

Accuracy of Resistive Index of Color Doppler Ultrasonography in Detecting Acute Unilateral Ureteric Obstruction due to Calculus

Zainab Safdar¹, Muhammad Naem Safdar², Rabeea Tahira² and Muhammad Shahid²

ABSTRACT

Objective: To assess the diagnostic accuracy of RI of colour Doppler ultrasonography for the diagnosis of acute unilateral ureteric obstruction due to calculus taking non-enhanced CT KUB as gold standard.

Study Design: Cross-sectional study.

Place and Duration of Study: This study was conducted at the Department of Radiology, Sir Ganga Ram Hospital, Lahore from October 2015 to March 2016.

Materials and Methods: A total of 150 patients were enrolled. Colour Doppler ultrasonography (CDUS) was done and measurements of RI of interlobar arteries were made. Three to five waveforms were recorded and average was noted. If $RI \geq 0.70$, the patients were labelled as positive otherwise negative. Then patients underwent computed tomography for confirmation.

Results: Mean age of patients was 41.10 ± 11.05 years. Mean RI on CDUS was 0.69 ± 0.11 . Sensitivity and specificity of RI were 93.15% (69/73) and 94.81% (73/74), PPV and NPV for RI were 94.44% and 93.59% respectively and diagnostic accuracy was 94% for detection of acute unilateral ureteric obstruction.

Conclusion: Diagnostic accuracy parameters of RI showed that it can be reliably suitable modality for detection of patients with suspected ureteric obstruction in its earliest stage.

Key words: Resistive index, Color Doppler ultrasonography, Acute unilateral ureteric obstruction, Enhanced computed tomography

Citation of article: Safdar Z, Safdar MN, Tahira R, Shahid M. Accuracy of Resistive Index of Color Doppler Ultrasonography in Detecting Acute Unilateral Ureteric Obstruction due to Calculus. Med Forum 2019;30(12):20-23.

INTRODUCTION

Urinary obstruction is one of the common reasons of acute as well as chronic kidney failure. There are several pathological processes, intrinsic and extrinsic to the urinary system, involved which may cause blockade.¹ Acute unilateral ureteral obstruction is a common incident, upsetting 5-15% population all over the world.² In Pakistan, it effects about 30.3% population.³ It has classical symptoms like severe flank or abdominal pain radiating to groin, haematuria, nausea and vomiting. Usually, obstruction is developed due to renal calculi and has no symptoms. When it is asymptomatic, ureteral obstruction is not deliberated. So, routine radiological investigations are mandatory to discover obstruction in urinary tract in patients of unsolved decreased renal function.⁴

¹. Department of Radiology Department, Sir Ganga Ram Hospital Lahore.

². Department of Medicine, Mayo Hospital, Lahore.

Correspondence: Dr. Zainab Safdar, Postgraduate Resident, Radiology Department, Sir Ganga Ram Hospital Lahore.

Contact No: 0333-4934093

Email: doczainab6@gmail.com

Received: March, 2019

Accepted: July, 2019

Printed: December, 2019

Computed tomography scan is the primary radiological tool to evaluate renal stones and is considered to be gold standard for detection of renal stones.⁵ It has 99% sensitivity and 98% specificity.⁶ Doppler ultrasound is an added tool which can be done in case when less radiation is appropriate. The chances of raised resistive index (RI) are high in case in whom urine drainage obstruction exists. In many centres, obstruction is doubted when $RI > 0.70$ or the difference of RI is > 0.10 in both kidneys.⁷

One study reported that the sensitivity and specificity of $RI \geq 0.70$ were 92% and 88% in detecting renal obstruction.⁸ Another study reported the sensitivity and specificity of $RI \geq 0.70$ were 87.5% and 85% in detecting renal obstruction.⁹ But a recent study reported that with $RI > 0.70$ as cut off level, the sensitivity was 76.23% and specificity was 88.13% by taking CT as gold standard.¹⁰ Rationale of this study is to assess the diagnostic accuracy of resistive index of color Doppler ultrasonography for detection of acute unilateral ureteric obstruction due to calculus. CT scan is costly as compared to Doppler ultrasound and it exposes patient to significant amount of radiation. Due to radiation exposure, CT scan can't be performed in pregnant women. Color Doppler ultrasonography (CDUS) is cheaper, widely available and does not expose to radiations. But due to ambiguity in evidences available in literature, RI on CDUS is not used widely. Through

this study, we want to confirm whether RI on CDUS has accuracy enough to diagnose the ureteric obstruction.

MATERIALS AND METHODS

This cross sectional survey was conducted at Department of Radiology, Sir Ganga Ram Hospital Lahore from 1st October 2015 to 31st March 2016 and comprised one hundred and fifty patients. Patients of age 20-60 years of either gender with renal colic pain, unilateral flank pain that radiate to groin, testicles, back or periumbilical region for >6 hours and having suspicion of obstruction of ureter due to calculus were included. Those patients with pain > 5days, having congenitally anomalous kidney, patients who had pre-existing renal disease, bilateral flank pain, and solitary kidneys were excluded. Demographic details were noted. Doppler Ultrasound was done using Toshiba Diagnostic Ultrasound Machine (Nemio) using 3 to 5 MHz probe with the patient lying in lateral position. Measurements of RI of interlobar arteries were made at 3-sites of kidney i.e. upper, middle & lower poles. About 3-5 waveforms were observed and average RI was noted. If $RI \geq 0.70$, the patients were labelled as positive otherwise negative. Then patients undergone non-enhanced helical CT KUB for confirmation of results by having findings of either stone in ureter, enlarged kidney, hydronephrosis, perinephric fluid or ureteric dilatation were noted. Data was analyzed by SPSS version 20.

RESULTS

Mean age of patients was 41.10 ± 11.05 years. There were 82(54.67%) male and 68(45.33%) were female patients. Mean duration of pain of patients was 16.13 ± 5.33 . Mean RI on CDUS was 0.69 ± 0.11 (Table 1). The sensitivity and specificity of RI on CDUS was 93.15% and 94.81%. PPV and NPV of RI for detection of acute unilateral ureteric obstruction was 94.44% and 93.59% respectively. Overall diagnostic accuracy of RI for detection of acute unilateral ureteric obstruction was 94% (Table 2).

Table No.1: Characteristics of patients (n=150)

Age	41.10±11.05
Male	82 (54.7%)
Female	68 (45.7%)
Duration of pain	16.13±5.33
Resistance index on ultrasound	0.69±0.11

Table No.2: Diagnostic Accuracy of RI of CDUS

RI CDUS	CT KUB		Total
	Positive	Negative	
Positive	68	4	72
Negative	5	73	78
Total	73	77	150

Sensitivity= 93.15%, Specificity= 94.81%

PPV= 94.44%, NPV= 93.59%, Diagnostic Accuracy= 94%

DISCUSSION

The ureteric obstruction is the most common problem all over the world and the calculi is main cause of ureteric obstruction. About, 3% adults and 2% paediatrics have ureteric obstruction. The fast and precise detection of ureteric obstruction helps in urgent management and less complications including urinary tract infection, blood pressure and kidney failure. X-ray, renal ultrasound, intravenous urogram and computed tomography are most common diagnostic tools. These tools have some restrictions. About 5% calculi are not detected on x-ray KUB. Sometimes, calculi stuck in part of ureter which crosses pelvic bone and is scarcely identifiable.¹¹⁻¹⁵

Computed tomography and grey-scale ultrasound are the most common modalities to detect calculi and obstruction in patients of acute renal colic.^{12,16} While grey-scale renal ultrasound alone can consistently recognise a massing system dilatation, but usually, it is impossible to distinguish between obstructive and non-obstructive sources. As prolonged obstruction causes hormonal changes and thus causes diffused vasoconstriction of vascular bed, imaging of different blood flow patterns is cooperative indiscriminating obstructive from non-obstructive pyelocaliectasis.¹⁶⁻¹⁸ The accessibility of duplex Doppler ultrasound is deceptively an attractive and well reproducible helper to less-invasive investigative method.¹⁹ The incidence and prevalence of acute unilateral obstructive uropathy are 8.0 & 47.7 per 1,000,000 people respectively in paediatric age group in UK. The prevalence in South Asian countries is 3-times higher than Whites while the incidence is >3-times than Whites and parallel increase has been observed in adult population. The high occurrence is due to high incidence of congenital syndromes in South Asian countries. Acute unilateral obstructive uropathy is more common in men than women with male to female ratio was 1.54:1. In South Asia, this ratio is 1:1 as genetic diseases are mainly autosomal receding.²⁰ In large surveys, done in older patients with urinary obstruction, the prevalence of 20-35% is projected. About 60% men with moderate to severe symptoms did not access their physicians. Autopsy investigations detected hydronephrosis in 3.8% adults and 2% peditrics.^{21,22}

Doppler ultrasound is a helpful modality that can be done in cases in whom radiation exposure can be harmful like in pregnant females. An increased RI can be detect when urinary obstruction is present.²¹ Renal artery RI is most commonly applied Doppler indices. Doppler ultrasound is a non-invasive tool which can provide useful information regarding renal hemodynamics and is an accurate tool to detect renal obstruction. In cases of acute obstruction, pressure of renal calyces raised causing changes in renal blood-

flow having high RI (>0.7). The RI can have sensitivity of 75.5% and specificity 92.5%.²³

In this study diagnostic accuracy of RI was determined by taking CT-KUB as gold standard. Sensitivity and specificity of RI for the diagnosis of acute unilateral ureteric obstruction was 93.15% (69/73) and 94.81% (73/74). However positive predictive and negative predictive value for RI was 94.44% and 93.59% respectively. Overall diagnostic accuracy of RI was 94%. Patients' age and gender was stratified to see the effect of these variables on the diagnostic accuracy of RI. In patients in age group 20-40 and 41-60 years no significant difference was seen for diagnostic accuracy parameters (sensitivity, specificity, PPV and NPV). Among male and female patients diagnostic accuracy of RI was almost same with very minor difference for diagnosing acute unilateral ureteric obstruction. So these result clearly depicts that RI can be effectively used for detection of acute unilateral ureteric obstruction irrespective of age and sex of patients.

Several studies found an elevated RI in case of acute ureteric obstruction.^{12,17} Geavlete et al²² reported RI 0.76, sensitivity 75.5%, specificity 92.5% reported RI 0.77, Platt et al⁸ reported RI>0.70, sensitivity 92%, specificity 88% and it is reported RI>0.70, sensitivity 91.8%, specificity 92.8% who found mean RI>0.70 in obstructed kidneys. These studies support the results of this study. Azam et al¹⁰ in their study showed that study keeping RI >0.70 as cut off value for renal obstruction, sensitivity 76.23% and specificity 88.13%, PPV was 91.6% and NPV was 68.42% and diagnostic accuracy was 80%. Ashraf et al⁹ in their study found that RI showed 87.5% sensitivity, 85% specificity and 12.5% false negative rate in diagnosing acute renal obstruction.

In cases of renal obstruction, conventional B-mode ultrasound when combined with color Doppler ultrasound may be applied to evaluate changes in pattern of blood flow created because of prolonged obstruction when structural deformities become apparent. This is stated as RI. In few animal model, it was showed that renal obstruction can cause multifaceted series of events in renal vessels. There is an preliminary increase in intra-luminal pelvi-ureteric pressure which arises without dilatation subsequently hemodynamic responses of transformed perfusion because of high vascular resistance. Hydronephrosis develops if obstruction is not resolved. Ultrasound has its own restrictions in diagnosing the obstruction.

By allowing direct assessment of hemodynamic reaction in renal arteries, Doppler ultrasound has higher chances of detecting renal obstruction. Obstruction can causes high renal vascular resistance which can leads to decrease in in diastolic flow, causing major changes in Doppler wave-form. It is recognized that intra-renal RI is increased in substantial renal obstruction, which can discriminate between obstructive and non-obstructive

uropathy and proposing 0.70 RI value as discriminatory value to differentiate between both.

The accurate diagnosis of renal obstruction is important as it can lead to complications like urinary tract infections, hypertension and kidney failure. Normal ultrasound, X-ray, urogram and computed tomography are most common tools for detection of obstruction. But, few methods have some limitations in some cases. The CT has superiority over other modalities as it helps to reach an answer to the patient's clinical condition. Many mimickers of renal colic have been reported in such patients which include appendicitis, diverticulitis, bowel obstruction or herniation, intra-abdominal fluid collections (abscess/haematoma), tubo-ovarian abscess, aortic aneurysms, pancreatitis and neoplasms.²³ CT scan is costly as compared to Doppler ultrasound and it exposes patient to significant amount of radiation. Due to radiation exposure, CT scan can't be performed in pregnant women. Color Doppler ultrasonography is cheaper, widely available and does not expose to radiations.

CONCLUSION

Diagnostic accuracy parameters of RI of CDUS showed that it can be reliably suitable modality for detection of patients with suspected patient of ureteric obstruction in its earliest stage. Now local evidence has been attained and in future, we can replace CT scan with Doppler USG to diagnose acute ureteric obstruction.

Author's Contribution:

Concept & Design of Study:	Zainab Safdar
Drafting:	Muhammad Naeem Safdar
Data Analysis:	Rabeea Tahira, Muhammad Shahid
Revisiting Critically:	Zainab Safdar, Muhammad Naeem Safdar
Final Approval of version:	Zainab Safdar

Conflict of Interest: The study has no conflict of interest to declare by any author.

REFERENCES

1. Shin SH, Kim JW, Kim JW, Oh MM, Moon DG. Defining the degree of intravesical prostatic protrusion in association with bladder outlet obstruction. *Korean J Urol* 2013;54(6):369-72.
2. Moe OW. Kidney stones: pathophysiology and medical management. *Lancet* 2006;367(9507):333-44.
3. Amanullah GK, Lal S, Soomro MI, Jalbani MH. Calculus anuria and its remedy. *J Ayub Med Coll Abbottabad* 2010;22(1).
4. Gosmanova EO, Baumgarten DA, O'Neill WC. Acute kidney injury in a patient with unilateral

- ureteral obstruction. *Am J Kidney Dis* 2009; 54(4):775-9.
5. Sharma A. Unenhanced helical CT in renal colic. *Inter J Radiol* 2005;4:1.
 6. Rucker CM, Menias CO, Bhalla S. Mimics of Renal Colic: Alternative Diagnoses at Unenhanced Helical CT 1. *Radiographics* 2004;24 (suppl_1): S11-S28.
 7. Kessler TM, Gerber R, Burkhard FC, Studer UE, Danuser H. Ultrasound assessment of detrusor thickness in men—can it predict bladder outlet obstruction and replace pressure flow study? *J Urol* 2006;175(6):2170-3.
 8. Platt JF, Rubin JM, Ellis JH, DiPietro MA. Duplex Doppler US of the kidney: differentiation of obstructive from nonobstructive dilatation. *Radiol* 1989;171(2):515-7.
 9. Ashraf Z, Mansoor T, Ashai M, Ahmad I, Lateef W. Duplex Doppler ultrasonography: an excellent initial investigation in obstructive uropathy. *Inter J Surg* 2009;20:11.
 10. Azam A, Haq A, Beg MA. Role of renal arterial resistive index (RI) in obstructive uropathy. *JPM* 2013;63:1511-5.
 11. Bertolotto M, Perrone R, Rimondini A. [Kidney obstruction: potential use of ultrasonography and Doppler color ultrasonography]. *Arch Italian Urol Androl* 2000;72(4):127-34.
 12. Haroun A. Duplex Doppler sonography in patients with acute renal colic: prospective study and literature review. *Int Urol Nephrol* 2003;35(2): 135-40.
 13. Mostbeck GH, Zontsich T, Turetschek K. Ultrasound of the kidney: obstruction and medical diseases. *Eur Radiol* 2001;11(10):1878-89.
 14. Bude RO, Rubin JM. Relationship between the Resistive Index and Vascular Compliance and Resistance 1. *Radiol* 1999;211(2):411-7.
 15. Tublin ME, Bude RO, Platt JF. The resistive index in renal Doppler sonography: where do we stand? *Am J Roentgenol* 2003;180(4):885-92.
 16. Gurel S, Akata D, Gurel K, Ozmen MN, Akhan O. Correlation Between the Renal Resistive Index (RI) and Nonenhanced Computed Tomography in Acute Renal Colic How Reliable Is the RI in Distinguishing Obstruction? *J Ultrasound Med* 2006;25(9):1113-20.
 17. Onur MR, Cubuk M, Andic C, Kartal M, Arslan G. Role of resistive index in renal colic. *Urol Res* 2007;35(6):307-12.
 18. Pepe P, Motta L, Pennisi M, Aragona F. Functional evaluation of the urinary tract by color-Doppler ultrasonography (CDU) in 100 patients with renal colic. *Eur J Radiol* 2005;53(1):131-5.
 19. Sauvain J, Pierrat V, Chambers R, Bui XP, Palascak P, Boursheid D, et al. [Echography and pulsed Doppler of the arteries of the renal parenchyma in obstructive syndromes and dilatation of the excretory cavities of the kidney]. *J Radiol* 1988;70(6-7):389-98.
 20. Achoribo V. A Case Study on Parasitic Infectious Diseases in Pregnant Women in Four Hospitals in Ghana: University of Ghana; 1996.
 21. Affronti G, Clerici G, Canonico S, Arena S, Di Renzo G. Invited Lectures. *J Matern Fetal Neonat Med* 2010;23(S1):1-96.
 22. Geavlete P, Georgescu D, Cauni V, Niță G. Value of duplex Doppler ultrasonography in renal colic. *Eur Urol* 2002;41(1):71-8.
 23. Tamm EP, Silverman PM, Shuman WP. Evaluation of the Patient with Flank Pain and Possible Ureteral Calculus 1. *Radiol* 2003;228(2):319-29.