Diagnostic value of renal resistive index for the assessment of renal colic

Kavakli H S, Koktener A, Yilmaz A

ABSTRACT

Introduction: The aim of this study was to investigate the value of renal resistive index (RI) for the assessment of renal colic and to determine whether it is predictive of renal stone disease.

Methods: A total of 70 participants were included in the research study. Group I comprised 43 patients with acute unilateral ureteral obstruction due to a stone disease (G1), while Group 2 consisted of seven patients with flank pain without stone disease (G2) and the control group comprised 20 healthy individuals with two normal kidneys (G3). Urinalysis, abdominal plain film radiography, conventional ultrasonography (US) and colour Doppler US were performed in all three groups. RI was calculated for all patients using Doppler US. The RI values in G1 were then compared with those in G2 and the control group.

Results: There were statistically significant differences in the RI between the stone-positive group and stone-free groups (0.71 +/− 0.07 for G1; 0.69 +/− 0.06 for G2; 0.62 +/- 0.03 for G3, p-value < 0.05).

Conclusion: RI measurement using Doppler US can be effectively used for the assessment of renal colic patients by non-invasive means.

Keywords: Doppler ultrasound, emergency department, renal colic, resistive index, stone disease

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INTRODUCTION

Ureterolithiasis is a frequent cause of admission to emergency departments, and it is mostly diagnosed through radiologic imaging.[1] Plain abdominal radiography, conventional ultrasonography (US) and intravenous urography (IVU) are widely applied diagnostic tests for assessment of acute renal colic.[2] Doppler and conventional US findings promote diagnosis in patients with flank pain.[3]

Although helical computed tomography (CT) has been considered the gold standard for the diagnosis of obstructive uropathy, it is not always a convenient option.[4] Moreover, 5% of all urinary calculi are radiolucent, and radioopaque calculi that lie in the segment of the ureter within the bony pelvis may be confused with phleboliths. In conventional US, findings related to the disease are not seen in 50% of the patients with acute urinary obstruction, and distinguishing an obstructed from a non-obstructed dilated renal collecting system is not easy.[5] Doppler US can improve the clinical utility of US in patients with urinary obstruction by using a resistive index (RI) to quantify changes in intrarenal arterial Doppler US waveforms. [RI = (peak systolic velocity – end diastolic velocity)/peak systolic velocity]. Doppler and conventional US can confirm not only the morphologic, but also the functional information on altered blood flow and urinary flow in patients with urinary obstruction.[5-9] This study aimed to investigate the utility of RI in the diagnosis of renal colic due to stone disease.

METHODS

Our study included 50 consecutive patients with flank pain who were admitted to our emergency service and 20 healthy individuals without any urological symptoms. Patients were grouped according to the presence of flank pain but stone on US at admission: Group 1 (G1) included patients who had flank pain and were stone-positive; Group 2 (G2) comprised patients who had flank pain but were stone-negative; and Group 3 (G3, control) consisted of healthy individuals. Only patients who had monolateral renal colic at admission were included in the study. The inclusion criteria were no clinical history and laboratory data suggestive of renal, renovascular or cardiovascular disease. All patients reported to the emergency service 4–48 hours after the onset of renal colic.

The presence of a stone was diagnosed by plain abdominal radiography and US. All patients underwent conventional and Doppler US. All US examinations were performed by the same radiologist. The US system, Sonoline Antares (Siemens AG, Munich, Germany), which was equipped with a 2–5 MHz convex transducer,

Department of Emergency, Ankara Ataturk Training and Research Hospital, Bilkent Yohu No. 3, Bilkent 06800, Ankara, Turkey

Kavakli HS, MD
Specialist

Department of Radiology, Fatih University, Alparslan Turkes Cd No. 57, Emek 06510, Ankara, Turkey

Koktener A
Associate Professor

Department of Anaesthesiology, Duzce University, Konuralp Yerleskesi, Konuralp 81620, Duzce, Turkey

Yilmaz A, MD
Assistant Doctor

Correspondence to:
Dr Havva Sahin Kavakli
Tel: (90) 312 291 2500
Fax: (90) 312 291 2739
Email: havvasahin1973@yahoo.com

Table I. Demographic characteristics of participants.

Characteristic	No. (%)			
	G1 (n = 43)	G2 (n = 7)	G3 (n = 20)	Total (n = 70)
Gender				
Female	14 (32.6)	1 (14.3)	15 (75.0)	30 (42.9)
Male	29 (67.4)	6 (85.7)	5 (25.0)	40 (57.1)

G1: Group 1; G2: Group 2; G3: Group 3 (control)

Table II. Distribution of symptoms in the groups.

	No. (%)			
	G1 (n = 43)	G2 (n = 7)	G3 (n = 20)	Total (n = 70)
Accompanying symptom				
Present	24 (55.8)	3 (42.9)	0 (0.0)	27 (38.6)
Absent	19 (44.2)	4 (57.1)	20 (100.0)	43 (61.4)
Flank pain				
Present	43 (100.0)	7 (100.0)	0 (0.0)	50 (71.4)
Absent	0 (0.0)	0 (0.0)	20 (100.0)	20 (28.6)
Received drug				
Yes	25 (58.1)	4 (57.1)	0 (0.0)	29 (41.4)
No	18 (41.9)	3 (42.9)	20 (100.0)	21 (30.0)

G1: Group 1; G2: Group 2; G3: Group 3 (control)

was used. The Doppler time-velocity spectra for each kidney were representative of all components of arterial flow, from early-systolic to end-diastolic Doppler shifts. Segmental and interlobar arteries were insonated using a 2–4 mm Doppler gate. Waveforms were optimised for measurement using the lowest pulse repetition frequency without aliasing (to maximise waveform size), the highest gain without obscuring background noise and the lowest wall filter. Three reproducible waveforms from each kidney were obtained, and RIs from these waveforms were averaged to arrive at the mean RI values for each kidney.[9]

Statistical analysis was performed using the one-way ANOVA test. A p-value < 0.05 was considered statistically significant. All data were expressed as mean ± standard deviation. RI values determined by colour Doppler US results were compared using ANOVA, followed by a post hoc Tukey's Honestly Significant Difference test in case of any identified differences.

RESULTS

The demographic characteristics of the patients are shown in Table I and the distribution of symptoms in the groups is shown in Table II. 40 (57.1%) patients were male and 30 (42.9%) were female. The median age was 41 ± 13 (range 16–73) years. The mean RI values for patients in G1 (n = 43), G2 (n = 7) and G3 (n = 20) were 0.71 ± 0.07, 0.69 ± 0.06 and 0.62 ± 0.03, respectively. The mean RI for G1 was found to be significantly higher than that for G2 and G3 (Table III). The RI levels in patients who had flank pain (n = 50) were significantly higher than those in the control group ($p < 0.05$) (Table IV). RI levels increased significantly in patients with haematuria (n = 39) compared to those without haematuria ($p < 0.05$) (Table IV). 27 out of the 50 (54.0%) patients with flank pain and 25 out of 43 (58.1%) G1 patients showed accompanying symptoms such as emesis and vomiting. No significant differences were noted in renal RI levels with respect to age and gender ($p = 0.513$, $p = 0.059$, respectively).

DISCUSSION

Renal Doppler US is a highly sensitive and specific test that can be useful in the diagnosis of acute unilateral renal obstruction.[1,10-13] Doppler US can be used to measure renal blood flow as well as to calculate RI. The RI is a ratio of peak systolic velocity and end diastolic velocity derived from the Doppler spectrum.[9] It is a physiological parameter that ensures indirect measurement of the degree of resistance within intrarenal vessels.[14,15] Previous animal and human studies have determined that the threshold RI (measured at the arcuate or interlobular arteries) to identify obstructive uropathy is 0.70. Above this value, the dilation can be considered to be of obstructive origin, with a 93% sensitivity and 100% specificity due to a lack of homogeneity in these studies.[14,16]

Doppler US with measurement of the RI in the

Table III. Resistive index (RI) of the three groups.

Group	Mean RI ± SD
G1	0.71 ± 0.07
G2	0.69 ± 0.06
G3	0.62 ± 0.03

G1: Group 1; G2: Group 2; G3: Group 3 (control); SD: standard deviation

Table IV. Resistive index (RI) of patients with and without flank pain and those with and without haematuria.

	Mean RI ± SD
Flank pain	
Present (n = 50)	0.71 ± 0.07
Absent (n = 20)	0.62 ± 0.03
Haematuria	
Present (n = 39)	0.71 ± 0.06
Absent (n = 11)	0.61 ± 0.06

SD: standard deviation

intrarenal arteries is very useful, as obstruction (except in the peracute stage) leads to intrarenal vasoconstriction, with a consecutive increase of the RI above the upper limit of 0.7; however, the case is diferent for non-obstructive dilatation.[7,16,17] Clinicians differentiate physiological hydronephrosis from urinary tract obstruction using the RI.[9,14,18-20] As the sensitivity of RI drops substantially after 48 hours, renal Doppler US is useful for diagnosing acute renal obstruction 6–48 hours after the onset of symptoms.[10]

US is an alternative method to IVU, as it does not involve ionising radiation or intravenous contrast; however, it is less accurate than IVU for both diagnosis of obstruction and lithiasis. Although non-contrast helical CT has become the gold standard for the diagnosis of ureterolithiasis, it is not used widely due to its inaccessibility and the radiation exposure involved.[4] Doppler US is non-invasive, painless, readily available and relatively easy to apply, and it entails no radiation exposure. It would be especially useful in patients in whom intravenous contrast agent administration must be avoided (pregnancy, contrast agent allergy and renal dysfunction).[7,10,17,21,22] According to the results of our study, RI is useful for the early identification of renal colic patients in the emergency department, particularly for those who must avoid radiation and contrast agents.

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