Renal Doppler – Hospital Based Study and Review of Literature

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ABSTRACT

Introduction: Study was done for screening of Renovascular hypertension by Colour Doppler ultrasonograph. Renal Doppler is a noninvasive, inexpensive diagnostic procedure that is capable of accurately screening for renovascular disease. Study objective was to screen the patients suspected of renovascular hypertension by colour Doppler ultrasonography and to exclude patients for further evaluation by arteriography.
Material and methods: Study was done for screening of renovascular hypertension by colour Doppler ultrasonography (CDUS). Patient was examined after 6hrs of fasting and was comfortably positioned supine, with head and shoulders slightly elevated.With the use of a 60 degree Doppler angle, a peak systolic velocity (PSV) was obtained within the aorta at the level of the superior mesenteric artery. The probe was directed slightly inferior to this position, and the origin of the right and left renal arteries were identified. The smallest sample volume was chosen. The sample gate was placed in center of arterial lumen. Side-to-side difference of the resistive index (delta RI) between the right and left kidney, indicating a RAS on the side with the relatively lower RI was calculated. Student's t-test was used for determining significance of difference of means of RI and delta RI in normal and RAS.
Results: In our study atherosclerotic RAS outnumbered Takayausu's and FMD cases in our study. No accessory renal arteries were detected. In the present study, 25 of cases out of 50 had kidney size <8 cm or difference in size of two kidneys >1.5 cm out of which 11 were having RAS.Stenosis of the renal arteries were predominantly unilateral.The maximum and minimum value of PSV of renal artery at the site of stenosis in RAS patients were 255.4 cm/sec and 168 cm/sec respectively with a mean value of 226.59 cm/sec. Significant differences were noted for both the acceleration and acceleration time between the normal and stenosed renal artery groups.RI values of normal intrarenal vessels of 77 kidneys was high, resistive index of intrarenal vessels was low.
Conclusion: This non-invasive, low cost and safe method can become primary modality in examination of RAS and may prevent unnecessary angiography.

Keywords: Renal Doppler, Renal Artery Stenosis, Doppler Parameters

INTRODUCTION

Renovascular hypertension (RVH) affects 15%-30% of patients who have clinical criteria suggestive of renovascular disease. Non invasive tests for detection of RAS include ACE inhibitor scintigraphy, Colour Doppler ultrasonography (CDUS), and magnetic resonance (MR) angiography of the renal arteries.[1]

The prognosis of RAS is optimistic because it can be cured by angioplasty, stent placement and, or surgery. Different Doppler parameters have been obtained from the main renal artery and intrarenal branches, so called direct and indirect parameters.[2]

Two types of criteria for detection of RAS can be used.

- Proximal criteria: The peak systolic velocity (PSV) of the Doppler waveforms from the renal artery (RA) ≥180cm/s for stenosis over 60% of the arterial diameter (the mean velocity of the normal artery is around 100cm/s) and renal aortic ratio>3.5.
- Distal (or intraparenchymal) criteria: Related to a slow rise of the peak velocity distal to the stenosis, so called pulsus tardus parvus, with prolonged acceleration time (time to peak) and a reduction of the ipsilateral resistive index(RI) to <0.45.

The study was undertaken with the following aims:

To screen the patients suspected of renovascular hypertension by colour Doppler ultrasonography, to exclude patients for further evaluation by arteriography and to screen young hypertensive patients.

The results obtained were correlated with the clinical findings, sensitivity and specificity of colour Doppler sonography.

MATERIAL AND METHODS

This study was conducted in the Postgraduate Department of Radiodiagnosis and imaging, Government Medical College Jammu on patients suspected of having renovascular hypertension referred from Department of Medicine and Paediatrics during the period of study. Study was done for screening of renovascular hypertension by colour Doppler ultrasonography (CDUS) in patients presenting with any of the following clinical criteria:

- Epigastric or flank bruit (systolic or diastolic).
- Accelerated or malignant hypertension.
- Unilateral small kidney discovered with any clinical study.
- Severe hypertension in a child or young adult or after age 50 years.
- Sudden development or worsening of hypertension at any age.
- Hypertension and unexplained impairment of renal

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How to cite this article: Jahangeer Ahmad Bhat, Murassa Shamshad, Aresalan Malik, Iqbal Bhat[3], Iqbal Dar. Renal doppler – hospital based study and review of literature. International Journal of Contemporary Medical Research 2017;4(8):1820-1825.

function.
- Sudden worsening of renal function in a hypertensive patient.
- Hypertension refractory to an appropriate three-drug regimen.
- Impairment of renal function after treatment with an ACE inhibitor.
- Hypertension and extensive arterial occlusive disease.

There are no absolute contraindications for performing renovascular colour Doppler ultrasonography. Patients who couldnot cooperate or were not “sonogenic” and patients who were unable to suspend respiration were excluded from the study. Before evaluating a patient by CDUS, informed consent was obtained from the patient.

All studies were done on VOLUSON 750 and TOSHIBA XARIO Colour Doppler Ultrasound Scanners with a curvilinear probe with 3.5-5 MHz frequency.Patient was examined after 6hrs of fasting and was comfortably positioned supine, with head and shoulders slightly elevated. Echotexture, corticomedullary differentiation, parenchymal abnormalities and size were evaluated by the grey scale. In supine position, the abdominal aorta was visualised in sagittal and transverse orientations. Longitudinal survey of the abdominal aorta was performed from celiac artery to the bifurcation to evaluate the amount of atherosclerotic plaque. With the use of a 60 degree Doppler angle, a peak systolic velocity (PSV) was obtained within the aorta at the level of the superior mesenteric artery. This was used for analysing the ratio of the PSV in the renal artery to that in the aorta (renal-aortic ratio). The aorta was then visualised in the coronal view, and the origin of superior mesenteric artery was identified arising from anterior aspect of the aorta. The probe was directed slightly inferior to this position, and the origin of the right and left renal arteries were identified. Near the hilum of the kidney each renal artery divides into anterior and posterior branches, which in turn divide into segmental arteries supplying the different renal segments. In transverse scanning plane, the right renal artery origin is at approximately 11 o’clock relative to the transverse image of the aorta, and runs in a short right dorsolateral arc. The left renal artery origin is at 5 o’clock relative to the transverse image of the aorta and frequently descends slightly in a left posterolateral direction.

Another method of identifying the main RAs, particularly the areas of the ostia, has been termed the “banana peel” view. In this situation, again, the patient was turned to the opposite decubitus position from the vessel being examined. The decubitus position is particularly effective in obese patients with soft abdomens, because the pannus falls toward the table. This leaves behind a hollow anterior to the paraspinus muscle, which is excellent for placement of the transducer and minimizes depth between the probe and the RA. For the banana peel view, the transducer was oriented longitudinally. The aorta was located, and the transducer was moved in an anterior-to-posterior direction until the RA was identified arising from it, coursing toward the transducer.

With the Doppler angle of insonation 60 degree or less and parallel to the direction of flow, PSV and end diastolic velocity were obtained at the origin and proximal portion of each renal artery. The patient was then placed in lateral decubitus position, and the ipsilateral kidney was identified in a sagittal plane. With the use of a 0 degree Doppler angle of insonation, the PSV and end diastolic velocity measurements of distal main renal artery were obtained. The maximal peak systolic velocity was recorded at the origin / proximal, mid and distal renal artery at a minimum. The one with most marked slope was selected for recording the PSV. If significant stenosis was detected, the Doppler spectrum was recorded within the stenosis and distal to each stenosis. A search for accessory renal arteries was performed by looking at both the aorta and the kidneys (figure 1-3).

The second part of examination was for intrarenal evaluation of vessels. The patient was asked to lie in lateral decubitus positions. Spectral Waveforms were recorded from at least 3 locations: the segmental arteries at the upper, mid and lower pole, size and height of the spectral waveforms were increased. The segmental arteries were interrogated at the lowest feasible angle of insonation, which is usually 20 degree or less. The waveforms were analysed quantitatively to determine the resistive index, acceleration time, and/or

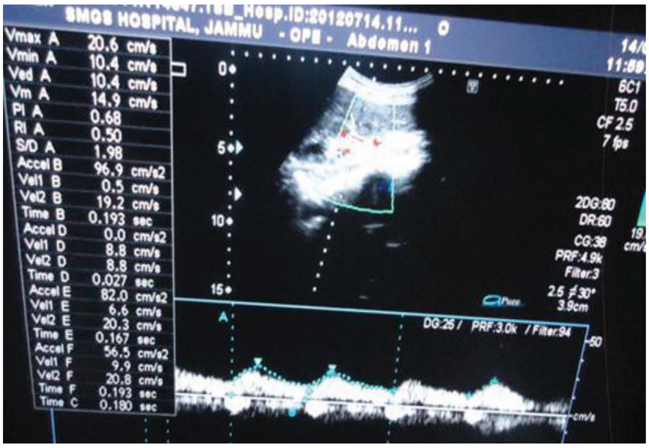

Figure-1: Showing positive intrarenal parameters for diagnosis of RAS. (PSV = 20.6 cm/s, RI=0.5, Accel 96.9 cm/s² and time of 0.193).

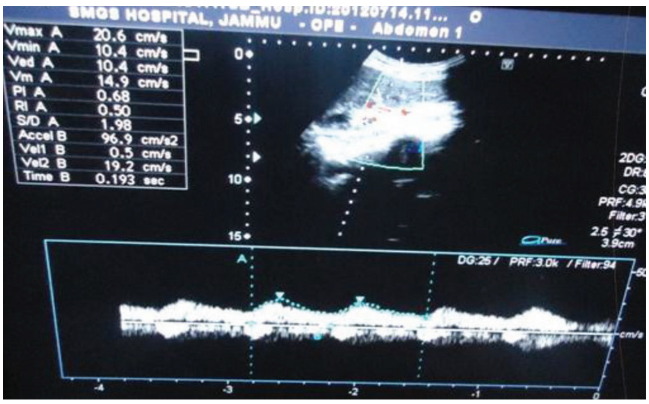

Figure-2: Renal hilar sampling reveals characteristic damping (“tardus parvus”) of segmental artery waveform. Note the delayed upstroke and rounded contour with prolonged systolic acceleration time.

acceleration. Angle correction was done when acceleration was measured. The acceleration time was measured from the onset of the systolic upstroke to the early systolic peak or its disappearance site or at the highest point of the systolic spectrum when these features of an early systolic peak cannot be identified. Qualitative analysis of each waveform for the normal systolic upstroke, early systolic compliance peak, and/or tardus parvus waveform was performed.

The smallest sample volume was chosen. The sample gate was placed in center of arterial lumen. Side-to-side difference of the resistive index (delta RI) between the right and left kidney, indicating a RAS on the side with the relatively lower RI was calculated.

STATISTICAL ANALYSIS

Student's t-test was used with the help of SPSS version 21 for determining significance of difference of means of RI and delta RI in normal and RAS.

RESULTS

Fifty patients with clinically suspected RAS were referred to our department for Doppler ultrasonography. Males outnumbered the females with 30 patients (30%) being males and 20 (40%) being females, with a sex ratio of 1.5: 1. The average age of patients was 43.8 years. The age of the patients ranged from 14 years to 72 years. Majority of patients were in age group of 60 years and above i.e. 16 cases (32%) followed by the age group of 20-39 i.e. 13 cases (26%). Patients with normal renal arteries constituted the main bulk of cases with 32 cases (64%). Eighteen cases (36%) turned to be RAS. The commonest clinical feature was headache seen in 41 cases (82%) followed by giddiness seen in 16 cases (32%). Palpitation was seen in 14 cases (28%). Four patients (8%) presented with mild breathlessness.The commonest clinical criterion by which patients presented was hypertension with unilateral atrophic kidney and was present in 50% of cases followed by young hypertension seen in 24% of cases. Accelerated-malignant hypertension and drug resistant hypertension were present in 20% and 10% of cases respectively. Four cases of Takayausu's arteritis also underwent CDUS and among them two had RAS. Out of total 18 RAS patients, 15 cases (83.33%) were found to have Atherosclerotic disease, 2 cases (11.11%) were found to have Takayasu's arteritis and 1 case (5.56%) was having fibromuscular dysplasia. Majority of patients had unilateral renal artery stenosis. Bilateral renal artery stenosis were seen in five (5) cases.

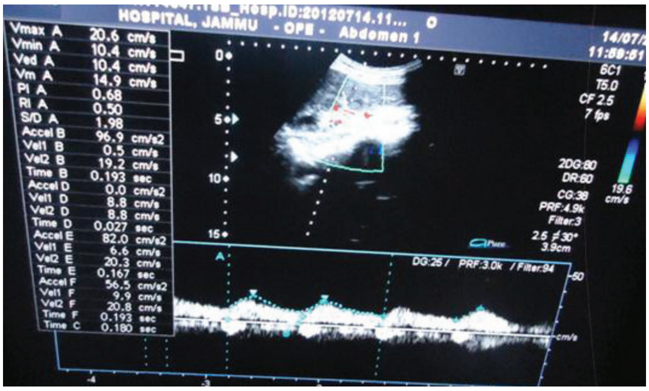

Figure-3: Lowest value of RI of 0.50 observed in study.

Among 13 cases of unilateral RAS, involvement of left side was seen in 10 cases. Size of unilateral kidney measuring less than 8 cm or difference in size of two kidneys >1.5 cm was seen in 25 cases. Atherosclerotic plaques in aorta and/proximal renal artery were seen in 10 cases. Increased echogenicity and altered corticomedullary differentiation was noted in 2 cases.

Colour Doppler imaging mode showed narrowing in luminal diameter in 11 cases (61.11%), and post-stenotic turbulent flow in 13 (72.22%) of cases.PSV > 180 cm/sec was seen in 14 cases and renal aortic ratio > 3.5 cm/sec was seen in 15 cases of RAS.

The maximum and minimum value of PSV of renal artery at the site of stenosis in 18 stenotic kidneys were 255.4 cm/sec and 168 cm/sec respectively with a mean value of 226.59 cm/sec. The maximum and minimum value of renal-aortic-ratio in 23 stenotic kidneys were 5 and 2.5 respectively with a mean value of 3.69.

At PSV >180 cm/s as diagnostic marker, the results are sensitivity (78.26%), specificity (100%), accuracy (95%), positive predictive value (100%); and, negative predictive value (93.90%) (table-1).

PSV < 25 cm/s was seen in 13 cases (17 kidneys), acceleration <300 cm/s² and time >0.07 seconds was seen in 15 cases (19 kidneys). Pulsus parvus tardus was observed in 12 cases (16 kidneys) (table-2).

Taking acceleration <300 cm/s² as a diagnostic marker the results were; sensitivity (82.6%), specificity (89.6%), accuracy (88%), positive predictive value (70.37%); and, negative predictive value (94.5%) (table-3).

Resistive index of normal intrarenal vessels of 77 kidneys was high with minimum value of 0.54 and maximum value of 0.81 and mean value of 0.63.

Resistive index of intrarenal vessels of 23 RAS kidneys was low with minimum value of 0.50 and maximum value of 0.65 and mean value of 0.53.

Most of RAS patients have RI value ≤0.54 and most of the normal patients have RI > 0.54.

Diagnosis	PSV > 180 cm/s	PSV ≤ 180 cm/s	Total
RAS	18 (true +ve)	5 (false –ve)	23
Normal	0 (false +ve)	77 (true –ve)	77
Total	18	82	100

Table-1: Peak systolic velocity

Diagnosis	PSV <25cm/s	PSV ≥25cm/s	Total
RAS	17 (true +ve)	6 (false –ve)	23
Normal	11 (false+ve)	66 (true –ve)	77
Total	28	72	100

Table-2: At PSV < 25cm/s as diagnostic marker

There was a significant difference in the mean RI values of normal and RAS with mean RI of RAS as 0.53 (SD=0.033) and mean RI of normal kidneys as 0.63 (SD=0.065). Difference of means was found statistically significant using student's t-test with a p-value < 0.0001.

The intra-individual lateral comparison i.e. delta RI shows large difference for two kidneys. The delta RI has value > 0.05 in RAS patients while in normal patients the value was <0.05 except in 4 cases. In three cases of bilateral renal artery stenosis the delta RI was less than 0.05.Mean delta RI of normal patients was 0.034 (SD=0.021) and mean delta RI of RAS patients 0.059 (SD=0.026). The difference of means of delta RI was statistically significant using student's t-test with a p-value of <0.0001.

Taking cut off RI ≤0.54 to label a renal artery stenosis, the results are depicted in table 4.

Role of RI (≤ 0.54 as cut off) as a diagnostic marker are sensitivity (73.9%), specificity (93.5%), accuracy (89%), positive predictive value (77.27%); and, negative predictive value (92.3%) (table-4).

Taking cut off of >0.05 for delta RI to label RAS. There were 13 (true positive) cases and 5 false negative cases while as there were 4 (false positive) and 28 (true negative) cases.

We over looked a total of 8 RAS in five patients, including false negative test results in 3 with bilateral RAS. False negatives with bilateral RAS must therefore be estimated as the most important error source of the method.

Taking delta RI as a diagnostic marker the results were; sensitivity, specificity and accuracy were 72.22%, 87.5%, 82% respectively. PPV was 76.47% and NPV also had acceptable value of 84.8%.

Sensitivity, specificity and accuracy of CDUS for diagnosis of RAS was found to be 94.44%, 96.87% and 96% respectively.

DISCUSSION

In our study atherosclerotic RAS outnumbered Takayausu's and FMD cases in our study. 18 of 50 cases in our study were positive for RAS (23 stenotic renal arteries). Out of these, 15 cases (83.33%) were found to have Atherosclerotic disease, 2 cases (11.11%) were found to have Takayasu's arteritis and 1case (5.56%) was having fibromuscular dysplasia. Li et al (2006)[3] studied 187 renal arteries in Chinese people. Of the 93 stenosed renal arteries (diameter reduction, 50%-99%), 42 were caused by atherosclerosis, 30 by Takayasu's arteritis, and 21 by fibromuscular dysplasia.

In our study no accessory renal arteries were detected. Bude et al (2003)[4] concluded that failure to detect accessory renal arteries should not unduly affect the utility of a noninvasive test for detecting RVH.

Size of unilateral kidney measuring < 8 cm or difference in size of two kidneys >1.5 cm is important grey scale feature suggestive of renovascular hypertension. In the present study, 25 of cases out of 50 had kidney size <8 cm or difference in size of two kidneys >1.5 cm out of which 11 were having RAS. In a study, conducted by Aburahama et al (2012)[5] they found mean kidney length was 10.4 cm in patients with ≥60% stenosis vs 11.0 cm in patients with <60% stenosis

Diagnosis	Acceleration < 300 cm/s²	Acceleration ≥ 300cm/s²	Total
RAS	19 (true +ve)	4 (false –ve)	23
Normal	8 (false+ve)	69 (true –ve)	77
Total	27	73	100

Table-3: Taking acceleration <300 cm/s² as a diagnostic marker the results

Diagnosis	RI ≤ 0.54 (+VE)	RI >0.54 (-VE)	Total
RAS	17 (true +ve)	6 (false –ve)	23
Normal	5 (false+ve)	72 (true –ve)	77
Total	22	78	100

Table-4: Taking cut off RI ≤ 0.54 to label a renal artery stenosis

(P<.0001). Twelve percent of patients with ≥60% stenosis had a kidney length of ≤8.5 cm vs 4% in patients with <60% stenosis (P = .0003).

In our study, 13 out of 18 patients with RAS were found to have unilateral stenosis, thus indicating that the stenosis of the renal arteries is predominantly unilateral. Out of the above mentioned 13 patients, 10 had left sided stenosis whereas the remaining 3 had stenosis of right renal artery. Bilateral renal artery stenosis were seen in five (5) cases. Harding et al (1992)[6] found significant unilateral disease in 11%, and bilateral disease in 4%.

In our study Colour Doppler imaging mode showed narrowing in luminal diameter in 11 cases (61.11%), and post-stenotic turbulent flow in 13 cases (72.22%). In a study done by Helenon et al (1995) they found colour-coded turbulence in 21 cases out of 40 cases of RAS (stenosis grade ≥ 50%).

Peak systolic velocity in our present study was >180 cm/s in 14 cases (18 stenotic kidneys) and renal aortic ratio >3.5 cm/sec was seen in 15 cases (19 stenotic kidneys) of RAS. The maximum and minimum value of PSV of renal artery at the site of stenosis in RAS patients were 255.4 cm/sec and 168 cm/sec respectively with a mean value of 226.59 cm/sec. The maximum and minimum value of renal-aortic-ratio in RAS patients were 5 and 2.5 respectively with a mean value of 3.69. So in our study PSV >180 cm/s has a sensitivity of 78.26%, specificity of 100%, accuracy of 95%, PPV of 100% and NPV of 93.9%. Aburahma et al (2012)[5] found the mean PSVs and RARs for normal, <60%, and ≥60% stenosis were 173, 236, and 324 cm/s (P < .0001), and 2.2, 2.9, and 4.5, respectively (P < .0001). The PSV cutoff value that provided the best overall accuracy for ≥60% stenosis was 285 cm/s, with a sensitivity, specificity, and overall accuracy of 67%, 90%, and 81%, respectively. The RAR cutoff value with the best overall accuracy for ≥60% stenosis was 3.7, with a sensitivity, specificity, and overall accuracy of 69%, 91%, and 82%, respectively. A PSV of ≥180 cm/s and RAR of ≥3.5 had a sensitivity, specificity, and overall accuracy of

72%, 81%, and 78% in detecting ≥60% stenosis. In a study done by Soares et al (2006)[7] they found the mean values of PSV, 272.791 cm/s; RAR, 3.716; and angiographic percent stenosis, 51.731%. Receiver operating characteristic curves showed higher accuracy for RAR with stenoses of 60% or greater versus PSV. They concluded that for detecting stenosis of 60% or greater, RAR is the most accurate parameter at a threshold of 2.5.

In our study parvus and tardus waveform was seen in 12 out of 18 cases (16 kidneys out of 23 stenotic kidneys) of RAS. Helenon et al (1995)[8] found parvus and tardus waveform in 7 cases out of 40 cases of RAS (stenosis grade ≥80%).

In our study PSV < 25 cm/s was seen in 13 cases (17 stenotic kidneys), and in 11 normal kidneys. Six (6) stenotic kidneys were missed. Li et al (2006)[3] found with threshold values of RIR greater than 5, PSV greater than 150 cm/s in the renal artery, renal-aortic ratio greater than 2, and PSV less than 25 cm/s in the interlobar artery, the sensitivity values were 88%, 81%, 70%, and 74%, respectively.

In our study significant differences were noted for both the acceleration and acceleration time between the normal and stenosed renal artery groups. Acceleration < 300 m/s² and acceleration time >0.07s was found in 15 cases of RAS (19 stenotic renal vessels) with a sensitivity of 82.6% and specificity of 89.6% and accuracy of 88%. PPV was 70.37% and NPV was 94.5%. In this study there were four (4) occasions in which the acceleration was >300cm/s² and yet high grade stenoses were present on angiography. Baxter et al (1996)[9] used cut-off values of 3m/s² and 0.07s for AI and AT, respectively, obtained a sensitivity of between 78 and 89% and specificity of 83-94% for the detection of RAS of 60% or more.

In the present study, RI values of normal intrarenal vessels of 77 kidneys was high with minimum value of 0.54 and maximum value of 0.81 and mean value of 0.63. Resistive index of intrarenal vessels of 23 RAS kidneys was low with minimum value of 0.50 and maximum value of 0.65 and mean value of 0.53. Most of RAS patients have RI value ≤0.54 and most of the normal patients have RI >0.54. There was a significant difference in the mean RI values of normal and RAS with mean RI of RAS as 0.53 (SD=0.033) and mean RI of normal kidneys as 0.63 (SD=0.065). Difference of means was found statistically significant using student's t-test with a p-value < 0.0001.

The intra-individual lateral comparison i.e., delta R.I shows large difference for two kidneys. The delta R.I has value greater than 0.05 in 13 RAS patients while in normal patients the value was less than 0.05 except in 4 cases. In three cases of bilateral renal artery stenosis the delta RI was less than 0.05. False negatives with bilateral RAS must therefore be estimated as the most important error source of the method. Mean delta RI of normal patients was 0.034 (SD=0.021) and mean delta RI of RAS patients 0.059 (SD=0.026). The difference of means of delta RI of normal renal vessel and stenotic renal vessel was statistically significant using student's t-test with a p-value of <0.0001. In the present study sensitivity and specificity of RI was 73.9% and 93.5% respectively at RI value of ≤ 0.54. The accuracy was 89%. Delta RI >0.05 has a sensitivity of 72.22%, specificity of 87.5%, and accuracy 82%.

Middleton et al (1989)[10] performed colour Doppler ultrasound with point-spectral analysis on eight patients with post biopsy renal transplant arteriovenous fistulas and reported that the resistive index of native kidneys is normally 0.60 to 0.92. Riehl et al (1997)[11] study showed an RI variation of between 0.47and 0.90 for an inter-individual comparison of non stenosed kidneys. The intra-individual lateral comparison shows only a small difference in the RI for the two kidneys (0.02±0.02).

In the present study the Doppler sonographic diagnosis of RAS rests on detection of intra-individual, significant reduction of the ipsilateral RI exceeding different tested threshold values by comparison with the contralateral kidney or significant reduction of ipsilateral RI ≤0.54. Patriquin et al (1992)[12] noticed that in kidneys with stenotic arteries, the RIs were lower (0.43-0.54) than in healthy subjects (0.56-0.63). Schwerk et al (1994)[13] have shown that lateral comparison of resistive indices is suitable for duplex sonographic detection of stenoses. RAS >50% show significant lateral differences (delta RI % >5%) as compared to resistive indices with unilateral RAS. For delta RI, no significant difference was noted between controls and patients with mild RAS; highly significant differences, however, were noted for both moderate and severe RAS (P < .001). Sensitivity and specificity of a cut off delta RI of > 5% were 82% and 92% for RAS > 50% and 100% and 94% for moderate RAS and RAS > 60%. In bilateral RAS > 50%, however, calculation of delta RI is potentially biased by undergrading of stenosis. They also showed that RI of stenotic kidneys is significantly lower than normal kidneys. Riehl et al (1997)[11] found a significant difference of RI between kidneys with RAS (0.48±0.11) and without RAS (0.63±0.08; P < 0.001). In addition, a significant difference of the delta RI was noted in patients with RAS (24.4%±12.5%) and the controls without RAS (3.6%±2.7%). Using a combination of both RI and delta RI, threshold values of RI = 0.45 resp. delta RI = 8% yields a sensitivity of 92.5% and a specificity of 95.7% in the detection of haemodynamically effective RAS.

Ardalan et al (2007)[14] noticed that with a cut-off level of 0.55 for intrarenal resistive index, the sensitivity of this parameter to detect proximal renal arterial stenosis was about 85%. Conclusively, PSVs and intrarenal RI were negatively correlated.

In a study performed by Li et al (2007)[15] found that the RI values in the atherosclerotic group were much higher than those in the nonatherosclerotic group for the 3 stenotic subgroups (Takayasu arteritis, FMD and an atherosclerotic group). They found that RI value in nonatherosclorotic group was 0.59 ± 0.10 (n=8) for moderate stenosis (50 - 69 %) and 0.45±0.11 (n=50) for severe stenosis (70-99%). For atherosclerotic group RI value was 0.73±0.11 (n=8) for moderate stenosis and 0.66±0.13 (n=30) for severe stenosis. They concluded that different RI cut-off values should be established according to atherosclerotic and

nonatherosclerotic RAS, and consideration of influencing factors for the RI will help reduce misdiagnosis.
In the present study sensitivity, specificity and accuracy of Doppler sonography was very high, 18 of 50 cases (23 stenotic kidneys out of 100 kidneys) were diagnosed as RAS so having a sensitivity of 94.44%, specificity of 96.87% and accuracy of 96% in detecting RAS. Helenon et al (1995)[8] concluded that the sensitivity and specificity of CDUS for detection of RAS or thrombosis were 89% and 99% respectively. Krumme et al (1996)[16] detected seventy-six RAS by increased peak systolic velocity (>2 m/s), and an additional 19 stenoses were identified by delta RI (>0.05). The combined analysis of PSV and delta RI resulted in a sensitivity of 89% and specificity of 92%. The PPV was 92% and the NPV was 88%.

CONCLUSION

In conclusion CDUS is a valuable technique which provides a direct non-invasive means of assessing both the anatomical characteristics and the functional significance of arterial stenosis. CDUS and the analysis of intrarenal Doppler spectra are recommended as a useful method for noninvasive diagnosis of RAS, however, this data suggest that only combination of intra- and extrarenal scanning with CDUS represents an effective screening method for significant renal artery stenosis in hypertensive patients. This non-invasive, low cost and safe method can become primary modality in examination of RAS and may prevent unnecessary angiography.

REFERENCES

1. Soulez G, Oliva VL, Turpin S et al. Imaging of renovascular hypertension: respective values of renal scintigraphy, renal Doppler US, and MR angiography. Radiographics 2000;20:1355-1368.
2. Conkbayir I, Yucesoy C, Edguer T et al. Doppler sonography in renal artery stenosis: an evaluation of interarenal and extrarenal imaging parameters. Clin Imaging 2003;27:256-260.
3. Li JC, Wang L, Jiang YX et al. Evaluation of renal artery stenosis with velocity parameters of Doppler sonography. J Ultrasound Med 2006;25:735-742.
4. Bude, RO, Forauer AR, Caoili EM et al. Is it necessary to study accessory arteries when screening the renal arteries for renovascular hypertension? Radiology 2003;226:411-416.
5. Aburahma AF, Srivastava M, Mousa AY et al. Critical analysis of renal duplex ultrasound parameters in detecting significant renal artery stenosis. J Vasc Surg. 2012 May 15.
6. Harding MB, Smith LR, Himmelstein SI et al. Renal artery stenosis: prevalence and associated risk factors in patients undergoing routine cardiac catheterization. J Am Soc Nephrol 1992;2:1608-1616.
7. Soares GM, Murphy TP, Singha MS et al. Renal artery duplex ultrasonography as a screening and surveillance tool to detect RAS: a comparison with current reference standard imaging. J Ultrasound Med 2006;25:293-298.
8. Helenon O, el Rody F, Correas JM et al. Colour Doppler US of renovascular disease in native kidneys. Radiographics 1995;15:833-854.
9. Baxter GM, Aitchison F, Sheppard D et al. Colour Doppler ultrasound in renal artery stenosis: intrarenal waveform analysis. Br J Radiol 1996;69:810-815.
10. Middleton WD, Kellman GM, Leland Melson GL et al. Post biopsy renal transplant arteriovenous fistulas: Colour Doppler US characteristic. Radiology 1989; 171:253-257.
11. Riehl J, Schmitt H, Bongartz D et al. Renal artery stenosis: evaluation with colour duplex ultrasonography. Nephrol Dial Transplant. 1997;12:1608-14.
12. Patriquin HB, Lafortune M, Jequier JC et al. Stenosis of the renal artery: assessment of slowed systole in downstream circulation with Doppler sonography. Radiology 1992;184:479-485.
13. Schwerk WB, Restrepo IK, Stellwaag M et al. Renal artery stenosis: Grading with image directed Doppler US evaluation of renal resistive index. Radiology 1994; 190:785-790.
14. Ardalan MR, Tarzamani MK, Shoja MM. A correlation between direct and indirect Doppler ultrasonographic measures in transplant renal artery stenosis. Transplant Proc. 2007;39:1436-8.
15. Li JC, Yuan Y, Qin W, Wang L, Dai Q, Qi ZH, Meng H, Cai S, Jiang YX. Evaluation of the tardus-parvus pattern in patients with atherosclerotic and nonatherosclerotic renal artery stenosis. J Ultrasound Med. 2007;26: 419-26.
16. Krumme B, Blum U, Schwertfeger E et al. Diagnosis of renovascular disease by intra- and extrarenal Doppler scanning. Kidney Int. 1996;50:1288-92.

Source of Support: Nil; **Conflict of Interest:** None

Submitted: 30-06-2017; **Accepted:** 31-07-2017; **Published:** 17-09-2017