

Original Research Article

Role of duplex ultrasonography in patients with renal parenchymal disease: renal resistive index vs serum creatinine level

Yassar Shiekh, Aamir Javed Khan, Shafqat Shabir Bhawani*

Department of Radiodiagnosis, Government Medical College Srinagar, Jammu and Kashmir, India

Received: 22 July 2019

Accepted: 29 July 2019

***Correspondence:**

Dr. Shafqat Shabir Bhawani,

E-mail: dr.shafqatshabir@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: In view of the fact that Brightness (B)-mode ultrasound findings in patients with renal parenchymal disease are profoundly non-specific, this study was carried out to determine the efficiency of color Doppler sonography for assessing renal function. In this series, the relationship between the resistive index (RI) of renal interlobar artery and serum creatinine level was analyzed for any relevant association of this color Doppler index with the serum creatinine level.

Methods: In this prospective cross-sectional study, 40 patients with renal parenchymal disease having serum creatinine level >1.4 mg/dL were chosen amidst routine revisits. The control group comprised of 40 normal subjects with serum creatinine levels <1.4 mg/dL. After assessing the kidneys of these subjects with gray-scale ultrasound for presence of any stones, hydronephrosis, and/or space occupying lesions instead of, they were subsequently interrogated with color Doppler sonography and RI calculated.

Results: The mean serum creatinine levels±SD in the case and control groups were 6.7±0.7 mg/dL and 1.0±0.4 mg/dL, respectively. The mean±SD resistive index (RI) was 79.0%±1.8% in the diseased group and 60.3%±0.7% in the healthy subjects (p<0.001). The correlation between the RI and the serum creatinine level was statistically significant (p<0.001).

Conclusions: Resistive index (RI) measurement by color doppler ultrasonography is a reasonable prognosticator of functional outcome in patients with renal parenchymal disease.

Keywords: Doppler ultrasonography, Gray-scale ultrasound, Interlobar artery, Resistive index, Renal parenchymal disease, Serum creatinine

INTRODUCTION

With the recent advances in ultrasound technology, sonographic evaluation of the kidneys has greatly improved and has now become the primary imaging modality for evaluating renal diseases.¹ Ultrasound is a cheap and easily accessible modality for screening of patients with renal dysfunction besides being radiation free.^{2,3} Despite a recent surge in the use of duplex sonography in renal transplant patients to detect acute graft rejection and distinguish it from other causes of

allograft dysfunction, its use in native kidneys has remained limited.^{4,5} Small renal size, raised parenchymal echogenicity coupled with reduced cortical thickness are characteristic sonographic features in chronic renal diseases, nevertheless, highly non-specific.^{4,9} For instance, a mild rise in renal cortical echogenicity on B-mode ultrasound can be seen in approximately 15% of normal individuals and hence spuriously interpreted as renal parenchymal disease.⁵ In addition to morphological abnormalities, Duplex ultrasound provides hemodynamic information about the intrarenal and extrarenal

vasculature highlighting the changes in the renal blood flow.¹⁰ Doppler ultrasonography can, therefore, be used as a suitable method for functional evaluation in those with renal parenchymal disease. We undertook this study with the purpose of evaluating the association between the resistive index (RI) of arcuate or interlobar arteries of the native kidney and serum creatinine level anticipating that duplex sonography may play a pivotal role in evaluation of native kidney function.

METHODS

Ours was a prospective cross-sectional study carried out between August 2018 to June 2019. The case cohort constituted individuals with renal parenchymal disease having serum creatinine levels >1.4 mg/dL. For comparison, a group of normal healthy individuals with no underlying renal disease and serum creatinine level <1.4 mg/dL were also incorporated in the study. Patients with renal stones (unilateral or bilateral), hydronephrosis, space occupying lesions and renal artery stenosis were excluded from the study. The sample size comprised of 40 subjects per cohort (confidence interval- 95% and study power-90%) with mean age of 43.8±2.9 years (age range, 20-80 years). To eliminate the confounding effect of gender, equal number of males and females were included in each group. Patient information such as name, age, gender, ultrasound findings (B-mode and colour doppler), and laboratory test results (serum creatinine and BUN level) were recorded on a pre-set proforma. The subjects were referred from nephrology out-patient department of our hospital, Government Medical College Srinagar. These individuals underwent ultrasonographic evaluation of kidneys to exclude renal stones, hydronephrosis or any mass lesion. After meeting the inclusion criteria, the kidneys were subsequently interrogated with color Doppler and interlobar/ arcuate arterial resistive indices were calculated bilaterally. Multiple samples (five in each kidney) from upper, mid and lower renal poles were taken to increase the efficacy. Serum creatinine levels were measured within three days of the ultrasonography. All the ultrasound examinations were performed by a radiologist with special expertise in genitourinary radiology on GE LOGIC S8 machine using 3-5 MHz curvilinear transducer.

Statistical analysis

Data analysis was performed by a statistician using statistical software (SPSS, version 20.0). The variables were expressed as mean±SD. Quantitative data was analyzed using two sample independent t-test and Pearson's correlation coefficient. A p-value less than 0.05 was considered as statistically significant.

Ethical considerations

After properly explaining the objectives and methods of the study, written consent was obtained from all the participants.

RESULTS

The mean age±SD of the subjects was 48.8±3.3 years for the case and 38.8±2.4 years for the control group (p =0.013). No statistically significant difference (p=0.874) in the mean RI values among different age groups in both the cohorts was noted. Mean serum creatinine levels±SD in the case and control groups were 6.7±0.7 mg/dL and 1.0±0.4 mg/dL, respectively. 64.3±6.8 mg/dL was the mean BUN level in case group in comparison to 13.7±0.8 mg/dL in the control group (p <0.0015). The mean renal length±SD and parenchymal thickness ±SD in case of right kidney, as measured by B-mode ultrasonography were 94.8±3.4 and 11.1±0.57 mm for the case group and 105.05±1.4 (p=0.013) and 12.5±0.4 mm (p =0.044) for the control group, respectively (Figure 1).

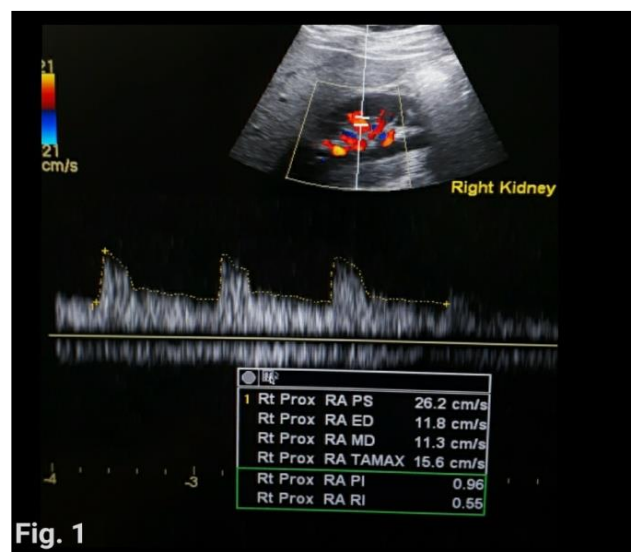


Figure 1: Color doppler sonography with spectral waveform analysis of right mid-pole interlobar artery in a healthy control showing RI of 0.55.

The mean renal length±SD and parenchymal thickness±SD for left kidney were 97.3±3.5 and 11.5±0.5 mm for the case, and 105.7±1.6 (p =0.047) and 13.6±0.5 mm (p=0.014) for the control group, respectively. Tables 1 and 2 show the distribution of RI amongst the case and control groups, respectively. The mean±SD RI was 79.0%±1.8% in the diseased group and 60.3%±0.7% in the healthy subjects (p <0.001).

Figure 1 shows the normal resistive index of 0.55, as measured from right mid-pole interlobar artery in a healthy subject. The correlation between the RI and the serum creatinine level was statistically significant (p <0.001). The sensitivity and specificity of the RI (as a diagnostic test) in comparison to the serum creatinine level (as the gold-standard) were derived from ROC (receiver operating characteristic) curve analysis. All individuals with an RI value >71.6% had deranged creatinine levels and all subjects with an RI <63.1% had serum creatinine levels within the normal range (63.1%

and 71.6% were thus the cut-off values with the highest sensitivity and specificity, respectively). In general, the RI of 67.0% appeared to be the optimal cut-off value with sufficient sensitivity and specificity for ascertaining the renal function.

Table 1: Resistive index (RI) values in patients with renal parenchymal disease.

RI (in %)	Number of patients (n)	Percent (%)
61-70	10	25
71-80	18	45
81-90	8	20
≥91	4	10

Table 2: Resistive index (RI) values in healthy controls in our study.

RI (in %)	Number of subjects (n)	Percent (%)
<60	14	35
61-70	11	27.5
71-80	10	25
81-90	3	7.5
≥91	2	5

DISCUSSION

The main aim of our study was to assess the relationship between serum creatinine levels and resistive index (RI) of renal interlobar artery in patients with renal parenchymal disease and normal individuals. A significant association between these variables was found ($p < 0.001$), which is in coherence with the previous literature. In a similar study, Kim et al. obtained a statistically significant difference between the RI values of patients with renal parenchymal disease and those of the control group.⁴ Besides, a significant association was noted between serum creatinine levels and resistive indices of interlobar arteries ($p < 0.05$). Their study was based on 96 individuals with the cut-off value of serum creatinine between controls and those with renal parenchymal disease being 1.4 mg/dL. A decline in renal function with consequent rise in serum creatinine may lead to renal architectural remodelling involving blood vessels, glomeruli and interstitium thereby increasing the arterial resistance. This rise in arterial resistance results in decrease in diastolic flow and thus increase in resistive index (RI).^{11,12} Nori et al, and Izumi et al, observed that sudden deterioration of renal function (acute renal failure) leads to an increase in resistive index of interlobar arteries there by advocating the role of color Doppler in acute renal failure.^{3,11} Quايا and Bertolotto studied the prognostic role of Doppler ultrasound in patients with acute renal failure and found a positive correlation between declining RI values and serum creatinine levels.⁹ Romano et al. did a study on diabetic subjects to assess the role of RI in predicting deteriorating renal function and found a significant correlation between resistive index and worsening renal function. They concluded that

a RI value ≥ 0.80 can help in predicting renal functional outcome in diabetic patients with microalbuminuria.¹³ In a study on earthquake victims with crush injury, Keven et al. concluded that renal resistive index (RI) measurement can be helpful in predicting recovery from acute renal failure.¹⁴ Yoon et al, evaluated the role of doppler sonography in predicting the temporal relationship between serial RI values and serum creatinine levels in rabbits with acute renal failure and found that a decrease in RI value heralded the decrease in serum creatinine level. They concluded that color doppler sonography is an effective tool in predicting the course of acute renal failure, however, the correlation between serial RI values and serum creatinine levels was not strong.¹⁵ In our series, increase in RI did not correlate completely with the increment in serum creatinine level. For instance, patients with mildly raised serum creatinine level (2.5 mg/dL) had a high resistive of 0.91 in comparison to RI of 0.72 in patients with serum creatinine level of 15 mg/dL. In addition, some subjects in the control group had a relatively high RI of 0.70 - 0.75 despite having normal serum creatinine levels of less than 1mg/dL.

Our study has a drawback in the form of significant difference in the mean age of subjects in the case and control groups, therefore, any difference in RI values between the two groups might be due to confounding effect of age. Amongst all the variables, i.e, renal size, cortical thickness and resistive index; the RI value correlated more closely with renal dysfunction and serum creatinine levels.

CONCLUSION

From this study, we came to the conclusion that in patients with renal parenchymal disease, interlobar arterial RI measurement by color doppler sonography is an effective and reproducible prognosticator of functional outcome.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee and with the 1964 Helsinki declaration and its later amendments AR comparable ethical standards

REFERENCES

1. Quايا E, Bertolotto M. Renal parenchymal diseases: is characterization feasible with ultrasound? *Eur Radiol.* 2002;12(8):2006-20.
2. Khati NJ, Hill MC, Kimmel PL. The role of ultrasound in renal insufficiency: the essentials. *Ultrasound.* 2005;21(4):227-44.
3. Nori G, Granata A, Leonardi G, Sicurezza E, Septa C. The US color Doppler in acute renal failure. *Minerva Urol Nefrol.* 2004;56(4):343-52.
4. Kim SH, Kim WH, Choi BI, Kim CW. Duplex Doppler US in patients with medical renal disease:

- resistive index VS serum creatinine level. Clin Radiol.1992;46(3):219-20.
5. Goldberg SB. Diagnostic ultrasound. Lippincott RaVen. 1997:787-863.
 6. Kondo A, Akakura K. Assessment of renal function with color Doppler ultrasound in autosomal dominant polycystic kidney disease. International j urol. 2001;8(3):95-8.
 7. Brkljacic B, Sabljari-Matovinovic M, Putarek K, Soldo D, Morovic-Vergles J, Hauser M. Renal vascular resistance in autosomal dominant polycystic kidney disease: evaluation with color Doppler ultrasound. Acta Radiol. 1997;38(5):840-6.
 8. Sutton D. Textbook of Radiology and Imaging. 7th ed. London: Churchill Livingstone; 2003: 885-1069.
 9. Bertolotto M, Quaia E, Rimondini A, Lubin E, Pozzi Mucelli R. Current role of color Doppler ultrasound in acute renal failure. Radiol Med (Torino). 2001;102(5-6):340-7.
 10. Krumme B. Renal Doppler sonography-update in clinical nephrology. Nephron Clin Pract. 2006;103(2):24-8.
 11. Izumi M, Sugiura T, Nakamura H, Nagatoya K, Imai E, Hori M. Differential diagnosis of prerenal azotemia from acute tubular necrosis and prediction of recovery by Doppler ultrasound Am J Kidney Dis 2000;35(4):713-9.
 12. Pollack HM, McClennan BL. Clinical Urography 2nd ed. Philadelphia: W.B. Saunders; 2000:2546-7.
 13. Nosadini R, Velussi M, Brocco E, Abaterusso C, Carraro A, Piarulli F. Increased Renal Arterial resistance predicts the course of renal function in type 2 diabetes with microalbuminuria. Diabetes 2006;55(1):234-9.
 14. Keven K, Ates K, Yagmurlu B, Nergizoglu G, Kutlay S, Aras S, et al. Renal Doppler ultrasonographic findings in earthquake victims with crush injury. J Ultrasound Med. 2001;20(6):675-9.
 15. Yoon DY, Kim SH, Kim HD, Na DG, Goo JM, Choi HJ et al. Doppler sonography in experimentally induced acute renal failure in rabbits: resistive index versus serum creatinine levels. Invest Radiol. 1995;30(3):168-72.

Cite this article as: Shiekh Y, Khan AJ, Bhawani SS. Role of duplex ultrasonography in patients with renal parenchymal disease: renal resistive index vs serum creatinine level. Int J Adv Med 2019;6:1438-41.