ORIGINAL ARTICLE

COMPARISON OF DOPPLER INDICES BETWEEN OBSTRUCTED AND NON-OBSTRUCTED KIDNEY

Saira Ilyas[1]✉, Fiza Waseem[2], Aun Bin Tariq[2], Sara Shaukat[3], Afzaal Mehmood[1]

[1]Azeem Ultrasound and X-ray Center, Gujrat-Pakistan, [2]Hussain Hospital Lahore-Pakistan
[3]Amna Medical and Children Clinic Lahore-Pakistan

Background: Acute renal colic is a common acute urologic conditions often caused by urolithiasis. However, diagnosis of obstruction due to urolithiasis sometimes becomes difficult especially when there is an insufficient dilation of urinary tract proximal to obstruction. In these situations, intrarenal artery doppler assessment may be utilized as a diagnostic modality.The aim of this study to evaluate intra-renal arterial Doppler parameters in patients presenting with unilateral acute renal colic, comparing obstructed and non-obstructed kidneys. **Methods:**This case controled study was done at Azeem Ultrasound and Xray Center and was completed in 6 months from 12-12-2023 to 11-06-2024. Sixty individuals were included in the study. Pelvicalyceal system dilatation was examined in each kidney using USG images. For the evaluation of inter-lobar arteries, a minimum of 3 doppler spectra were taken, and their mean was calculated. Resistiv index (RI) was measured using the standard formula, and the mean RI value was determined for each kidney. **Results:** The resistive index was elevated in the obstructed group (0.72±0.10) versus the unobstructed group (0.63±0.07; p<0.001). The predictive accuracy showed a sensitivity of 70.0%, a specificity of 86.67%, a postive pridictive value (PPV) of 78.97%, and an negatieve predictiev value (NPV) of 80.15%. **Conclusion:**The comparison of Doppler indices between obstructed and unobstructed kidneys in patients with urolithiasis reveals significant differences. Elevated RI and PI values, along with increased PSV, highlight that hemodynamics is altered in the presence of renal obstruction. These findings support the use of Doppler ultrasound as a valuable diagnostic tool, helping in the timely identification and management of obstructive uropathy.

Keywords: Urolithiasis; Acute renal colic; Obstructive uropathy; Doppler ultrasound; Resistive index; Pulsatility index

Citation: Ilyas S, Waseem F, Tariq AB, Shaukat S, Mehmood A. Comparison of doppler indices between obstructed and non-obstructed kidney. J Ayub Med Coll Abbottabad 2024;36(4):744–8.

DOI: 10.55519/JAMC-04-14004

INTRODUCTION

Urolithiasis is a common urologic condition in the general population with a global incidence of 115 million cases in 2019.[1] It may result in obstructive uropathy, any structural obstruction to flow of urine out of the urinary tract. As a result of this hindrance, pelvicalyceal dilatation occurs that, if left untreated, can causekidney damage.[2] The frequent symptoms of urolithiasis include acute renal colic, dysuria, hematuria, and difficulty passing urine.[3] Among these, renal colic is the most common presentation of renal obstruction with a prevalence of 18% in Pakistan.[4]

Prompt and correctidentification is important to prevent irreversible damage to the kidneys and guaranteeright management. However, diagnosing urinary obstruction due tostones becomes challenging sometimes, especially when there is insufficient dilation of the urinary tract proximal to obstruction.[5] The initial evaluation includes blood and urineanalysis, and imaging studies. It is challenging to diagnose early obstructive uropathy. When the urinary tract is obstructed, the pressure in the kidney rises, decreasing renal parenchymal compliance. It has a more significanteffect on intraparenchymal venous blood flow than arterial flow.[6–8]

Doppler ultrasonography has emerged as a potential diagnostic tool for evaluating renal blood flow and assessing the presence of obstruction. It is used to evaluate hemodynamics, and the resistivity (RI) and pulsatility (PI) offerdata about resistance to flow within blood vessel.[9] Viyannan *et al*., 2021 reported that RI in the arteries of the patients with obstructed kidneys was higher (0.75) than in those with unobstructed kidneys (0.56), with a p-value < 0.001, a sensitivity of 85% and a specificity of 93%.[5] Nadzri *et al*., 2015 also reported that RI was substantially varied between obstructed and non-obstructedkidney. Obstructed kidney had higher RI value (0.78) than non-obstructed kidney (0.70), with a p-value <0.05. For Doppler ultrasound the sensitivity was found as 100% and the sepecificty was 53%.[10]

However, there remains a gap in understanding how these Doppler parameters perform in patients presenting with acute renal colic, particularly within the first 24 hours of symptom onset. So, this study aimed to

evaluate intra-renal arterial Doppler parameters in patients presenting with unilateral acute renal colic, comparing obstructed and non-obstructed kidneys. By investigating these parameters, the study seeks to determine the use of Doppler ultrasonography in enhancing diagnostic accuracy and facilitating timely intervention, ultimately improving patient outcomes in cases of acute ureteric colic.

MATERIAL AND METHODS

This was a case controled study (cases were considered if they have Obstructed kidenies and controls were taken as non-Obstructed kidenies). The study was conducted at Azeem Ultrasound and Xray Center and was completed in 6 months from 12-12-2023 to 11-06-2024. The study included 60 patients (30 patients with Obstructed and 30 patients with non-Obstructed kidenies). The calculated sample size was very small in both groups, so we took 30 in each group. The sample size was calucalted uing mean RI as 0.75±0.08[5] in Obstructed kidnies and 0.56±0.09[5] in non Obstructed kidnies, using 80% power of test, 95% confidence level and 5% margin of error. We used convenient sampling technique to collect the data.

Patients aged 18–75 years presenting to or referred by a urologist with complaints of unilateral lumbar pain within 24 hours of onset were included in the study. Pateint with history of surgery, known renal malignancy, known chronic kidney disease, renal artery stenosis,and post-renal transplant were excluded.

After obtaining approval from ethical committee of the institute and informed consent from participants, 60 individuals were included in the study. Demographic variables such as age, gender, weight, and height were noted on pre-designed proforma. Clinical records were also monitored to assess serum urea and creatinine. We used Gray-scale ultrasonography in all patients ahving Philips iU-22 with C 1-5 transducer. Likewise, doppler evaluation of intra-renal arterieswas carried out using Siemens Acuson S-3000 with 6C1-HD transducer.Pelvicalyceal system dilatation was examined in each kidney using USG images. For the evaluation of inter-lobar arteries, a minimum of 3 doppler spectra were taken, and their mean was calculated.

The Doppler waveforms were generated using the lowest possible pulse repetition frequency to avoid aliasing, which maximized the Doppler spectrum size and minimized measurement error. Additionally, the lowest wall filter settings appropriate for each ultrasound scanner were employed. The Doppler sample width was adjusted to 2–3 mm. RI was measured using the standard formula, and the mean RI value was determined for each kidney.Normal RI ranges between 0.50–0.70 and value more than 0.70 denotes renal obstruction.[5]

SPSS version 26 was used for statistical analysis. Frequency and percentage were calculated for qualitative variable such as age groups, gender. Independent t-test was carried out for the continuous variables. While, chi-square statistics was used to determine the association between categorical variables. The supposed significance level was $p \leq 0.05$.The ROC(Receiver operating characteristic) curve was made and the AUC (area under the curve) was then estimated to compare the overall predictive accuracy of RI.

RESULTS

Table 1 shows the demographic parameters of patients. The mean age of patients was 44.70±15.93 years, indicating a middle-aged group with moderate variability. Males comprised 56.7% of the sample, while females accounted for 43.3%, showing a slight male predominance. The mean height was 165.82±7.00 cm, whereas the mean weight was 73.30±14.60 kg. Table-2 demonstrates clinical parameters of patients. The mean serum creatinine level was 1.33±0.77 mg/dl. The mean serum urea was 21.55±10.62 mg/dl. The mean PI was 0.89±0.29. The RI was 0.68±0.10, indicating normal to slightly elevated renal resistance. The PSV averaged 78.74±41.62 cm/s, while the EDV averaged 23.20±10.35 cm/s.

Table-3 compared various parameters between obstructed and unobstructed groups. The analysis shows no significant difference in age (obstructed: 44.50±15.41; unobstructed: 44.90±16.70; p=0.924) or gender distribution (p = 0.297) between the groups. Weight also does not differ significantly (obstructed: 72.90±12.83; unobstructed: 73.70±16.40; p=0.834), nor does height (obstructed: 166.90±7.69; unobstructed: 164.73±6.18; p=0.234). Significant differences were observed in serum creatinine levels, with the obstructed group showing higher levels (1.68±0.87) compared to the unobstructed group (0.98±0.45; p<0.001), indicating renal impairment. Serum urea levels were also higher in the obstructed group (25.70±11.84) versus the unobstructed group (17.40±7.32; p=0.002).

The pulsatility index was higher in the obstructed group (1.04±0.35) compared to the unobstructed group (0.75±0.10; p<0.001), indicating increased resistance to blood flow. Similarly, the resistive index was elevated in the obstructed group (0.72±0.10) versus the unobstructed group (0.63±0.07; p<0.001). Peak systolic velocity was also higher in the obstructed group (100.17±43.61) compared to the unobstructed group (57.32±25.93; p<0.001). However, no significant difference was found in end diastolic velocity (obstructed: 25.33±10.02; unobstructed: 21.07±10.39; p=0.112).

Table-4 shows predictive accuracy of RI. The analysis RI revealed that in the obstructed kidney group, 21 patients had an RI >0.70, while 9 had an RI ≤0.70. In the unobstructed group, 4 patients had an RI >0.70, and 26 had an RI ≤0.70. The predictive accuracy showed a

sensitivity of 70.0%, indicating that the test correctly identified 70% of obstructed kidneys, and a specificity of 86.67%, meaning it accurately identified 86.67% of unobstructed kidneys. PPV was 78.97%, suggesting a high likelihood that a positive test indicated obstruction, while NPV was 80.15%, indicating a strong chance that a negative result meant no obstruction. Overall, the diagnostic accuracy was 78.33%, reflecting the test's effectiveness in diagnosing obstructed kidneys.

Figure-1 showed ROC curve demostrating sensitivity and specificity of RI. The area under ROC curve was 0.77, indicating good diagnostic performance in distinguishing between obstructed and unobstructed kidneys.

Table-1: Demographic parameters of patients

Parametes		Mean±SD
Age (years)		44.70±15.93
Gender n (%)	Male	34 (56.7%)
	Female	26 (43.3%)
Height (cm)		165.82±7.00
Weight (kg)		73.30±14.60

Table-2: Clinical parameters of patients

Parameters	Mean±SD
Serum Creatinine (mg/dl)	1.33±0.77
Serum Urea (mg/dl)	21.55±10.62
Pulsatility index	0.89±0.29
Resistive index	0.68±0.10
Peak systolic velocity (cm/s)	78.74±41.62
End diastolic velocity (cm/s)	23.20±10.35

Table-3: Comparison of parameter between obstructed and unobstructed groups

Parameters		Mean±SD		*p*-value
		Obstructed Kidney Group	Unobstructed Kidney Group	
Age (years)		44.50±15.41	44.90±16.70	0.924[a]
Gender	Male	15 (44.1%)	19 (55.9%)	0.297[b]
	Female	15 (57.7%)	11 (42.3%)	
Weight (kg)		72.90±12.83	73.70±16.40	0.834[a]
Height (cm)		166.90±7.69	164.73±6.18	0.234[a]
Serum Creatinine (mg/dl)		1.68±0.87	0.98±0.45	<0.001[a]
Serum Urea (mg/dl)		25.70±11.84	17.40±7.32	0.002[a]
Pulsatility Index		1.04±0.35	0.75±0.10	<0.001[a]
Resistive Index		0.72±0.10	0.63±0.07	<0.001[a]
Peak systolic velocity (cm/s)		100.17±43.61	57.32±25.93	<0.001[a]
End diastolic velocity (cm/s)		25.33±10.02	21.07±10.39	0.112[a]

SD = Standard deviation; cm = centimetre; kg = kilogram; mg/dl = milligram per decilitre; cm/s = centimetre per second; [a] = independent sample t-test was used; [b] = chi-square test was used; p≤0.05 was significant.

Table-4: Predictive Accuracy of Resistive Index

Parameters		Obstructed Kidney	Unobstructed Kidney
RI	>0.70	21	4
	≤ 0.70	9	26
Predictive Accuracy	Sensitivity	70.0%	
	Specificity	86.67%	
	PPV	78.97%	
	NPV	80.15%	
	Diagnostic Accuracy	78.33%	

RI = Resistive index; PPV = positive predictive value; NPV = negative predictive value

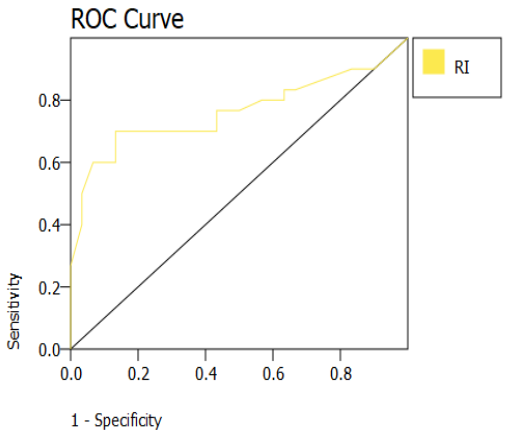

Figure-1: ROC curve demostrating sensitivity and specificity of RI

DISCUSSION

Urolithiasis, characterized by the formation of stones in the urinary tract, is a common urologic condition that can lead to significant complications, including renal obstruction.[11,12] Timely diagnosis and management are critical to preventing irreversible kidney damage.[13] Doppler ultrasound has emerged as a valuable non-invasive tool for assessing renal hemodynamics, particularly in differentiating between obstructed and non-obstructed kidneys.[10,13–15] So this research was conducted to explore the comparison of Doppler indices, including RI, PI, PSV, and EDV, in patients with urolithiasis.

RI is a measure derived from Doppler ultrasound that assesses intra renal artery resistance.[15,16] An RI greater than 0.70 is often

indicative of renal obstruction.[17] The current study showed that there was a significant variation in RI between obstructed and unobstructed kidneys.Obstructed kidneys had a higher RI (0.72±0.10), compared to unobstructed kidneys (0.63±0.07). This finding aligns with previous researches indicating that elevated RI values are associated with increased resistance to blood flow, reflecting compromised renal perfusion due to urolithiasis.[5,18]

A study by Katal *et al*. showed that mean RI was higher in obstruced kidneys (0.70±0.04) than in unobstructed kidneys (0.59±0.04).[17] Another study perfomed by Viyannan *et al*. revealed that RI was substantially higher in obstructed kidneys (0.75), compared to 0.56 in the unobstructed kidneys.[5] These findings are comparable to the present study. The present study also showed that the obstructed group had a significantly higher PI (1.04±0.35) than the unobstructed group (0.75±0.10). A higher PI suggests increased vascular resistance and reduced renal blood flow.[19] These findingshighlight that it is valuable to assess both RI and PI to find out any renal vascular resistance and predict the presence of obstructive uropathy.

Peak systolic velocity is a measure of the maximum speed of blood flow during systole.[20] The current results demonstrate that the obstructed group had a significantly higher peak systolic velocity (100.17±43.61 cm/s) than the unobstructed group (57.32±25.93 cm/s). Elevated peak systolic velocity in obstructed kidneys is caused by compensatory mechanisms where increased flow velocity occurs due to resistance. This observation is particularly common in acute renal colic, where a sudden obstruction leads to increased intrarenal pressure and the resultant hemodynamic changes.

On the other hand, the end diastolic velocity did not show a substantial variation between the two groups (25.33±10.02 cm/s in obstructed vs. 21.07±10.39 cm/s in unobstructed). This lack of significant variation indicate that diastolic flow remains relatively stable due to compensatory renal perfusion mechanisms or collateral circulation.

Elevated RI and PI values in patients with obstructed kidneys suggest that Doppler ultrasound can be used as a reliable diagnostic tool for identifying renal obstruction in urolithiasis. Thesensitivity and specificity was reported as 70.0% and 86.67%, respectively, for RI. It supports its use in clinical practice mainly because it offers a balance between correctly identifying obstructed kidneys and reducing the chances of false positive results.

Furthermore, PPV of 78.97% indicated that when the test indicates obstruction, there's a strong likelihood that the patient truly has an obstructed kidney and NPV of 80.15% also suggested that if the test suggests no obstruction, there is a strong chance the patient does not have significant obstruction. Our findings are consistent with previous researches that have emphasized on the use of Doppler indices to assess renal obstruction. Katal *et al*. reported that the sensitivity and specificity of RI to diagnose acute renal obstruction were 86.54% and 100%, respectively [17]. Similarly, another study reported the sensitivity and specificity of RI to be 85% and 93%, respectively [5]. One more study documented that sensitivity, specificity, PPV, and NPV of RI were 97.7%, 100%, 100% and 86.67%, respectively.[15]

In the present study, AUROC of 0.77 alsosupports the effectiveness of Doppler indices in diagnosing kidney obstruction. Additionally, a significant *p*-value (<0.001) and a 95% confidence interval (0.66–0.87) indicated that Doppler ultrasound is a strong tool to differentiate between obstructed and unobstructed kidneys.

However, several limitations also limit the implications of these results. The sample size is small and could be expanded to enhance the strength of the findings. Additionally, variations in operator experience and ultrasound equipmentimpact Doppler measurements. It highlights the needs for standardized protocols in the clinical practice.

CONCLUSION

The comparison of Doppler indices between obstructed and unobstructed kidneys in patients with urolithiasis reveals significant differences. Elevated RI and PI values, along with increased PSV, highlight that hemodynamics are altered in the presence of renal obstruction. These findings support the use of Doppler ultrasound as a valuable diagnostic tool, helping in the timely identification and management of obstructive uropathy.

AUTHORS' CONTRIBUTION

SI, FW: Conceptualization of the study, proof reading, write-up. ABT, SS, AM: Data collection, data analysis, data interpretation.

REFERENCES

1. Anish T, Vijayakumar K, Leela IAK. Domestic and Environmental Factors of Chikungunya-affected Families in Thiruvananthapuram (Rural) District of Kerala, India. J Glob Infect Dis 2011;3(1):32–6.
2. Badar N, Salman M, Ansari J, Ikram A, Qazi J, Alam MM. Epidemiological trend of chikungunya outbreak in Pakistan: 2016–2018. PLoS Negl Trop Dis 2019;13(4):e0007118.
3. Bloch D, Roth NM, Caraballo EV, Muñoz-Jordan J, Hunsperger E, Rivera A, *et al*. Use of Household Cluster Investigations to Identify Factors Associated with Chikungunya Virus Infection and Frequency of Case Reporting in Puerto Rico. PLoS Negl Trop Dis 2016;10(10):e0005075.

4. Campbell KM, Haldeman K, Lehnig C, Munayco CV, Halsey ES, Laguna-Torres VA, *et al*. Weather Regulates Location, Timing, and Intensity of Dengue Virus Transmission between Humans and Mosquitoes. PLoS Negl Trop Dis 2015;9(7):e0003957.
5. Chikungunya worldwide overview. European Centre for Disease Prevention and Control. [Internet]. [cited (2024 Dec 17]. Available from: https://www.ecdc.europa.eu/en/chikungunya-monthly
6. Choo MS, Blackwood RA. School-Based Health Education in Yucatan, Mexico about the Chikungunya Virus and Mosquito Illness Prevention. Infect Dis Rep 2017;9(2):6894.
7. Elsinga J, van der Veen HT, Gerstenbluth I, Burgerhof JGM, Dijkstra A, Grobusch MP, *et al*. Community participation in mosquito breeding site control: An interdisciplinary mixed methods study in Curaçao. Parasit Vector 2017;10(1):434.
8. Gail MH, Haneuse S. Power and Sample Size for Multivariate Logistic Modeling of Unmatched Case-Control Studies. Stat Methods Med Res 2019;28(3):822–34.
9. García-Betancourt T, Higuera-Mendieta DR, González-Uribe C, Cortés S, Quintero J. Understanding Water Storage Practices of Urban Residents of an Endemic Dengue Area in Colombia: Perceptions, Rationale and Socio-Demographic Characteristics. PLoS One 2015;10(6):e0129054.
10. Grabenstein JD, Tomar AS. Global geotemporal distribution of chikungunya disease, 2011–2022. Travel Med Infect Dis 2023;54:102603.
11. Hossain MS, Hasan MdM, Islam MS, Islam S, Mozaffor M, Khan Md AS, *et al*. Chikungunya outbreak (2017) in Bangladesh: Clinical profile, economic impact and quality of life during the acute phase of the disease. PLoS Negl Trop Dis 2018;12(6):e0006561.
12. Khan AW, Taylor-Robinson AW. Is Pakistan becoming a safe haven for chikungunya virus? Current status and proposed measures to curtail this emerging public health threat. Infect Dis Health 2018;23(4):237–42.
13. Mahmud AS, Kabir Md I, Engø-Monsen K, Tahmina S, Riaz BK, Hossain Md A, *et al*. Megacities as drivers of national outbreaks: The 2017 chikungunya outbreak in Dhaka, Bangladesh. PLoS Negl Trop Dis 2021;15(2):e0009106.
14. Makrufardi F, Phillabertha PS, Safika EL, Sungkono. Factors associated with dengue prevention behaviour in riverbank area: A cross-sectional study. Ann Med Surg 2021;66:102450.
15. Manimunda SP, Vijayachari P, Uppoor R, Sugunan AP, Singh SS, Rai SK, *et al*. Clinical progression of chikungunya fever during acute and chronic arthritic stages and the changes in joint morphology as revealed by imaging. Trans R Soc Trop Med Hyg 2010;104(6):392–9.
16. Mehmood A, Khan FK, Chaudhry A, Hussain Z, Laghari M. A, Shah I, *et al*. Risk Factors Associated with a Dengue Fever Outbreak in Islamabad, Pakistan: Case-Control Study. JMIR Public Health Surveill 2021;7(12):e27266.
17. Mohan A, Kiran D, Manohar IC, Kumar DP. Epidemiology, clinical manifestations, and diagnosis of chikungunya fever: lessons learned from the re-emerging epidemic. Indian J Dermatol 2010;55(1):54–63.
18. Mourad O, Makhani L, Chen LH. Chikungunya: An Emerging Public Health Concern. Curr Infect Dis Rep 2022;24(12):217–28.
19. O'Meara WP, Simmons R, Bullins P, Freedman B, Abel L, Mangeni J, *et al*. Mosquito Exposure and Malaria Morbidity: A Microlevel Analysis of Household Mosquito Populations and Malaria in a Population-Based Longitudinal Cohort in Western Kenya. J Infect Dis 2020;221(7):1176–84.
20. Oqbazgi MD. Treatment and Prevention of Chikungunya Fever: Current Status and Prospective. InChikungunya Virus-A Growing Global Public Health Threat. IntechOpen 2021.
21. Pinchoff J, Silva M, Spielman K, Hutchinson P. Use of effective lids reduces presence of mosquito larvae in household water storage containers in urban and peri-urban Zika risk areas of Guatemala, Honduras, and El Salvador. Parasit Vectors 2021;14(1):167.
22. Shil P, Kothawale DR, Sudeep AB. Rainfall and Chikungunya incidences in India during 2010–2014. Virus Dis 2018;29(1):46.
23. Thiberville SD, Moyen N, Dupuis-Maguiraga L, Nougairede A, Gould EA, Roques P, *et al*. Chikungunya fever: Epidemiology, clinical syndrome, pathogenesis and therapy. Antiviral Res 2013;99(3):345–70.
24. Whiteman A, Loaiza JR, Yee DA, Poh KC, Watkins AS, Lucas KJ, *et al*. Do socioeconomic factors drive Aedes mosquito vectors and their arboviral diseases? A systematic review of dengue, chikungunya, yellow fever, and Zika Virus. One Health 2020;11:100188.

Submitted: July 4, 2024	*Revised: November 5, 2024*	*Accepted: November 15, 2024*

Address for Correspondence:

Dr Saira Ilyas, Azeem Ultrasound and Xray Center, Gujrat-Pakistan
Email: drsairailyas@gmail.com