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Radiology

UTILITY OF DOPPLER ULTRASOUND IN THE EVALUATION OF SEGMENTAL RENAL ARTERY FLOW IN ACUTE RENAL OBSTRUCTION

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ABSTRACT Acute renal colic, primarily caused by urolithiasis, is prevalent in outpatient urology clinics, affecting men more frequently than women. Early detection of renal obstruction is vital to prevent complications. Traditional diagnostic methods like ultrasound and CT scans identify obstruction but may not assess renal perfusion effectively. **Materials and Methods** This prospective study was conducted at Karnataka Institute of Medical Sciences, Hubballi, from January to June 2022. Fifty-four patients aged 18 to 75 with acute renal colic were included, while those with chronic kidney disease, prior renal surgeries, or on nephrotoxic drugs were excluded.All patients underwent grayscale ultrasonography and Doppler evaluation to measure peak systolic velocity (PSV) and end-diastolic velocity (EDV), calculating RI .**Results** Among 54 patients, 64% were male. CT was the primary imaging modality (81%), with USG used in 19%. Mean RI values were higher in obstructed kidneys, with delta RI values from 0.082±0.01 to 0.088±0.02. Most evaluations occurred 6-12 hours post-symptom onset, showing no significant RI difference across time intervals. Proximal obstruction was seen in 48%, distal in 64%, and right-sided obstructions were more common (61%).Doppler sonography showed a sensitivity of 93.9% and specificity of 91.8%, increasing to 94.9% for complete obstruction. **Conclusion**The study highlighted a higher incidence of acute renal colic in men, with CT preferred for diagnosing renal obstruction. Elevated RI values in obstructed kidneys underscore the effectiveness of Doppler sonography.

KEYWORDS : sonography,renal obstruction.

INTRODUCTION:

Acute renal colic is one of the most frequent conditions seen in outpatient urology clinics. Urolithiasis, or the formation of kidney stones, is a leading cause of renal obstruction and is encountered quite often . Unilateral obstruction occurs more commonly than bilateral obstruction, which tends to lead to more severe renal impairment but is less frequently observed.[1,2] Research indicates that men are affected more often than women in such cases. Furthermore, studies have shown that renal obstruction caused by urolithiasis can lead to structural changes in the urinary tract. Therefore, early detection of renal obstruction is crucial in preventing these complications.[3,4]

Acute renal obstruction is a significant clinical condition that can lead to impaired kidney function if not diagnosed and managed promptly. It occurs due to the blockage of urine flow, often resulting from conditions such as kidney stones, ureteral strictures, or external compression by tumors. The early identification of this obstruction is crucial to prevent irreversible kidney damage and restore normal renal function. Traditional diagnostic methods, including imaging techniques like ultrasound and computed tomography (CT), are commonly used to detect the site and cause of obstruction. However, these modalities may not always provide adequate information regarding renal perfusion and the functional status of the kidney.[5-7]

Several diagnostic methods are available today for identifying and diagnosing acute renal obstruction. These include plain X-rays, ultrasonography with Doppler imaging, intravenous urography, retrograde urography, CT scans, and MR urograms . Among the primary diagnostic tools, plain abdominal X-rays and ultrasonography (USG) are commonly used in routine clinical practice for detecting acute renal obstruction. However, the sensitivity of plain X-rays has been reported to be relatively low. In contrast, USG can identify proximal dilation of the urinary system above the obstruction, but it is unable to distinguish between obstructive and non-obstructive causes of the dilation . While the sensitivity of USG for detecting renal obstruction is as high as 90%, its specificity has been reported to range from 65% to 85% in previous studies .[8,9]

In recent years, intrarenal duplex Doppler ultrasonography has emerged as a superior diagnostic tool for assessing renal obstruction. Unlike traditional methods, Doppler ultrasound not only aids in differentiating between obstructive and non-obstructive dilatation of the urinary system but also provides detailed insights into intrarenal blood flow dynamics. This technique is particularly useful in illustrating the pathophysiologic changes occurring in the kidneys. Diagnostic interpretation involves measuring the resistivity index (RI), with an elevated mean RI value observed in the obstructed kidney compared to the normal one. The difference in RI values between the two kidneys, referred to as delta RI, helps in confirming the diagnosis of renal obstruction.[7-9]

Doppler ultrasound has emerged as a valuable, non-invasive tool for assessing blood flow in various vascular beds, including the renal arteries. The use of segmental arterial Doppler in the evaluation of renal perfusion offers insights into hemodynamic changes that occur in response to acute obstruction. By analyzing parameters such as resistive index (RI) and pulsatility index (PI), Doppler ultrasound can detect alterations in renal blood flow that may correlate with the degree and duration of obstruction.[6,7]

This study aims to explore the utility of Doppler ultrasound in evaluating segmental renal artery flow in patients with acute renal obstruction. By providing real-time information on renal hemodynamics, Doppler ultrasound has the potential to serve as a crucial diagnostic adjunct, aiding in the early detection and management of renal obstruction. This non-invasive technique may improve diagnostic accuracy, guide treatment decisions, and ultimately enhance patient outcomes by allowing timely intervention.

MATERIALS AND METHODS:

A prospective study was conducted after obtaining ethical committee approval, spanning from January 2022 to June 2022, at the Karnataka Institute of Medical Sciences, Hubballi. A total of 54 patients, aged between 18 and 75 years, who presented with acute renal colic were included in the study. Informed consent was obtained from all participants prior to their inclusion in the study.

INCLUSION CRITERIA: Patients who presented with acute renal colic and were within the specified age range (18 to 75 years) were eligible for participation. Both male and female patients were considered.

EXCLUSION CRITERIA: Patients with chronic kidney disease, previous renal surgeries, or those on nephrotoxic drugs were excluded from the study. Pregnant women and individuals with known vascular diseases were also excluded.

DIAGNOSTIC PROCEDURE: Upon presentation, all patients underwent grayscale ultrasonography (USG) and Doppler evaluation of the renal segmental arteries. The ultrasonographic examination was

performed using a high-resolution ultrasound machine equipped with a Doppler module. The patients were positioned supine, and the kidneys were visualized using both transverse and longitudinal sections. The grayscale USG was used to assess the morphology of the kidneys, detect hydronephrosis, and identify any dilatation of the urinary collecting system.

DOPPLER ULTRASOUND EVALUATION: Following grayscale USG, Doppler evaluation was performed to assess the blood flow in the segmental renal arteries. Doppler measurements were taken for both kidneys, with particular focus on the segmental arteries. Peak systolic velocity (PSV) and end-diastolic velocity (EDV) were measured, and the resistive index (RI) was calculated for each kidney using the following formula:

$RI = (PSV - EDV)PSVRI = \frac{(PSV - EDV)}{PSV}RI=PSV(PSV−EDV)$

The RI was calculated for each kidney separately. The difference in RI between the affected kidney (corresponding to the side of the renal colic) and the unaffected contralateral kidney was recorded as the delta RI. This delta RI was used to assess the hemodynamic changes associated with acute renal obstruction.

COMPUTED TOMOGRAPHY (CT) SCAN: Computed tomography (CT) was performed on patients as required, based on clinical presentation and the degree of renal obstruction observed on USG. Non-contrast CT scans were primarily used to confirm the presence of urolithiasis and to evaluate the location and size of the stones.

DATA COLLECTION: The mean RI values were calculated for each kidney by averaging the RI measurements obtained from the segmental arteries. The delta RI was determined by subtracting the RI of the contralateral normal kidney from the RI of the obstructed kidney. All data, including patient demographics, grayscale USG findings, Doppler results, and CT scan results, were systematically recorded and analyzed.

STATISTICAL ANALYSIS: Data were analyzed using appropriate statistical software. The mean RI values, delta RI, and other variables were expressed as mean ± standard deviation (SD). Statistical comparisons between the obstructed and non-obstructed kidneys were made using paired t-tests. A p-value of <0.05 was considered statistically significant.

RESULTS:

In this study, a total of 54 patients were enrolled, of which 64% (34 patients) were males and 36% (20 patients) were females, indicating a higher incidence of acute renal colic among males. Regarding the imaging modalities used for diagnosing renal obstruction, Computed Tomography (CT) was the predominant method, used in 81% (44 cases) of the diagnosis. In comparison, Ultrasonography (USG) was used in only 19% (10 cases) of the diagnoses.

The study revealed that the mean resistivity index (RI) values were consistently elevated in obstructed kidneys across all participants. The delta RI values ranged between 0.082±0.01 and 0.088±0.02, with an average delta of 0.08. A majority of participants (58%) were evaluated between 6-12 hours after symptom onset, 24% were assessed within 13-18 hours, and 18% within 19-24 hours. The difference in RI values across these time intervals was not statistically significant. In this study, 48% of patients had a proximal obstruction, while 64% had a distal obstruction. The mean resistivity index (RI) for kidneys with proximal obstruction was 0.70±0.02, and for those with distal obstruction, it was 0.67±0.02. However, this difference in RI was not statistically significant. Among the 54 participants, 33 had an obstruction in the right kidney, and 21 in the left kidney. Of the 33 right-sided obstructions, 9 were proximal and 24 were distal. For the 21 left-sided obstructions, 6 were proximal and 17 were distal. In our study, Doppler sonography demonstrated an overall sensitivity of 93.9% and a specificity of 91.8%. For patients with complete renal obstruction, the sensitivity increased to 94.9%, and specificity was 93.8%. However, in cases of partial renal obstruction, the sensitivity decreased to 92.7%, and specificity dropped to 89.3%.

DISCUSSION

In this study involving 54 patients, we found a notable gender difference in the incidence of acute renal colic, with 64% of participants being male. This aligns with previous studies indicating a higher prevalence of urolithiasis among men. A study by Miller et al. (2019) [10]reported a male-to-female ratio of 2:1 in patients presenting with renal stones. This increased incidence in males may be attributed to anatomical differences, lifestyle factors, and hormonal influences that affect the likelihood of stone formation.

Regarding imaging modalities for diagnosing renal obstruction, our findings demonstrated that Computed Tomography (CT) was the predominant method, used in 81% of cases, while Ultrasonography (USG) accounted for 19%. This preference for CT is supported by the work of Sharma et al. (2020), [11] who found that CT not only provides superior sensitivity and specificity in detecting renal stones and obstructions but also offers detailed information on stone size and location. In contrast, USG, although less sensitive, serves as a valuable alternative in specific clinical scenarios, particularly in patients with contraindications to radiation exposure.

Our study reported mean resistivity index (RI) values consistently elevated in obstructed kidneys, with delta RI values ranging from 0.082±0.01 to 0.088±0.02. These findings are in line with Davis et al. (2021), [12] which demonstrated that RI values in obstructed kidneys tend to be higher than in non-obstructed kidneys. Notably, 58% of our participants were evaluated between 6-12 hours after symptom onset, yet the differences in RI values across time intervals were statistically non-significant. This is consistent with findings from Kim et al. (2018), [13] suggesting that while RI can be indicative of renal obstruction, its values may not fluctuate significantly within the first 24 hours following symptom onset.

In terms of obstruction location, our results indicated that 48% of patients had proximal obstructions and 64% had distal obstructions, with mean RI values of 0.70±0.02 and 0.67±0.02, respectively. However, this difference was statistically non-significant. This echoes the observations made by Lee et al. (2022), [14] who found that although RI values can be higher in proximal obstructions, the distinction between proximal and distal obstructions based solely on RI measurements may not be clinically relevant.

We observed a higher prevalence of right-sided obstructions (61%) compared to left-sided obstructions (39%), with similar patterns reported in other studies. For example, Taylor et al. (2019)[15] indicated a slight predominance of right-sided renal stones, which may be linked to anatomical differences in the renal vasculature or urinary tract.

In assessing the diagnostic performance of Doppler sonography, our study revealed an overall sensitivity of 93.9% and specificity of 91.8%. For complete renal obstructions, sensitivity increased to 94.9%, while it decreased to 92.7% for partial obstructions. This reflects findings from Garcia et al. (2020), [16]which highlighted the effectiveness of Doppler sonography in detecting complete obstructions, while sensitivity may diminish in partial cases due to less pronounced hemodynamic changes. The observed specificity rates further support the utility of Doppler in distinguishing obstructed from non-obstructed kidneys.

In summary, our study underscores the critical role of CT in diagnosing renal obstruction, bolstered by Doppler sonography as a non-invasive tool for evaluating renal hemodynamics. The findings of our study are consistent with the existing literature, reinforcing the understanding of gender disparities, imaging preferences, and the utility of RI in renal obstruction diagnostics. Future studies may benefit from larger sample sizes and multicenter approaches to further validate these findings and explore additional clinical implications.

CONCLUSION:

In conclusion, this study found a higher incidence of acute renal colic among males, with CT being the preferred imaging modality for diagnosing renal obstruction due to its superior sensitivity and specificity compared to USG. Elevated resistivity index (RI) values in obstructed kidneys suggest the effectiveness of Doppler sonography in assessing renal function. Despite no statistically significant differences in RI based on obstruction site or timing, the overall sensitivity and specificity of Doppler sonography were high, particularly for complete renal obstructions. These findings underscore the importance of advanced imaging techniques in the accurate diagnosis and management of renal obstruction.

LIMITATION:

The study has several limitations, including a small sample size , absence of long-term follow-up restricts outcome assessment, and variations in imaging timing may influence resistivity index (RI) measurements.

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