Ultrasound versus Intravenous Urography in the Evaluation of Patients with Hematuria

Mowafak M. Nakshabandi, PhD, D.S,*
Baqir K. Abed, PhD**
Abdulaziz Mohammed, M.B.Ch.B***

الخلاصـــة:

الهـدف: هدفت الدراسة لمقارنة الفحص بالأمواج فوق الصوتية مع التلوين الوريدي للمسالك البولية عند عيّنة من مرضى التبوّل الدَمَويّ.

المنهجيّـة: دراسة عيّنة من خمسة وستين مريض عانوا من تبوّل دَمَويّ (بنوعيه المجهري والظاهري) والذين اختيروا انتقائيا (غير عـشوائيا) بالعيادة الخارجية لجراحة المسالك البوليّة بمستشفى آزادي التعليمي في مدينة دهوك خلال الفترة من كانون ثاني 2006 ولغاية تـشرين الثـاني 2007.

النتائـج: من ثلاثة وأربعين مريض عانوا من التبوّل الدَمَويّ المجهريّ (ثلاثة وعشرين شُخِص فقط سبب التبوّل الدَمَويّ عندهم)، ومـن بـين اثنان وعشرون مريضا عانوا من التبوّل الدَمَويّ الظاهري (ستة عشر فقط كان عندهم أسباب واضحة)، ولم يتمّ التوصّل لسبب التبوّل الـدَمَويّ عند البقية (الستة والعشرين). اثنان وعشرون من المرضى وُجِدَ عندهم حصى الكلى، سبعة عشر منهم شخّصوا بالفحص بجهاز الأمواج فـوق الصوتيّة (السونار) وأربعة عشر شخصوا بالتلوين الوريدي للمسالك البولية. التضخّم الحميد للبروستات أو أورام المسالك البولية الخبيثة (للكلـى والمثانة) شخّصت بجهاز الأمواج فوق الصوتيّة (السونار) ولكن أربعة منهم شخصوا بالتلوين الوريدي للمسالك البوليّة. وكذلك كـان الفحـص بالأمواج فوق الصوتيّة (السونار) هو الطريقة التشخيصيّة المُستخدمَة في حالات التهاب المسالك البوليّة (خمسة مرضى)، بينما لم تـساعد كلتـا الطريقتين بتشخيص الأسباب المتعلقة بالإحليل مثل التضيّق أو الأسباب غير التشريحيّة.

الاستنتاجـات: دراسة عيّنة من خمسة وستين مريض عانوا من تبوّل دَمَويّ (بنوعيه المجهري والظاهري) والـذين اختيـروا انتقائيـا (غيـر عشوائيا). من ثلاثة وأربعين مريض عانوا من التبوّل الدَمَويّ المجهري (ثلاثة وعشرين فقط شُخِص سبب التبوّل الدَمَويّ عندهم)، ومـن بـين اثنان وعشرون مريضا عانوا من التبوّل الدَمَويّ الظاهري (ستة عشر فقط كان عندهم أسباب واضحة)، ولم يتمّ التوصّل لسبب التبوّل الـدَمَويّ عند البقية (الستة والعشرين).

التوصيـات: من نتائج البحث يفضل استخدام الفحص بالأمواج فوق الصوتيّة (السونار) لتقويم أو تشخيص مرضى التبوّل الـدَمَويّ. مـع ذلـك يجب اختيار طريقة التشخيص طبقا لحالة المريض والسبب المتوقع لحدوث التبوّل الدَمَويّ.

Abstract:

Objective: The aim was to compare transabdominal ultrasound examination and intravenous pyelography in the evaluation of patients with hematuria.

Methodology: A prospective study of sixty five patients with micro or macroscopical hematuria who were non randomly selected at the urosurgical outpatient clinic at Azadi General Teaching Hospital (Duhok) during the period from January 2006 to November 2007. They were assessed by ultrasound (U/S) & urography (IVU), and if needed by other sophisticated and invasive measures or intervention to determine the definite cause of hematuria. The result of U/S & IVU was compared according to the definite diagnosis.

Results: Out of 43 patients with microscopical hematuria, 23 patients had an obvious cause for hematuria, and out of 22 patients with gross hematuria, 16 patients had a definite disorder, and no cause could be detected in the rest 26 cases.
Urinary calculi were found in 22 patients, 17 of them detected by U/S and 14 patients were detected by IVU. All benign (Benign prostatic hypertrophy BPH) or malignant urological tumors (renal and bladder) were diagnosed by U/S but only 4 of them were detected by IVU. Similarly U/S was diagnostic in all urological infections (5 patients), while none of them was helpful in diagnosing causes in the urethra like stricture or causes without anatomical changes.
Conclusions: Sixty five patients with micro or macroscopical hematuria were assessed by ultrasound (U/S) & urography (IVU), to determine the definite cause of hematuria. Out of 43 patients with microscopical hematuria, 23 patients had an obvious cause for hematuria, and out of 22 patients with gross hematuria, 16 patients had a definite disorder, and no cause could be detected in the rest 26 cases.

Recommendations: Our results are in favor of using U/S in the initial evaluation of hematuria. However we must choose our diagnostic tool according to the patient's condition and suspected disorder causing hematuria.

Key words: Ultrasound, Urography, Hematuria.

* Assistant Professor, College of Medicine, Duhok University,
** Assistant Professor, College of Medical and Health Technology, Board of Technical Education
*** Senior Registrar (Urology), Azadi Teaching Hospital, Duhok.

Introduction:

Hematuria is defined as the presence of more than three red blood cells per high power field examination of the urine [1]. Both microscopic and macroscopic hematuria are encountered frequently in the clinical medical practice, particularly in the nephrology and urosurigcal branches and regarded as the most common finding in the urine examination [2].

Regarding the source or the cause of hematuria (excluding the systemic causes), it could be due to either glomerular (medical) cause where no abnormality could be seen by the imaging modalities, for example Glomerulonephritis [3], or local urological (surgical) one, for example Urinary stones, renal or bladder tumors, trauma including the surgical one, arteriovenous fistulae, malformations and congenital pathologies [4].

Ultrasonography (Trans-abdominal and the colored Doppler) is a non invasive, cheap, available and with acceptable accuracy in the initial evaluation of the non-glomerular cause of hematuria whether the source is in the kidney (regardless of the renal function) [5], bladder, prostate or vascular one [6]. Ultrasonography (U/S) is the method of choice for the evaluation of the children with congenital anomalies of the urinary tract, and it is safe in pregnancy and it can differentiate cystic from solid masses [7], but it still of little benefit in the evaluation of the early urothelial tumors of the renal pelvis and ureter and it is considered to be "operator dependent". On the other hand, intravenous urography is regarded as the standard method for the evaluation of patients with hematuria [8], its objective result and low cost in comparison with computerized tomography scan (CT) or magnetic resonance imaging (MRI) has made intravenous urography (IVU) more popular method than other studies [9].

However, some conditions like contrast sensitivity, renal dysfunction, congestive cardiac failure and pregnancy limit the use of IVU for its high risk [10], and has low sensitivity in the diagnosis of small bladder tumors and it is not able to differentiate cystic from solid masses [11].

The study aims to compare the use of U/S and IVU in the evaluation of patients with hematuria.

Methodology

A prospective study of sixty five patients with micro or macroscopical hematuria who were non randomly selected at the urosurgical outpatient clinic at Azadi General Teaching Hospital (Duhok) during the period from January 2006 to November 2007. The exclusion criteria were fever, heavy exercise, menstruation or vaginal bleeding, past history of known urological pathology or urethral catheterization, recent abdominal trauma and those patients with contraindication for IVU.

Initially, urinalysis is performed to confirm the presence of more than three red blood cells per high power field. Transabdominal ultrasound examination of the urinary system using the 3.5 MHz probe (using TOSHIBA ultrasonography from Japan) was done by the same expert operator or sonographer and IVU is also performed at radiology department of Azadi Teaching Hospital after good preparations which are done under supervision of expert radiologist, the result of U/S and IVU were compared with each other and with the definite surgical diagnosis which was done by the Senior urologist.

Further investigations or interventional procedures were performed to reach the definite cause of the hematuria like CT scan, MRI, cystoscopy, ascending pyelography and ureteroscopy.

Statistical analysis was done by using descriptive statistics which include frequencies, percentages and screening test to measure the sensitivity and specificity with positive and negative predictive values of U/S, IVU and surgical diagnosis which regarded as a gold standard.

Results

There were 28 male and 37 female, their age ranges from 2-75 years. Microscopical hematuria seen in 43 patients and macroscopical one in 22 cases.

Regarding the causes of microscopical hematuria, urinary stones were found in 12 (27.9 %), urinary tract infection (UTI) in 5(11.6%), urethral tumors in 2 (4.6%), renal tumor inl (2.3%), urethral stricture in 1(2.3%), prostatic malignancy in one patient (2.3%) and bleeding BPH in one (2.3%). No cause could be detected in further investigations in 20 patients (46.5%) with microscopical hematuria.

In patients with macroscopical hematuria, urinary stone was found in 10 (45.4%) patients, urothelial tumor in 4 (18.1%), renal tumor in 1 (4.5%), BPH in one (4.5%) and bleeding from bladder mucosa in one patient (4.5%) and no cause could be detected in the rest 5(22.7%) patients.

The overall results regarding the causes of hematuria were found in 40 (61.5%) patient and no abnormal results were detected in 25 (38.4%) patients.

Table 1. Distribution of the study population according to the pathology and method of diagnosis

	Pathology	Definite diagnosis	IVU (+ve)	U/S (+ve)
Stones	Renal	**16**	**10**	**14**
	Ureteric	5	4	2
	Bladder	1	0	1
	Total	22	14(63%)	17(77%)
Masses	Renal	2	1	2
	Bladder	6	2	6
	Prostatic	1	0	1
	BPH	2	1	2
	Total	11	4	11
Urinary Tract Infection	Renal	2	1	2
	Bladder	2	0	2
	Prostatic	1	0	1
	Total	5	1(20%)	5(100%)
Others	Stricture	1	0	0
	Mucosal Bleeding	1	0	0
	Total	2	0	0

IVU=Intravenous Urography, U/S=Ultrasonography

Table (1) shows the details of the causes of hematuria, and the initial results of ultrasound, intravenous urography results and their sensitivities.

Urinary tract calculi were the definite diagnosis in 22 patients. Ultrasound revealed the calculi or evidence showing the existence of calculi (such as pathologic hydronephrosis) in 17 patients (77%). In comparison, IVU detected the calculi in 14 patients (63 %). A bladder calculus was found in 1 patient on US and confirmed by cystoscopy, but IVU could not detect it. There were 2 cases of renal neoplasm diagnosed by CT, and 6 cases of bladder neoplasm, all diagnosed by U/S (less than 2 cm) while the IVU gave positive results in 2 cases only (large size filling defects). US examination was able to suspect prostatic neoplasm in one case

with a normal IVU which was diagnosed by tru-cut prostatic biopsy.

Urinary tract infections in form of pyelonephritis, pyonephrosis, cystitis and prostatitis seen in 1, 1, 2 and 1 patient respectively by U/S but only one of these patients gave positive results in IVU.

Overall, cystoscopy was carried out in 28 patients and demonstrated 6 bladder tumors, 2 BPH, 1 vesical stone, 1 urethral stricture, 1 prostatic cancer and 1 case of vesical mucosal bleeding, and the rest of 16 cystoscopies were normal. Neither U/S nor IVU were valuable in the diagnosis of urethral stricture or causes of hematuria that doesn't cause anatomical change like bleeding from mucosa in anatomically normal urinary bladder.

Ultrasound falsely demonstrated hydronephrosis (moderate in severity) in 3 patients in whom no pathology could be found in IVU. Regarding the surgical diagnosis as gold standard, the U/S has 82.5% sensitivity and 88% specificity, table 2, while IVU has 47.5 % sensitivity and 100 % specificity, table 3.

Table 2. Sensitivity and specificity of US versus surgical diagnosis in detection of the causes of hematuria

		Surgical diagnosis		Total
		+ve	- ve	
Ultrasonography	+ve	33	3	36
	-ve	7	22	29
Total		40	25	65

Regarding the surgical diagnosis as a gold standard, the US has 82.5 % sensitivity and 88 % specificity. Positive predictive value= 91.6 % & Negative predictive value=75.8 %

Table 3. Sensitivity and specificity of IVU versus surgical diagnosis in detection of the causes of hematuria.

		Surgical diagnosis		Total
		+ve	-ve	
IVU	+ve	19	0	19
	-ve	21	25	46
Total		40	25	65

Regarding the surgical diagnosis as a gold standard the IVU has 47.5 % sensitivity and 100 % specificity. PPV= 100 % & NPV=54.3 %

Discussion

Hematuria; either gross or microscopic, may be indicative of a serious disease of the urinary tract. Although in this study the females were more frequently presented with hematuria than males, contrary to other study which showed the reverse [7]. Kidney and ureteric calculi were the most common causes of hematuria, followed by urinary neoplasm then urinary tract infections. In agreement with the literature [1], a definite disorder could be

found more frequently in patients with macroscopical hematuria than in those with microscopical one [7].

Although IVU is preferred for the diagnosis of urological causes of hematuria for its objective results and standard process [1,4], ultrasound in this study is proved to be superior to IVU in detecting urinary tract tumors, especially in urothelial tumors of the bladder and the kidneys in their early stages when there was no impact on the collecting system, (in this study all the bladder and renal tumors were detected by U/S, while 3 out of 9 urinary tumors were detected by IVU), a similar results were reported by one study [7]. Another study has examined the diagnostic accuracy of IVU and transabdominal U/S in 100 patients with bladder carcinoma, it demonstrated that U/S is significantly more sensitive than IVU (96% versus 87%; $P< 0.01$) for urinary bladder detection [8]. In addition that U/S could detect upper urinary tract dilatation secondary to bladder cancer when IVU failed to do so due to poor renal function, U/S has been suggested as a cost-effective diagnostic method in cases of superficial bladder cancer as it can detect mucosal lesions as small as 4-5 mm when the bladder is full, and most of the bladder tumors are superficial and low grade.

Regarding the urinary stones, U/S was more sensitive in detecting renal and vesical stones, while IVU was more sensitive for ureteric stones. Although IVU is regarded as the gold standard investigation in urology with 100% sensitivity and specificity if excretion of the contrast occurs ([1], this differs from the result in our study possibly due to the different technique used in the other centers.

A study was conducted to determine the accuracy of U/S and CT scan without contrast in the diagnosis of urinary stones in 75 children, it found that U/S had a sensitivity of 90%, 38%, and 75% for calculi of the kidney, ureter and both kidneys and ureter respectively [9]. It was showed that a sensitivity of 91% for US in the diagnosis of residual stones [10].

Another study has investigated the hyperechoic spots accidentally found in the kidney on U/S. Thirty nine patients had hyperechoic spots, while no calculi were detected on the ordinary radiography, while in 31 patients out of them, there were calculi seen in the spiral CT. So, the author concluded that U/S is an effective diagnostic tool in finding calculi of patients with asymptomatic hematuria [11]. Although most calculi that are seen only as hyperechoic spots have no clinical value, the cause of hematuria can be explained by U/S.

A study was performed to assess patients with microscopical hematuria by U/S when IVU results were normal; it was found that 29% of 101 patients with a normal IVU result had abnormal finding in U/S. However, none of the U/S findings were clinically significant (supported by CT and angiogram). So, the author concluded that U/S examination is not necessary in patients with microscopical hematuria and normal IVU result [12].

There are some limitations in the diagnosis of the cause of hematuria in patients with urethral and some vesical or prostatic lesions. Measures like cystoscopy can be helpful when initial hematuria and suspected urethral pathology are present, while IVU and U/S results are normal. A study has compared the results of ultrasound in 516 patients with hematuria and with those in 1788 controls; it was reported that a sensitivity of 93% and specificity 100% for detecting the cause of hematuria [13].

We had a limitation of few cases with urethral and prostatic lesions, measures such as urethrography or urethrocystoscopy can be helpful when initial hematuria and a suspected urethral pathology are present, while U/S and IVU are normal.

Conclusions

Sixty five patients with micro or macroscopical hematuria were assessed by ultrasound (U/S) & urography (IVU), to determine the definite cause of hematuria. Out of 43 patients with microscopical hematuria, 23 patients had an obvious cause for hematuria, and out of 22 patients with gross hematuria, 16 patients had a definite disorder, and no cause could be detected in the rest 26 cases. Urinary calculi were found in 22 patients, 17 of them

detected by U/S and 14 patients were detected by IVU. All benign (Benign prostatic hypertrophy BPH) or malignant urological masses (renal and bladder) were diagnosed by U/S, but only 4 of them were detected by IVU. Similarly, U/S was diagnostic in all urological infections (5 patients).

Recommendations

Although ultrasound examination is regarded as an operator-dependent in comparison with IVU, still we may rely on it for diagnosing the cause of hematuria rather than by IVU for its higher sensitivity and specificity in detecting early renal pathologies and in the cases where IVU is contraindicated. However, we must choose our diagnostic tool according to the patient's condition and the most suspected disorders causing hematuria.

References

1. Gerber, G.; Brendler, C.: Evaluation of the Urologic Patient: History, Physical Examination and Urinalysis. In: Walsh, P.; Retik, A.; Vaughan, E., et al., **Campbell's Urology**. 8th ed. 2002, Philadelphia: WB Saunders, P.P.83-110.

2. Schulam, P.; Kawashima, A.; Sandler, C.; Barron, B.; Lamki, L. and Goldman, S.: Urinary Tract Imaging–Basic Principles. In Walsh, P.; Retik, A.; Vaughan, E.; et al., **Campbell's Urology**. 8th ed. Philadelphia: WB Saunders; 2002, P.122-67.

3. Fleischer, A.: Renal and Urological Sonography. In Walsh, P.; Retik, A.; Vaughan, E.; et al., **Diagnostic Sonography: Principles and Clinical Applications. Philadelphia**: WB Saunders; 1989, P.433-517.

4. Jones, S. and Richards, D.: Imaging Investigation of the Urological Tract. In: Sutton, D. **Textbook of Radiology and Imaging**. 6th ed. New York: Churchill Livingstone; 1998, P.1113-29.

5. Yip, S.; Peh, W.; Tam, P.; Li, J. and Lam, C.: Role of Ultrasonography in Screening for Urological Malignancies in Patients presenting with Painless Haematuria. **Ann Acad Med Singapore**. 1999, 28: P.P.174-7.

6. Eberhardt, S. and Hricak, H.: **Radiology of the Urinary Tract**. In: Tanagho, E. and McAninch, J.: Smith's General Urology. 16th ed. New York (USA): Lange Medical Books/McGraw-Hill; 2004, P.62-111.

7. Esfahani, M. and Momeni, A.: Comparison of Ultrasonography and Intravenous Urography in the Screening and Diagnosis of Hematuria Cases: **Urology Journal,** 2006, 3(1): P.P.54-60.

8. Rafique, M. and Javad, A.: Role of Intravenous Urography and Transabdominal Ultrasonography in the Diagnosis of Bladder Carcinoma. **Int Braz J Urol**, 2004, 30:P.P.185-90.

9. Palmer, J.; Donaher, E.; O'Riordan, M. and Dell, K.: Diagnosis of Pediatric Urolithiasis: Role of Ultrasound and Computerized Tomography. **J Urol**. 2005, 174: P.P.1413-6.

10. Middleton, W.; Dodds, W.; Lawson, T. and Foley, W.: Renal Calculi: Sensitivity for Detection with US. **Radiology**, 1988, 167: P.P.239-44.

11. Marumo, K.; Horiguchi, Y.; Nakagawa, K.; et al.: Significance and Diagnostic Accuracy of Renal Calculi Found by Ultrasoography in Patients with Asymptomatic Microscopical Hematuria. **Int J Urol**. 2002, 9: P.P.363-7.

12. Moklis, J.; Arndt, W.; Downey, J.; Caballero, R. and Thompson, I.: Should Ultrasound Be Performed in the Patient with Microscopic Hematuria and A normal Excretory Urogram? **J Urol**. 1995, 154: P.P.1300-1.

13. Scialabba, A.; Vecchi, M.; Vigneri, S. et al.: The Ultrasonographic Examination in Hematuria. Evaluation of Diagnostic Possibilities. **Minerva Urol Nephrol**. 1992, 44: P.P.185-90.