Evaluation of Renal Resistivity Index Before and After Voiding Cystoureterography Examination in Patients With Vesicoureteral Reflux

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Vesicoureteral reflux (VUR) occurs commonly in children and can cause significant renal damage. The purpose of this study is to assess the changes in renal vasculature with spectral Doppler sonography in patients with VUR. In addition, the possible effects of voiding cystoureterography (VCU) on the kidneys in patients with VUR are investigated by calculating renal resistivity index (RI) values before and after VCU using spectral Doppler sonography. In this prospective study, 114 kidneys of 58 children ages 0 to 16 years were included. The RI values that were calculated before and after VCU and RI values in different grades of VUR were compared statistically. In patients with VUR, the renal parenchymal RI values before and after VCU were significantly higher than those in patients without VUR ($P < .05$). The mean pre-VCU RI values were 0.68 ± 0.03 and 0.65 ± 0.05 in patients with VUR and in the control group, respectively, and the mean post-VCU RI values were 0.68 ± 0.03 and 0.65 ± 0.04 in patients with VUR and in the control group, respectively. Calculating renal RI values from arcuate or interlobar renal arteries with spectral Doppler sonography while the patients are in a supine or lateral decubitus position is a useful technique in patients with VUR, being significantly higher in high-grade VUR patients than in low-grade VUR patients. There is no significant effect of the contrast agent reaching the renal calycial system during VCU examination on renal RI values.

Key words: vesicoureteral reflux, renal resistivity index, spectral Doppler, sonography

Vesicoureteral reflux (VUR) occurs commonly in children and can cause significant renal damage. The incidence of VUR in children with urinary tract

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infection is approximately 20% to 50%, and VUR is the precursor of end-stage renal disease in children and adults.[1,2] In children with VUR, there is a predisposition to renal infection, which as a result causes renal damage and scar formation, ending in deterioration of renal function, renal failure, hypertension, and renal growth retardation.[3–5]

The purpose of this study is to assess the changes in renal vasculature in patients with VUR with spectral Doppler sonography. The possible effects of voiding cystoureterography (VCU) on the renal vasculature were evaluated by calculating renal resistivity index (RI) values before and after VCU.

Materials and Methods

This prospective study evaluated 114 kidneys in a population of 58 pediatric patients who presented with a presumptive diagnosis of VUR. The ages of the patients were between 1 month and 16 years (mean 5.03 years). Seventy-eight kidneys without VUR were included as a control group.

Before the VCU examinations, urine culture results were verified with no active urinary tract infection in any patients. Diatrozat (Urovist Angiographin, Schering, Germany) was used in the VCU examinations. The grading of VUR was evaluated according to the following grading system of the international study group[6]:

Grade I VUR: reflux reaches to ureter.
Grade II VUR: reflux reaches to renal pelvis and calyces without causing any dilatation.
Grade III VUR: reflux reaches to renal pelvis and calyces, causing mild dilatation.
Grade IV VUR: reflux reaches to renal pelvis and calyces, causing moderate dilatation.
Grade V VUR: reflux reaches to renal pelvis and calyces, causing severe dilatation.

After obtaining informed consent from the parents of the patients, renal RI calculations before and after VCU examination were done from both kidneys of the patients with spectral Doppler sonography (Logiq 500 and Logiq 700, GE Medical Sys, Milwaukee, Wisconsin). The RI calculations were performed with 3.5- to 5-MHz convex probes from arcuate or interlobar renal arteries while the patients were in a supine or lateral decubitus position.

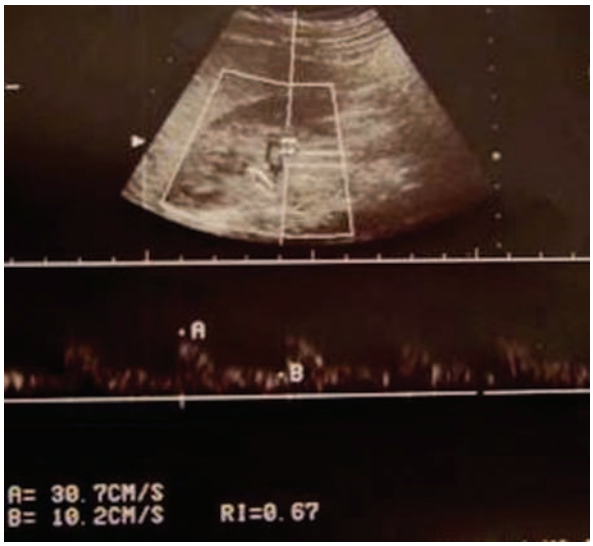


FIGURE 1. Spectral Doppler sonographic examination evaluating right kidney with grade I vesicoureteral reflux. Renal resistivity index is not increased.

Statistical analysis was performed using SPSS for Windows 10.0. Quantitative variables were described as mean ± standard deviation and qualitative variables as percentage (%). The correlation between the variables was evaluated by Pearson correlation test. Parametric tests were evaluated by Student *t* test and nonparametric tests by Wilcoxon signed-rank test, and $P < .05$ was accepted as a statistically significant difference. The RI values obtained before and after VCU were compared statistically to evaluate differences in RI after contrast media administration. Also, the RI values in different grades of VUR were compared with each other (see Figures 1–3).

Results

The mean age of the patients was 5.03 ± 4.2 years. The mean age was higher in patients with grade IV VUR and lower in patients with grade I VUR (see Table 1). Of the patients, 22 (37.9%) were male and 36 (62.1%) were female. Grade I VUR was found in 8.3% of the patients, grade II VUR in 47.2%, grade III VUR in 16.6%, grade IV VUR in

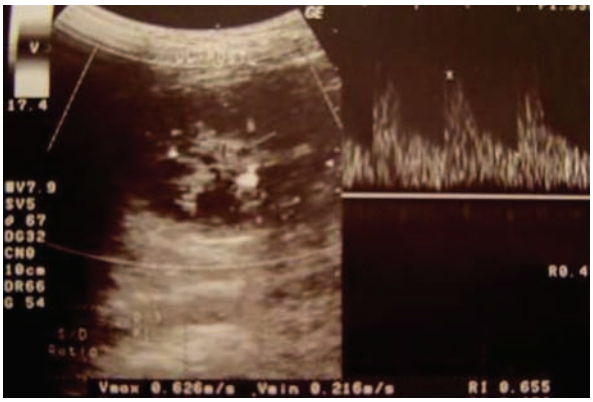


FIGURE 2. Spectral Doppler sonographic examination evaluating left kidney with grade III vesicoureteral reflux. Renal resistivity index is not increased.

19.4%, and grade V VUR in 8.3%. The distribution of the different grades of VUR in the right and left kidneys is summarized in Table 2. The mean RI values both before and after the VCU examination were higher in patients with VUR than those in patients without VUR ($P < .05$; see Table 3). The mean pre-VCU RI values were 0.68 ± 0.03 and 0.65 ± 0.05 in patients with VUR and in the control group, respectively, and the mean post-VCU RI values were 0.68 ± 0.03 and 0.65 ± 0.04 in patients with VUR and in the control group, respectively.

In patients with or without VUR, there was no statistically significant difference in the RI values obtained before and after the VCU examination. There was no significant difference among low-grade (grades I–III) and high-grade (grades IV, V) VUR patients either (see Table 4).

Statistically significant difference was detected when post-VCU mean RI values of grade III and grade IV VUR patients ($P < .01$) were compared, but this was not true for the comparison of pre-VCU mean RI values. There was no significant difference in the comparison of the mean RI values of other grades of VUR among each other in the pre-VCU or post-VCU values. Pre- and post-VCU mean RI values of high-grade VUR patients were significantly higher than those of the control group ($P < .05$).

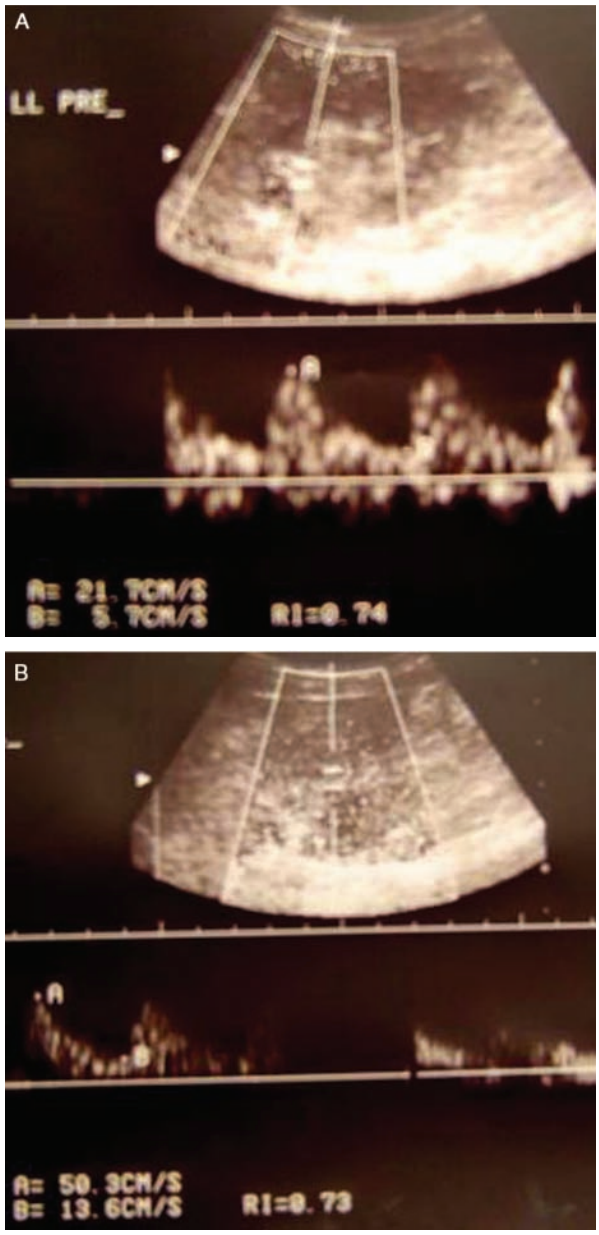


FIGURE 3. Spectral Doppler sonographic examination evaluating left kidney with grade V vesicoureteral reflux, (A) prior to and (B) after voiding cystoureterography. Renal resistivity index is increased, with no marked difference after voiding cystoureterography.

Discussion

VUR is one of the major etiologies of end-stage renal failure, and it is important to be diagnosed before its infectious complications. VCU is the gold-standard imaging modality in detecting VUR. It is also important in the follow-up of VUR.[7,8]

Reflux nephropathy occurs in 60% of the children with VUR. There is a direct correlation between the grade of VUR and the incidence of

TABLE 1.
Mean Age in Different Grades of Vesicoureteral Reflux (VUR)

	Age, y, Mean ± SD
Normal	5.6 ± 4.3
Grade I VUR	5.3 ± 4.2
Grade II VUR	3.5 ± 4.0
Grade III VUR	4.6 ± 4.0
Grade IV VUR	3.1 ± 3.7
Grade V VUR	3.8 ± 2.9
Total	5.0 ± 4.2

TABLE 2.
Distribution of Different Grades of Vesicoureteral Reflux (VUR) in Right and Left Kidneys (N = 114)

	Right Kidney	Left Kidney	Total
Normal	39	39	78
Grade I VUR	1	2	3
Grade II VUR	9	8	17
Grade III VUR	4	2	6
Grade IV VUR	3	4	7
Grade V VUR	0	3	3
Total	56	58	114

TABLE 3.
Pre-VCU and Post-VCU Mean RI Values in Patients With and Without VUR

	Pre-VCU Mean RI	Post-VCU Mean RI	*P*
Normal (n = 78)	0.65 ± 0.05	0.65 ± 0.04	>.05
VUR (n = 36)	0.68 ± 0.03	0.68 ± 0.03	>.05
P	<.05	<.05	

VCU, voiding cystoureterography; VUR, vesicoureteral reflux; RI, resistivity index.

reflux nephropathy.[9] Acute pyelonephritis is seen approximately twice as often in patients with high-grade VUR than in patients with low-grade VUR. There is also a direct correlation between the frequency of renal scar formation and the grade of VUR. The increase of the pressure in the ureter and renal pelvis due to VUR causes a decrease in the postglomerular blood flow supplying the renal medulla and cortex, resulting in ischemic damage.[10]

The calculation of renal parenchymal RI with spectral Doppler sonography is a noninvasive technique used to investigate the changes in the renal arterial system. RI values are calculated from the arcuate or interlobular renal arteries and should be performed to evaluate diseases affecting the tubulointerstitial or vascular systems.[11] In the case of hydronephrosis due to urinary tract obstruction, the pressure inside the renal pelvis increases progressively, resulting in a sudden and marked elevation in the RI value, which returns to normal limits when the obstruction disappears.[12]

Calculation of renal RI values has been widely used in the evaluation of renal transplant rejection, acute tubular necrosis, and obstructive pyeloectasis. In all of these circumstances, it is stated that RI values higher than 0.70 point to pathological changes.[11–13,14] Gilbert et al[15] and Fung et al[16] claim that the evaluation of RI values is useful in hydronephrotic children.

It is reported that in patients with renal scar formation, the changes in the interstitium may change the RI values. In other words, elevated RI values in patients with VUR may indicate renal pathological changes due to VUR or underlying pyelonephritis.[17,18]

Radmayr et al[11] found renal RI values in high-grade VUR patients to be significantly higher than the values in both low-grade VUR patients and the control group. A mean RI value of 0.77 was reported in patients with grade IV and grade V patients, which was significantly higher than that of grade I, II, and III patients. Mean RI values in patients with VUR were significantly higher than in patients without VUR, which is also supported by our study. On the other hand, Radmayr et al[11] did not compare the RI values of patients with low-grade and high-grade VUR with the control group separately. In our study, the mean RI values of low-grade and high-grade VUR patients were compared separately with the mean RI values of the control group, and no significant difference was found between the mean RI values of low-grade VUR patients and the control group. Our study showed mean RI values of high-grade VUR patients before and after the VCU examination to be significantly

TABLE 4.
Pre-VCU and Post-VCU Mean RI Values in Patients With Different Grades of VUR and in the Control Group (N = 114)

	Normal	Grade I VUR	Grade II VUR	Grade III VUR	Grade IV VUR	Grade V VUR
Pre-VCU mean RI	0.65 ± 0.05	0.66 ± 0.01	0.67 ± 0.04	0.67 ± 0.02	0.69 ± 0.03	0.68 ± 0.05
Post-VCU mean RI	0.65 ± 0.04	0.67 ± 0.05	0.68 ± 0.04	0.66 ± 0.02	0.71 ± 0.02	0.67 ± 0.04
P	>.05	>.05	>.05	>.05	>.05	>.05

VCU, voiding cystoureterography; VUR, vesicoureteral reflux; RI, resistivity index.

higher than that of the control group, which is also valid for other studies in the literature.

The possible effects of the VCU examination on renal RI values have not been studied widely up to now. Because VUR increases pressure in the renal pelvis, and the contrast agent used in the VCU examination that reaches the calycial system may increase the pressure in the renal pelvis through an osmotic effect, renal RI values in patients with VUR were evaluated in our study. The pre-VCU mean RI values were correlated with the post-VCU mean RI values both in patients with VUR and in the control group, but no statistically significant difference was demonstrated.

In conclusion, calculation of renal RI values with spectral Doppler sonography is a useful technique in patients with VUR, being significantly higher in high-grade VUR patients than in low-grade VUR patients. There is no significant effect of the contrast agent reaching the renal calycial system during the VCU examination on renal RI values.

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