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Review Article

Sensitivity and Specificity of Color Doppler Ultrasound Measurement in the Evaluation of Renal Artery Stenosis

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ABSTRACT

Renal artery stenosis typically results from plaque development. Mostly frequent cause of severe hypertension is RAS, which affects 1% to 5% of all patients with hypertension. Objective: To assess the sensitivity and specificity of Doppler ultrasound in RAS. Methods: Data from several search engines were retrieved for this literature view. Research was evaluated for both its quality and its usefulness. Data extraction from the whole journal articles was done. Results: Only 20 articles were used for extraction of data related to Sensitivity and Specificity of color Doppler ultrasound measurement in evaluation of RAS. The current study looked at the assessment of RAS. Conclusions: From assessing stenosis of renal artery diameter to analyzing the enhanced velocity field at the obstruction site, identifying new measures to describe plaque susceptibility in the renal artery has become more significant.

INTRODUCTION

Renal artery stenosis (RAS) is most prevalent causes of severe hypertension, affecting roughly 1% to 5% of all patients with hypertension [1]. The increasing prevalence of atherosclerosis in the adult population, as well as the existence of arterial blockage, which results in decreased renal blood flow and consequent renovascular hypertension [2]. The common cause of renal artery stenosis is atherosclerosis (63%) in individuals over the age of 50 [3]. Early detection of renal artery stenosis is a critical therapeutic goal since interventional treatment has the potential to alleviate or cure hypertension, preserve renal function, and avoid the development of kidney failure [4]. It is common to observe discrepancies in diagnosis between renal ultrasonography and are digital subtraction angiography (DSA) as well as between several RDU tests. Renal ultrasonography is operator dependent imaging modality. Nowadays, confirmation imaging is done with DSA before receiving additional treatment, as it is the gold standard for diagnosing RAS. RDU is more sensitive than DSA at 67-98% and more specific at 54-99% when it comes to identifying RAS [5]. The best doppler markers in the identification of relevant RAS is the renal artery peak

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systolic velocity, based on the hemodynamically RAS and prior publications. Unfortunately, there are significant inter-individual variations in the PSV of the renal arteries. Nevertheless, with broad threshold values ranging from 2 to 3.5, the diagnostic efficiency varied through series. Among other standard Doppler measures, the renal-segmental ratio (RSR) is the best choice for diagnosing RAS of 50% or above [6]. The axial and temporal resolution of ultrasonography is restricted by renal arteries [7]. We can use direct renal artery imaging to diagnose RAS using the traditional method. Signs of turbulence in the systolic phase seen by color imaging indicated the existence of stenosis. The PW Doppler is then positioned in the middle of the vessel, in the area of interest, at the location indicated by turbulence and faster-than-average flow rates. To produce a suitable curve for detecting velocities, the PW Doppler's velocity curves' gain, filter, and scales are changed. We suspected RAS when the renal artery PW Doppler revealed an elevated peak systolic velocity [8].

METHODS

Data from several search engines were retrieved for this literature view. Data for this literature study was collected from PubMed, science direct, NCBI, Medline, Medscape and Google scholar. Sensitivity, specificity and renal artery stenosis were utilized as search terms for publication. Only those papers which shows that individuals with renal artery stenosis were included after conducting unbiased database searches. Research was evaluated for both its quality and its usefulness. Data extraction from the whole journal articles was done.

RESULTS

Only 20 articles were used for extraction of data related to Sensitivity and Specificity of color Doppler ultrasound measurement in evaluation of RAS. The current study looked at the assessment of RAS.

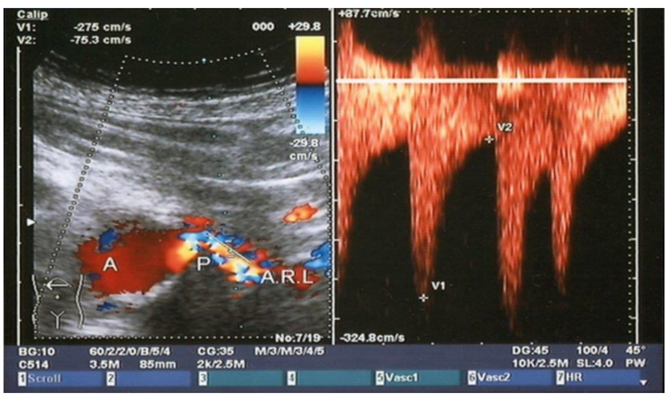

Figure 1: PSV of 278 cm/s is present in left-sided RAS >70% next to the ostium [9].

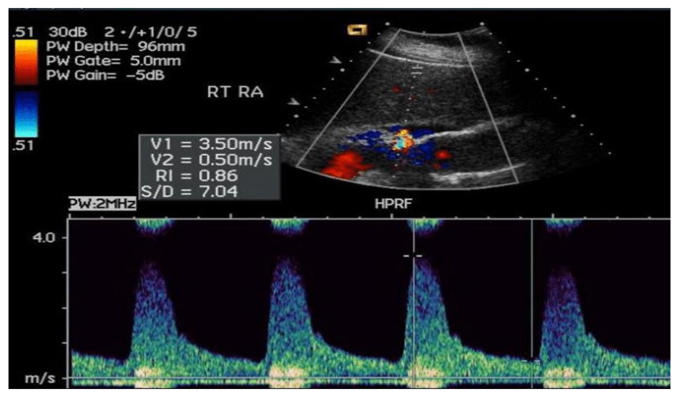

Figure 1: A significant stenosis is shown at the renal artery origin with a velocity of 3.5 m/s [10].

Study Name	Country	Objective	Findings
AbuRahma AF *et al.*, 2012	South Carolina	Assessment of significant RAS by Doppler parameters.	PSV with 285cm/s or renal aortic ratio with 3.7 can be used in the detection of >60% RAS [1].
Borelli FA *et al.*, 2013	Brazil	Evaluation of sensitivity, specificity, +ve predictive value and -ve predictive value in the diagnosis of renal artery stenosis.	Doppler shows good quality and efficacy in the detection of RAS with 82.90% sensitivity and 70% specificity [2].
Ripollés T *et al.*, 2001	Spain	To assess RAS by using intrarenal ultrasonography.	Intrarenal doppler with scanning technique with value of AT >80ms and Ac <1cm/s showed sensitivity and specificity for RAS [3].
Soares GM *et al.*, 2006	USA	Evaluation of RAS by duplex ultrasonography with DSA.	Renal artery duplex ultrasonographic parameters for 60% renal artery stenosis correlate with quantitative vessels analysis. Hence renal aortic ratio is better and accurate than peak systolic velocity [4].
Zhu R *et al.*, 2018	China	To assess discrepancies in measurements and diagnoses from several renal duplex ultrasonography (RDU) exams, as well as the causes of these discrepancies.	Peak systolic velocity, tardus-parvus waveform measures, and the ratio of PSV in the renal artery with stenosis to PSV in the aorta were all obviously more discordant in the group with discordant diagnoses than in the group with correctly identified cases [5].
Li JC *et al.*, 2006	China	Determine the ideal threshold values for these parameters and assess the velocity parameters' accuracy in diagnosing renal artery stenosis (RAS) using color Doppler sonography.	The RIR's optimal cutoff is 5, making it the optimum velocity parameter for detecting RAS (≥50%). Reducing misdiagnosis can be achieved by valuing PSV-influencing parameters in the renal artery. RAS has the most diagnostic efficacy when combined with PSV less than 15 cm/s and RIR more than 5 in the interlobar artery [6].

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Hedayati N *et al.*, 2011	USA	To evaluate the clinical and technical factors that predict the ability to perform RA-DUS examination.	According to the stringent criteria applied in the prospective, one-third of the RA-DUS investigations were deemed incomplete. The likelihood of obtaining a comprehensive RA-DUS examination is higher for an experienced ultrasound technologist [7].
de Oliveira IR *et al.*, 2000	Brazil	Improvement in the diagnosis of RAS by new index method.	In addition to other Doppler US characteristics, this indicates the reliability of the RSR index for the diagnosis of RAS. The establishment of Doppler US technique as a useful clinical and research imaging modality for the diagnosis of RAS may be aided by this novel index [8].
Fu-shun Pan et al., 2017	China	To evaluate the ability of transplant renal artery stenosis to be seen using ultrasonography.	In predicting TRAS, the CEUS's AUC, accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were, in order, 0.93, 93.4%, 89.7%, 96.1%, 92.2%, and 92.8% [9].
Motew SJ *et al.*, 2000	Arizona	Evaluating the diagnostic precision of hilar analysis and Doppler scanning inquiry in the diagnosis of RAS.	A reliable screening method for identifying severe stenosis or blockage of the main renal artery. To be utilized as the only screening study, hilar analysis is insufficiently sensitive. Renovascular disease linked to polar vessels cannot be identified using either technique [10].
Zhang HL *et al.*, 2009	USA	To evaluate RAS with using multiple imaging modalities with risk and accuracy.	Between ultrasonic and catheter angiography, contrast-enhanced computed tomographic angiography and magnetic resonance angiography fall in the middle range of precision and cost. New approaches to quantify the hemodynamic importance of renal artery stenoses and exciting new developments in magnetic resonance are now accessible. New contrast agents reduce the danger of nephrogenic systemic fibrosis [11].
Kawarada O *et al.*, 2006	Japan	Examine the effectiveness of the method for Doppler ultrasound-renal artery identification.	The best predictive value, with a sensitivity of 89%, specificity of 89%, and accuracy of 89%, was obtained with a PSV cutoff value of 219 cm/sec. The predictive values for favorable and negative outcomes were 83% and 93%, respectively. PSV assessment is a noninvasive and very reliable way to identify people with renal artery stenosis [12].
Yura T *et al.*, 1993	Japan	Phasic renal artery blood flow velocity measured using Doppler ultrasonography in individuals with chronic nephritis.	Peak systolic velocity, end-diastolic velocity, resistive index, and pulsatility index were obtained by analyzing the Doppler velocity waveform; creatinine clearance was associated. Doppler ultrasonography's ability to measure renal arterial blood flow may be helpful for a noninvasive, straightforward, quick, and easy assessment of renal function, albeit there are a number of modifying factors that must be taken into account [13].
Lao D *et al.*, 2011	USA	Assessment of RAS with atherosclerotic patient by renal Doppler ultrasound.	The routes associated with hypertension in ARAS, the best invasive and non-invasive techniques for assessing the renal arteries, the medicines for ARAS that are now available, and an assessment of upcoming instruments and algorithms that could be helpful in assessing patients for renal treatment [14].
Saeed A *et al.*, 2009	Sweden	To investigate new velocimetric color duplex sonography indices' diagnostic potential in the detection of RAS.	In terms of the acceleration index, the corresponding sensitivity and specificity were 85 and 75% for the early systolic blood flow acceleration and 83 and 79% for the acceleration index. According to ACCmax and Aimax, patients with an estimated glomerular filtration rate of less than 30 ml/min/1.73 m2 had corresponding values of 90 and 73% and 74 and 88%, respectively [15].
Solar M *et al.*, 2011	Czech Republic	To assess the identification of renal artery stenosis using duplex ultrasonography and magnetic resonance angiography.	DUS demonstrated a sensitivity and specificity of 85% and 84% in the identification of substantial RAS. In every analyzed kidney except one, MRA produced acceptable image quality. 93% and 93%, respectively, were the sensitivity and specificity of MRA in identifying substantial RAS [16].
Cui Y *et al.*, 2020	China	Investigating the precision of RAS grading using contrast ultrasonography (CEUS).	Regarding the diagnosis of renal artery stenosis, the following values were obtained for CEUS: 88.9%, 87.8%, 88.5%, 93.5%, and 80.0%, respectively. These values also included the positive predictive value and negative predictive value. Renal artery stenosis was graded using both CEUS and DSA with no discernible differences [17].

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Zeller T *et al.*, 2014	Germany	Assessment of RAS by updating diagnosis with treatment.	An advantageous result of RAS revascularization in contrast to treatment. Referrals for endovascular renal artery revascularization have dropped. Appropriate patient selection is critical for a therapeutic benefit after revascularization of RAS; revascularization is recommended only when evidence of the hemodynamic importance of RAS has been demonstrated [18].
Wang Y *et al.*, 2023	China	To investigate the diagnostic efficiency of duplex ultrasonography by analyzing the renal artery in patients with Takayasu's arteritis.	For TAK patients, 143 cm/s, 152 cm/s, and 183 cm/s were found to be the suggested levels of RPSV for the diagnosis of RAI, ≥50% RAS, and≥70% RAS, respectively. It was discovered that all three of these thresholds' sensitivity, specificity, and accuracy were higher than 80% [19].
Jennings CG *et al.*, 2014	United Kingdom	Evaluation of stenotic renal lesions' clinical importance.	Increased cardio-vascular mortality and an increased incidence of cardiovascular events are linked to atheromatous RAS. Clinical professionals are now advocating intensive medical therapy instead than interventional revascularization due to data from big clinical studies [20].

DISCUSSION

The accuracy of ultrasound as a screening method for renal arterial disease varies greatly depending on the operator and can range from around 60% to over 90% in kidneys that can be imaged, such as kidney transplant renal arteries. When screening for main renal artery stenosis, color Doppler ultrasonography frequently fails to show the whole renal artery and fails to identify the greatest PSV. Usually, an ultrasound does not sufficiently evaluate or even identify accessory renal arteries. When compared to other modalities, the incidence of technical failure is higher when these issues are coupled with restricted vision of the renal vasculature because of gas or fat in the abdomen [11]. However, due to advancements in vascular echo technology, duplex ultrasonography may now visualize RAS without adding to the hazards involved. It can also noninvasively offer hemodynamic parameters, such as flow velocity, without the need for contrast medium. Nevertheless, the accuracy and correlation of %DS between ultrasonographic parameters for the identification of hemodynamically relevant RAS have not been sufficiently examined in any of the published studies [12]. Investigating different factors on the renal arterial blood flow velocity will be important in order to assess how it varies in different forms of renal disease [13]. Low renal artery RRI (<75-80) and EDV suggest the absence of microvascular illness and enhanced resistance. Hemodynamically substantial stenosis is identified by spectral widening and increased velocity on ultrasonography. On Doppler ultrasonography, severe stenosis can cause tardus-parvus form alterations, which are shown as a slower systolic acceleration and a lowered RI [14]. Similar, strong diagnostic accuracy is provided by ACC (max) and AI (max) in other studies for the diagnosis of a hemodynamically significant renal artery stenosis, in individuals with significantly lower filtration rates [15]. A primary conclusion of the DUS in comparison to the DSA are decreased sensitivity and negative predictive value in terms of identifying severe renal artery stenosis. Based on some data, individuals with RAS ≥80% have a mean resistive index that falls well within the physiological range [16]. The only valid methods for identifying high-grade stenosis are the resistive index and systolic acceleration time. The most often used parameter is PSV, however it can also be somewhat affected by arterial wall stiffness, chronic renal illness, and mistakes in angle measurement [17]. Therefore, DUS is now the only diagnostic technique that can consistently evaluate the importance of a RAS. It is a non-invasive, commonly repeated bedside examination. A resistive index of more than 0.05 is strongly specifically correlated with at least 70% angiographic diameter stenosis [18]. According to a different study, in TAK patients, both RPSV and RIR had good diagnostic efficacies in determining RAS. Both the diagnostic and cutoff values show acceptable discrimination for varying degrees of stenosis, with both accuracies over 80% [19]. Duplex ultrasonography is affordable and safe, and it is especially useful as a screening tool to rule out FMD in persons with a low risk of disease and in patients for whom other imaging modalities are contraindicated. Jennings CG et al. (2014) discovered that duplex ultrasonography has 85% sensitivity and 82% specificity for diagnosing RAS, and that Doppler assessment of renal artery velocity may be used to evaluate the functional severity of the stenosis [20].

CONCLUSIONS

Over the decades, technological innovation has substantially increased the accuracy of RAS diagnosis. From assessing the narrowing of the renal artery diameter to analyzing the enhanced velocity field at the obstruction site, identifying new measures to describe plaque susceptibility in the renal artery has become more significant.

AUTHORS CONTRIBUTION

Conceptualization: MAR
Methodology: MAR
Formal analysis: LA, AA, AR
Writing, review and editing: SHMG, SK

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All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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REFERENCES

[1] AbuRahma AF, Srivastava M, Mousa AY, Dearing DD, Hass SM, Campbell JR, et al., Critical analysis of renal duplex ultrasound parameters in detecting significant renal artery stenosis. Journal of Vascular Surgery. 2012 Oct; 56(4): 1052-60. doi: 10.1016/j.jvs.2012.03.036.

[2] Borelli FA, Pinto IM, Amodeo C, Smanio PE, Kambara AM, Petisco AC, et al., Analysis of the sensitivity and specificity of noninvasive imaging tests for the diagnosis of renal artery stenosis. Arquivos Brasileiros de Cardiologia. 2013; 101: 423-33. doi: 10.5935/abc.20130191.

[3] Ripollés T, Aliaga R, Morote V, Lonjedo E, Delgado F, Martínez MJ, et al., Utility of intrarenal Doppler ultrasound in the diagnosis of renal artery stenosis. European Journal of Radiology. 2001 Oct; 40(1): 54-63. doi: 10.1016/S0720-048X(00)00263-1.

[4] Soares GM, Murphy TP, Singha MS, Parada A, Jaff M. Renal artery duplex ultrasonography as a screening and surveillance tool to detect renal artery stenosis: a comparison with current reference standard imaging. Journal of Ultrasound in Medicine. 2006 Mar; 25(3): 293-8. doi: 10.7863/jum.2006.25.3.293.

[5] Zhu R, Xu Z, Zhenhong QI, We YE, Wang J, Kong J, et al., How to diagnose renal artery stenosis correctly using ultrasound? Evaluation of results of renal arteries duplex ultrasonography examinations. Medical Ultrasonography. 2018 Aug; 20(3): 298-305. doi: 10.11152/mu-1341.

[6] Li JC, Wang L, Jiang YX, Dai Q, Cai S, Lv K, et al., Evaluation of renal artery stenosis with velocity parameters of Doppler sonography. Journal of Ultrasound in Medicine. 2006 Jun; 25(6): 735-42. doi: 10.7863/jum.2006.25.6.735.

[7] Hedayati N, Del Pizzo DJ, Harris SE, Kuskowski M, Pevec WC, Lee ES, et al., Predictors of diagnostic success with renal artery duplex ultrasonography. Annals of Vascular Surgery. 2011 May; 25(4): 515-9. doi: 10.1016/j.avsg.2011.02.008.

[8] de Oliveira IR, Widman A, Molnar LJ, Fukushima JT, Praxedes JN, Cerri GG. Colour Doppler ultrasound: a new index improves the diagnosis of renal artery stenosis. Ultrasound in Medicine & Biology. 2000 Jan; 26(1): 41-7. doi: 10.1016/S0301-5629(99)00119-2.

[9] Ultrasound diagnostics of renal artery stenosis - Scientific Figure on ResearchGate. Last cited 30th Nov 2023. Available At: https://www.researchgate.net/figure/Left-sided-renal-artery-stenosis-70-adjacent-to-the-ostium-predilection-site-for_fig1_281575973.

[10] EFSUMB Course Book, 2nd Edition Ultrasound in vascular diseases - Scientific Figure on ResearchGate. Last cited 30th Nov 2023. Available At: https://www.researchgate.net/figure/Renal-artery-stenosis-Despite-no-angle-correction-a-velocity-of-35-m-s-is-displayed-at_fig5_33992761.

[11] Zhang HL, Sos TA, Winchester PA, Gao J, Prince MR. Renal artery stenosis: imaging options, pitfalls, and concerns. Progress in Cardiovascular Diseases. 2009 Nov; 52(3): 209-19. doi: 10.1016/j.pcad.2009.10.003.

[12] Kawarada O, Yokoi Y, Takemoto K, Morioka N, Nakata S, Shiotani S. The performance of renal duplex ultrasonography for the detection of hemodynami - cally significant renal artery stenosis. Catheterization and Cardiovascular Interventions. 2006 Aug; 68 (2): 311-8. doi: 10.1002/ccd.20837.

[13] Yura T, Yuasa S, Sumikura T, Takahashi N, Aono M, Kunimune Y, et al., Doppler sonographic measurement of phasic renal artery blood flow velocity in patients with chronic glomerulonephritis. Journal of Ultrasound in Medicine. 1993 Apr; 12(4): 215-9. doi: 10.7863/jum.1993.12.4.215.

[14] Lao D, Parasher PS, Cho KC, Yeghiazarians Y. Atherosclerotic renal artery stenosis—diagnosis and treatment. InMayo Clinic Proceedings. 2011 Jul; 86(7): 649-657. doi: 10.4065/mcp.2011.0181.

[15] Saeed A, Bergström G, Zachrisson K, Guron G, Nowakowska-Fortuna E, Fredriksen E, et al., Accuracy of colour duplex sonography for the diagnosis of renal artery stenosis. Journal of Hypertension. 2009 Aug; 27(8): 1690-6. doi: 10.1097/HJH.0b013e32832c417d.

[16] Solar M, Zizka J, Krajina A, Michl A, Raupach J, Kizo L, et al., Comparison of duplex ultrasonography and magnetic resonance imaging in the detection of significant renal artery stenosis. Acta Medica (Hradec Kralove). 2011 Jan; 54(1): 9-12. doi: 10.14712/18059694.2016.10.

[17] Cui Y, Zhang Q, Yan J, Wu J. The value of contrast-enhanced ultrasound versus Doppler ultrasound in grading renal artery stenosis. BioMed Research International. 2020 Sep; 2020. doi: 10.1155/2020/7145728.

DOI: https://doi.org/10.54393/pbmj.v6i11.966

[18] Zeller T, Macharzina R, Rastan A, Beschorner U, Noory E. Renal artery stenosis: Up-date on diagnosis and treatment. Vasa. 2014 Jan; 43(1): 27-38. doi: 10.1024/0301-1526/a000325.
[19] Wang Y, Wang Y, Zhang L, Ge Z, Li J, Yang Y, et al., The performance of duplex ultrasonography for the assessment of renal artery stenosis in Takayasu's arteritis patients. Arthritis Research & Therapy. 2023 Aug; 25(1): 139. doi: 10.1186/s13075-023-03121-8.
[20] Jennings CG, Houston JG, Severn A, Bell S, Mackenzie IS, MacDonald TM. Renal artery stenosis—when to screen, what to stent? Current Atherosclerosis Reports. 2014 Jun; 16: 1-9. doi: 10.1007/s11883-014-0416-2.