

Role of Color Doppler in Unilateral Acute Renal Obstruction

Dr. Balaji Selvaraj¹, Dr. Suhasini Balasubramaniam², Dr. Amarnath Chellathurai³, Dr. Sathyan Gnanasigamani⁴, Dr. Rajakumari Thirumaran⁵

¹(Assistant Professor, Department of Radiology, Stanley Medical College, Chennai, India)

²(Associate Professor, Department of Radiology, Stanley Medical College, Chennai, India)

³(Professor & Hod, Department of Radiology, Stanley Medical College, Chennai, India)

⁴(Associate Professor, Department of Radiology, Stanley Medical College, Chennai, India)

⁵(Junior Resident, Department of Radiology, Stanley Medical College, Chennai, India)

Abstract

Aims and objectives : The present study aims to establish the role and utility of color Doppler as a non invasive method in the diagnosis of unilateral acute renal obstruction

1. To study the utility of color Doppler in the diagnosis of unilateral acute renal obstruction.

2. To compare the color Doppler study with IVP.

Material And Methods: The study was carried out on 30 patients who was referred to the Ultrasound with symptoms of acute unilateral renal obstruction. All patients underwent color doppler ultrasound with convex probe (3.5-5 MHz). The mean RI of the affected kidney and delta RI between the affected and the normal kidneys are correlated and compared with intravenous pyelography as the standard test.

Results : Out of the 26 kidneys later proven as completely obstructed by IVP 12 kidneys had RI between 0.69 & 0.70. 10 kidneys had RI between 0.71 & 0.72. 4 kidneys had a mean RI of more than 0.72 which was significantly higher than that of the normal contralateral kidney. Out of the 4 kidneys proven to be partially obstructed by IVP later, none had a mean RI of more than 0.66. All of these had a mean RI in the range of 0.60-0.65. However these values were also higher than that of the normal contralateral kidneys.

Conclusion: Doppler ultrasound is a useful diagnostic tool in unilateral acute renal obstruction. Doppler Ultrasound was useful in diagnosing obstruction even when USG findings were normal. Resistive indices and to greater extent difference of the resistive indices are highly sensitive and specific in detecting obstruction. It has an added advantage of being non invasive, free of radiations and also provides information about the degree of obstruction which is valuable from the intervention point of view.

Keywords: Acute renal obstruction, Color Doppler (CD), Resistive index (RI), Ultrasonogram (USG), contralateral kidney

Introduction

Ultrasonography (USG) remains a commonly used modality in the initial evaluation and diagnosis of renal obstruction. It can dependably detect dilatation of the urinary system proximal to the level of obstruction, which is an indirect evidence for the diagnosis. However, urinary system dilatation seen on USG has been shown to be sensitive (90%) but not specific (65-84%) in the diagnosis of renal obstruction (Ellenbogen *et al.*, 1978). It has been reported that the diagnosis of obstructive uropathy may be missed by USG because pyelocaliectasis may occur late in obstructive conditions and often the findings are normal despite severe renal dysfunction (Platt *et al.*, 1993).

For urinary tract diseases, plain x-ray of the abdomen and excretory urography have been the main line of investigation for a long time. Excretory urography, however, is a time-consuming, costly and invasive investigation with side effects. USG is thus being used increasingly in the diagnosis of urinary tract diseases as the initial investigation. A further advancement to conventional USG is duplex doppler sonography (DDUSG).

Animal studies have shown that there is a definite rise in vascular resistance in the renal arteries when the kidney is obstructed (Dodd *et al.*, 1991). Arterial RI measurements by duplex Doppler USG have been advocated for the diagnosis of obstruction (Platt *et al.*, 1989). Doppler USG enables detection of subtle intrarenal blood flow changes associated with various pathophysiologic conditions. Platt *et al.* suggested that Doppler USG is promising for distinguishing obstructive from nonobstructive dilatation in a small group of patients.

Traditionally, the evidence of renal obstruction provided by USG has been indirect and dependent on the anatomical criterion of dilatation of the PCS and ureter proximal to the level of obstruction. However, USG fails to reveal hydronephrosis in acute obstruction of the kidney in up to 35% of cases (Laing *et al.*, 1985). More

direct functional evidence of obstruction has usually required scintigraphy, but recently, Doppler US techniques have been used to obtain functional information in suspected renal obstruction (Platt *et al.*, 1989).

USG imaging may miss the diagnosis of obstruction in a variety of situations. Mild dilatation may be overlooked or considered clinically insignificant. Some patients with obstructive renal failure may show no PCS dilatation. The reasons for this are unclear; in some patients it may relate to dehydration or to decompression of the pelvicalyceal system by rupture of a calyceal fornix.

PCS dilatation may be missed if the PCS system is filled with blood clot, calculus, tumor or pus. Intermittent ureteric obstruction, particularly caused by ureteric calculi, may also lead to a failure to visualize the collecting system with USG (Webb, 2000).

On the contrary, in an attempt not to miss the diagnosis of obstruction in patients with only mild PCS dilatation, the false positive rate of diagnosis may be as high as 26% (Webb *et al.*, 1984). Causes of a false-positive diagnosis include: (i) Visualization of a normal PCS system, when there are anatomical variants such as extra renal pelvis, when the bladder is distended (Ellenbogen *et al.*, 1978) or under conditions of diuresis. (ii) Visualization of a dilated but unobstructed system when there is vesico-ureteric reflux (VUF), a distensible system after previous obstruction or infection, dilated calyces or during normal pregnancy (Fried, 1979). (iii) Central renal fluid collections other than the PCS, including normal vessels, renal artery aneurysm and peripelvic cysts (Patel *et al.*, 1994).

Acute unilateral ureteric obstruction results in a complex sequence of changes in renal blood flow and ureteric pressure. In the first two hours, the renal blood flow increases, because of afferent arteriolar vasodilatation and the ureteric pressure increases. From two to six hours of obstruction, the renal blood flow decreases, secondary to vasoconstriction of the efferent arterioles and the ureteric pressure remains elevated. Subsequently, at six to eighteen hours, the renal blood flow remains reduced because of vasoconstriction of the afferent arterioles and the ureteric pressure decreases. The overall reduction in blood flow shows not much of a change in twenty four to thirty six hours.

The role of renal Doppler USG in the evaluation of acute renal obstruction has been vigorously debated. Rodgers *et al* (1992) found an elevated RI in acutely obstructed kidneys, especially when compared with the RI in normal contralateral kidneys and with a control group of healthy subjects. Similar results were obtained by Platt *et al* (1993) in 23 patients with acute unilateral ureteric obstruction. However, others have reported that Doppler USG is highly insensitive for detecting acute renal colic.

The application of proper technique is essential for obtaining accurate results in Doppler USG. The most common reason for obtaining a normal RI in the presence of significant obstruction is a technical error. The use of the correct scale to expand the waveform size to fill as much of the available displays as possible, without aliasing, is crucial (Shokeir *et al.*, 1999).

Intravenous urography or CT scan were the gold standards for demonstrating obstruction. IVU or CT scan were also used to detect the site and degree of obstruction. The site of obstruction was considered to be proximal, if it was up to or proximal to the L3 vertebral level and distal, if beyond. The degree of obstruction was considered complete in cases with delayed excretion of contrast material and partial in patients with prompt excretion of contrast. In patients with a nondilated PCS, increasingly dense nephrogram on IVU or demonstration of calculus on CT, were the criteria used to diagnose obstruction.

II. Material And Methods

The study was carried out on 30 patients referred to the Ultrasound Section of Department of Radiodiagnosis, Rajindra Hospital, Patiala from either Emergency or Outdoor patients department with symptoms of acute unilateral renal obstruction.

All patients underwent color doppler ultrasound with convex probe (3.5-5 MHz). The results obtained by color doppler were correlated with IVP done later.

Inclusion Criteria :

1. All patients with unilateral renal obstructive symptoms of acute onset without any medical or surgical renal disease.
2. Positive results with IVP which was done after Doppler analysis.

Examination Technique

This study was conducted in patients presenting within 36 hours with symptoms of unilateral acute renal obstruction. The kidney on the side of obstruction was treated as the case kidney and the contralateral non obstructed normal kidney served as control. All patients underwent Doppler ultrasound with 3.5-5MHz transducer.

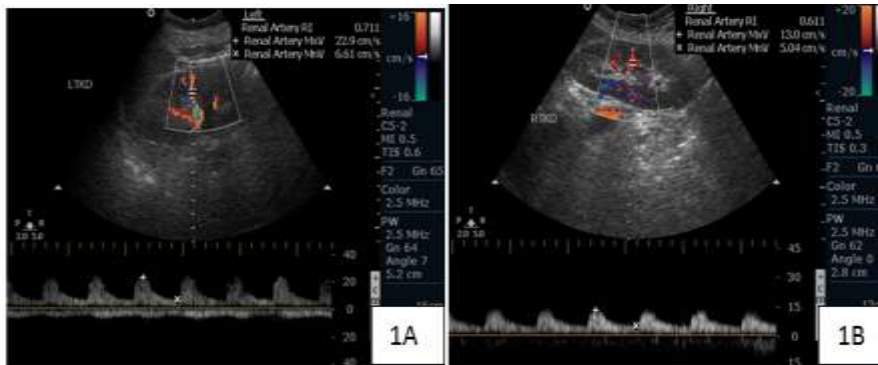


Fig 1 A & 1b : Pulse Doppler Of Both Kidneys Showing Normal Intrarenal Arterial Flow Wave Pattern But With Difference In Ri .1a:Left Kidney With Lower Ureteric Calculus Shows Increased Ri (0.7) Compared To Right Kidney (1b).Note That There Is No Evidence Of Hydronephrosis In Left .

Presence or absence of PCS dilatation was assessed on grey scale images. At least 5 doppler spectra were obtained from more than 3 regions of the kidney. The arcuate arteries at the corticomedullary junctions, interlobar arteries along the borders of medullary pyramids or both were selected for this purpose. Doppler wave forms were made using lowest pulse repetition frequency without allaising. This maximized the size of the Doppler spectrum and decreased the percentage error in measurements. The lowest possible wall filter for each ultrasound scanner was used. The Doppler sample width was set at 2-5mm. The renal RI was calculated as

$$RI = \frac{\text{Peak systolic velocity} - \text{End diastolic velocity}}{\text{Peak systolic velocity}}$$

Δ RI was calculated as the difference between the RI of the affected and control kidney. Mean values were calculated for RI and Δ RI.

IVP was set as the gold standard for demonstrating obstruction. IVP was interpreted as negative with normal renoureteric unit. The degree of obstruction was considered complete in cases with delayed excretion of contrast material and partial in patients with prompt excretion of contrast. In patients with a nondilated PCS, increasingly dense nephrogram on IVU were the criteria used to diagnose obstruction. The site of obstruction was considered to be proximal, if it was up to or proximal to the L3 vertebral level and distal, if beyond.

Datas were systematically collected, tabulated and analysed.

III. Observations

The present study was conducted on total of 30 patients who presented with complaints of unilateral acute renal colic to the emergency dept of Rajindra hospital Patiala.

These patients were subjected to CDUSG after ruling out medical conditions of the kidneys. All Our Observations Has Been Tabulated From Table 1- 3

Table 1

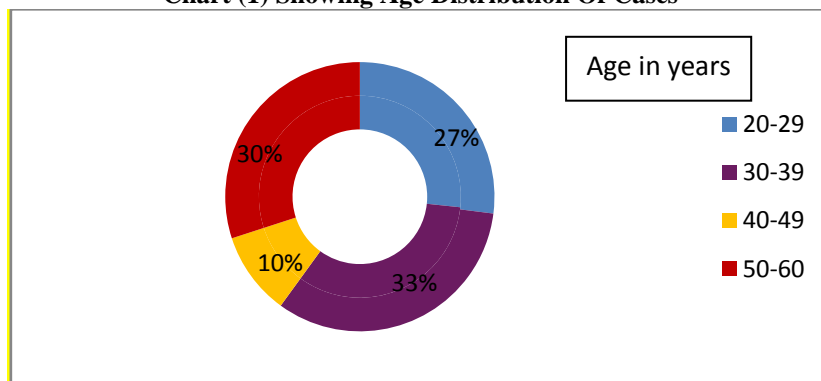
CASE.No	CALCULUS/OTHER CAUSE	Mean RI		□ RI
		R/K	L/K	
1	Calculus lower end of left ureter	0.69	0.77	0.08
2	7mm calculus upper end of right ureter	0.76	0.69	0.07
3	Mass in the cervix	0.7	0.56	0.14
4	6mm calculus lower end of left ureter	0.67	0.72	0.05
5	6mm calculus right ureter lower end	0.71	0.62	0.09
6	1cm calculus left ureter lower end	0.5	0.62	0.12
7	8mm calculus lower end of left ureter	0.61	0.71	0.1
8	7mm calculus lower end of right ureter	0.69	0.59	0.1
9	9mm calculus lower end of right ureter	0.72	0.61	0.11
10	8mm calculus lower end of right ureter	0.69	0.6	0.09
11	6.7mm calculus lower end right ureter	0.7	0.58	0.12
12	7.5mm calculus right VUJ	0.73	0.6	0.13
13	1.16cm calculus right ureter lower end	0.65	0.5	0.15
14	6mm calculus left ureter lower end	0.61	0.73	0.12
15	10mm calculus right ureter lower end	0.72	0.55	0.17
16	7mm calculus left ureter lower end	0.57	0.71	0.11
17	6.3 mm calculus lower end of rt ureter	0.7	0.56	0.14
18	5mm calculus right ureter lower end	0.65	0.58	0.07
19	6mm calculus left ureter lower end	0.65	0.72	0.07
20	8.4mm calculus right ureter lower end	0.69	0.62	0.07
21	9mm calculus lower end of right ureter	0.65	0.59	0.06
22	8mm calculus lower end of right ureter	0.69	0.62	0.07

23	9mm calculus lower end of right ureter	0.7	0.63	0.07
24	Left ureter lower end 6mm calculus	0.65	0.71	0.06
25	Right ureter lower end 8mm calculus	0.72	0.61	0.11
26	Right ureter lower end 9mm calculus	0.7	0.62	0.08
27	Left ureter upper end 7mm calculus	0.65	0.72	0.07
28	Right ureter lower end 8mm calculus	0.7	0.6	0.1
29	Left ureter lower end 9mm stone	0.65	0.72	0.07
30	Right ureter calculus 8mm middle 1/3.	0.69	0.63	0.06

Out of the 30 patients , 10 patients (33%) were in 30-39 yrs age group,20-29 yrs and 30-39 yrs formed 27% and 30% of the total respectively- **Chart (1)** . Least number was from 40-49 yrs age group.

In the study conducted females outnumbered the males.(55.3% females vs 46% males)

Chart (1) Showing Age Distribution Of Cases



Most of the patients presented to the radiology department within 6-12 hrs after onset of renal colic forming 63.3% of the total group. 23.3% of the patients presented within 6 hrs & 10% of the patients presented within 18-24hrs.Only one patient presented between 12-18hrs after onset of renal colic.**Chart (2)**

In the study conducted by us 19 patients (64%) had right sided colic where as 11 patients (36%) had left sided colic. Out of the patients examined by us majority of the patients (29 patients) had colic due to calculus disease forming 97% of the total.

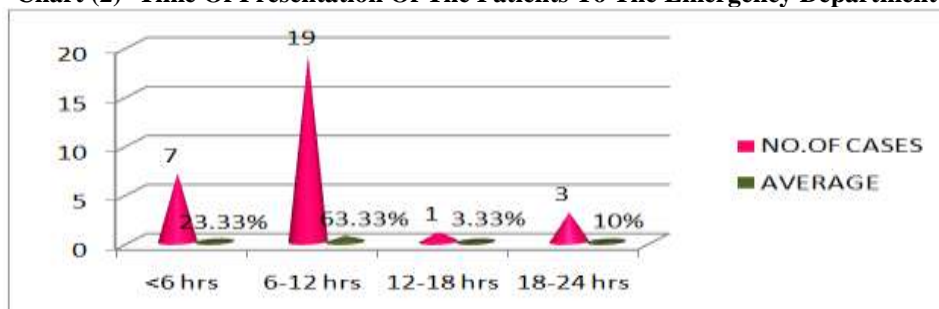
Only one patient had cause other than calculus ie cancer cervix. 28 out of 30 patients had distal obstruction (93%) while only 2 patients had proximal cause of obstruction. 26 patients out of 30 had complete obstruction which was later confirmed on IVP. They formed 87% of the total. Rest of the 4 patients had partial obstruction. 30% of the patients that is 9 out of 30 patients had hydronephrosis and 6 patients had hydroureter (20%). 5 patients had combined hydroureteronephrosis(16.6%).

Mean resistive indices (RI) were calculated for the acutely obstructed kidneys and also for the normal contralateral unobstructed kidneys. Out of the 26 kidneys later proven as completely obstructed by IVP 12 kidneys had RI between 0.69 & 0.70. 10 kidneys had RI between 0.71 & 0.72. 4 kidneys had a mean RI of more than 0.72 which was significantly higher than that of the normal contralateral kidney.

Out of the 4 kidneys proven to be partially obstructed by IVP later, none had a mean RI of more than 0.66. All of these had a mean RI in the range of 0.60-0.65. However these values were also higher than that of the normal contralateral kidneys.

Out of the contralateral normal kidneys all had a mean RI of <0.68 except for two which had a mean RI OF 0.69.

Chart (2) -Time Of Presentation Of The Patients To The Emergency Department



Keeping a discriminatory value of mean RI ≥ 0.69 as significant for obstruction we found a sensitivity of 100% for completely obstructed kidneys. The overall sensitivity with a threshold of 0.69 was 86.6% and specificity was 93.3%.

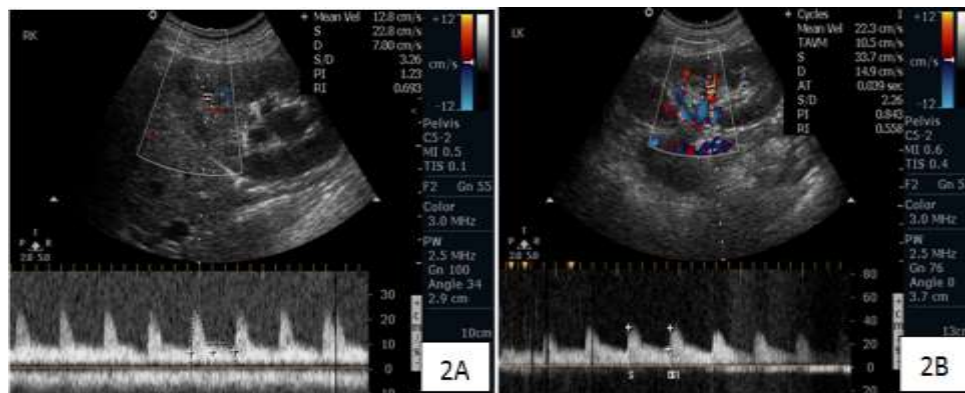


Fig 2a & 2b : Pulse Doppler Of Both Kidneys Showing Normal Intrarenal Arterial Flow Wave Pattern But With Difference In Ri .2a;Right Kidney With Grade 1 Hydronephrosis Due To Lower Ureteric Obstruction Shows Increased Ri (0.69) Compared To Left Kidney (2b)..

The difference in RI (Δ RI) was calculated between the obstructed and the normal contralateral control kidneys. It was found that with patients with complete obstruction the Δ RI was between 0.06-0.10 in 14 patients (54%), between 0.11-0.15 in 10 patients (39%) and >0.15 in one patient.

In patients with partial obstruction 2 patients had Δ RI of 0.06-0.10(50%). There was one patient each in 0.11-0.15 & >0.15 range respectively.

Only one patient with complete obstruction had a Δ RI <0.06 .

It was noted from our observation that in both cases of complete as well as partial obstruction the difference in RI between the affected and the normal kidneys was always >0.06 except in one case. **Chart (3)**

Thus with a threshold of Δ RI ≥ 0.06 a high sensitivity of 96% was obtained and specificity was 100%. With a higher threshold for delta RI the sensitivity decreased but the specificity remained unchanged.

Table 2 Showing The Ri Values Among The Obstructed And Unobstructed Kidneys

Ri Range	Complete Obstruction	Partial Obstruction	Unobstructed Kidneys
<0.6	0	0	5
0.6 -0.65	0	4	20
0.66-0.68	0	0	3
0.69-0.70	12	0	2
0.71-0.72	10	0	0
>0.72	4	0	0

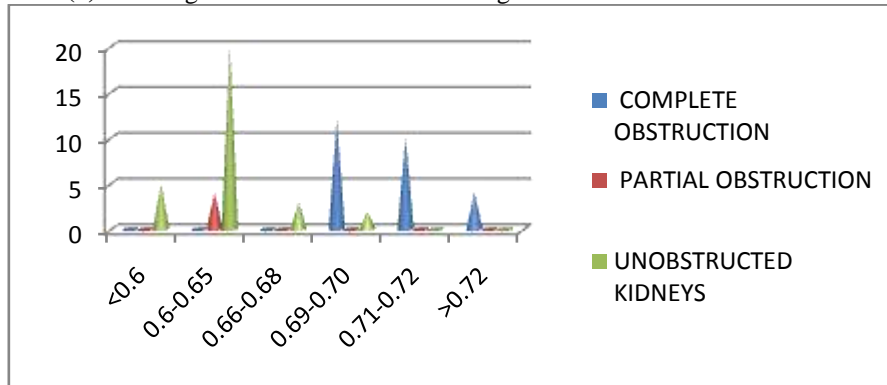
Table 3 Showing The Delta Ri Values Among The Patients With Renal Obstruction

Delta Ri Range	Patients With Complete Obstruction	Patients With Partial Obstruction
<0.06	1	0
0.06-0.10	14	2
0.11-0.15	10	1
>0.15	1	1

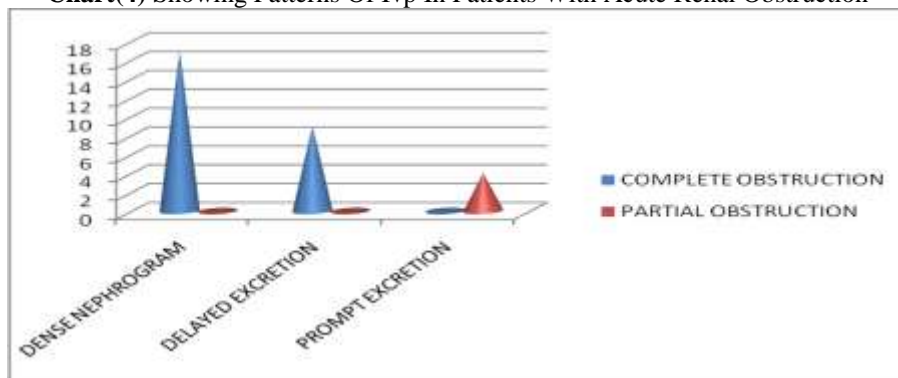
The 30 patients underwent IVP and the degree of obstruction was determined. They were grouped as complete and partially obstructed on the basis of IVP. Presence of delayed or dense nephrogram was noted. These patterns indicate complete obstruction. Out of the 30 patients examined 26 had complete obstruction. Out of 26 patients 17 patients had a dense nephrogram on IVP forming 65% of the total. 9 patients had delayed excretion of contrast.

These patients had dilatation of the pelvic calyceal system proven by ultrasound. They formed 35% of the total. Remaining 4 patients had prompt excretion of contrast and were classified as patients with partially obstructed kidneys - **Chart (4)**

Chart(3) Showing The Delta Ri Values Among The Patients With Renal Obstruction



Chart(4) Showing Patterns Of Ivp In Patients With Acute Renal Obstruction



IV. Review Of Literature

R.H.Gottlieb et al (1989) studied average resistive indices of 15 kidneys of 8 patients who had no renal dysfunction. They studied the Doppler waveform from the interlobar arteries. The average RI of 4 kidneys with acute obstruction was found out to be 0.75. The average RI of 4 normal contralateral kidneys was 0.58 which was significantly less than the obstructed kidneys. They concluded that pathological renal process such as urinary tract obstruction may be characterised by abnormally high resistive indices which can be detected on color doppler USG.

JF Platt, M.A. DiPietro *et al* (1989) evaluated 21 kidneys. Out of which 14 were obstructed and 7 were non obstructed with CDUSG before percutaneous nephrostomy. In addition 10 of the obstructed kidneys were evaluated with CDUSG after nephrostomy. 13 out of 14 obstructed kidneys were found to have RI>0.7 while none of the non obstructed kidneys had RI<0.7. Relief from obstruction caused a reduction in the RI in 9 out of 10 obstructed kidneys which were evaluated with CDUSG after percutaneous nephrostomy. They concluded that when a collecting system is imaged additional use of color Doppler may help to distinguish between obstructed and non obstructed kidneys.

Rodgers and Balts (1992) evaluated 48 patients with normal renal tracts and 20 patients with unilateral acute renal colic out of whom 14 had urographic evidence of renal obstruction. The mean RI of the 14 obstructed kidneys were 0.704 ± 0.0622 compared to the mean RI of normal kidneys 0.62 ± 0.064 . The Δ RI of the obstructed and contralateral normal kidneys were 0.08 ± 0.04 which was also significantly higher than the Δ RI seen between the normal pair of kidneys (0.02 ± 0.017). The study also found that in 10 patients RI reverts to normal after passage of the calculus.

Chen JH *et al* (1993) evaluated 28 normal patients and 27 patients with acute obstructed uropathy. The renal obstruction was diagnosed by IVP or anterograde pyelography. They found out that the RI was correlated with the degree of obstruction. The mean RI for non obstructed and obstructed kidneys was 0.64 ± 0.08 and 0.74 ± 0.54 respectively. More than 93% of the significantly obstructed kidneys had RI>0.7. They concluded that the results can be appealed clinically to justify surgical interventions for acute obstructed uropathy.

deHelou (1993) studied 60 patients with acute unilateral renal obstruction keeping 30 controls. IVP was used as the standard test. The Δ RI was ≥ 0.06 in obstructed kidneys and was ≤ 0.03 in normal pair of kidneys. The study concluded that Δ RI is more specific and sensitive than the assessment of RI of the obstructed kidney alone. It improves the performance of USG in the initial diagnosis of acute urinary tract obstruction.

Platt and Rubin (1993) studied 23 patients with acute unilateral obstruction proven by IVP. The mean RI (0.77 ± 0.07) was significantly higher than that of normal kidneys (0.6 ± 0.04). They also found that RI elevation occurs before PCS dilatation in 4 patients (17%). RI may increase before PCS dilatation and usually occurs by 6 hours. They concluded that doppler ultrasound contributes to diagnosis especially when ultrasound is the first modality.

Brkljacic (1994) measured the RI in 33 persons without renal symptoms and 21 patients with renal symptoms. The mean RI was 0.709 ± 0.039 and 0.59 ± 0.03 in obstructed and normal groups respectively. The mean Δ RI was 0.118 ± 0.034 in obstructed patients and 0.014 ± 0.012 in non obstructed group. Since Δ RI had more statistical significance it was concluded that comparison of RI values in patients with unilateral renal obstruction proved more useful in the diagnosis of the obstruction.

deTolido (1996) studied 121 patients with acute unilateral renal colic and 70 healthy individuals with color doppler. The RI and Δ RI were determined and compared with urographic findings (time of delay pyelogram between both kidneys). In 70 healthy individuals RI was 0.62 ± 0.045 and Δ RI was 0.018 ± 0.01 respectively. In 121 patients with obstruction RI was $\geq 0.69 \pm 0.06$ and Δ RI was 0.09 ± 0.055 respectively using a cut off of RI ≥ 0.70 and Δ RI ≥ 0.06 as an indicative value of obstruction sensitivity was 91.8% and specificity was 92.8%. The study concluded that color doppler USG is useful to fundamentally evaluate the consequences of the obstruction on renal function.

L. opdenakker *et al* (1997) studied 70 patients referred to the emergency department with renal colic with color Doppler USG. The 70 patients underwent CD USG to determine the RI of the affected and the unaffected side. Δ RI > 0.69 and Δ RI of 0.06 were set up as cut off values. They found out that mean RI was 0.7 ± 0.06 and Δ RI was 0.08 – 0.13 on the affected side as compared to the normal side [RI is 0.59]. They found out that the accuracy dropped after 48 hours. They concluded that renal duplex USG is useful for diagnosing acute renal obstruction between 6 and 48 hours after onset of symptoms.

M. Bertolotto *et al* (1998) studied 29 patients with colic episodes with color Doppler USG. All the patients had no treatment with NSAID's. They found out the patients with acute colic had elevated RI in the obstructed kidney than the normal contralateral kidney [0.73 ± 0.02 Vs 0.61 ± 0.05]. They also found out that after the administration of diuretics the RI of the obstructed kidneys [0.81 ± 0.02] was much higher than that of the unobstructed kidneys [0.64 ± 0.05].

Mitchell E tublin *et al* (1998) studied 21 kidneys which were hydronephrotic with color Doppler. Out of these 14 kidneys which were confirmed to be acutely obstructed were found to have RI of 0.67 ± 0.04 which was significantly higher than the mean RI of kidneys with non obstructive pyelectasis (0.64 ± 0.04). More over they found that RI levels returned to normal after nephrostomy. They duplicated these results in a larger study of 229 kidneys. Using a discriminatory value of mean RI of 0.7 the sensitivity and specificity of Doppler diagnosis was 92% and 88% respectively. They also found that accuracy of color Doppler increased when the RI of the obstructed kidney was compared with that of the unaffected contralateral kidney. An RI difference greater than 0.10 between the kidneys was seen only in true obstructive pyelectasis. Thus they proved the accuracy of color Doppler in acute renal obstruction.

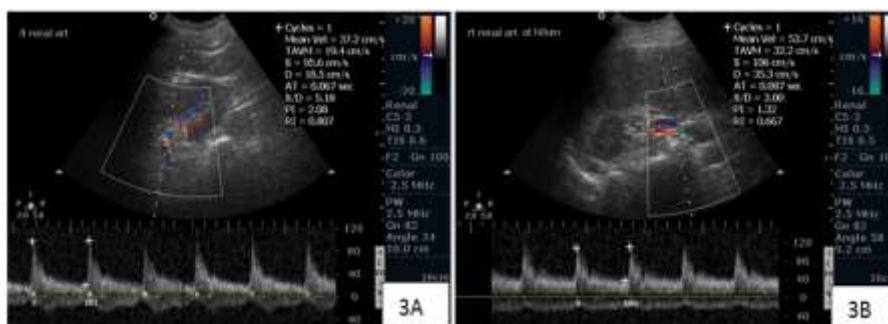


Fig 3 A & 3 B : Pulse Doppler Of Both Kidneys Showing Normal Renal Arterial Flow Wave Pattern But With Difference In Ri .3a;Left Kidney With Lower Ureteric Calculus Shows Increased Ri In Left Renal Artery (0.8) Compared To Right Kidney (3b).Note That There Is No Evidence Of Hydronephrosis In Left In Gray Scale .

Miletic (1998) between 1993 to 1996 studied 54 patients with unilateral renal obstruction. 78 patients with non renal abdominal problems were treated as control. It was found out that the mean RI was 0.72 ± 0.04 in patients with renal obstruction vs 0.64 ± 0.04 in normal patients. The Δ RI was 0.09 ± 0.04 and 0.02 ± 0.01 in study and control group respectively. It was further found out that Δ RI had a slightly higher specificity than RI. This study further proves the reliability of doppler indices in acute unilateral renal obstruction.

Ahmed A.Shokur, Mohamed R.Mahran *et al* (1999) studied 22 pregnant women with acute unilateral renal obstruction due to stone disease, 71 patients without loin pain and 20 non pregnant females with normal kidneys. All patients were subjected to CDUSG. Unilateral urethral obstruction was confirmed by radiological / endoscopic techniques. They found out that the mean R1 of the patients with acute obstruction was 0.69 ± 0.03 which was higher than the mean R1 of the other 2 groups [0.64 ± 0.05 and 0.62 ± 0.04]. The Δ R1 of the obstructed patients was significantly higher than the other groups [0.06 ± 0.01 Vs 0.006 ± 0.003 and 0.006 ± 0.004]. They found out that R1 was 91% specific and 87% accurate and Δ R1 was 99% accurate and 100% specific. They concluded that Δ R1 is a highly specific and sensitive test that can replace IVP especially in patients with pregnancy and constant allergy.

Shokeir and Abdulmaabaud (1999) studied 117 patients with suspected renal colic and evaluated them with IVP and color Doppler. IVP proved unilateral obstruction in 68 patients. These patients had a mean RI of 0.73 which was significantly higher than that in normal patients (mean RI 0.63). The Δ RI was also significantly higher (0.09) in patients with obstruction than with normal patients (0.001). This shows that renal doppler studies are highly sensitive and specific test for the diagnosis of unilateral acute renal obstruction. It can replace IVP in undesirable conditions.

Ahmed A Shokier, Magdy Abdul Mahmoud (2000) studied 109 patients presenting with unilateral flank pain. These patients were subjected to CDUSG and spiral CT. IVP was performed and stones were confirmed by IVP and follow up of the patients for passage of stones. The R1 of the kidneys and Δ R1 for each patient were calculated. Δ R1 was considered positive if ≥ 0.04 . In 52 patients confused to have acute unilateral obstruction. Δ R1 was positive in 47 patients and CT was positive in 50 patients. In 57 normal patients change in R1 (Δ R1) was negative in all patients with a specificity of 100% where as CT was negative in 50 patients with specificity of 96%. They concluded that change in resistance index and CT are sensitive and specific tests which contribute significantly to the diagnosis of unilateral renal obstruction and can replace IVP in undesirable conditions.

Petris or Geaviete *et al* (2001) studied 377 cases referred to the emergency department within 4 – 12 hours after symptoms of unilateral colic. These patients were subjected to IVP, gray scale and color Doppler USG. They found out that in the group of patients with acutely obstructed kidney (IVP non functional) and with HDN and normal contralateral kidney R1 was ≥ 0.69 in 87% and Δ R1 ≥ 0.06 in 90% patients. In the second group of patients with acute obstruction and without HDN and normal contralateral kidney R1 ≥ 0.69 in 73.5% and Δ R1 ≥ 0.06 in 82.5% patients. In patients with incompletely obstructed kidneys with IVP showing varying degrees of HDN and normal contralateral kidneys R1 ≥ 0.69 in 58.3% and Δ R1 was ≥ 0.06 in 64.5%. In patients with normal kidneys R1 < 0.69 in 80% and Δ R1 < 0.06 in 89% of the cases. They found out that the mean R1 was 0.76 in 306 obstructed kidneys which was significantly higher than the mean R1 of 448 normal kidneys. The Δ R1 in patients with obstruction was significantly higher than the patients with normal kidneys [0.08 Vs 0.001]. The R1 was sensitive in 75.5% of the cases and specific in 92.5% cases and Δ R1 was sensitive in 80.7% of the cases and specific in 95.7% cases. They concluded that renal DDV could detect acute renal obstruction and could replace IVP as it is a highly specific and sensitive test.

Ahmed M. Shoba, Abdul, A. Shokir *et al* (2002) evaluated the role of CDUSG in patients with obstructed anuria before and after relief. They studied 40 obstructed and 48 normal kidneys. In the obstructed kidneys the mean R1 was 0.78 ± 0.05 and it decreased to 0.7 ± 0.09 at 3 days after drainage and to 0.68 ± 0.08 at 7 days. In the non obstructed group the mean R1 was 0.66 ± 0.04 . The fall in R1 in patients with obstruction after relief was also correlated with the fall in serum creatinine after relief. They concluded that in the setting of acute renal obstruction CDUSG is a highly sensitive test and has good correlation with serum creatinine values.

Grant A Bateman, Ramesh Cuganesan (2002) studied 12 patients with unilateral acute renal obstruction proven by helical CT and 12 patients as control. They found that the mean RI of obstructed kidneys was significantly more than normal kidneys [0.67 ± 0.08 Vs 0.62 ± 0.05]. They concluded that color doppler improves diagnostic accuracy of acute renal obstruction uropathy.

Abdel Abdel Haimed Sehata *et al* (2003) conducted studies on 47 patients with acute obstructive uropathy and subjected them to CD USG. Based on urographic studies the patients were divided into completely obstructed, partially obstructed and non obstructed kidneys. They found that RI in the obstructed group ranged between 0.7 and 1. They concluded that color and power doppler have an important role in the differentiation between obstructed and non obstructed uropathy.

Haroun (2003) examined 176 kidneys with duplex doppler sonography. 42 patients were found to have obstruction by IVP. 46 persons were found to be normal. The RI and Δ RI of these normal patients were found to be 0.59 ± 0.05 and 0.003 ± 0.01 respectively. The RI and Δ RI were 0.7 ± 0.06 and 0.009 ± 0.02 respectively in obstructed kidneys. The study concluded that doppler sonography is recommended in cases where IVP is contraindicated.

Akcar and Ojkan (2004) studied the diagnostic accuracy of color doppler USG in 28 patients with acute unilateral renal colic keeping 27 normal patients as control. The mean RI of obstructed and control kidneys were 0.71 and 0.60 respectively and the mean Δ RI between obstructed and control group was 0.1 and 0.03 respectively. This study infers that color doppler can be used in the evaluation of renal obstruction and RI and Δ RI are not time dependant parameters.

Lee HJ *et al* (2004) studied 31 patients with unilateral renal colic proven by IVP and 30 patients as control and evaluated them with color doppler. With a cut off of $RI \geq 0.7$ they found a sensitivity of 80% with patients having acute obstruction. They concluded that doppler USG is useful in case of acute obstruction.

Mohammad Umar Amin, Abdul Gaffar (2004) studied 100 patients with renal colic due to suspected ureteric calculus. They found out that RI of the obstructed kidneys was 0.77 and was significantly higher than the mean RI of normal kidneys. There was also significant difference in the RI of the intrarenal arteries of the obstructed and normal contralateral kidneys. They found out that cut off $RI \geq 0.7$ and Δ RI of ≥ 0.08 proved reliable in diagnosing renal obstruction. They concluded that changes in RI measured by duplex sonography contribute significantly to the diagnosis of unilateral renal obstruction.

Oktar So *et al* (2004) studied 15 patients with acute unilateral colic d/t calculus and 15 normal patients as control group. The diagnosis was confirmed on IVP/CT. They found out that in acute cases the mean RI of the obstructed side was higher than the normal side [0.62 ± 0.06 Vs 0.5 ± 0.06] [Δ RI is significant]. They concluded that color Doppler is useful tool in evaluation of acute obstruction uropathy.

Suna Ozhan Oktar *et al* (2004) studied 15 patients with acute renal colic due to unilateral calculi and 15 patients having chronic obstructed uropathy due to stones. The diagnosis was confirmed by IVP or CT. They found out that in acute cases, the mean arterial resistance index on obstructed side (0.62 ± 0.06) was higher than that of non obstructed side (0.57 ± 0.06) which was statistically significant. They found that renal arterial RI helps to differentiate acute renal obstruction from chronic cases.

Pepe and Mota (2005) studied 100 patients with unilateral renal colic with color doppler ultrasound and a cut off of $RI \geq 0.69$ and or a difference between the RI (Δ RI) of 10% or both was set up. 90 patients were confirmed to have stone by standard urography. Out of these patients mean RI was 0.73 in patients with renal colic vs 0.62 in normal patients. In 2 patients RI was < 0.69 but in these patients the Δ RI was $> 10\%$. They concluded that color doppler USG in a patient with unilateral renal colic or PCS dilatation improves the diagnostic accuracy of ultrasound.

Cubuk (2007) studied 27 patients who had symptoms of renal colic. Out of 27, 16 patients had obstruction proven by IVP or CT. Using color doppler it was found that these patients had a mean RI of 0.69 ± 0.04 and Δ RI of 0.07 ± 0.02 , while patients without obstruction had a mean RI of 0.16 ± 0.06 and Δ RI of 0.01 ± 0.03 . This study supports the fact that color doppler USG helps to distinguish between obstructed and non obstructed kidneys by demonstrating altered renal perfusion.

Saboo SS *et al* (2007) studied 40 patients presenting to the emergency OPD with symptoms of unilateral acute renal colic with CD USG. Obstruction was confirmed with CT or IVP. 25 patients had complete obstruction where as 15 had partial obstruction. In 40 patients studied the mean RI in obstructed kidneys were significantly higher than in the contralateral normal kidney [0.72 Vs 0.64]. The RI values in obstructed kidneys were considerably or significantly higher than in normal or partially obstructed kidneys. Using a discriminatory value of 0.7 for obstruction, they obtained a sensitivity of 90%. With a Δ RI of 0.06 a sensitivity of 95% and specificity of 100% were obtained. They concluded that the Doppler USG is a useful diagnostic tool in unilateral acute renal obstruction and RI and Δ RI were sensitive indices for detecting obstruction.

Yung-Shun Juan *et al* (2008) studied 84 patients who were diagnosed as unilateral acute renal obstruction by CT or IVP. These patients were to be treated with ESWL. They found that there was a statistically significant difference between the mean RI of the obstructed and the contralateral kidneys [0.67 ± 0.04] Vs [0.616 ± 0.054]. They concluded that intra renal resistance indices represent the integration of arterial compliance and peripheral resistance therefore having diagnostic and prognostic effects. [Higher pre ESWL RI correlates with lower ESWL treatment rates].

Granata A *et al* (2009) assessed the role of Doppler USG by resistive index (RI) and difference in RI (Δ RI) in patients with unilateral acute renal obstruction. They studied 36 patients with suspected renal colic with IVP as gold standard. 8 patients were found to have obstruction. These patients had higher Δ RI 0.116 ± 0.03 and 8 patients found to have partial obstruction were found to have a Δ RI of 0.09 ± 0.05 . These were significantly higher from the Δ RI of non obstructed kidneys 0.015 ± 0.024 . They found out a sensitivity of 93.8% and specificity of 95%. They concluded that CD USG represents a highly sensitive and specific test that can significantly contribute to the diagnosis of renal obstruction in patients with acute renal colic. It should be used as the first line imaging method in suspected acute renal colic as well as patients with acute renal insufficiency and pregnant patients with allergy to the contrast media.

Zubair Ashraf *et al* (2009) did a prospective study to compare the diagnostic accuracy of Doppler duplex USG and IVP in the detection of obstruction of the urinary tract. IVP could detect the cause of obstruction in 68 of 80 obstructed kidneys. After confirming the obstruction on IVP the 80 kidneys were subjected to USG and color Doppler. By keeping a discriminatory value of $RI \geq 0.7$ CDUSG was able to detect obstruction in 70 out of 80 kidneys [sensitivity 87.5%]. They concluded that CDUSG can be used to improve the detection specificity and accuracy in diagnosing obstruction of the urinary tract and proves to be a suitable modality when IVP, MRI, CT, radionucleated imaging are too early investigations.

V. Discussion

In the present study 30 patients presenting with unilateral acute renal obstruction were studied with grey scale ultrasound and color Doppler ultrasound. The results were compared with intravenous pyelography.

Intravenous Pyelography (IVP) and USG are still the most commonly performed investigations in renal disorders. IVP has been a cornerstone in detecting obstruction in the urinary tract. IVP is necessary for differentiating and for detecting obstructing lucent stones. At the same time it provides information regarding the degree of obstruction present. The diagnostic accuracy of urogram is extremely high in patients with acute flank pain secondary to an obstructing stone — 85%.

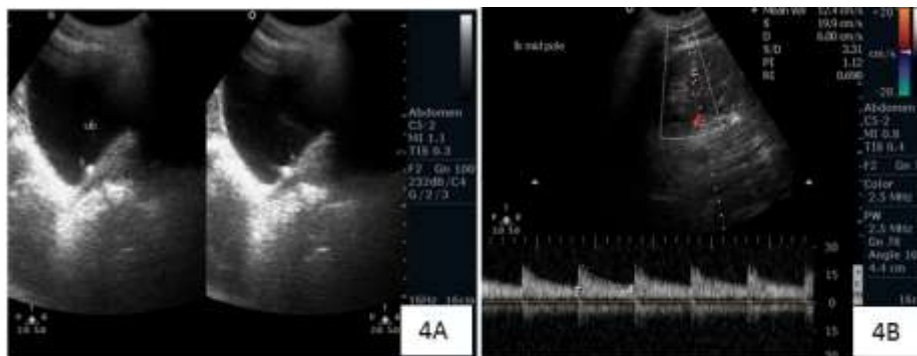


Fig 4a & 4b : Gray Scale Ultrasonogram Of Urinary Bladder Shows Left Vesicoureteric Junction Calculus Causing Increasing RI In Left Kidney, When Compared To Contralateral Kidney (Not Given In The Image) Eventhough Hydronephrosis Is Not Evident In The Kidney .

IVP, however, is time-consuming, invasive and costly and contraindicated in certain conditions viz Pregnancy, contrast sensitivity, renal failure, paediatric population etc. USG in such circumstances serves as a cheaper and effective alternative. Moreover, complimentary use of both modalities can provide pathognomonic information in many cases where either modality used is equivocal. In case of renal obstruction, conventional B-mode USG combined with colour flow Doppler can be used to detect the change in the blood flow pattern produced due to obstruction long before structural abnormalities become evident. This is expressed in what is known as Resistive Index (RI).

It has been demonstrated by animal studies that urinary tract obstruction causes complex series of events in renal vessels. There is an initial rise in intraluminal pelvi-ureteric pressure which occurs without dilatation followed by haemodynamic response of altered perfusion due to increased vascular resistance. Hydronephrosis occurs if obstruction is not relieved. Sonography has its own limitations in detecting obstruction as demonstrated in various earlier studies.

By allowing direct assessment of haemodynamic response in intrarenal arteries, CDUSG has increased the possibility of early detection of obstruction. Obstruction causes increase in renal vascular resistance leading to drop in diastolic flow, being the predominant change in Doppler wave form. This change is most simply measured and expressed as RI. It has been documented that the intrarenal resistance index is elevated in significant renal obstruction thus distinguishing between obstructive and non-obstructive uropathy and suggesting a discriminatory RI of 0.69 as being the value that differentiates between the two. Our study revealed significantly higher values of RI in the obstructed kidneys compared with controls and the value of 0.69 of RI resulted in excellent sensitivity and specificity in detecting obstruction. All those kidneys found to be obstructed on IVP were seen to have increased RI on CDUSG. Our current study showed us that the resistive index in obstructed kidneys is significantly increased as compared to non-obstructed kidneys. The study was able to establish that CDUSG had a sensitivity and specificity almost comparable to IVP in detection of renal obstruction thus supplementing earlier studies.

CDUSG is useful not only in detection of chronic established obstruction but has particular importance in cases of acute obstruction where dilatation of the renal collecting system has not yet set in. Thus, whenever a case of suspected renal obstruction is encountered, CDUSG can be done to determine increased RI and thus establish obstruction before further invasive investigations are undertaken to determine the level of obstruction.

Age and sex

In our study we studied 30 patients out of which 14 were males and 16 were females. These patients were between 20-60 years of age. These differences in age and sex were not significant in agreement with the other studies done to analyse the accuracy of color Doppler.

Duration of symptoms

In our study most of the patients presented between 6-12 hrs (63.3%), 7 patients within 6 hrs (23.3%), 3 patients within 24 hrs (10%) and 1 patient between 12-18 hrs. The RI values were similar in all these groups and does not show any significant change. This is in agreement with Saboo *et al*, Platt *et al* and Shokier *et al* that kidneys obstructed for more than 12 hrs do not have significantly higher RI than those with obstruction for a shorter duration. On the other hand de Toledo *et al* reported that the RI values were significantly higher in patients with renal colic more than 24 hrs. The variations in the observations could be related to the fact that the duration of obstruction in all these studies were based on clinical symptoms which may not correlate with anatomical obstruction.

Site of obstruction:

In our study among 30 patients 28 patients had distal obstruction while 2 patients had proximal obstruction. This had no significance on the RI values. This is in agreement with Platt *et al* and Shokier *et al* who also had similar results.

Value of RI in detecting obstruction:

Using a thresh hold criteria of RI ≥ 0.69 Cubuk *et al* got a sensitivity of 90% and specificity 92%, L.Opdenakker *et al* had a sensitivity of 86% and specificity 90%, de Toledo *et al* had a sensitivity of 91.8% and specificity of 92%, Pepe *et al* got a sensitivity of 98.9% and specificity of 90.5%, Shokier Mahran *et al* had a sensitivity of 91% and specificity of 87% and Petris or Geaviete *et al* got a sensitivity of 75.5% and specificity of 92.5%.

Similar to these studies we kept a thresh hold of RI ≥ 0.69 as significant we had a sensitivity of 86.6% and specificity of 93.3%.

Comparison of studies based on a threshold of RI ≥ 0.69

Study	Sensitivity	Specificity
Cubuk <i>Et Al</i>	90%	92%
L.Opdenakker	86%	90%
De Tolido	91.8%	92%
Pepe <i>Et Al</i>	98.9%	90.5%
Mahran <i>Et Al</i>	91%	87%
Petris Or Geaviete <i>Et Al</i>	75.5%	92.5%
Present Study	86.6%	93.3%

Value of delta RI in detecting obstruction:

Using a threshold of delta RI of ≥ 0.06 Saboo *et al* got a sensitivity of 95% and specificity of 100%, Shokier had a sensitivity of 88% and specificity of 100%, de Tolido had a sensitivity and specificity of 91.8% and 92% respectively, de Helou had a sensitivity and specificity of 93% and 100% respectively, shokier Maran *et al* had 99% sensitivity and 100% specificity, Petris or Geaviete *et al* had a sensitivity of 80.5% and specificity of 90.5%.

Similarly in our study also keeping delta RI ≥ 0.06 as a discriminatory value we got a sensitivity of 96% and a specificity of 100%.

Comparison of various studies with delta RI ≥ 0.06 as threshold.

Study	Sensitivity	Specificity
Saboo <i>Et Al</i>	95%	100%
Shokier	88%	100%
De Tolido	91.8%	92%
De Helou	93%	100%
Petris Or Geaviete <i>Et Al</i>	80.5%	90.5%
Mahran <i>Et Al</i>	99%	100%
Present Study	96%	100%

VI. Results

The study was carried out on 30 patients referred to the Ultrasound Section of Department of Radiodiagnosis, Rajindra Hospital, Patiala from either Emergency or Outdoor patients department with symptoms of acute unilateral renal obstruction

Out of the 30 patients majority belonged to 30-39 yrs age group (33%). 14 patients were males and 16 were females.

Out of 30 patients, 29 patients had calculus as the cause of obstruction (97%) whereas one patient had ca cervix as cause of renal obstruction. All the patients presented within 24 hrs of onset of colicky symptoms and none of them had medical renal disease. Most of the patients had right sided obstruction (64%). 28 out of 30 patients had distal obstruction (93%) while 2 patients had proximal cause of obstruction (7%). 26 patients out of 30 had complete obstruction (87%) while 4 patients had partial obstruction (13%). 30% of the patients that is 9 out of 30 patients had hydronephrosis and 6 patients had hydroureter (20%). 5 patients had combined hydroureteronephrosis (16.6%). Out of the 26 kidneys later proven as completely obstructed by IVP 12 kidneys had RI between 0.69 & 0.70. 10 kidneys had RI between 0.71 & 0.72. 4 kidneys had a mean RI of more than 0.72 which was significantly higher than that of the normal contralateral kidney. Out of the 4 kidneys proven to be partially obstructed by IVP later, none had a mean RI of more than 0.66. All of these had a mean RI in the range of 0.60-0.65. However these values were also higher than that of the normal contralateral kidneys.

Out of the contralateral normal kidneys all had a mean RI of <0.68 except for two which had a mean RI of 0.69. Keeping a discriminatory value of mean RI ≥ 0.69 as significant for obstruction we found a sensitivity of 100% for completely obstructed kidneys. The overall sensitivity with a threshold of 0.69 was 86.6% and specificity was 93.3%.

It was found that with patients with complete obstruction the Δ RI was between 0.06-0.10 in 14 patients (54%), between 0.11-0.15 in 10 patients (39%) and >0.15 in one patient.

In patients with partial obstruction 2 patients had Δ RI of 0.06-0.10 (50%). There was one patient each in 0.11-0.15 & >0.15 range respectively.

Only one patient with complete obstruction had a Δ RI <0.06 . It was noted from our observation that in both cases of complete as well as partial obstruction the difference in RI between the affected and the normal kidneys was always >0.06 except in one case. With a threshold of RI ≥ 0.06 a high sensitivity of 96% was obtained and specificity was 100%. With a higher threshold for Δ RI the sensitivity decreased but specificity remained the same. Site and degree of obstruction were confirmed on intravenous pyelography.

VIII. Conclusion

To conclude Doppler ultrasound is a useful diagnostic tool in unilateral acute renal obstruction. Doppler Ultrasound was useful in diagnosing obstruction even when USG findings were normal. Resistive indices and to greater extent difference of the resistive indices are highly sensitive and specific in detecting obstruction. It has an added advantage of being non invasive, free of radiations and also provides information about the degree of obstruction which is valuable from the intervention point of view.

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