

## Genitourinary radiology

# Colour Doppler sonography and plain abdominal radiography in the management of patients with renal colic

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**Abstract.** To assess whether the routine use of urography (IVU) is still needed in the management of patients with renal colic and suspected ureteral calculus obstruction, we prospectively evaluated 52 patients with renal colic by a combination of colour Doppler ultrasound (CDU) and plain abdominal radiography (KUB). Forty-six patients (88.4%) were successfully treated without the need for IVU. Urography was required as a pre-lithotripsy procedure ( $n = 4$ ) and to confirm non-dilated ureteral calculus obstruction uropathy ( $n = 2$ ). The mean resistive index (RI) in normal subjects ( $n = 14$ ) was  $0.62 \pm 0.06$  and in obstructed kidneys ( $n = 37$ ) was  $0.68 \pm 0.07$ , the difference being statistically significant ( $p < 0.001$ ). Eight patients with functionally significant high-grade obstruction had a mean RI of  $0.69 \pm 0.06$ , absent ureteral jet and interrenal RI difference  $> 0.07$ . CDU and KUB provide anatomical and functional information sufficient for the management of the great majority of patients with renal colic without the use of urography.

**Key words:** Genitourinary system, ultrasound - Hydronephrosis - Ureteral calculi

## Introduction

The combination of real-time sonography and plain abdominal radiography (KUB) has been shown to be as effective as urography (IVU) for evaluating patients with renal colic and suspected ureteral calculus obstruction [1-9]. However, this approach suffered from potential false-negative diagnosis in patients with grade 1 hydronephrosis and non-dilated ureteral calculus obstruction, and provided no functional information on the degree or severity of obstruction.

Preliminary investigations have demonstrated the ability of Doppler ultrasound in evaluating renal function in patients with medical parenchymal disease [10, 11]. This study was performed in order to assess the value of colour Doppler ultrasound (CDU) in ureteral calculus obstruction and to test whether its combination with KUB can obviate the routine use of IVU in patients with this disease.

## Methods

Between September 1991 and February 1992, 52 consecutive patients presenting with renal colic and suspected to have ureteral calculus obstruction were investigated upon admission to the Accident and Emergency Department by a combination of CDU and KUB. It was agreed with the clinicians that an IVU would additionally be performed only if it was felt to be essential for the patient's management. The patients comprised 51 adults (44 men, 7 women) with an age range from 19 to 64 years (mean 41.5 years) and 1 child aged 10 years. The majority of patients ( $n = 43$ ) had symptoms of less than 3 days' duration, while only 9 patients had had symptoms for more than 3 days.

Patient preparation consisted of intravenous hydration or oral ingestion of 500 ml of water in order to obtain a full bladder and to enhance ureteral jets. All patients were initially examined by real-time sonography of both kidneys for detection of hydronephrosis manifested as separation of the renal sinus polar echoes in excess of 5 mm. This was followed by a CDU examination of the urinary tract using a general-purpose sector transducer (Acuson 128, Mountain View, CA) operating at a pulsed Doppler frequency of 3.5 MHz. A 3 mm sample volume and low pass filter (125 Hz) were used. Three to seven Doppler samples were obtained from the intrarenal arteries of each kidney on both sides during arrested inspiration. The time-velocity Doppler waveforms were analysed for resistive index (RI) values using the Acuson computer measurement system;

**Table 1.** Summary statistics of the resistive index study

Diagnostic group	No. of Patients	No. of kidneys examined	Mean resistive index (RI)	Standard deviation ( $\pm 1$ SD)	No. of observations	Significant difference
I Normal	14	27	0.62	0.06	119	
II Dilated obstructed	34	RI(+) = 33 RI(-) = 27	0.70 0.61	0.06 0.06	176 109	<< 0.001
III Non-dilated obstructed	4	RI(+) = 4 RI(-) = 2	0.59 0.62	0.05 0.03	22 7	Nil
II, III All obstructed	38	RI(+) = 37 RI(-) = 29	0.68 0.61	0.07 0.06	198 116	<< 0.001

RI(+), resistive index in obstructed kidneys; RI(-), resistive index in contralateral normal kidneys

**Table 2.** Ureteral jets

		Jets		
		Absent	Symmetrical	Asymmetrical
Non-obstructed kidneys ( $n = 14$ )	14	0	14	0
Obstructed kidneys ( $n = 38$ )	36	24	10	2

RI was defined as the ratio [(peak systolic velocity – minimum end diastolic velocity)/(peak systolic velocity)]. The bladder was examined in a transverse section and the number of ureteral jets at both ureteral orifices recorded during 5 min of scanning. Functional correlation with the serum creatinine level was obtained in all patients.

A total of 433 RI measurements were undertaken on the 52 patients, giving an average of approximately 4 measurements per kidney. Individual RI measurements were pooled within each diagnostic group to obtain the group mean RI values, and for testing for significant differences between sample variances and means using Snedecor's *F*-test and Student's *t*-test respectively.

## Results

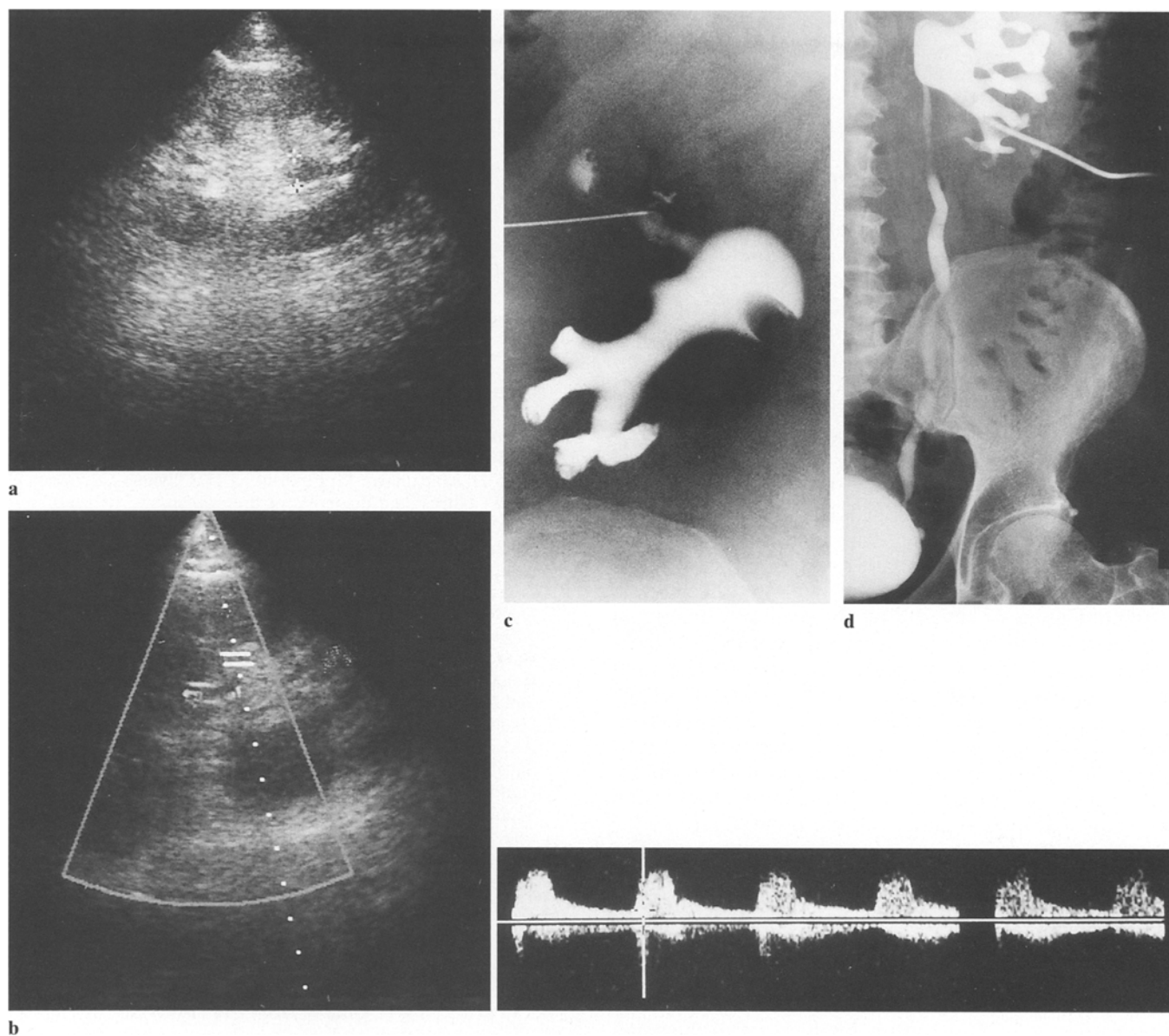
Thirty-eight patients had ureteral calculus obstruction and 14 patients had a normal urinary tract, as confirmed by clinical data and case records. Of 38 patients with ureteral calculus obstruction, 27 had spontaneous passage of a small calculus less than 5 mm in radiographic size and 11 underwent intervention procedures for removal of stone. Of 29 patients with acute obstruction (i.e. symptoms of less than 3 days' duration), 26 (89.6%) had spontaneous passage of calculus and 3 (10.4%) underwent intervention. Of 9 patients with subacute obstruction (i.e. symptoms of more than 3 days' duration), 1 (11.1%) had spontaneous passage of calculus and 8 (88.9%) underwent intervention. Four patients had non-dilated ureteral calculus obstruction, 2 of whom had spontaneous passage of calculus while the other 2 underwent lithotripsy for impacted calculus causing pain.

Plain abdominal radiographs showed calculi in 25 of 38 patients with urinary tract obstruction caused by ureteral calculus. The combination of CDU and KUB provided correct diagnosis in all 14 patients with a normal urinary tract and in 37 patients with ureteral calculus obstruction. The combination of CDU and KUB failed to diagnose non-dilated ureteral calculus obstruction in only 1 patient, while correct diagnoses were obtained in all patients with grade 1 hydronephrosis proven to have ureteral calculus obstruction. The majority of patients ( $n = 46$ ) were completely managed with CDU and KUB without the use of urography. Six patients required additional IVU requested by urologists as a pre-lithotripsy procedure ( $n = 4$ ) and to confirm non-dilated ureteral calculus obstruction ( $n = 2$ ).

The data analysis of the recorded RI values or observations for each group of patients is summarised in Table 1, together with the statistical significance of differences between normal and obstructed kidneys. The mean RI of normal kidneys ( $n = 27$ ) in 14 patients with 119 observations was  $0.62 \pm 0.06$ . The interrenal difference (IRD) of the average RI values between normal kidneys in the same subject was always  $< 0.06$ . The mean RI of obstructed kidneys ( $n = 37$ ) in 38 patients with 198 observations was  $0.68 \pm 0.07$ . In only 1 patient with obstruction could no RI values or Doppler signals be obtained because of a small pyelonephritic kidney. In obstructed kidneys 18 RI values or observations (9%) were  $< 0.60$ ; 14 of these values were due to either non-dilated ureteral calculus obstruction or recent passage of calculus. The IRD of the average RI values between obstructed kidney and contralateral normal kidney was  $> 0.06$ . There was a statistically significant difference between mean RI values of normal and obstructed kidneys ( $p < 0.001$ ).

The results of ureteral jets are summarised in Table 2. Asymmetrical jets were identified as weak jets with a discrepancy in number, i.e. at least 4 jets fewer on the obstructed side than on the contralateral normal side. Jets were symmetrical in all 14 normal subjects. It was not possible to obtain jets in 2 patients with obstruction because they could not tolerate a full bladder.

Eight patients with functionally significant obstruction with either elevation of the serum creatinine level above  $115 \mu\text{mol/l}$  ( $n = 4$ ), decreased relative glomerular



**Fig. 1a-d.** Images of functionally significant high-grade obstruction in an adult man with anuria, high serum creatinine, right kidney nephrectomy, and acute left ureteral calculus obstruction. **a** Longitudinal sonogram of the left kidney showing separation of the lower pole sinus echoes compatible with grade 1 hydronephrosis (calyceal diameter 9.6 mm). **b** Doppler waveform obtained from the intrarenal artery showing a significantly elevated resistive index (RI) of 0.80. **c** Fine-needle antegrade pyelogram demonstrating complete obstruction of the left kidney at the pelvi-ureteric junction by a large non-opaque calculus. **d** Nephrostogram following extracorporeal shock wave lithotripsy showing disappearance of calculus and relief of obstruction

filtration rate on technetium-99 m diethylenetriamine-pentaacetic acid (DTPA) renography ( $n = 3$ ), or delay in excretion on IVU of more than 30 min ( $n = 1$ ), had a mean RI of  $0.69 \pm 0.06$ , absent ureteral jet and IRD  $> 0.07$ .

## Discussion

Our results have shown that IVU may no longer be required as a routine procedure in the management of patients with suspected ureteral calculus obstruction. Clinicians and radiologists in our institution were satisfied with the information provided by the combination of CDU and KUB as the sole imaging procedure needed for the investigation of the great majority of patients (88.4%) with renal colic. This result compares favourably with an overall accuracy of 88% reported by Deyoe et al. [12] for the combination of CDU and KUB in the evaluation of acute renal obstruction. Selective IVU was required for the management of some patients before extracorporeal shock wave lithotripsy (ESWL), and to confirm non-dilated ureteral calculus obstruction. In this study, the important criteria for intervention were in the following order: size of calculus  $\geq 6$  mm; duration of symptoms  $> 3$  days, indicating stone impaction that is unlikely to pass spontaneously (the stone size may be less than 5 mm and causing no hy-

dronephrosis); an elevated serum creatinine level; urosepsis; grade 2 or 1 hydronephrosis;  $RI > 0.69$ ;  $IRD > 0.07$ ; and absent ureteral jet on CDU.

In unilateral ureteral calculus obstruction two pathophysiological parameters can be studied on CDU. Firstly, the RI can be elevated due to a rise in renal arterial vascular resistance produced by preglomerular vasoconstriction with subsequent reduction in diastolic blood flow and glomerular filtration, and secondly an abnormal ureteral jet can be identified at the ureteral meatus in the bladder. The addition of a colour Doppler facility to real-time sonography provided pathophysiological information that helped to eliminate potential pitfalls in diagnosis due to grade 1 hydronephrosis, by demonstrating an elevated  $RI > 0.60$ ,  $IRD > 0.06$ , and abnormal ureteral jet suggesting obstruction in a minimally dilated collecting system. However, non-dilated ureteral calculus obstruction remains a diagnostic pitfall that can be missed by CDU because of the lack of dilatation and abnormal changes in the RI and ureteral jet, although KUB might demonstrate a calculus in the line of the ureter in the majority of cases ( $n = 3$ ). The information provided by CDU can also help to differentiate varying degrees or severity of obstruction – functional information similar to that obtained from IVU or technetium-99 m DTPA renography. This can be classified into low-grade obstruction with  $0.60 < RI < 0.69$ ,  $IRD > 0.06$ , and a ureteral jet that can be absent, symmetrical or asymmetrical. A functionally significant high-grade obstruction (Fig. 1) that can lead to potential damage to kidney function will show an elevated  $RI > 0.69$ ,  $IRD > 0.07$  and an absent ureteral jet.

Our results are comparable with other reported figures in recent studies with regard to mean RI values in normal and obstructed kidneys [11, 13] and the ureteral jets findings [14]. However, they are different from the results of other investigators [15–17] who reported a mean RI values of 0.58 and 0.60 for normal kidneys and mean RI values of 0.75 and 0.77 for obstructed kidneys respectively. This is probably because of the small number of patients with obstruction (4 patients) in the study of Gottlieb et al. [15], and perhaps because our study included 13 patients with very acute obstruction ( $< 8$  h), 4 patients with non-dilated ureteral calculus obstruction and 12 patients with a present ureteral jet indicative of partial obstruction in whom the RI values may be less than 0.70. As mentioned by Platt [16] the technique is operator dependent hindered with technical errors, and the RI values can be affected by certain pathophysiological conditions. Nevertheless, it is important to compare the results of RI values of each kidney in the same subject, looking for a significant IRD between the obstructed kidney and the contralateral normal kidney.

In conclusion, the combination of CDU and KUB provides sufficient anatomical and functional information for the management of the great majority of patients with renal colic without the routine use of urography. It is an effective alternative method that could replace IVU in the initial evaluation and follow-up of patients with suspected ureteral calculus obstruction. Se-

lective IVU can be performed as a second-line investigation in patients considered candidates for ESWL or other intervention, to confirm non-dilated ureteral calculus obstruction, and when the combination of CDU and KUB remains undiagnostic on follow-up examination of a patient with persistent colic.

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