M. Ghafoori MD[1]
Sh. Shiva MD[2]

The Relation between Serum Creatinine and Renal Resistance Index in Parenchymal Kidney Disease

Background/Objective: Considering the fact that gray-scale ultrasonography findings in patients with non-surgical kidney disease are highly non-specific, this study was conducted to evaluate the efficacy of color Doppler ultrasonography for determining a quick assessment of the renal function. In this study, the association between the kidney interlobar artery resistive index (RI) and serum creatinine level was investigated to identify whether this index has a significant relationship with the serum creatinine level.

Patients and Methods: In a cross-sectional study, 30 patients with non-surgical parenchymal renal disease who had a serum creatinine level>1.4 mg/dL were selected during regular revisits. 30 normal individuals with serum creatinine levels<1.4 mg/dL were also selected as the comparison group. The kidneys of these subjects were investigated with gray-scale ultrasonography for bilateral symmetry, absence of stones, hydronephrosis, and any space occupying lesion. They were then evaluated with color Doppler ultrasonography and the RI was measured in 10 interlobar arteries (5 in each kidney).

Results: The mean±SD serum creatinine level was 6.5±0.6 mg/dL in the case and 1.0±0.3 mg/dL in the control group. The mean RI was 78.0%±1.9% for the case and 59.3%±0.8% for the control group ($p<0.001$). A significant correlation was found between the serum creatinine level and the RI ($r=0.68$, $p<0.001$).

Conclusion: In renal parenchymal disease, measuring RI by Doppler ultrasonography is a fair predictor of renal function.

Keywords: Doppler ultrasonography, renal artery, resistive index, serum creatinine, renal failure

Introduction

With introduction of wideband transducers and advances in beam former technology, the ultrasound imaging of the kidneys has greatly improved in recent years.[1] Nowadays, renal Doppler ultrasonography has been established as a diagnostic tool for the daily nephrological work-up. Extra- and intra-renal flow signals are obtained for different indications.[2] Ultrasonography is the best screening modality to evaluate patients presenting with renal insufficiency and can give an effective assistance in the differential diagnosis of its causes.[3,4]

Although recently, Doppler ultrasonography has been frequently used to evaluate kidney transplant rejection and its causes, the utilization of this technique for the diagnosis of disorders in native and non-transplanted kidneys (with the exception of renal artery stenosis) is not common.[5,6] Gray scale ultrasonography findings in patients with non-surgical kidney disease are highly non-specific.[5-10] For example, a mild increase in kidney echogenicity in gray-scale ultrasonographic imaging, which causes the kidney become more echogenic than the liver, is a finding that can be seen in about 15% of the general population and is indistinguishable from that of a renal parenchymal disorder.[6] Considering this fact and that Doppler ultrasonography can be a suitable method to evaluate renal

1. Assistant Professor, Department of Radiology, Iran University of Medical Sciences, Tehran, Iran.
2. Department of Radiology, Iran University of Medical Sciences, Tehran, Iran.
Corresponding Author:
Mahyar Ghafoori
Address: Department of Radiology, Hazrate Rasoul Hospital, Niayesh St., Tehran, Iran.
Tel: +98-216-6509057
Fax: +98-216-6517118
E-mail: Ghafoori@hbi.dmr.or.ir

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function in those with parenchymal kidney disease, this cross-sectional study was conducted to evaluate the relation between the native kidney interlobar artery resistive index (RI) and serum creatinine level, to see whether this index has a significant association with the serum creatinine level or not.

Patients and Methods

This cross-sectional study was conducted in Tehran Hashemi-Nejad Hospital. The case group included subjects with parenchymal renal disease who had a serum creatinine level >1.4 mg/dL. Individuals with unilateral or bilateral hydronephrosis or abnormalities other than diffuse echogenicity changes of the renal parenchyma in ordinary ultrasonography (e.g., renal cysts, tumors, or stones) were excluded from the study. None of the cases had evidence of renal artery stenosis in Doppler study.

The comparison group consisted of normal individuals with a serum creatinine level <1.4 mg/dL; they had also normal blood pressure.

Considering a confidence interval of 95% and a study power of 90%, the minimum sample size was estimated to be 30 subjects in each group, based on the findings of a previous study that revealed a variance of 0.035 and an expected difference between means of 0.196. To remove the effect of gender as a confounding variable, each group consisted of 15 males and 15 females.

In this study a data collection form was used that consisted of items for the subject's name, age, gender, date of ultrasonography, date the laboratory tests performed, a checklist for gray-scale ultrasonography and color Doppler findings, and serum blood unrae nitrogen (BUN) and creatinine laboratory results.

The subjects included in this study were selected from patients who were admitted to Hashemi-Nejad Hospital, Tehran, Iran. Their kidneys were evaluated with gray-scale ultrasonography to confirm bilateral renal symmetry and the absence of stones, hydronephrosis, and any space occupying lesion. Subsequently, they were investigated with color Doppler ultrasonography and the RI was measured in 10 interlobar arteries in both kidneys—5 in the right and 5 in the left kidney. Patients serum creatinine level was measured within three days of the ultrasonography. All the ultrasonographic examinations were performed by a radiologist with an Esaote-Technus MP ultrasound machine with 3–5 MHz multifrequency convex 40 R transducer.

Statistical Analysis

The statistical analyses were performed by SPSS 11.0. The variables are presented as mean±SD. The comparisons of variables were done with Student's t test for independent variables and Pearson's correlation coefficient. The sensitivity and specificity of the RI compared to the serum creatinine level were calculated by a receiver operator characteristics (ROC) curve.

Ethical Considerations

The objectives and methods of the study were clearly explained for all participants and written consents were obtained.

Results

The mean±SD age of participants was 43.6±3.1 years for the case and 33.6±2.7 for the comparison group (p=0.019).

There was no significant difference (p=0.784) between the mean RI among different age groups in both the case and the comparison groups.

The mean±SD serum creatinine level was 6.5±0.6 mg/dL in the case and 1.0±0.3 in the comparison group. The mean BUN level was 62.1±5.7 mg/dL in the case and 12.6±0.7 mg/dL in the comparison group (p<0.001).

The mean±SD renal length and parenchymal thickness measured by gray-scale ultrasonography of the right kidney were respectively, 95.9±3.5 and 12.1±0.58 mm for the case group, and 106.06±1.5 (p=0.012) and 13.6±0.5 mm (p=0.048) for the comparison group (Figure 1).

The mean±SD renal length and parenchymal thickness of the left kidney were respectively, 98.4±3.6 and 12.6±0.6 mm for the case, and 106.8±1.7 (p=0.046) and 14.7±0.6 mm (p=0.016) for the comparison group (Figure 1).

The distribution of RI among the healthy and diseased subjects is presented in Tables 1 and 2.

The mean±SD RI was 78.0%±1.9% in the case and

59.3%±0.8% in the comparison (p<0.001).

A significant correlation was found between the serum creatinine level and the RI (r=0.68, p<0.001).

The sensitivity and specificity of the RI (as a diagnostic test) as compared to the serum creatinine level (as the gold-standard) were calculated by ROC curve analysis. All subjects with an RI >70.5% had abnormal creatinine levels and all with an RI <62.0% had normal creatinine levels (70.5% and 62.0% were thus the cutoff values with the highest specificity and sensitivity, respectively). Overall, the RI of 66.0% seemed to be the best cutoff point with acceptable sensitivity and specificity for the determination of renal function.

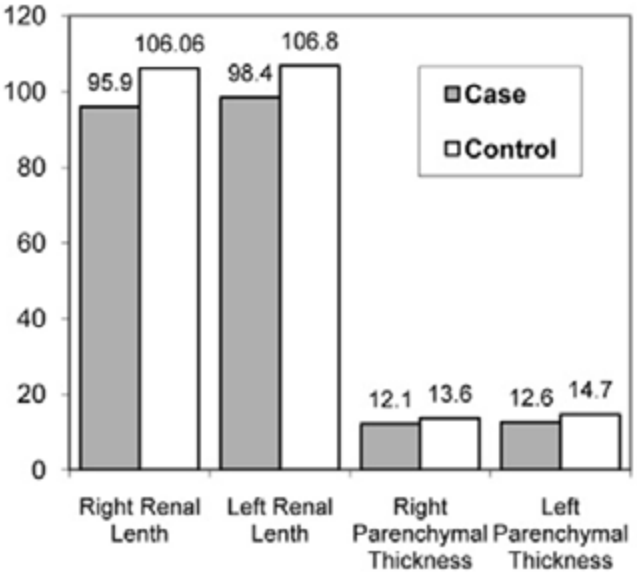

Fig 1. The mean of renal length and parenchymal thickness in the right and left kidneys were measured by gray-scale ultrasonography.

Discussion

The main objective of this study was to evaluate the association between serum creatinine and the RI of the kidney interlobar artery in patients with renal disease and normal individuals. Considering the results obtained, there is a significant relationship between these variables (r=0.68, p<0.001). This association has been confirmed in all previous studies and in this regard, this study is consistent with others. In a very similar study performed in 1992 in South Korea, 68 patients with creatinine levels >1.4 mg/dL and clinically perceivable renal disease, and 28 normal individuals with creatinine levels ≤1.4 mg/dL and without clinically observable kidney disorder as the comparison group, were selected and investigated with Doppler ultrasonography; the RI was calculated and compared with serum creatinine levels.[5] The RI of the renal disease group and the comparison group revealed a significant difference statistically (p<0.01). A significant correlation between the serum creatinine level and the RI (r=0.4389, p<0.05) was observed.

Table 1. The RI values in healthy subjects of this study

RI	Frequency	percent
≤50	1	1.8
51–60	19	33.3
61–70	15	26.3
71–80	13	22.8
81–90	6	10.5
≥91	3	5.3

Table 2. The RI values in patients with renal disease

RI	frequency	percent
61–70	7	24.1
71–80	13	44.8
81–90	6	20.7
≥91	3	10.3

Such a relation is predictable because with a decrease in renal function and thus an increase in serum creatinine, a change in renal structures would be anticipated, including glomerules, blood vessels, and interstitial tissue. As the renal vessels become involved, the arterial resistance increases and ultimately this rise in resistance manifests as a decrease in diastolic blood flow which in turn, would cause an increase in the RI.[11,12]

Nori et al. and Izumi et al. reported that RI increases in many diseases causing acute renal failure including acute tubular necrosis, hepato-renal syndrome, polyarteritis nodosa, hemolytic-uremic syndrome, thrombotic thrombocytopenic purpura and lupus nephritis. They considered Doppler ultrasound as an effective diagnostic tool in evaluating acute renal failure.[4,13]

Quaia and Bertolotto in a study concluded that follow-up of acute renal failure, during and after medical treatment, is the most useful field of employment of color Doppler ultrasonography, since a progressive lowering of RI is correlated to a progressive recovery of renal function.[1]

Romano and colleagues in a study on type 2 diabetic

patients evaluated the value of RI for the prediction of worsening renal function in diabetic nephropathy. In their study, RI was significantly correlated with increased blood pressure and decreased renal function. They suggested that an RI ≥80% can predict the outcome of renal function in type 2 diabetic patients with microalbuminuria.[14]

Keven and colleagues in a study on earthquake victims found that in crush injury, measurement of renal RI can be useful for the prognosis of recovery from acute renal failure.[15]

Yoon and colleagues investigated the temporal trend in the RI measured by Doppler ultrasonography and serum creatinine values in the course of experimentally-induced reversible acute renal failure in rabbits. They concluded that the change in the RI preceded the change in serum creatinine levels in the course of reversible acute renal failure. They then concluded that Doppler sonography is useful in predicting the course of acute renal failure but there was a weak linear correlation between RI and serum creatinine levels.[16]

In our study, the increase in RI was not completely correlated with the increase in serum creatinine—as an indicator of renal function. For example, patients were observed with a slightly elevated serum creatinine level (3.0 mg/dL) but a high interlobar artery RI of 90%. On the other hand, there were patients with a high serum creatinine level (16 mg/dL) but an interlobar artery RI of 70%. There were also individuals in the comparison group with a relatively high RI of 69% but a creatinine level of 0.7 mg/dL. Therefore, there were patients with kidney disease.

In this study, the mean age of the case and comparison groups was significantly different. The difference in RI observed between these two groups therefore may be attributed to the effect of age on the amount of RI.

Other findings in this study, in addition to the results of previous studies were that among the variables studied, i.e., the kidney length, parenchymal thickness, and RI, the RI was more closely correlated with renal dysfunction and serum creatinine level than other factors.

We therefore, concluded that in renal parenchymal disease, measuring RI by Doppler ultrasonography is a fair predictor of renal function.

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