Original Article

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Renal Arterial Doppler in Acute Ureteric Obstruction: A Prospective Study

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Abstract

Introduction: Acute renal colic due to ureteric obstruction is one of the leading causes of morbidity.

Aims and Objectives: To study arterial Doppler waveform alterations in patients with acute ureteric obstruction presenting with or without dilatation of the pelvicalyceal system. To evaluate and compare the resistive indices (RI) in unilateral obstructed kidney with the contralateral non-obstructed kidney taken as control, with final diagnosis established by computed tomography (CT).

Materials and Methods: A prospective study was carried on 60 patients who are referred to the Department of Radiodiagnosis, Vydehi Institute of Medical Sciences and Research Centre, Bengaluru with a history of acute renal colic from December 2010 to June 2012 (18 months). Patients were subjected to gray scale ultrasonography followed by renal arterial Doppler studies. The final diagnosis was based on CT.

Results: The mean RI in obstructed kidneys was significantly higher than in non-obstructed kidneys (0.72 vs. 0.63; $P < 0.001$). The distal obstruction showed more RI value of 0.72 ± 0.05 than proximal obstruction RI value 0.7 ± 0.04. Both peak systolic velocities and end diastolic velocities were reduced in obstructed kidney in comparison to contralateral normal kidney, and the differences in velocities were statistically significant.

Conclusion: Renal arterial Doppler is a useful diagnostic modality and can be used as a supplemental tool in the evaluation of patients with acute renal obstruction.

Key words: Acute ureteric obstruction, End diastolic velocity, Peak systolic velocity, Renal Doppler, Resistivity indices

INTRODUCTION

Acute renal colic due to ureteric obstruction is one of the leading causes of morbidity.[1] Ureteric obstruction predisposes to urinary infection, renal damage, and failure. Gray scale ultrasonography (USG) though useful in the diagnosis of hydronephrosis fails to reveal the acute obstruction of the kidney in 35% of the cases.[2] Even with meticulous technique, USG fails to detect obstruction in a very small proportion of patients, when pelvicalyceal system (PCS) dilatation is not detected due to diuresis resulting from underlying renal parenchymal disease, dehydration, intermittent obstruction by calculus, and decompression of the PCS occurring due to calyceal fornix tear.[1] Intravenous urography (IVU) or computed tomography (CT) urography is the gold standards for demonstrating acute ureteric obstruction.[2] Both these modalities involve radiation, which may not be desirable in patients, especially those who present with multiple episodes of renal colic.

Whenever there is complete acute ureteric obstruction due to calculus, there will be changes in the renal blood flow with associated elevation in renal pelvic pressure.

In the initial few hours, there will be dilation of afferent arterioles, leading to increase in blood flow. After 5 h, there will be a subsequent decrease in the flow likely due to the

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action of prostaglandins and other vasoactive substances on the afferent arterioles.[3] This reduced renal flow can last for more than 24 h, even when the pelvic calyceal pressure is returning toward normal.

The pathophysiological changes that occur due to reduction in renal blood flow due to obstruction by the calculus can be conveniently demonstrated by using Doppler USG parameter, that is, resistive index (RI) wherein the RI will increase after 6 h of obstruction and will attain its peak between 6 and 48 h, with minor fluctuations thereafter.[4]

In a study conducted by Platt *et al.*,[5] they have observed that whenever there is a PCS obstruction, the observed RI was >0.7 as compared to non-obstructed PCS with RI <0.7.

Aims and Objectives

1. To study renal arterial Doppler waveform alterations in patients in acute renal obstruction presenting with or without dilatation of the PCS
2. To evaluate and compare the RI in acute renal obstruction with the normal contralateral kidney taken as control, with final diagnosis established by CT.

MATERIALS AND METHODS

A prospective study is carried on 60 patients who are referred to the Department of Radiodiagnosis, Vydehi Institute of Medical Sciences and Research Centre, Bengaluru with a history of acute renal colic from December 2010 to June 2012. All patients with a history of acute renal colic (<24 h) and subsequently found to have urinary calculi by CT were included. Pregnant females in whom right sided pelvicalyceal dilatation is a physiologic entity, patients with bilateral outflow tract obstruction due to benign prostatic hyperplasia, patients with bladder tumors, urethral stricture, medical renal disease, diabetes, and hypertension were excluded.

The selected patients were subjected to gray scale USG and Doppler evaluation of renal arteries done. The kidney on the side of obstruction was treated as the case, and the contralateral normal (unobstructed) kidney served as the control.

All patients are subjected to USG and Doppler in HD 15, Philips, India using a 3.5-5 MHz transducer. Presence or absence of PCS dilatation was assessed in each kidney on the gray scale images. The machine calculated the RI, which is derived from the three Doppler spectra obtained from upper, mid, and lower interlobar arteries, and the mean RI is taken. The renal RI could also be calculated manually as follows: (Peak systolic velocity-end diastolic velocity)/peak systolic velocity. Δ RI is determined as the difference in RI of the corresponding kidney and normal contralateral kidney.

CT is done for confirmation of calculus causing obstruction using General Electric Medical system 16 slice multidetector row CT equipment. Non-enhanced CT scan of the abdomen is performed extending from the dome of the diaphragm to iliac crest with 5 mm spiral sections followed by 1.25 mm reconstruction. CT scan was used to detect PCS dilatation if any, the obstructing calculus and also its site of obstruction. Those patients not confirmed to have obstruction by CT are excluded from the study (Figures 1-4).

All data are systematically collected, tabulated, and analyzed using Microsoft Excel and Strata 6 for Windows. Student's *t*-test is used in the univariate analysis for continuous variables, and Chi-square test is used for analysis of non-contiguous data. $P < 0.05$ is considered to be statistically significant.

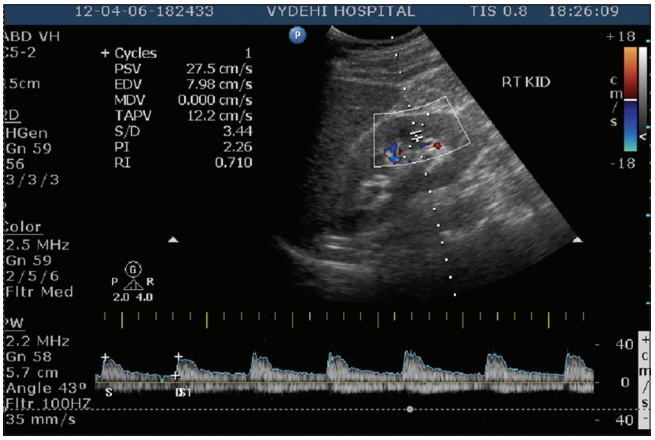


Figure 1: Case 1: Pain since 15 h duration due to right proximal ureteric calculus: Obstructed kidney, resistive indices - 0.71 in interlobar artery

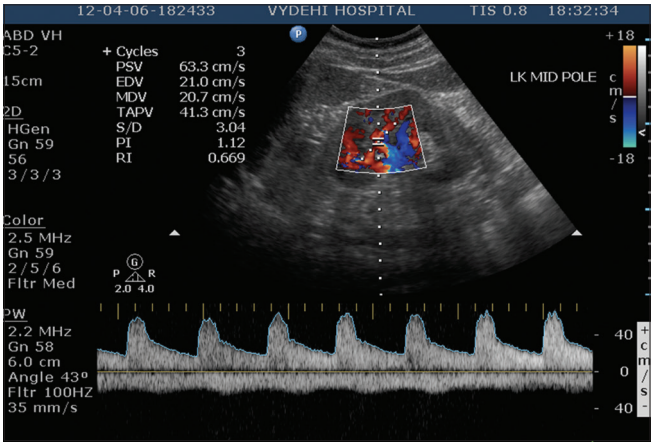


Figure 2: Case 1: Pain since 15 h duration due to right proximal ureteric calculus: Contralateral normal kidney, resistive indices - 0.67 in interlobar artery

RESULTS

In all, 60 patients (120 kidneys; 60 obstructed kidneys as cases and 60 unobstructed contralateral kidneys as controls) were part of this analysis. Doppler is performed in all and subsequently CT scan.

Among 60 patients, 46 were men and 14 were women. The mean age (in years) is 39.24 ± 14.12 (18-65) in men and 34 ± 14.27 (14-55) in women. This difference is statistically not significant (Graph 1).

On gray scale USG, PCS dilatation was observed in 53 (88.4%) patients while it was absent in 7 (11.7%) (Graph 2).

CT confirmed proximal obstruction in 37 cases and distal obstruction in 23 cases (Table 1). In kidneys showing PCS dilatation RI value was 0.7 ± 0.04, in non-dilated kidneys RI value was 0.7 ± 0.06. Arterial Doppler studies were useful in diagnosing acute renal obstruction even in those cases, where PCS dilatation was absent on gray scale USG.

The RI and its mean in obstructed kidneys are significantly higher than in unobstructed kidneys (0.72 vs. 0.63; $P < 0.001$). RI is higher in obstructed kidneys in all the cases. Δ RI, the difference in RI in obstructed (0.05) and unobstructed kidney (0.18) is 0.09 (Table 2).

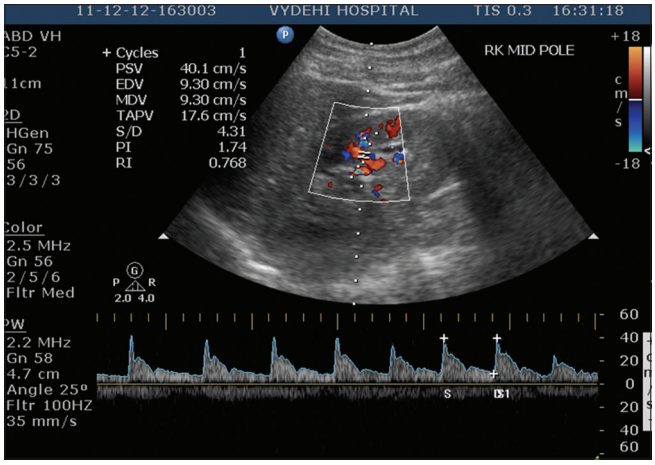


Figure 3: Case 2: Pain since 7 h duration due to right distal ureteric calculus: Obstructed kidney, resistive indices - 0.768 in interlobar artery

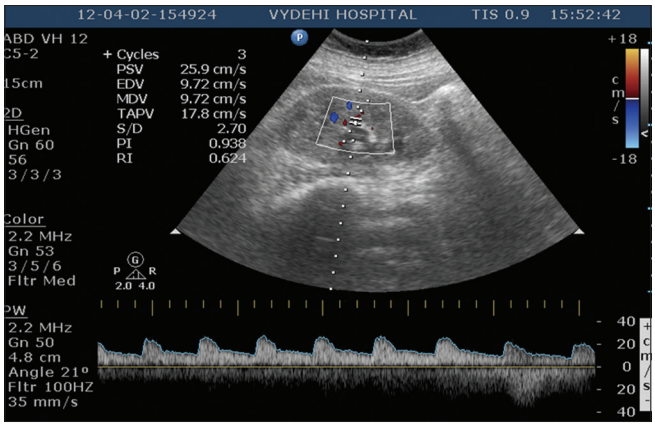


Figure 4: Case 2: Pain since 7 h duration due to right distal ureteric calculus: Contralateral normal kidney, resistive indices - 0.62 in interlobar artery

Table 1: Site of obstruction in CT

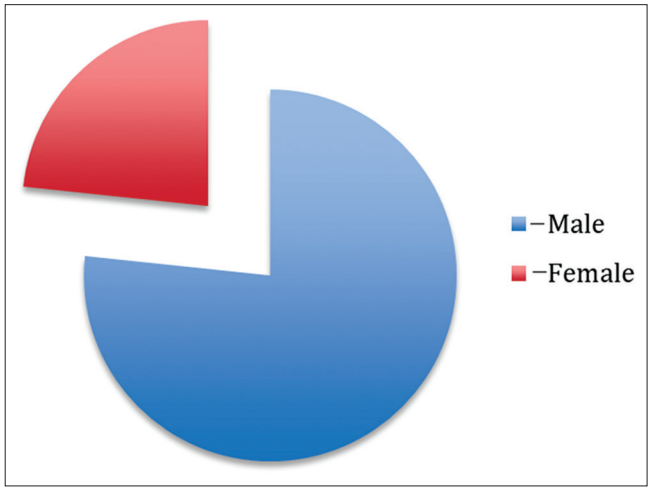
Site of calculus in CT	Frequency
Right proximal	18
Right distal	17
Left proximal	19
Left distal	6

CT: Computed tomography

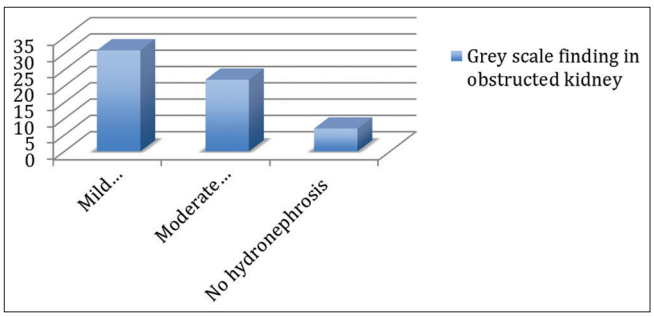
Table 2: RIs in obstructed and unobstructed kidney

Kidney	RI
Obstructed	0.72±0.05
Unobstructed	0.63±0.04
Δ RI	0.09±0.08

RI: Resistive indices



Graph 1: Sex distribution



Graph 2: Gray scale finding in obstructed kidney

The site of obstruction was proximal in 37 (62%) cases and distal in 23 (38%). Mean RI of the obstructed kidneys with distal obstruction was higher (0.72 ± 0.05), than in the kidneys with proximal obstruction (0.70 ± 0.04). However, the difference was statistically not significant ($P = 0.189$).

Most of the patients (48.3%) are evaluated between 6 and 12 h with RI - 0.69, 13.3% within 0-6 h, 21.7% within 13-18 h, and 16.7% within 19-24 h after the onset of symptoms. RI values were similar in the groups evaluated after 6 h (Table 3).

The mean peak systolic velocity in obstructed kidneys was 52.7 ± 13.9 cm/s and in unobstructed kidney was 54 ± 11.4 cm/s. Hence, there were reduced velocities in the peak systolic velocities, and it was statistically significant ($P = 0.042$) (Table 4).

The mean end diastolic velocity in obstructed kidneys was 15.2 ± 5.6 cm/s and in unobstructed kidney was 19.7 ± 3.7 cm/s. Hence, there was reduced end diastolic velocities in obstructed kidney, and it was statistically significant ($P = 0.012$) (Table 5).

DISCUSSION

Gray scale USG is the investigation of choice in the initial evaluation of acute renal obstruction, as it is easily available, portable, and non-ionizing. However, urinary system dilatation seen on gray scale USG is sensitive in 90% but specific in only 65-84% of renal obstruction.[2]

Table 3: Relationship of RI with duration of obstruction

Resistive Indices	0-6 h *N*=8	7-12 h *N*=29	13-18 h *N*=13	19-24 h *N*=10
Obstructed kidney (RI)	0.69±0.07	0.72±0.04	0.71±0.02	0.73±0.04
Unobstructed kidney (RI)	0.62±0.03	0.64±0.03	0.62±0.03	0.61±0.05
Delta (RI)	0.07±0.04	0.07±0.03	0.08±0.05	0.11±0.03

RI: Resistive indices

Table 4: Peak systolic velocity in obstructed and unobstructed kidney

Kidney	Peak systolic velocity cm/s
Obstructed	52.7±13.9
Unobstructed	54±11.4

Table 5: End diastolic velocity in obstructed and unobstructed kidney

Kidney	End diastolic velocity cm/s
Obstructed	15.2±5.6
Unobstructed	19.7±3.7

The sensitivity of USG in detecting PCS dilatation in acute obstruction was 88.3% in our study.

USG is less accurate than excretory urography, as it shows less detail of the PCS anatomy and makes a poor assessment of upper urinary tract drainage. Functional information of the contrast excretion during urography is not provided by USG.[3]

The IVU once the mainstay of diagnosis of acute obstruction is rapidly being replaced by non-contrast enhanced CT.[3] However, CT is expensive.

Acute ureteric obstruction by a calculus results in a complex sequence of changes that is reflected on renal blood flow and ureteric pressure.[6] Whenever there is a unilateral acute ureteric obstruction, in the first 2 h there is will be increase in the renal pelvic pressure due to increasing in renal blood flow due to afferent arteriolar vasodilation.[6] Between 2 and 6 h, there will be reduced blood secondary to renal vasoconstriction. The elevated pelvic pressure seen after 6 h will last for few more hours; after 18 h, the renal blood flow will decrease due to afferent arteriolar vasoconstriction with associated reduction in pelvicalyceal pressure.[7]

The role of renal arterial Doppler USG in the evaluation of acute renal obstruction is vigorously debated.[8] Studies by Rodgers *et al.*[6] and Platt *et al.*[1] have shown an elevated RI in acutely obstructed kidneys, when compared with the RI in normal contralateral kidneys of the same patients. They also found similar results when acutely obstructed kidneys were compared with healthy subjects as control groups.

Tublin *et al.*[3] applied discriminatory thresholds for obstruction (mean RI ≥0.70 and Δ RI ≥0.10) and correlated the results of Doppler sonography and found the sensitivity and specificity of Doppler USG were only 44% and 82%, respectively.

In our study of 60 patients, we found that the RI in obstructed kidneys is significantly higher than the RI in the unobstructed kidneys (0.72 vs. 0.63; $P < 0.001$). The RI was higher in obstructed kidneys in all cases. The difference between the obstructed and unobstructed kidneys (Δ RI) ranged from 0.02 to 0.21 with a mean Δ RI of 0.09. Our results correlate well with many studies reported earlier by Badr and Brenner,[9] Shokeir and Abdulmaaboud,[10] Miletic *et al.*[11]

We also investigated the shortest duration of acute renal obstruction that can cause elevation of RI. We divided our patients into four groups (0-6 h, 7-12 h, 13-18 h, and 19-24 h) based on the duration of the renal colic. RI values were similar after 6 h in three groups of patients. But, it was <0.7 in patients presenting between 0 and 6 h

with mean RI of 0.69 ± 0.07 which correlated with the earlier study.[4] This suggests that there is no change in Doppler waveform alterations and takes time for changes to appear and necessitates repeat scan after 6 h of clinical obstruction, this finding is seen in consents with previous studies showing increase in RI occurring after as little as 6 h of clinical obstruction.[12]

We also studied the effect of the level of obstruction on RI values. Distal obstruction had more RI value (0.72 ± 0.05) compared to proximal obstruction (0.7 ± 0.04), and the values were not statistically significant. However, the study done by de Toledo *et al.*[13] showed that patients with proximal ureteric obstruction have RIs higher than those with distal obstruction.

Seven patients who did not have PCS dilatation on USG were later confirmed to have the obstruction on CT. RI values were higher in all these patients (0.71). The sensitivity of USG in detecting PCS dilatation in acute obstruction was 88.3% in our study this is seen in consensus with the recent one done by Saboo *et al.*[14]

CONCLUSION

Gray scale USG is the commonly used modality in the initial evaluation of acute renal obstruction. The sensitivity of gray scale USG for detecting obstruction is found to be 88.3%. Renal arterial Doppler is a useful additional diagnostic tool in diagnosing acute ureteric obstruction even when the PCS is not dilated. The site of obstruction affected the RI values in which distal obstruction had a higher value than proximal obstruction. The duration of symptoms at presentation affected the RI values in acute ureteric obstruction and was positive in only after 6 h necessitating repeat Doppler study after first 6 h of renal colic.

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