ORIGINAL ARTICLE Cardiovascular Imaging

Doppler association of renal artery stenosis with coronary artery disease in hypertensive versus normotensive patients

Syed Muhammad Yousaf Farooq[1], Yasir Shahid[2], Syed Amir Gilani[3], Aruj Latif[2], Mahrukh Amna[2], Maida Iqbal[1].
[1]*Department of Radiography and Imaging Technology, Green International University, Lahore, Pakistan*
[2]*The University of Lahore, Lahore, Pakistan*
[3]*Department of Medical Diagnostic Imaging, College of Health Sciences, University of Sharjah, United Arab Emirates.*

SUBMISSION: 16/04/2024 - ACCEPTANCE: 31/07/2024

ABSTRACT

Background: The most frequent cause of renal artery stenosis (RAS) in adults is atherosclerosis. Renal function loss and elevated blood pressure (hypertension) are potential causes of renal artery stenosis (RAS) development. Due to poor systemic blood flow to the kidneys, renal artery stenosis (RAS) may also be linked to low blood pressure. Additionally, the kidneys secrete hormones that control blood pressure. Renal artery stenosis (RAS) carries a substantial mortality risk in people with Coronary artery disease (CAD) and is linked to early cardiovascular (CV) events.

Objective: To find the Doppler association of renal artery stenosis with coronary artery disease in hypertensive versus normotensive patients.

Material and Methods: This was a case control study, conducted at Radiology/Cardiology departments of Mardan Medical Complex (MMC), Mardan for duration of 9 months. Normotensive patients and hypertensive patients both with Coronary artery disease (CAD) were included in this study. All patients with known kidney disease were excluded from the study.

Results: A total 90 patients were included in study with equal distribution in both groups (hypertensive N=45, normotensive N=45). The patients included in normotensive group had mean age of 46.1±15.8 while hypertensive patients group had mean age of 45.04±9.7.

Conclusion: The study concluded that progression of Renal Artery Stenosis (RAS) had a strong association with development of Coronary artery disease (CAD).

CORRESPONDING AUTHOR, GUARANTOR
Dr. Syed Muhammad Yousaf Farooq
Department of Radiography and Imaging Technology, Green International University, Lahore, Pakistan
E-mail: Yousafgelani@gmail.com

KEY WORDS
Hypertension, Coronary artery disease, Renal Artery Stenosis, Doppler Indices.

Introduction

Progressive occlusion of the renal artery due to renal artery stenosis (RAS) is a factor contributing to hypertension and ischemic nephropathy that can potentially be rectified.[1] Patients having renal artery stenosis (RAS) equal to or exceeding 50% experience notably higher occurrences of myocardial infarction or necessitate cardiac revascularization compared to individuals without RAS.[2] Significantly, the presence of significant renal artery stenosis (RAS) worsens the progression of coronary artery disease (CAD). Even with coronary revascularization, individuals with CAD and RAS ≥ 50% exhibit notably diminished survival rates.[3] Atherosclerotic renal artery stenosis (RAS) is commonly accepted as a potentially treatable factor contributing to both arterial hypertension and renal insufficiency.[4-7] Cardiovascular disease (CVD) is a prevalent complication of chronic kidney disease (CKD), and it is one of the leading causes of mortality in this population. Therefore, it is extremely important for individuals with chronic kidney disease (CKD) to avoid the advancement of cardiovascular disease (CVD). Given that both renal artery stenosis (RAS) and coronary artery disease (CAD) can be brought on by atherosclerosis, a buildup of plaque inside the arterial walls, there may be a connection between the two disorders. The coronary and renal arteries, among other arteries throughout the body, can become narrowed or blocked because of atherosclerosis.[8] Age, hypertension, diabetes, and smoking are some of the risk factors that are similar between coronary artery disease (CAD) and renal artery stenosis (RAS). Renal artery stenosis (RAS) may be more likely to develop in patients with coronary artery disease (CAD), and vice versa. The same underlying mechanism of atherosclerosis in renal artery stenosis (RAS) patients has been proven in studies to raise the risk of cardiovascular events, such heart attack and stroke.[9] In various studies; it has been found that atherosclerosis accounts for 60-97% of cases of renal artery stenosis across different regions or populations and between 10% and 20% of documented cases of end-stage renal diseases are associated with a history of renal ischemia.[10] Doppler ultrasonography's among hypertensive patients has resulted in an increased detection rate of renal-artery stenosis.[11]

In our clinical observations, RAS is commonly seen in CAD. This study will include hypertensive and none hypertensive CAD patients for establishing an association with RAS. The ultrasonographic, none invasive technique may be helpful for management of such patients.

Methodology:

It was case control study, conducted at Radiology/ Cardiology departments of Mardan Medical Complex (MMC), Mardan for duration of 9 months. The sample size was calculated using a formula for two proportions, taking percentages of renal artery stenosis (RAS) in hypertensive and normotensive patients of coronary artery disease (CAD) as 46.2% and 19.5% respectively.[12] Hence, at 5% level of significance, and 80% power, the calculated sample size was 45 in each group (45= Hypertensive, 45 = Normotensive) i.e. 90. Convenient sampling technique was used to collect the data. Patients of both genders between age group 20-70 years were included. Normotensive and hypertensive patients with Coronary artery disease were included in this study. Patients with chronic kidney disease, single kidneys, end stage renal disease and renal transplantation were excluded.

Procedure:

Study was conducted after the approval from Research ethical committee dated 05-01-2023, Ref #: REC-UOL-336-02-2023, The University of Lahore. Data was collected according to the data collection sheets. Consent was taken from all the participants. Patients with CAD reporting to hospital for angiography were evaluated for RAS by Doppler ultrasonography. Because of the depth of the arteries, the motion caused by respiration, and the presence of intra-abdominal gas, RAS scanning was extremely challenging and demands a high level of competence. Patients were advised for 12 hours fast

Table 1:

Characteristics of patients	Frequencies and Percentages
Age (Mean ± S.D)	45.5 ± 13.0
Systolic blood pressure	149.2 ± 36.0
Gender	
Male	34 (37.8%)
Female	56 (62.2%)
Renal Artery Stenosis	
Yes	43 (47.8 %)
No	47 (52.2 %)
Hypertensive	45 (50%)
Normotensive	45 (50%)

Table 2: Comparison between hypertension and renal artery stenosis.

		Hypertension		Total	P-value
		Normotensive	Hypertensive		
Renal Artery Stenosis	**no**	41	6	47	0.000
		91.1%	13.3%	52.2%	
	Yes	4	39	43	
		8.9%	86.7%	47.8%	
Total		45	45	90	
		100.0%	100.0%	100.0%	

Above table 2, underscore a higher prevalence of RAS among hypertensive individuals compared to normotensive individuals, highlighting a significant correlation between RAS and hypertension.

prior to examination. The procedure was begin with the patient lying down and the head of the bed was elevated by about 30 degrees. A low-frequency scan head (2.5–5.0 MHz) was used to visualize the abdominal aorta and renal arteries (RAs). The front abdominal wall and the flank are the two most typical approaches to scan the RAs. A distinct method was employed depending on which part of the renal vasculature was being studied. The anterior technique was used to examine the major RAs in the majority of cases. The intrarenal vasculature and primary RAs was scanned using the flank approach. Each of these windows has its own set of limitations, which are determined by the individuals body habit and a range of other factors e.g., a patients ability to hold their breath.

Statistical Analysis:

Data was analyzed using SPSS software version 25. Frequencies and percentages were calculated for qualitative data. Mean ± S.D was calculated for quantitative data. Independent sample t-test was applied to check the association renal artery stenosis with coronary artery disease in hypertensive and normotensive. P-value less than 0.05 was considered significant.

Table 3: Mean comparison between hypertension and Doppler indices.

	Hypertension	N	Mean	Std. Deviation	Std. Error Mean	P-value
Renal artery diameter	**Normotensive**	45	7.0176	.20452	.03049	*0.000*
	Hypertensive	45	5.6196	.77498	.11553	
Peak systolic velocity (PSV)	**Normotensive**	45	88.3333	13.89899	2.07194	*0.003*
	Hypertensive	45	128.7778	8.33636	1.24271	
Aortic systolic velocity	**Normotensive**	45	3.2353	.79560	.11860	*.100*
	Hypertensive	45	2.1333	.81464	.12144	
Renal-aortic ratio (RAR)	**Normotensive**	45	.8533	.20736	.03091	*.479*
	Hypertensive	45	3.7444	.19720	.02940	
Resistive index (RI)	**Normotensive**	45	.6200	.11402	.01700	*0.003*
	Hypertensive	45	1.0356	.20131	.03001	
Pulsatility index (PI)	**Normotensive**	45	1.0320	.19645	.02929	*0.002*
	Hypertensive	45	1.6800	.13203	.01968	

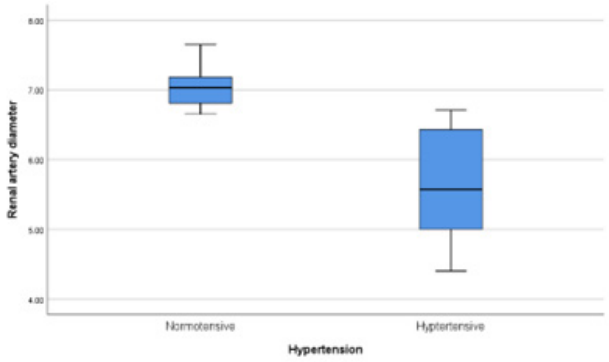

Figure 1: *Renal artery diameter and Hypertension (HTN)*

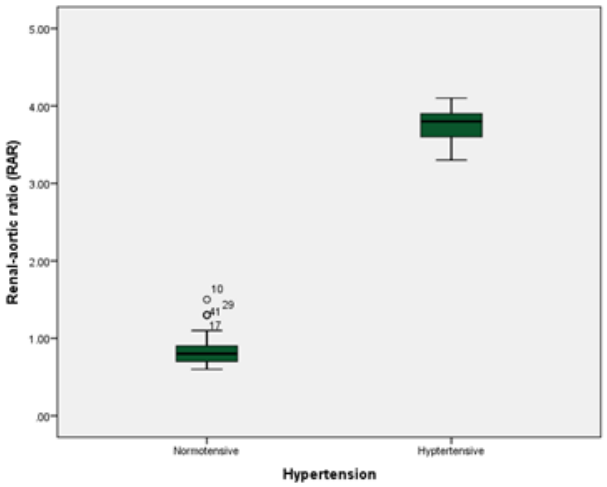

Figure 2: *Renal Aortic Ratio (RAR) and Hypertension (HTN)*

Results:

The hypertensive group has an average age of 45.0 ± 9.6 years, while the normotensive group has an average age of 46.1 ± 15.7 years.

Renal Artery Diameter: Normotensive individuals had a mean renal artery diameter of 7.0176 mm, while hypertensive individuals had a smaller mean diameter of 5.6196 mm, demonstrating a significant difference ($p < .001$).

Peak Systolic Velocity (PSV): Hypertensive individuals exhibited higher peak systolic velocities (128.7778 cm/s) compared to normotensive individuals (88.3333 cm/s) ($p = 0.003$).

Aortic Systolic Velocity: Normotensive individuals had a higher mean aortic systolic velocity (3.2353 cm/s) compared to hypertensive individuals (2.1333 cm/s), though this difference did not reach statistical significance ($p = 0.100$).

Renal-Aortic Ratio (RAR): The renal-aortic ratio (RAR) did not show a significant difference between hypertensive and normotensive groups ($p = 0.479$).

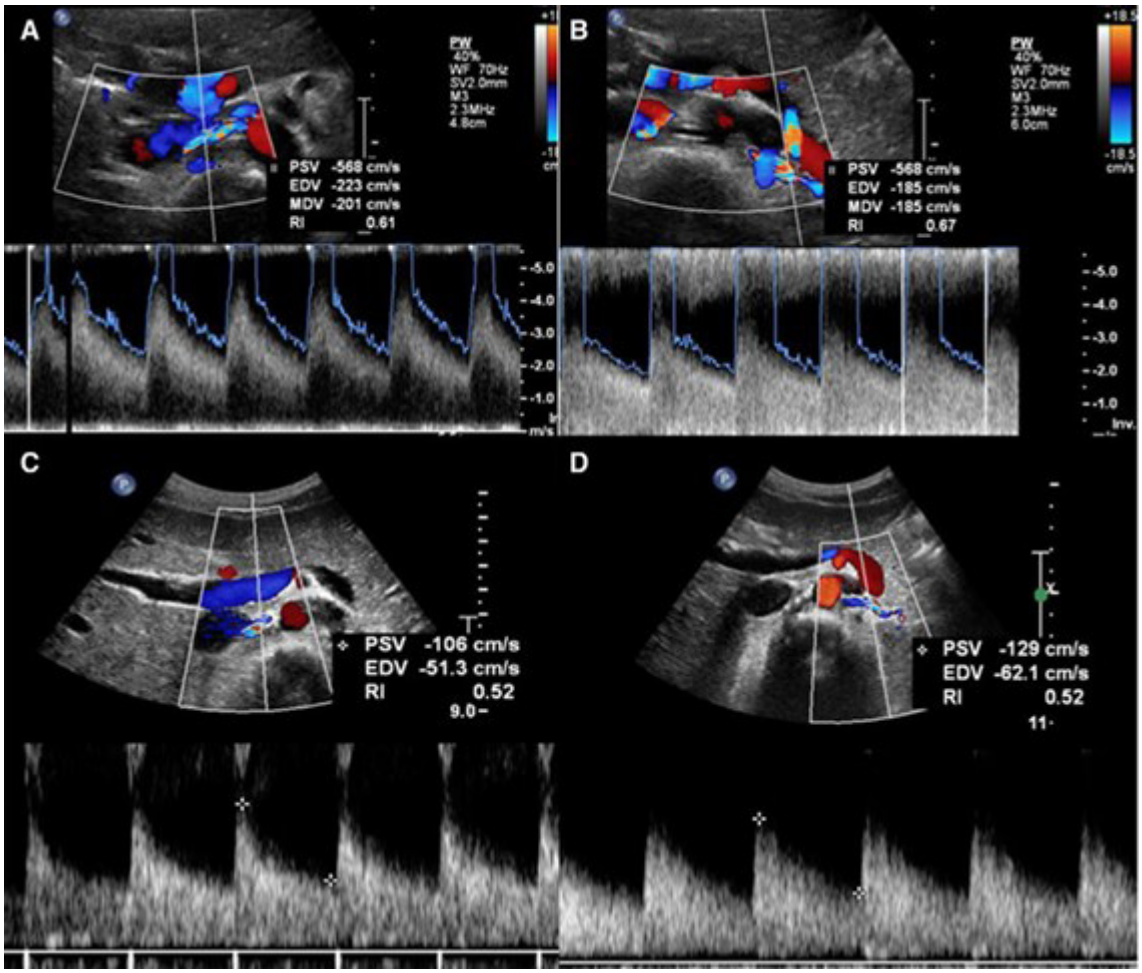

Image 1: *Patient was hypertensive, On Doppler presence of severe stenosis in bilateral renal arteries was found. In panel A: Peak Systolic Velocity (PSV) was 568 cm/s, End Diastolic Velocity (EDV): 223 cm/s, Mean Doppler Velocity (MDV): 201 cm/s and Resistive Index (RI): 0.61. Waveform: Shows the Doppler spectrum with the corresponding flow velocities over time. In panel B: PSV: 568 cm/s, EDV: 158 cm/s, MDV: 185 cm/s and RI: 0.67. In panel C: PSV: 106 cm/s, EDV: -51.3 cm/s (indicative of reverse flow in diastole) and RI: 0.52. Waveform: The Doppler spectrum shows bidirectional flow, with negative values indicating flow reversal. Panel D: PSV: 129 cm/s, EDV: -62.1 cm/s (indicative of reverse flow in diastole), RI: 0.52. Waveform: The Doppler spectrum again shows bidirectional flow, with negative values during diastole.*

Resistive Index (RI) and Pulsatility Index (PI): Both the resistive index and pulsatility index were significantly higher in hypertensive individuals compared to normotensive individuals (RI: p = 0.003, PI: p = 0.002). (Table 3)

In (Figure 1), the finding of this plot is that there is a significant difference in the renal artery diameter between the two groups. The hypertensive group has a higher median renal artery diameter than the normotensive group, which means that their renal arteries are more dilated on average. The hypertensive group also has a larger range of renal artery diameters than the normotensive group, which means that their renal arteries vary more in size. This could indicate that hypertension affects the elasticity and structure of the renal arteries.

In (Figure 2), the box plot that compares the renal aortic ratio (RAR) of people with normal and high blood pressure. It shows that people with high blood pressure have a higher median and a wider range of RAR than people with normal blood pressure. RAR is a measure of the relative size of the renal artery compared to the aor-

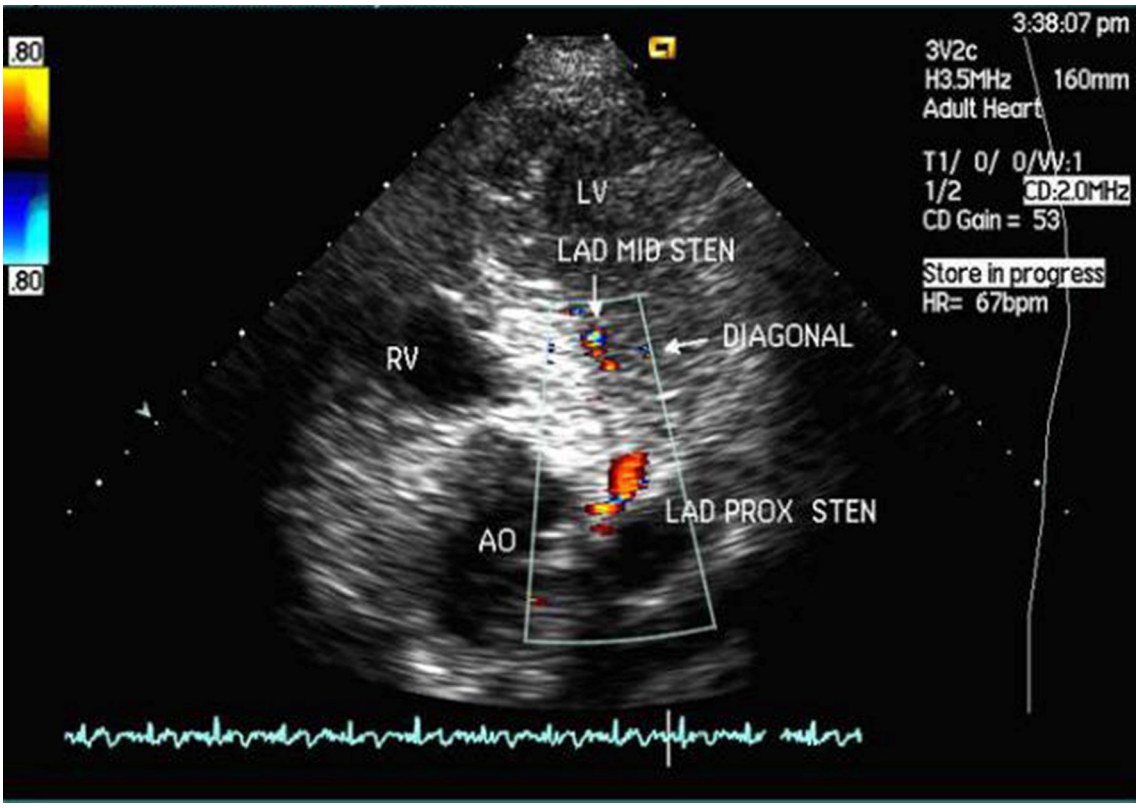

Image 2: *Patient has a history of hypertension and coronary artery disease. LAD Mid Stenosis Indicates stenosis in the mid portion of the Left Anterior Descending artery. LAD Proximal Stenosis: Indicates stenosis in the proximal portion of the Left Anterior Descending artery. Diagonal Branch: The diagonal branch of the LAD, which may also show areas of concern. The color Doppler highlights turbulent flow in these regions, indicating significant stenosis.*

ta, the main artery of the body. A higher RAR means that the renal artery is larger or more dilated than the aorta. This could indicate that high blood pressure affects the blood flow and structure of the renal artery.

Discussion:

The most frequent secondary cause of hypertension is renal artery stenosis, which is mostly brought on by atherosclerosis. An ultrasonography diagnostic is preferable in individuals who are suspected. Renal artery stenosis (RAS) that was accidentally discovered and is asymptomatic does not need revascularization. Renal artery stenting is the recommended treatment for symptomatic individuals who need revascularization. A multidisciplinary team is ideal for selecting suitable patients for revascularization, which necessitates careful examination of lesion severity. All patients with atherosclerotic renal artery stenosis (RAS) should get medical therapy based on recommended guidelines, which includes managing diabetes, hypertension, and taking statins and other antiplatelet medications while also quitting smoking and promoting physical exercise.[12] The pathophysiology of renal artery stenosis (RAS) has an impact on the clinical effects of Renal artery stenosis (RAS), which are mostly connected to hypertension (HTN) and renal hypo perfusion.[13] The demographic distribution, age, gender and life style are main contributory factors for development of coronary artery disease (CAD) which can be early diagnosed by evaluating Renal artery stenosis (RAS) particularly when associated with hypertension. In this study the higher prevalence of these associated diseases was recorded in 31-50 year of age groups. CDC has reported risk range even from 20 years. However, other studies support our findings where they also suggested high risk in these ages. Studies also reported that females are at more risk of devel-

oping coronary artery disease (CAD) and hypertension. Our results also showed same trend but no significant difference was found between groups. In KPK May factors contributes to high prevalence of heart disease in females. The major factors included late diagnosis, suboptimal treatment, delayed hospitalization, multiple pregnancies and underlying comorbidities (hypertension, diabetes, obesity). Life modification, awareness and early diagnosis may reduce the disease burden in females.[14,15] Demographic distribution of Khyber Pakhtoon Khawa (KPK) has same origin therefore it may have minimal effect on disease outcomes but high prevalence from Peshawar district may be due to easy accessibility of the patients to HMC, Peshawar.

Investigating the physiological response to RAS and the impacts of stenosis geometry, measuring the effectiveness of arterial pressure control mechanisms in relation to stenosis severity, predicting future renal artery stenosis (RAS) situations and its association with coronary artery disease (CAD) were the objectives of the current study. Other geometric metrics exhibited minimal influence on hemodynamics, with stenosis % and artery diameter being the primary factors.[16] SBP is easy marker for diagnosing the hypertension and associated changes due to arterial stenosis. Although some other clinical trial established no significant association between RAS and hypertension but our results established.[17] Although studies favored our result by associating renal hypertension (RHTN) with multi organ failure and high risk of cardiovascular diseases.[17,18] Renal artery diameter (RAD) is also a parameter and has investigated by several methods like angiography and Doppler ultrasound (DUS). The results of the current investigation showed that the left and right RAs differed significantly in length and diameter. The breadth of the right RA was found to be substantially less than the left. These results agree to studies CT-based studies on length and involvement of specific renal artery. They also associated age an aggravating factor for causing the disease.[19] renal aortic ratio (RAR) is another parameter for diagnosing the RAS. It is the ration of renal and aortic blood flow resistance and may cause ischemia. Stenosis is an syndromes' event and may involve many arteries of the heart, brain, peripheral and etc. therefore the ratio between renal and major artery (aorta) gives and overall pattern of blood flow. The aorta and its branches are frequently involved in stenosis, which leads to various vascular stenosis, the most prevalent of which is type V, followed by type I. This causes aortic stenosis to occur more frequently than atherosclerosis, and suprarenal aortic stenosis can affect ultrasonic hemodynamic measures including RPSV, IPSV, RI, and AT, among others. Second, because of the possibility of redistribution of systemic blood flow brought on by the stenosis of several branches, such as the brachiocephalic trunk, the renal artery's blood perfusion state may differ from that of patients with non-renal artery stenosis. Thirdly, as was already indicated, renal artery stenosis (RAS) patients' renal artery stenosis is often segmental and circumferential, as opposed to the localized and eccentric stenosis brought on by atherosclerotic plaque. There may be differences between the hemodynamic state and ultrasonic parameters of stenosis and atherosclerosis. However, the renal artery stenosis (RAS) ultrasound diagnostic criteria developed in earlier research are mostly based on patient data with atherosclerotic renal artery stenosis (RAS), the majority of whom are older and have various disease features. Therefore, it is important to perform independent study on the ultrasound diagnostic markers of renal artery stenosis in renal artery stenosis (RAS) hypertensive patients as the prior ultrasound diagnostic criteria may not be relevant to stenosis-involving renal arteries.[19,20]

Color duplex is none invasive methods for diagnosing the blood flow velocity, blood flow pattern, resistance, pulsatility index and pulsus parvus et tardus which were also key patterns of renal artery stenosis (RAS) in coronary artery disease (CAD) patients in our findings and are consistent with observations made by several other studies.

Conclusion: Therefore, it is concluded that all above parameters are good markers for diagnosing the renal artery stenosis (RAS) in coronary artery disease (CAD patients. Resistive indexed, renal aortic ratio (RAR) ratio, renal artery diameter (RAD), blood flow patterns could be the replacement of invasive techniques like angiography etc. **R**

References

1. Garovic VD, Textor SC. Renovascular hypertension and ischemic nephropathy. Circulation. 2005 Aug 30;112(9):1362-74.
2. Conlon PJ, Little MA, Pieper K, Mark DB. Severity of renal vascular disease predicts mortality in patients undergoing coronary angiography. Kidney international. 2001 Oct 1;60(4):1490-7.
3. Edwards MS, Craven TE, Burke GL, Dean RH, Hansen KJ. Renovascular disease and the risk of adverse coronary events in the elderly: a prospective, population-based study. Archives of internal medicine. 2005 Jan 24;165(2):207-13.
4. Bettmann MA, Dake MD, Hopkins LN, Katzen BT, White CJ, Eisenhauer AC, et al. Atherosclerotic vascular disease conference. Writing Group VI: Revascularization. Circulation 2004; 109:2643–2650.
5. Turi ZG, Jaff MR. Renal artery stenosis: searching for the algorithms for diagnosis and treatment. J Am Coll Cardiol 2003; 41:1312–1315.
6. Weinrauch LA, D'Elia JA. Renal artery stenosis: 'fortuitous diagnosis', 'problematic therapy'. J Am Coll Cardiol 2004; 43:1614–1616.
7. Pasternak RC, Criqui MH, Benjamin EJ, Fowkes GR, Isselbacher EM, McCullough PA, et al. Atherosclerotic vascular disease conference. Writing Group I: Epidemiology. Circulation 2004; 109:2605–2612.
8. Fujii H, Kono K, Nishi S. Characteristics of coronary artery disease in chronic kidney disease. Clinical and experimental nephrology. 2019 Jun 1;23:725-32.
9. Zandparsa A, Habashizadeh M, Farsani EM, Jabbari M, Rezaei R. Relationship between renal artery stenosis and severity of coronary artery disease in patients with coronary atherosclerotic disease. International Cardiovascular Research Journal. 2012 Sep;6(3):84.
10. Park S, Jung JH, Seo HS, Ko YG, Choi D, Jang Y, et al. The prevalence and clinical predictors of atherosclerotic renal artery stenosis in patients undergoing coronary angiography. Heart and vessels. 2004;19(6):275–9.
11. Radermacher J, Chavan A, Bleck J, Vitzthum A, Stoess B, Gebel MJ, Galanski M, Koch KM, Haller H. Use of Doppler ultrasonography to predict the outcome of therapy for renal-artery stenosis. New England Journal of Medicine. 2001 Feb 8;344(6):410-7.
12. Anagnostis P, Vaitsi K, Mintziori G, Goulis DG, Mikhailidis DP. Non-coronary atherosclerotic cardiovascular disease in patients with familial hypercholesterolaemia. Current Medical Research and Opinion. 2020 May 3;36(5):731-40.
13. Safian RD. Renal artery stenosis. Progress in cardiovascular diseases. 2021 Mar 1;65:60-70.
14. McClelland RL, Chung H, Detrano R, Post W, Kronmal RA. Distribution of coronary artery calcium by race, gender, and age: results from the Multi-Ethnic Study of Atherosclerosis (MESA). Circulation. 2006 Jan 3;113(1):30-7.
15. Mehta PK, Bess C, Elias-Smale S, Vaccarino V, Quyyumi A, Pepine CJ, Bairey Merz CN. Gender in cardiovascular medicine: chest pain and coronary artery disease. European heart journal. 2019 Dec 14;40(47):3819-26.
16. Andayesh M, Shahidian A, Ghassemi M. Numerical investigation of renal artery hemodynamics based on the physiological response to renal artery stenosis. Biocybernetics and Biomedical Engineering. 2020 Oct 1;40(4):1458-68.
17. Courand PY, Dinic M, Lorthioir A, Bobrie G, Grataloup C, Denarie N, Soulat G, Mousseaux E, Sapoval M, Azizi M, Amar L. Resistant hypertension and atherosclerotic renal artery stenosis: effects of angioplasty on ambulatory blood pressure. A retrospective uncontrolled single-center study. Hypertension. 2019 Dec;74(6):1516-23.
18. Maw AM, Thompson LE, Ho PM, Kennedy KF, Maddox TM, Valle JA, Sandhu A, Masoudi FA, Messerli FH, Daugherty SL. Implications of guideline updates for the management of apparent treatment resistant hypertension in the United States (a NCDR research to practice [R2P] pro-

ject). The American journal of cardiology. 2020 Jan 1;125(1):63-7.
19. Abd Elrahim E. Computed tomography evaluation of renal artery morphometry in adults: The impact of age and gender. Saudi medical journal. 2020 Jan;41(1):34.
20. Hinchliffe RJ, Forsythe RO, Apelqvist J, Boyko EJ, Fitridge R, Hong JP, Katsanos K, Mills JL, Nikol S, Reekers J, Venermo M. Guidelines on diagnosis, prognosis, and management of peripheral artery disease in patients with foot ulcers and diabetes (IWGDF 2019 update). Diabetes/metabolism research and reviews. 2020 Mar;36:e3276.

READY - MADE CITATION

Syed Muhammad Yousaf Farooq, Yasir Shahid, Syed Amir Gilani, Aruj Latif, Mahrukh Amna, Maida Iqbal. Doppler association of renal artery stenosis with coronary artery disease in hypertensive versus normotensive patients. Hell J Radiol 2025; 10(1): 16-24.