

Duplex Doppler Ultrasonography: An Excellent Initial Investigation In Obstructive Uropathy

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Citation

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Abstract

A prospective study was undertaken to compare the diagnostic accuracy of Duplex Doppler Ultrasonography (DDUSG) and Intravenous Pyelography (IVP) in detection of obstruction in the urinary tract. IVP could detect the cause of obstruction in 68 out of 80 obstructed kidneys (sensitivity: 85%). Hydronephrosis as a consequence of obstruction had sensitivity of 92.5%. Prior animal studies have shown that obstruction anywhere in the renal tract changes the vascular resistance and Doppler wave form in renal and intrarenal arteries. This causes an increase in the renal Resistive Index (RI). RI is defined as: $\text{Peak Systolic Velocity} - \text{Peak Diastolic Velocity} / \text{Peak Systolic Velocity}$ in a defined vessel. After confirming the obstruction on IVP, the above 80 kidneys were subjected to conventional sonography and then to DDUSG. DDUSG could detect obstruction in 70 out of 80 kidneys by detecting an increase in renal RI (sensitivity: 87.5%). Subsequent peroperative detection of obstruction was also done. We also studied 80 normal kidneys and determined their RI. All kidneys with an RI of >0.70 were considered obstructed. Though some obstructed kidneys had an RI of <0.7 , all non-obstructed kidneys studied as controls had an RI of <0.70 . DDUSG can thus be used to improve the detection, specificity and thus the accuracy of diagnosing obstruction in the urinary tract. It proves to be a reliably suitable modality for detection of obstruction in the renal tract in its earliest stage when IVP, MRI, CT scan, radionuclide imaging and retrograde pyelography are too early investigations.

INTRODUCTION

Real-time ultrasound has become a widely available investigation technique. Ultrasound, being a safe, cheap, non-invasive and relatively simple investigation, has been adopted as the diagnostic aid where available and possible. 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 DDUSG. Using direct pressure measurements, animal studies have shown that urinary tract obstruction results in increased intrarenal vascular resistance and that vascular resistance falls following the release of obstruction¹. DDUSG allows the determination of this renal RI. Animal studies have shown that renal obstruction changes the renal arterial waveform. DDUSG is useful for detecting these changes because increased vascular resistance results in more marked reduction in diastolic flow than in systolic flow. Duplex Doppler thus helps to differentiate between obstructive and non-obstructive uropathy². A transcutaneous application of

this technique is safe and repeatable and provides useful information on circulatory dynamics of the arterial and venous systems of the obstructed kidneys³.

It is further emphasized that complimentary use of sonography in conjunction with high-dose urography can provide pathognomonic information in many cases when the singular application of either modality could render only equivocal data. Correlation of nephrosoundography with excretory urography will frequently obviate the necessity of performing retrograde pyelography or angiography.

The study was intended to determine the diagnostic accuracy of DDUSG as compared to IVP to determine urinary obstruction and increase in renal resistive index. We restricted our study to the kidneys dilated due to obstruction.

MATERIALS AND METHODS

The study was conducted over a period of 20 months from July 2001 to February 2003 in the JN Medical College Aligarh. In all, 80 obstructed kidneys in 54 patients were studied. There were 38 males and 16 females in the study. The patients had signs and symptoms referable to urinary tract disease such as pain, haematuria, lump, acute retention,

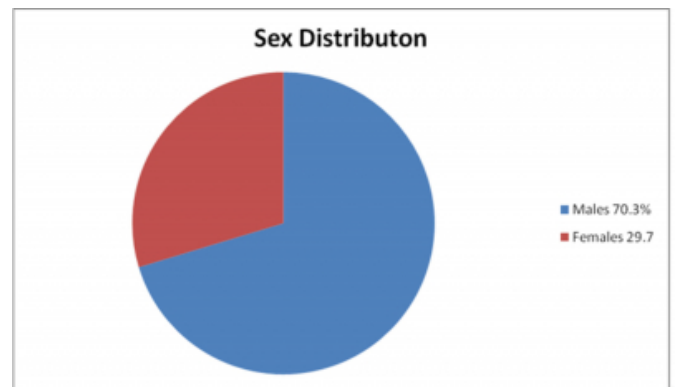
dysuria and cystitis. They were clinically evaluated and on suspicion of obstruction they were subjected to radiological evaluation in the form of Intravenous Pyelography, Conventional USG and then Duplex Doppler USG. All patients were prepared two days prior to IVP by administering laxatives and deflating agents. The patients were kept “nil per-orally” a night before examination. A plain x-ray of abdomen and pelvis was performed initially followed by injecting Sodium ditrizoate intravenously in a dose of 1ml/kg body weight. None of our patients developed any drug reaction. Post-contrast films were taken immediately and then at 5-, 15- and 30-minute intervals. In patients with poor renal function where no opacification of the urinary tract was seen, films were taken at 45 and 60 minutes and even later if required. A post-micturition film was also taken. A standing column of dye in the ureterogram phase was considered as a sign of obstruction. Hydronephrosis on IVP was graded as per earlier definitions ⁴. All patients who had obstruction were then subjected to renal ultrasound using a 3.5MHz transducer (with linear and sector transducer). Sonography was done in supine and prone positions. Logitudinal, coronal and transverse scans of the kidneys were taken. Hydronephrosis was again graded as per earlier defined criteria ⁴. Conventional sonography in these patients was combined with colour flow Doppler to detect the increase in the renal resistive index. Renal resistive index is defined as the ratio of the difference of Peak Systolic (A) and Peak Diastolic Velocity (B) to Peak Systolic velocity $(A - B / A)$ in a defined vessel -- renal or intrarenal. An RI of >0.70 was considered as suggestive of obstruction. It has been determined in earlier studies by Platt et al., that 0.70 is a reasonable level to discriminate between obstructed and non-obstructed kidneys ². In their series, an RI of greater than or equal to 0.70 had a sensitivity of 92%, a specificity of 88% and an accuracy of 90% for diagnosing renal obstruction. We also took the value of 0.70 of RI as a cut-off point to determine obstruction.

RESULTS

The study was conducted to compare the findings of IVP with DDUSG in patients with obstructive uropathy. We sought to determine whether kidneys found to be obstructed on IVP had raised RI and whether DDUSG could help in early diagnosis of urinary obstruction. We also evaluated 40 control kidneys where there was no obstruction. All control kidneys had a non-dilated pelvicalyceal system, had no radio-opaque shadow in the KUB region, normal excretion and passage of contrast and no filling defect in the ureters. All non-obstructed controls had a resistive index of less than

0.70. The range of the resistive index in controls was between 0.49 and 0.70, with a mean of 0.61. There were 80 obstructed kidneys evaluated in 54 patients with the highest number of patients in the 11-40 year age group; 28 patients (51.9%) had bilateral affection of kidneys. The youngest patient was 10 years of age and the oldest one 85 years. The mean age of presentation was 36 years. Of 54 patients, 38 (70.4%) were males and 16 (29.6%) were females with a male-to-female ratio of 2.4:1. [Fig.1]

Figure 1
Figure 1



Renal stones were the commonest cause of obstruction in our series seen in 52.5% of the patients followed by PUJ obstruction (20%), bladder carcinoma (10%), ureteric calculus (7.5%), BPH (5%) and carcinoma of the cervix (5%). [Table 1]

Figure 2
Table 1

| Disease | No. of kidneys | Percentage |
|-------------------|----------------|------------|
| Renal Stones | 42 | 52.5 |
| PUJ Obstruction | 16 | 20 |
| Ca Bladder | 8 | 10 |
| Ureteric Calculus | 6 | 7.5 |
| BPH | 4 | 5 |
| Ca Cervix | 4 | 5 |

The symptomatology was variable ranging from a simple intermittent flank pain that was mild in intensity to acute urinary obstruction and renal lump or painless haematuria. [Table 2]

Figure 3

Table 2

| Symptoms | No. of Patients | Percentage |
|-----------------|-----------------|------------|
| Pain | 44 | 81.5 |
| Haematuria | 32 | 59.3 |
| Renal Lump | 12 | 22.2 |
| Acute Retention | 6 | 11.1 |
| Dysuria | 4 | 14.81 |
| Cystitis | 24 | 44.4 |

The duration of symptoms ranged from 3 months to 5 years with a mean duration of 1.5 years.

Excretory urography was able to detect the cause of obstruction in 68 out of 80 kidneys yielding a sensitivity of 85% and a specificity of 87.5%. Diagnosis of hydronephrosis by IVP had a sensitivity of 92.5% and a false-negative rate of 7.5%.

B-mode USG done after IVP was able to detect obstruction in 66 out of 80 obstructed kidneys yielding a sensitivity of 82.5% and a specificity of 92.5%. Hydronephrosis was detected with a sensitivity of 97.5% and a false-negative rate of 2.5%.

All the kidneys with obstruction and hydronephrosis detected on IVP and subsequently by conventional sonography were subjected to Duplex Doppler Sonography to determine the increase in resistance to blood flow in both renal and intrarenal arteries and hence the increase in Resistive Index. Of the 80 obstructed kidneys, 70 had an increase in the RI of >0.70 in either of the two arteries, the range of increase in RI being between 0.71 to 1.42. However, in all 80 kidneys the range was from 0.46 to 1.42 with a mean of 0.76. Ten of the obstructed kidneys had an RI of <0.70. The increased RI thus had a sensitivity of 87.5% in detecting renal obstruction, a specificity of 85% and a false-negative rate of 12.5%.

DISCUSSION

Intravenous Pyelography (IVP) and USG are still the most commonly performed investigations in renal disorders. IVP thus 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% . 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 ¹⁵. 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 ⁶⁷⁸.

By allowing direct assessment of haemodynamic response in intrarenal arteries, DDUSG 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 ¹⁰. 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 0.70 as being the value that differentiates between the two (2). Our study revealed significantly higher values of RI in the obstructed kidneys compared with controls and the value of 0.70 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 DDUSG. The range of RI and mean RI for obstructed kidneys (0.71-1.42, 0.76) was significantly higher than that of non-obstructed kidneys (0.49-0.70, 0.61). 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 DDUSG had a sensitivity and specificity almost comparable to IVP in detection of renal

obstruction thus supplementing earlier studies. DDUSG 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, DDUSG can be done to determine increased RI and thus establish obstruction before further invasive investigations are undertaken to determine the level of obstruction.

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