Original Research Article

Role of renal Doppler sonography as a diagnostic tool in patients with various renal disease

Uttareshvar Mahaling Dhumal[1*], Balaji Kombade[2]

[1]Assistant Professor, Department of Radiodiagnosis, MIMSR Medical College Latur, Maharashtra, INDIA.
[2]Associate Professor, Department of Radiodiagnosis, Government Medical College Latur, Maharashtra, INDIA.
Email: uttareshvar@gmail.com

Abstract

Background: Renal Doppler sonography has been established as a diagnostic tool of the daily nephrological work-up. Extra- and intrarenal flow signals are obtained for different indications. **Aim:** To evaluate the role of renal Doppler in various native renal diseases and to define the role of renal Doppler in nephrological workup of patients with these disorders. **Material and Methods:** The study group included 76 patients with various renal disease which were categorized under obstructive nephropathy(n=25), medical renal disease (renal parenchymal disease, n=43) and 8 cases of renal masses. The control group included 20 patients with age range between 6 to 68 yrs. **Results:** The mean R.I. in the obstructed kidneys (0.729) was significantly higher than the mean R.I. in the controls (0.57± 0.05) and in the contralateral normal kidney (0.58±0.04).The mean R.I. of 0.78 ± 0.06 in case with CRF was significantly different from that of controls (0.57± 0.05). High frequency signals with a large systolic diastolic gradient with high peak systolic velocities were seen in all four cases of RCC. **Conclusion:** Being aware of several pitfalls which may lead to false results, nephrologists may use renal Doppler sonography as the first screening method of choice as the diagnostic tool.
Key Words: Renal diseases, Doppler sonography, resistive index, pulsatility index, diagnosis.

[*]**Address for Correspondence:**
Dr. Uttareshvar Mahaling Dhumal, Assistant Professor, Department of Radiodiagnosis, MIMSR Medical College Latur, Maharashtra, INDIA.
Email: uttareshvar@gmail.com
Received Date: 18/11/2017 Revised Date: 09/12/2017 Accepted Date: 20/01/2018
DOI: https://doi.org/10.26611/1013513

Access this article online

Quick Response Code:

Website: www.medpulse.in

Accessed Date: 27 January 2018

INTRODUCTION

Renal disorders encompass a spectrum of diseases ranging from congenital diseases, to those due to obstruction, to the renal parenchymatous diseases, to the systemic diseases affecting the kidney and also focal lesions like tumors and cysts.[1]An early detection of chronic kidney disease at the earliest possible stage should be a priority. Although gray scale sonography can provide important anatomical information it lacks the ability to provide significant physiological data.Duplex Doppler sonography has the potential to provide physiological information regarding renal arterial resistance and has been extensively used in renal transplants. Its role in the detection of significant renal artery stenosis by combining extrarenal and intrarenal approaches is also well established even though the technique is marred by several technical difficulties.[2]Doppler ultrasonography detects not only renal macroscopic vascular abnormalities but also identifies changes in blood flow at the microvascular level.[3] Evaluation of vascular impedance at different sites of the renal parenchyma may suggest functional or structural changes within the kidneys and could provide useful diagnostic and prognostic information. This study has been undertaken to evaluate the role of renal Doppler in various native renal diseases and to define the role of renal Doppler in nephrological workup of patients with these disorders.

How to cite this article: Uttareshvar Mahaling Dhumal, Balaji Kombade. Role of renal Doppler sonography as a diagnostic tool in patients with various renal disease. *MedPulse – International Journal of Radiology.* January 2018; 5(1): 09-14.
http://www.medpulse.in/Radio%20Diagnosis/

MATERIAL AND METHODS

The study was conducted in the Department of Radiodiagnosis at a Tertiary Care Hospital. The patients included in the study were those with various renal disease presenting in the department, categorized under obstructive renal disease, Medical renal disease and renal neoplasms. An attempt was made to sub categorize the patients in medical renal diseases and obstructive renal diseases by keeping certain inclusion criteria based on a thorough workup of patients by history, clinical examination, laboratory investigations, gray scale sonography findings and clinical course on follow up. This was imperative since histopathological confirmation by biopsy was not available in most patients barring few exceptions.

Control subjects of different ages with no apparent health related complaints and with no past / family history of any significant disease (mostly included attendants accompanying the patients) were also included to obtain standardized normal values of renal Doppler indices in different age groups. The controls ranged from 6 yrs to 68 yrs of age. A detailed medical history was recorded in each subject with particular attention to exclude evidence of diabetes, systemic infections, and renal disease, injury or stones. All controls had normal blood pressure and physical examination was unremarkable in all. Further gray scale sonography revealed normal size, shape, position and echotexture of kidneys with normal corticomedullary differentiation and compact pelvicalyceal systems.

Doppler evaluation: First the kidneys were optimally visualized in the B-mode image in the right and left lateral decubitus positions. After obtaining an optimum B-mode, color flow and duplex Doppler were activated and the values of Doppler indices were measured in the proximal middle and distal thirds of at least three interlobar arteries (in the upper mid and lower poles respectively). A mean value is calculated for the Doppler indices for each kidney. In addition, in patients with obstructed nephropathy ureteral jets were evaluated bilaterally and their number and symmetry were noted on each side. In neoplasms, the lesions were assessed for the amount and pattern of vascularity, morphology of vessels and the spectral Doppler indices of the vessels were calculated. The renal vein and IVC were also traced and presence of any tumour thrombus was noted. Appropriate pulse repition frequency, color and Doppler gain settings and high pass filter were selected for each examination.

RESULTS

The study group included 76 patients with various renal disease which were categorized under obstructive nephropathy (n=25), medical renal disease (renal parenchymal disease, n=43) and 8 cases of renal masses. The control group included 20 patients with age range between 6 to 68 yrs. The intrarenal vasculature appeared normal in all cases of AGN with colour/ power Doppler and the spectral waveforms obtained at the level of interlobar arteries showed normal low resistance high diastolic flow pattern in all the cases.

Table 1a: Doppler Indices in medical renal disease

Doppler Index		AGN n=12 (N=6)	Nephrotic Syndrome n=24 (N=12)	Diabetic Nephropathy n=16 (N=8)	CRF n=22 (N=11)
R.I.	≤0.60	7 (4)	12 (6)	–	–
	0.61-0.70	5 (3)	8 (5)	2 (1)	3 (2)
	0.71-0.80	–	3 (2)	10 (5)	9 (7)
	>0.80	–	1 (1)	4 (2)	9 (7)
P.I.	≤1.00	5 (4)	11 (6)	–	–
	1.01-1.40	7 (4)	11 (6)	3 (2)	2 (1)
	1.41-1.80	–	–	8 (5)	6 (4)
	>1.80	–	2 (1)	5 (3)	14 (8)
MAT	≤70 ms	11 (6)	23 (12)	12(7)	21 (11)
	> 70 ms	1 (1)	1 (1)	4 (3)	1 (1)
MAI	≤300 cm/s^2	–	–	–	4 (3)
	>300 cm/s^2	12 (6)	24 (12)	16 (8)	18 (10)

Table 1b: Doppler Indices in medical renal disease

Doppler Index		Pyelonephritis n=6 (N=3)	Renal Amyloidosis n=2 (N=1)	Analgesic nephropathy n=2 (N=1)	Hypertensive Nephrosclerosis n=2 (N=1)
R.I.	≤0.60	–	–	–	–
	0.61-0.70	–	1 (1)	–	–
	0.71-0.80	6 (3)	1 (1)	2 (1)	2 (1)
	>0.80	–	–	–	–
P.I.	≤1.00	–	–	–	–

	1.01-1.40	1 (1)	–	–	–
	1.41-1.80	4 (3)	–	2 (1)	2 (1)
	>1.80	1 (1)	2 (1)	–	–
MAT	≤70 ms	6 (3)	2 (1)	2 (1)	2 (1)
	> 70 ms	–	–	–	–
MAI	≤300 cm/s^2	–	–	–	–
	>300 cm/s^2	6 (3)	2 (1)	2 (1)	2 (1)

(n=No. of kidneys; N=No. of cases; R. I.= resistive index; P.I.= pulsatilityindex; MAT=Mean Acceleration Time; MAI= Mean Acceleration Index)

Table 2: Mean R.I. and P.I. in Medical Renal Disease

Case	No. of kidneys	Mean R.I.	Mean P.I.
AGN / Acute Nephritic Syndrome	12	0.57	0.98
Nephrotic syndrome	24	0.61	1.10
Chronic Renal Failure	22	0.78	2.19
Diabetic Nephropathy	16	0.77	2.048
Pyelonephritis	6	0.75	1.55
Renal Amyloidosis	2	0.78	2.31
Analgesic nephropathy	2	0.78	1.66
Hypertensive Nephrosclerosis	2	0.73	1.67
Controls	40	0.57	1.02

Renal resistive index does not appear to correlate well with raised echotexture, especially the lower grades and when the echotexture is normal. The finding of normal renal echotexture corresponds to a mean value of R.I. of 0.72, while higher grades of raised echotexture correspond to a lower value of R.I. However, a plot of the variance of R.I. vs renal echotexture shows the high variance (0.0154) in case of normal echotexture. This corresponds to the fact that a large no. of cases of diabetic nephropathy had a normal echotexture, yet had a high R.I., also most cases of nephritic and nephrotic syndromes had a raised echotexture (grade1 or 2) but had near normal values of R.I. However, grade 3 echotexture corresponds to a high R.I. with low variance. Similarly, it is the diminution or loss of corticomedullary differentiation that is associated with a high R.I. values with low variance, yet the normal or accentuated corticomedullary differentiation do not demonstrate this relationship. An intriguing observation made from this study is by postulating the renal compartment affected by a particular disease process and observing the R.I. It is well known that different renal diseases, initially affect a particular histological compartment (nephritic and nephrotic syndromes affect preferentially the glomeruli, the pyelonephritis, analgesic nephropathies, drug induced nephritis are typical tubulo-interstitial diseases, diabetes preferentially affects the vessels and glomeruli and amyloidosis affects the glomeruli, peritubular regions as well as the blood vessels. Ultimately however with disease progression all the four compartments are affected as is the case in chronic renal failure and end stage renal disease). The mean R.I. with selective involvement of glomerular compartment is 0.59, while when all the four compartments are involved the mean R.I. is 0.783. Involvement of tubulo-interstitial and vascular compartments also leads to high R.I. values.

Table 3: R.I., P.I. and DELTA R.I. inObstructive Renal Disease

Type of Obstruction	No. of cases	Mean R.I. Obstructed kidney	Mean R.I. Normal kidney	Mean P.I. Obstructed kidney	Mean P.I. Normal kidney	Mean A.R.I.
Acute	12	0.729±0.02	0.58±0.04	1.50±0.24	0.97±0.18	0.14 ± 0.04
Chronic	13	0.64 ±0.05	0.57±0.06	1.15±0.19	0.93±0.14	0.07 ± 0.05

The mean R.I. in the obstructed kidneys (0.729) was significantly higher than the mean R.I. in the controls (0.57± 0.05) and in the contralateral normal kidney (0.58±0.04) with two-tailed P value less than 0.0001 and the difference considered to be extremely statistically significant. The value of mean R.I. in patients with chronic renal obstruction (0.64) was higher than the mean R.I. in the controls (0.57±0.05) and the normal contralateral kidney (0.57±0.06) with the p value of 0.0016 in both cases and the difference considered to be very statistically significant., however the p value was higher than that in acute obstruction.

Table 4: Enumeration of Doppler Features of Renal Neoplasms

Diagnosis	Vascularity	Mean PSV (cms/s)	Mean EDV (cms/s)	ΔF (KHz)	Mean RI	Involvement of Renal Vein	Involvement of IVC
RCC	Marked (CandP)	173.6	39.3	6.5	0.82/0.44	Thrombus in renal vein	Negative
RCC	Moderate (C)	49.4	14.2	2.6	0.72	Negative	Negative
RCC	Marked (CandP)	98	32	5.3	0.76/0.38	Negative	Negative
RCC	Marked (CandP)	80	22	4.3	0.76/0.41	Negative	Negative
AML	Minimal	28	10	1.5	0.59	Negative	Negative
AML	Moderate to minimal (CandP)	42	15	2.2	0.62	Negative	Negative
NEU	Marked (CandP)	114.5	53.4	6.2	0.62/0.42	Encasement	Negative
AML	Minimal to Absent	18	–	0.98	–	Negative	Negative
NHL	Minimal	26	12.6	1.4	0.51	Negative	Negative

(RCC= Renal Cell Carcinoma; AML=Angiomyolipoma; NEU=Neuroblastoma; NHL=Non Hodgkin's Lymphoma; ΔF=Mean Peak Systolic Doppler Shift Frequency; CandP=Central and Peripheral; PSV=Peak Systolic Velocity; EDV=End Diastolic Velocity)

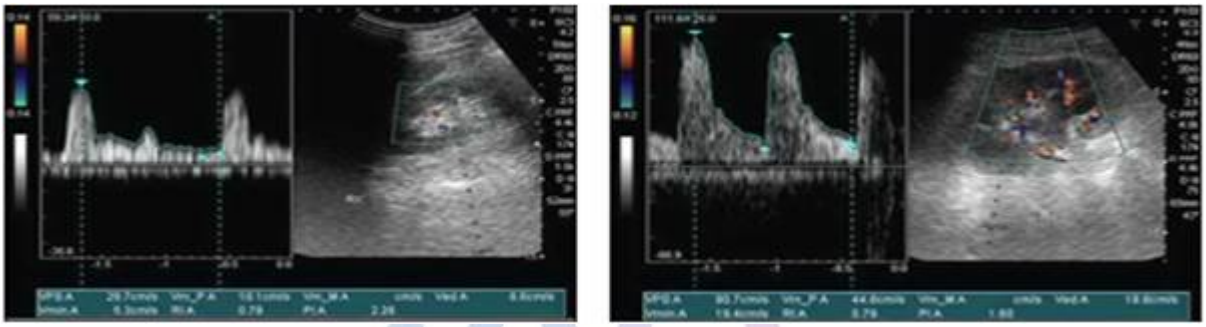

Figure 1 a, b: Two cases of diabetic nephropathy with normal renal echotexture and cm difference and showing abnormal high resistance spectral waveforms with raised values of R.I. and P.I.

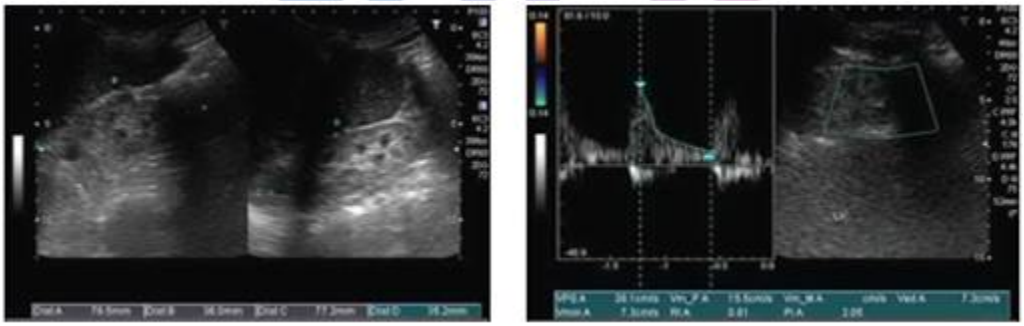

Figure 2: Acase of CRF with relative preservation of renal size with Doppler showing high resistance flow suggesting increased intrarenal vascular resistance.

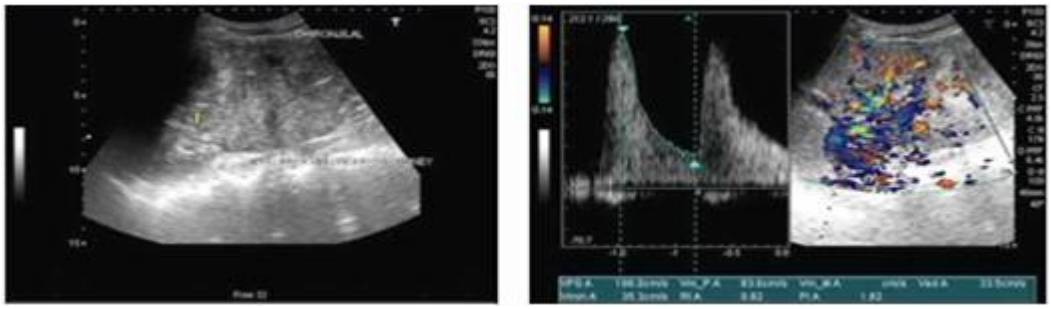

Figure 3: A case of renal cell carcinoma with Doppler showing a hypervasculartumour with high PSV and Doppler shifts.

DISCUSSION

The present study was undertaken to define the role of renal Doppler in nephrological workup of patients with native kidney dysfunction (obstructive, nonobstructive and neoplasms). The mean R.I. in cases of nephrotic syndrome was 0.61 ± 0.08 (S.D.) and was not significantly different from the mean R.I. of controls (0.57± 0.05). Similar findings have been observed in

several previous studies including by Argalia *et al* who observed normal values of R.I. in glomerulonephrosis.[4] Galesic K. *et al* also concluded that qualitative duplex sonography measure of renal arterial resistance –resistive index does not appear to be reliable in distinguishing different types of glomerulonephritis.[5]Two cases with nephrotic syndrome in our study had multiple and recurrent episodes and had raised renal echopattern with grade 3 renal echotexture with diminished corticomedullary differentiation. Both these cases had raised values of R.I. and P.I. in contrast to other cases where corticomedullary differentiation was preserved and the values of Doppler indices were normal. These two cases with recurrent episodes are likely to be progressing to chronic glomerulonephritis, with global renal involvement, and renal Doppler in the settings of appropriate clinical history may prove useful in documenting this progression in cases of nephrotic syndrome. Further studies are required in this area. The mean R.I. in cases of diabetic nephropathy was 0.77 ± 0.09 (S.D.) and was significantly different from that of controls (0.57± 0.05). 7 out of 8 patients (87.5%) had mean R.I. in their kidneys > 0.70 with 2 cases having values > than 0.80. Only one case had mean R.I. less than 0.70. Similar results have been obtained by several authors including Kim SH *et al* who concluded that renal Doppler indices reflect increased renal vascular resistance in NIDDM patients and correlates with clinical parameters of diabetic nephropathy, and R.I. and P.I. are useful markers for indicating diabetic vascular complications in NIDDM patients.[6] In our study there was no significant correlation between the grades/ amount of proteinuria and resistive index, however patients with microalbuminuria had a lower mean R.I. as compared to patients with overt proteinuria. Patients who had associated diabetic retinopathy had a higher mean R.I. (0.78) compared to patients without retinopathy (0.728), however there was no significant difference between early non proliferative and advanced proliferative retinopathy.[6,7] Some authors including JF Platt *et al* have found no significant difference in renal R.I. in early diabetic nephropathy from that without nephropathy, however contrasting findings are obtained in our studies with raised R.I. being present even in pts with micro albuminuria or trace macroalbuminuria.[8] The mean R.I. in cases of chronic renal failure was 0.78 ± 0.06(S.D.) and was significantly different from that of controls (0.57± 0.05). In end stage renal disease ultimately all the four compartments are affected, with fibroproliferative scarring of the kidneys. Hence the marked increase in R.I. and P.I.in chronic renal failure is not surprising. Increased renal resistive indices as a marker of accelerated decline in renal function in patients with chronic kidney disease have been reported earlier by Petersen *et al*.[9]

The mean R.I. with selective involvement of glomerular compartment is 0.59, while when all the four compartments are involved the mean R.I. is 0.783. Involvement of tubulointerstitial and vascular compartments also leads to high R.I. values. Similar findings have been echoed in the study by Platt JF *et al* who observed that active disease within the tubulointerstitial compartment or vasculitis or vasculopathy generally resulted in elevated R.I., whereas disease limited to the glomeruli, no matter how severe, did not significantly elevate the R.I.[10]Ikee R *et al* also demonstrated a direct relationship between resistive index and arteriolosclerosis in the damaged kidney.[11] Hence it seems that Doppler findings of an elevated R.I. and P.I. have a histological correlation, with disease confined to the glomerulus resulting in no significant changes and disease processes affecting the tubulointerstitium and vessels leading to varying degrees of rise in R.I and P.I. with most dramatic changes being present when all the four compartments become involved in chronic renal failure / end stage renal disease. Renal resistive index does not appear to correlate well with raised echotexture, especially the lower grades and when the echotexture is normal. The mean R.I. in the obstructed kidneys(0.729) was significantly higher than the mean R.I. in the controls (0.57± 0.05) and in the contralateral normal kidney (0.58 ±0.04). These results are similar to the observations made in several previous studies including those by Lee HJ and others, Akcar *et al*.[12,13] The value of mean R.I. in patients with chronic renal obstruction (0.64) was higher than the mean R.I. in the controls (0.57 ± 0.05) and the normal contralateral kidney (0.57 ± 0.06) with the p value of 0.0016 in both cases and the difference considered to be very statistically significant., however the p value was higher than that in acute obstruction. Similar findings have been obtained by Lee HJ *et al* who observed that Doppler sonography has a low sensitivity in diagnosing unilateral renal obstruction, but it may be useful when the obstruction is acute and severe.[12] Our study too leads to similar findings with the changes in renal Doppler indices (R.I. and P.I.) being most consistent and statistically significant in acute renal obstruction, with less significant results in chronic obstruction. Most common pattern of RCC is that of a hypervascular tumor with two types of Doppler signals being detectable. High frequency signals with a large systolic diastolic gradient with high peak systolic velocities, originating from A-V shunts. A second type of almost continuous signal with little systolic diastolic fluctuation and low R.I. values (low impedence signals), originating from neovascular tissue which lacks muscular walls and is characteristic of many tumors. The

high frequency signals originating from A-V shunts are also responsible for high frequency Doppler shifts (>2.5khz) being detected in hypervascular RCC. These Doppler findings should allow a confident diagnosis of a hypervascular RCC. However, conversely absence of these characteristics may not exclude malignancy and further imaging may be required.Color Doppler is invaluable in assessment of renal vein and I.V.C. in cases of renal masses. The fact that renal tumors have a propensity to spread along the renal veins and I.V.C (and even upto right atrium), and the ease and repeatability of USG and color Doppler makes it an important tool in cases of renal tumors. Being aware of several pitfalls which may lead to false results, nephrologists may use renal Doppler sonography as the first screening method of choice as the diagnostic tool.

REFERENCES

1. Robbins andCotran Pathologic Basis of Disease, 7th edition. Vinay Kumar, Abul K. Abbas,Nelson Fausto. Saunders. Published August 2004.
2. Bernd Krumme, Renal Doppler Sonography - Update in Clinical Nephrology. Deutsche KlinikfürDiagnostik, FachbereichNephrologie und Hypertensiologie, Wiesbaden, Germany. Nephron Clinical Practice 2006;103:c24-c28.
3. Viazzi F, Leoncini G, Derchi LE, Pontremoli R. Ultrasound Doppler renal resistive index: a useful tool for the management of the hypertensive patient. Journal of Hypertension. 2014;32(1):149-153.
4. Argalia G, D'ambrosio F, Mignosi U, Migliorini D, Lucarelli F, Giuseppetti GM, et al. Doppler echography and color Doppler echography in the assessment of the vascular functional aspects of medical nephropathies.Radiol Med (Torino). 1995 Apr;89(4):464-9.
5. Galesić K, Sabljar-Matovinović M, Tomić M, Brkljacić B. Renal vascular resistance in glomerular diseases-correlation of resistance index with biopsy findings,CollAntropol 2004 Dec;28(2):667-74.
6. Kim SH, Kim H, Kim SY, Choi YS, Lee KB, Kim BI, et al. Usefulness of Resistive Index and Pulsatility Index in Patient with Diabetic Nephropathy as Early Markers. Korean J Nephrol 2000 Sep;19(5):876-883.
7. Ohta Y, Fujii K, Arima H, Matsumura K, Tschuihashi T, Tokumoto M, *et al*. Increased renal resistive index in atherosclerosis and diabetic nephropathy assessed by doppler sonography. *J Hypertens* 2005; **23**:1905-1911.
8. Platt JF, Rubin JM, Ellis JH. Diabetic nephropathy: evaluation with renal duplex Doppler US.Radiology 1994 Feb;190(2):343-6.
9. Petersen LJ, Petersen JR, Talleruphuus U, Ladefoged SD, Mehlsen J, Jensen HA. The pulsatility index and the resistive index in renal arteries. Associations with long-term progression in chronic renal failure.Nephrol Dial Transplant 1997 Jul;12(7):1376-80.
10. Platt JF, Ellis JH, Rubin JM, DiPietro MA, Sedman AB. Intrarenal arterial Doppler sonography in patients with nonobstructive renal disease: correlation of resistive index with biopsy findings.AJR Am J Roentgenol 1990 Jun;154(6):1223-7.
11. Ikee R, Kobayashi S, Hemmi N, Imakiire T, Kikuchi Y, Moriya H, et al. Correlation between the resistive index by Doppler ultrasound and kidney function and histology.Am J Kidney Dis. 2005 Oct;46(4):603-9.
12. Lee HJ, Kim SH, Jeong YK, Yeun KM. Doppler sonographic resistive index in obstructed kidneys.J Ultrasound Med. 1996 Sep;15(9):613-8; quiz 619-20.
13. Akçar N, Ozkan IR, Adapinar B, Kaya T. Doppler sonography in the diagnosis of urinary tract obstruction by stone.J Clin Ultrasound. 2004 Jul-Aug;32(6):286-93.

Source of Support: None Declared
Conflict of Interest: None Declared