57 years may have an occult hematuria.(2) Blood in urine can be originated from any part of the urinary tract system, attributed to either glomerular or nonglomerular origins.

Glomerular hematuria almost always arises from a medical cause and diagnosis is made by histologic or serologic examinations. Thus, imaging modalities are of no diagnostic value.(1,3) Nonglomerular hematuria is mainly the sign of renal and bladder tumors, urinary tract infections, tuberculosis, trauma, urinary tract calculi, arteriovenous fistula, and renal vessels

Received May 2005
Accepted October 2005
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thrombosis. Intravenous urography (IVU) is the first diagnostic step and, in a sense, the standard method for the evaluation of patients with hematuria.[1,4] Its low cost and objective results, when compared with CT scan, has made IVU the popular method used in most studies.[4] However, some conditions, such as hypersensitivity to contrast media, moderate or severe kidney dysfunction, diabetes mellitus, multiple myeloma, congestive heart failure, and pregnancy limit the use of IVU or are accompanied by a high risk.[3,5,6] Furthermore, this test has a low sensitivity in the diagnosis of small kidney and bladder neoplasms and is not able to differentiate cystic from solid masses.[4]

Transabdominal ultrasonography (US) is a noninvasive tool with an acceptable accuracy in evaluation of the kidney, vessels, prostate, and bladder anatomy.[7] Since it is not dependent on contrast media excretion, US can be used regardless of the kidney function.[5] Ultrasonography is currently the method of choice for the evaluation of children with congenital anomalies of the urinary tract system. It can be used to differentiate solid and cystic masses.[3,8] Notwithstanding its many advantages, US is not recommended in the assessment of the urothelium and diagnosis of transitional cell carcinoma of the renal pelvis or the ureters.[4]

Although IVU is still the classic choice in the diagnosis of nonglomerular hematuria,[1] some clinicians use US in practice. We performed this study to compare the diagnostic value of US and IVU as the initial evaluation method in patients with hematuria.

Materials and Methods

From winter 2002 to autumn 2003, we performed a screening study on patients with hematuria at our urology clinic in Shahr-e-Kord, Iran. A total of 200 consecutive eligible patients were enrolled. The exclusion criteria were fever, viral infections, heavy exercise within the past 48 hours, vaccination within the past week, menstruation period in women, genitourinary trauma, recent sexual activity, and urinary tract infection documented by laboratory assessments. Patients with any condition that contraindicates IVU were excluded, as well.

The patients underwent urinalysis and urine culture. The presence of dysmorphic erythrocytes was determined. If hematuria was documented in urinalysis (more than 3 red blood cells per HPF), IVU, consisting of a plain abdominal radiography and subsequent radiographies after contrast medium injection, was performed under the supervision of a single radiologist. Also, transabdominal US of the urinary tract system with a 3.5-MHz probe was done by another radiologist who was blinded to IVU results.

Cystoscopy was performed in the following conditions: if IVU and US failed to demonstrate the cause, hematuria was reported to be at the beginning or the end of stream, or a pathology was found in the bladder. Rigid ureteroscopy was performed in the following conditions: if IVU and US failed to diagnose hematuria cause despite the presence of unilateral or bilateral pain and other symptoms, if cystoscopy showed a unilateral hematuria from one ureter, or if hydronephrosis without reflux and a definite diagnosis was detected. In case of the detection of a renal tumor in IVU or US, CT scan was carried out. To reduce the potential bias, cystoscopies and ureteroscopies were carried out by a single urologist.

Data including patients' characteristics, physical examination, and diagnostic measures were collected and analyzed. The chi-square, McNemar, and binomial tests were used and confidence intervals were calculated where appropriate. A P value less than .05 was considered significant.

Results

Two hundred patients with hematuria completed the study, of whom, 124 (62%) were male; thus, men were more likely to present with a chief complaint of hematuria. Of 200 patients, 132 (66%) were 40 years old or younger and 68 (34%) were older than 40.

The appearance of the urine specimen was colorless or pale yellow in 97 (48.5%) patients (microscopic hematuria), in 44 (45%) of whom an abnormal finding was detected in further investigation for hematuria causes, but the results were normal in the remaining 53 (55%). Forty-two patients with microscopic hematuria had urinary tract calculi, 1 had a urethral stricture, and 1 had a urethral diverticulum. A red urine was reported in macroscopic examination of 103 patients' specimens (gross hematuria) which was at the beginning of stream, at the end, and during the entire stream in 3 (2.9%), 9 (8.7%), and 91 (88.3%) patients, respectively. No abnormal findings were found in

27 (26%) of the patients with gross hematuria, while a cause for hematuria was confirmed in 76 (74%), including urinary calculi in 63 (61%), renal tumor in 3 (2.9%), bladder tumor in 6 (15.8%), and bleeding from vessels or mucosa of the bladder in 4 (3.8%). Overall, a leading cause for hematuria was found in 120 patients (60%) and no abnormal results were detected in 80 (40%). Identifying an etiology for hematuria was more likely if hematuria was gross (risk ratio = 1.63; confidence interval = 1.96 to 4.36; $P < .001$).

Table 1 demonstrates the causes found for hematuria and the results and sensitivities of IVU and US. Urinary calculi were the definite diagnosis in 105 patients. Ultrasonography revealed the calculi or evidence showing the existence of calculi (such as pathologic hydronephrosis) in 93 patients (46.5%) (58 men and 35 women; 64 in their first 4 decades and 29 older than 40 years). In comparison, IVU detected the calculi in 73 (36.5%) patients (43 men and 30 women; 41 in their first 4 decades and 32 older than 40 years). No significant differences in sex and age category were found between the patients with and those without urinary tract calculi. The results of IVU were normal in 21 of 93 patients (22.5%) with calculi or pathologic hydronephrosis detected by US; while, 3 of 73 patients (4%) with a diagnosis of calculi on IVU had a normal US result. A bladder calculus was found in 1 patient on US and confirmed by cystoscopy, but IVU could not detect it.

There were 3 cases of kidney neoplasm and 6 cases of bladder neoplasm, diagnosed by CT scan and cystoscopy, respectively. All bladder tumors were smaller than 1.5 cm. Ultrasonography was able to find all 9 urologic neoplasms, but only 2 renal tumors were detectable on IVU.

Overall, cystoscopy was carried out in 125

TABLE 1. *Results of ultrasonography (US) and intravenous urography (IVU) in patients with urinary tract calculi, tumors, and other disorders found in the workup for hematuria*

Disease	Definite diagnosis	IVU	US	*P* value
Calculus				
Kidney	43	28 (65.1)*	41 (95.3)	< .001†
Upper ureter	8	7 (87.5)	7 (87.5)	.98†
Middle ureter	14	11 (78.5)	9 (64.3)	.5†
Lower ureter	39	27 (69.2)	35 (89.7)	.039†
Ureter	61	45 (73.8)	51 (83.6)	.21†
Bladder	1	0	1	-
Total	105	73 (69.5%)	93 (88.6%)	< .001
Tumor				
Kidney	3	2 (66.7)	3 (100)	-
Bladder	6	0 (0)	6 (100)	-
Total	9	2 (22.3)	9 (100)	< .001‡
Other				
Urethral stricture	1	-	-	-
Urethral diverticulum	1	-	-	-
Bleeding from vessels or mucosa	4	-	-	-
Total	120	75 (62.5)	102 (85)	< .001†

*Values in parentheses are the sensitivity rates (%) of the respective diagnostic tool
†McNemar test
‡Binomial test

patients and demonstrated 6 and 1 cases of bladder tumors and calculus, respectively. In addition, there were 1 patient with urethral stricture, 1 with urethral diverticulum, and 4 with bleeding from vessels or mucosa, all revealed by cystoscopy only.

Overall, ultrasonography was more sensitive than IVU in cases of kidney or lower ureteral calculi and those of urinary tract tumors (Table 1), but in calculi of the middle and upper ureter and of the ureter as a whole, there were no differences in the sensitivity of US and IVU. Ultrasonography falsely demonstrated hydronephrosis in 6 patients in whom no pathologic finding was revealed by IVU. Also, US was unable to demonstrate hydronephrosis in 7 patients with a positive IVU result. Taking IVU as the gold standard for diagnosis of hydronephrosis, US had an 89.1% sensitivity and a 95.6% specificity (Table 2). Moreover, US and IVU could detect the cause of hematuria in 102 and 75 patients, respectively (85% versus 62.5%; $P < .001$).

TABLE 2. *Ultrasonography and intravenous urography results in the evaluation of hydronephrosis in patients with hematuria**

		Intravenous urography		Total
		+	-	
Ultrasonography	+	57	6	63
	-	7	130	137
Total		64	136	200

*The sensitivity and specificity were 89.1% and 95.6% for ultrasonography.

Discussion

Hematuria, either gross or microscopic, may be indicative of a serious disease of the genitourinary tract. Our study showed that hematuria is more frequent in men than in women. We found no explanation for this sign in 40% of the patients. Kidney and ureteral calculi were the most common causes of hematuria, followed by bladder and kidney neoplasms with a much lower frequency. In agreement with the literature,[1] a definite disorder could be found more frequently in patients with gross hematuria than in those with microscopic hematuria.

Intravenous urography is preferred for diagnosis of urologic causes of hematuria, because of its objective results and standard process.[1,4] It has been especially proved to be helpful for investigation of epithelial tumors of the kidney and the ureters.[4] However, in a study on 16 patients with ureteral tumor, it was shown that transabdominal US could detect all tumors. Ten of 16 patients had an IVU, in 4 of which, a nonfunctional kidney, in 3, an unexplained hydroureteronephrosis, and in 3, a filling defect were detected. There were only 2 cases of filling defects with irregular margins. The authors concluded that US is a good diagnostic tool in ureteral tumors.[9] We had no cases of malignancy in the epithelium of the urinary tract system.

There are different imaging methods that can be used for patients with hematuria, each with its own capabilities and disadvantages. A systematic approach is required to choose diagnostic tools in hematuria cases. A comparison of US and IVU in our series was in favor of US for both urinary tract calculi and tumors, raising a doubt in the use of IVU as the first choice (Table 1). Intravenous urography 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, US can be suggested as an alternative, regarding its accuracy in differentiating solid from cystic masses and to detect angiomyolipomas. Although controversy still exists, some physicians prefer US and dipstick for hematuria to diagnose kidney neoplasms in their early stages, so that surgical treatment can be effective.[10]

Rafique and Javed studied the diagnostic accuracy of IVU and transabdominal US in 100 patients with bladder carcinoma. They demonstrated that US is significantly more sensitive than IVU (96% versus 87%; $P < .01$). In addition, US 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 US be used as a cost-effective method in cases of suspected bladder tumor.[11] Moreover, Hoenig and coworkers have shown the value of US in 5 boys aged 11 to 18 years with transitional cell carcinoma.[12]

Although transrectal and transabdominal US cannot be used in the staging of tumors and determining their invasion to the bladder wall,[13]

they are able to show mucosal lesions greater than 4 mm to 5 mm when the bladder is full. In our series, 6 tumors of the bladder mucosa were detected by US and confirmed by cystoscopy, while IVU could not show tumors smaller than 1.5 cm. We speculate that since most bladder tumors are superficial and low grade, when detected by US, a bimanual physical examination of the pelvis and cystoscopy and resection are enough to assess the grade and invasion. Consequently, CT scan is not necessary and transurethral resection of bladder tumors can be performed before pathologic examination.

In a retrospective study by Eshed and Witzling, it was shown that CT scan, when carried out after US, could not provide additional information in children with kidney calculi aged 1 to 15 years. They suggested that US be used as the first step and CT scan be used only when US results are not normal or not definite.[14] In 2005, Palmer and colleagues performed a study to determine the accuracy of US 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 US could not detect the calculus in 41% of symptomatic patients, while CT scan was unable to show the calculus in 5%. The sensitivity of CT scan was high regardless of the calculi location; whereas, US had a sensitivity of 90%, 38%, and 75% for calculi of the kidneys, the ureters, and both kidneys and ureters, respectively.[15] In contrast to Eshed and Witzling's conclusions, they suggested that CT scan be performed if US is negative for urinary tract calculi. The sensitivity of US and IVU were 95% and 65% in our patients. Middleton and colleagues have shown a 91% sensitivity for US in the assessment of calculi remnants after percutaneous nephrolithotomy or shock wave lithotripsy.[16] On the contrary, a comparison between US, CT scan, plain radiography, and conventional linear tomography has shown that US has the lowest sensitivity for detecting calculi remnants.[17]

Marumo and coworkers have studied the hyperechoic spots accidentally found in the kidneys on US. They followed up 195 patients for 1 to 161 months and performed US 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 US is an effective diagnostic tool in finding calculi of patients with asymptomatic hematuria.[18] Although most calculi that are seen only as hyperechoic spots have no clinical value, the cause of hematuria can be explained by US.

Yilmaz and colleagues have studied 112 adult patients with renal colic and a diagnosis of ureteral calculus was made by US, IVU, and CT scan. The sensitivity and specificity were 19% and 97% for US, 52% and 94% for IVU, and 94% and 97% for CT scan, respectively.[19] The sensitivity of US in our series was 87% for upper, 64% for middle, 89% for lower, and 83% for the entire ureteral calculi. These rates were 87%, 78%, 69%, and 73% for IVU, respectively.

Although Doppler US with the measurement of resistive index and ureteral jet can increase the diagnostic value of US, ureteral calculi may not be detected when hydroureteronephrosis and ureteral dilatation is not present or when the patient is obese or has abdominal distention. We considered cases of pathologic hydronephrosis on US, when definite diagnose 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 US that we have found. It is noteworthy that we had 6 patients with extrarenal pelvis which were falsely diagnosed as hydronephrosis on US. Intravenous urography results were normal for hydronephrosis in these patients. Such cases warrant supplemental diagnostic measures. Intravenous urography is the gold standard with 100% sensitivity and specificity if excretion of contrast medium occurs.

The results of US 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. Consequently, further studies are needed to confirm this finding. In addition, US did not have the same accuracy in different parts of the ureter for diagnosis of calculi and the overall comparison of US and IVU for urinary calculi showed no meaningful difference.

A complementary imaging may help us achieve a better result with US. For instance, using US 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.[20]

We found that the likelihood of detecting a

disease responsible for hematuria is higher when investigated by US compared with IVU (sensitivities, 85% versus 62.5%). Mokulis and coworkers performed a study to assess patients with microscopic hematuria by US when the IVU results are normal. They found that 20% of 101 patients with a normal IVU result had abnormal findings on US. However, none of the findings were clinically important; CT scan and renal angiography revealed no findings in 6 of them. The authors concluded that US in not necessary in patients with microscopic hematuria and a normal IVP result.[21] A case-control study was done in Italy to compare the results of US in 516 patients with hematuria and with those in 1788 controls. They reported a sensitivity of 93% and a specificity of 100% for diagnosis of hematuria causes.[22] It seems that the evaluation of US and IVP regarding all diseases of the urinary tract system may not achieve a consensus; however, we suggest US when the diagnostic choice cannot be identified by the history, physical examination, and laboratory test results in patients with hematuria.

We had a limitation of few cases with bladder calculi and urethral lesions. Measures such as VCUG and cystoscopy can be helpful when initial hematuria and a suspected urethral pathology are present, while IVU and US results are normal.

Conclusion

Ultrasonography is operator dependent, compared to IVU. However, many clinicians rely on the US 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 lithotrpsy, transurethral resection, transureteral lithotripsy, ureteroscopy, and cystoscopy, US 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.

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Editorial Comment

The authors have mentioned that "evidence showing the existence of calculi" has been also considered as a diagnosis of urinary tract calculus on US. To elucidate, the authors have made an example, hydronephrosis which is only suggestive of calculi. However, the cause of hematuria cannot be determined by only the presence of hydronephrosis. One-third of the patients had hydronephrosis in their series, and if all of them are considered as patients with urinary tract calculi, a relatively large proportion of diagnoses by US are not definite. Thus, the superiority of US may be questioned if only definite diagnoses of urinary tract calculi are taken into account.

Abbas Basiri
Editor-in-Chief

Reply by Author

We evaluated all patients with hematuria by complementary measures other than US and IVU, such as ureteroscopy, cystoscopy, and CT scan, to achieve a definite diagnosis. Our aim was indeed to assess the potential of US for case finding in patients with hematuria, thus, considered cases of hydronephrosis and confirmed diagnosis of calculus (by later passage of calculus or diagnostic modalities) as *pathologic hydronephrosis* and positive for calculi. Other cases of hydronephrosis were not included in this analysis.

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