Cardiovascular Imaging ORIGINAL ARTICLE

Carotid Artery Stiffness In Adults Belonging To Urban And Rural Areas Of Punjab, Pakistan: A Comparative Study

Raheej Akhtar[1], Syed Muhammad Yousaf Farooq[2], Sidra Maryam[1], Areej Akhtar[1], Amna Rafique[1], Sania Maheen[1], Aruj Latif[1], Zeshan Haider[1], Syeda Moazza Ali[1].

[1]*University Institute of Radiological Sciences & Medical Imaging Technology, Faculty of Allied Health Sciences, The University of Lahore.*

[2]*Department of Radiography and Imaging Technology, Green International University.*

SUBMISSION: 20/02/2024 - ACCEPTANCE: 23/07/2024

ABSTRACT

Background: Duplex ultrasound (DUS) has become one of the main assessing methods for carotid diseases. Duplex ultrasound uses two techniques, traditional B-mode ultrasound and Doppler US. The screening of carotid artery stenosis using ultrasonography is essential for not only daily clinical settings but also management of patients with stiffness in carotid artery through the cross sectional area of the carotid artery. By comparing the people of rural and urban area, we will know about the stiffness caused by pollution.

Objective: To compare the Carotid Artery Stiffness in adults belonging to Urban and Rural areas of Punjab by ultrasonography.

Methodology: It was cross-sectional analytical study conducted in Department of Diagnostic Radiology, at Nishtar Hospital, Sehat Medical Complex, Lahore. Duration of study was 7 months. Total sample size was 135.

Result: In urban areas, the mean RCC stiffness was notably higher at 324.13 compared to the rural population's lower mean of 222.20. Similarly, the LCC stiffness in urban adults exhibited a higher mean of 329.52, while rural adults showed a lower mean of 239.34. The diameter measurements during systole and diastole also displayed variations between urban and rural settings. RCC diameter during diastole showed a statistically significant difference with an urban mean of 0.27 compared to the rural mean of 0.24.

Conclusion: Urban populations exhibited significantly higher RCC and LCC stiffness compared to rural counterparts. Additionally, urban individuals demonstrated larger RCC diameters during systole and diastole.

CORRESPONDING AUTHOR, GUARANTOR

Syed Muhammad Yousaf Farooq
Department of Radiography and Imaging Technology, Green International University.
E-mail: hod.rit@giu.edu.pk

KEY WORDS
Carotid Intima media thickness, atherosclerosis, hypertensive patients, duplex ultrasound.

Introduction

Carotid artery stiffness is a crucial factor linked to cardiovascular health. Cardiovascular diseases (CVDs) pose a significant health burden globally, with arterial stiffness being a crucial indicator of vascular health and a predictor of CVD risk. Understanding the variations in carotid artery stiffness among populations residing in different environments, specifically urban and rural areas, and holds paramount importance for preventive healthcare strategies. Research indicates that stiffness in the carotid artery differs between hypertensive and non-hypertensive adults, particularly in those older than 40 years [1]. Carotid stiffness has associations with the development and progression of carotid artery disease, being an independent factor for stroke and dementia [2]. Furthermore, studies have explored characteristics and risk factors of carotid atherosclerosis in populations at high risk of stroke in both urban and rural settings [3]. The non-invasive identification of arterial stiffness through routine ultrasound examinations of the carotid arteries emerges as a potent clinical strategy in preventing cardiovascular diseases (CVD). Carotid ultrasound, among various imaging modalities, stands out for its capability to non-invasively evaluate vascular anatomy and function, emphasizing its significance in proactive CVD prevention [4,5]. Carotid atherosclerotic plaques represent later stages of disease than CIMT and arterial stiffness. CIMT is seen as a double line pattern visualized between the intimal-luminal and the medial-adventitial interfaces of the carotid wall in a longitudinal view by B-mode ultrasound. IMT is preferably measured along the posterior wall of the CCA at least 5 mm below its termination. CCA IMT is relatively higher in old age and obese patients. Many invasive and noninvasive techniques to measure arterial stiffness are used. Methods such as dispensability, compliance, elastic modulus, and β-stiffness index are based upon the assessment of diameter and volume change during the cardiac cycle for the corresponding change in arterial pressure. Carotid artery is affected by many environmental factors such as obesity, hypertension, hyperlipidemia, diabetes, obesity, and age. In this Era Carotid artery, stiffness is a significant factor that serves as a marker of cardiovascular problems. Which may further lead to stenosis, plaque formation that further leads to embolism. Age-related modification in intima-media thickness and carotid artery stiffness and play development are sped by risk factors, including hypertension [6].

The rationale of comparing carotid artery stiffness in adults belonging to urban and rural areas of Punjab could be to investigate the impact of the environment and lifestyle on cardiovascular health. The carotid artery is a major blood vessel in the neck that supplies oxygen-rich blood to the brain. When this artery becomes stiff or narrow, it can lead to various cardiovascular diseases, including stroke, heart attack, and peripheral artery disease.

Material and Method:

It was a cross-sectional analytical study conducted in the Department of Diagnostic Radiology, at Nishtar Hospital, Sehat Medical Complex, Lahore. The duration of study was 7 months. The total sample size was 135. Both males and females were included. All normal adult individuals of urban and rural areas of Punjab were included. Individuals with any underlying pathologies of carotid artery were excluded. Data was analyzed using SPSS software version 25.

Procedure:

Data was collected after getting approval from Research Ethical Committee at the University of Lahore. Patients were recruited for the study keeping in mind the inclusion and exclusion criteria. Informed consent was taken from each study participant and all possible benefits and expected risks. Basic demographic and clinical information were noted down on a pre-designed data collection sheet by the researcher. Ultrasound was performed using Toshiba Xario XG with Linear Probe (7MHz-10MHz). We performed the scan by bringing the patient to the couch. The subject was supine during the carotid artery examination and made comfortable in a position that allows head rotation to the left side. We

performed the exam by standing or sitting at the end of the examination table near the participant's head or by standing on the patient's right side. The top of the head was about three inches from the end of the examination table and the head was rotated 45 degrees to the left. Four measurements were taken for each patient. Two measurements for the right systolic/diastolic diameters and two for the left systolic/diastolic were taken.

Data Analysis Procedure:

Data was analyzed using SPSS software version 25. Frequencies and Percentages were calculated for qualitative variables. Mean ± SD was calculated for quantitative variables. An Independent sample t-test was applied to check the association between rural/urban areas and stiffness/diameter of the carotid artery. A P-value less than 0.05 was considered significant.

Results:

The mean age was 30.3 ± 12.0 years and a body mass index (BMI) was 25.1 ± 5.13. Gender distribution revealed a slight majority of females, constituting 66.7%, while males accounted for 33.3%. The participants were equally distributed between rural and urban areas, with 50.4% residing in rural regions and 49.6% in urban settings. In terms of health indicators, the prevalence of obesity was notable, with 40% of the participants being obese and 60% being non-obese. Hypertension, a key cardiovascular risk factor, was observed in 25.9% of the population (Table 1). In urban areas, the mean RCC stiffness was notably higher at 324.13 compared to the rural population's lower mean of 222.20. Similarly, the LCC stiffness in urban adults exhibited a higher mean of 329.52, while rural adults showed a lower mean of 239.34. The diameter measurements during systole and diastole also displayed variations between urban and rural settings. RCC diameter during diastole showed a statistically significant difference with an urban mean of 0.27 compared to the rural mean of 0.24 (Table 2). These findings suggest distinct patterns of carotid artery stiffness and diameter dynamics between urban and rural populations, emphasizing the potential influence of environmental and lifestyle factors on vascular health. Results did not reveal a significant difference in RCC and LCC stiffness between those with and without hypertension (p-values of 0.812 and 0.421, respectively). However, significant variations were observed in diameter measurements. Individuals with hypertension showed a higher mean RCC diameter during systole (0.3600) compared to those without hypertension (0.3020), and similar trends were noted in LCC diameter during systole and both RCC and LCC diameters during diastole (Table 3). No significant difference in RCC and LCC stiffness between obese and non-obese individuals (p-values of 0.706 and 0.208, respectively) was found. However, significant variations were observed in diameter measurements. Obese individuals showed a higher mean RCC diameter during systole (0.33) compared to non-obese (0.30), and similar trends were noted in LCC diameter during systole (Table 4). During systole, males shows a mean right carotid artery diameter of 0.33, whereas females showed a slightly lower mean of 0.30 (p-value = 0.016). Similarly, for left carotid artery diameter during systole, males had a mean of 0.34, and females had a mean of 0.29 (p-value = 0.003). In diastole, the trend continued with males having a higher mean RCC diameter of 0.280 compared to females of 0.25, with a significant p-value of 0.036. The same pattern was observed in LCC diameter during diastole, with males having a mean of 0.28 and females having a lower mean of 0.24 (p-value = 0.001). Moreover, in stiffness, non-significant differences were found between genders. For RCC stiffness, males exhibited a mean of 283.86, and females had a mean of 267.25 (p-value = 0.660). Similarly, LCC stiffness showed a mean of 306.09 for males and 273.10 for females (p-value = 0.409) (Table 5). These findings suggest that gender differences in carotid artery stiffness are more prominent in diameter measurements during both systole and diastole, while stiffness itself does not show significant variations.

Table 1: Descriptive statistics

Variables	Frequencies (%)
Age	30.3 ± 12.0
BMI	25.1 ± 5.13
Gender	Male - 45 (33.3%) Female - 90 (66.7%)
Area	Rural – 68 (50.4%) Urban – 67 (49.6%)
Obesity	Obese – 54 (40%) Non-obese – 81(60%)
Hypertension	Yes – 35 (25.9%) No – 100 (74.1%)

Table 2: Comparison of carotid artery stiffness with adults of urban and rural areas

	Area	N	Mean	Std. Deviation	Std. Error Mean	P-value
RCC Stiffness	Urban	67	324.1307	251.18731	30.68741	.001
	Rural	68	222.2097	130.89626	15.87350	
LCC Stiffness	Urban	67	329.5258	268.96603	32.85943	.000
	Rural	68	239.3474	140.20047	17.00180	
RCC Diameter (systole)	Urban	67	.3301	.07995	.00977	.048
	Rural	68	.3041	.07118	.00863	
LCC Diameter (systole)	Urban	67	.3209	.07967	.00973	.237
	Rural	68	.3049	.07724	.00937	
RCC Diameter (Diastole)	Urban	67	.2796	.07306	.00893	.004
	Rural	68	.2463	.05925	.00718	
LCC Dimeter (Diastole)	Urban	67	.2693	.07583	.00926	.113
	Rural	68	.2496	.06744	.00818	

Table 3: Comparison of carotid artery stiffness with Hypertension

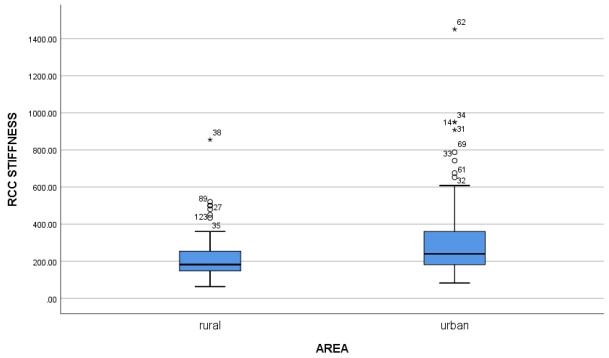
	Hypertension	N	Mean	Std. Deviation	Std. Error Mean	P-value
RCC Stiffness	Yes	35	280.38	202.887	34.294	.812
	No	100	270.13	207.450	20.745	
LCC Stiffness	Yes	35	267.52	185.802	31.406	.421
	No	100	289.90	228.726	22.872	
RCC Diameter (systole)	Yes	35	.3600	.08458	.01430	.000
	No	100	.3020	.06770	.00677	
LCC Diameter (systole)	Yes	35	.3663	.08493	.01435	.000
	No	100	.2941	.06720	.00672	
RCC Diameter (Diastole)	Yes	35	.2997	.07683	.01299	.001
	No	100	.2499	.06028	.00603	
LCC Dimeter (Diastole)	Yes	35	.3034	.07933	.01341	.000
	No	100	.2439	.06288	.00629	

Table 4: Comparison of carotid artery stiffness with Obesity						
	Obesity	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**P-value**
RCC Stiffness	**Obese**	54	264.58	186.90	25.43	.706
	Non-obese	81	278.26	218.09	24.23	
LCC Stiffness	**Obese**	54	296.97	259.78	35.35	.208
	Non-obese	81	275.52	186.21	20.69	
RCC Diameter (systole)	**Obese**	54	.3331	.08876	.01208	.029
	Non-obese	81	.3063	.06551	.00728	
LCC Diameter (systole)	**Obese**	54	.3383	.08963	.01220	.002
	Non-obese	81	.2958	.06548	.00728	
RCC Diameter (Diastole)	**Obese**	54	.2744	.07595	.01034	.106
	Non-obese	81	.2551	.06193	.00688	
LCC Dimeter (Diastole)	**Obese**	54	.2793	.08332	.01134	.008
	Non-obese	81	.2460	.06057	.00673	

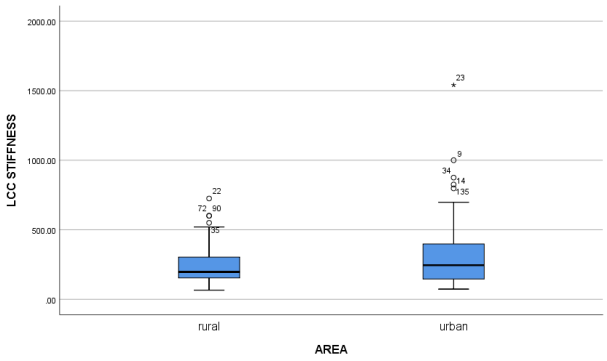
Table 5: Comparison of carotid artery stiffness with gender						
	Gender	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**P-value**
RCC Diameter (systole)	**Male**	45	.3393	.07936	.01183	0.016
	Female	90	.3059	.07295	.00769	
LCC Diameter (systole)	**Male**	45	.3409	.08081	.01205	0.003
	Female	90	.2988	.07395	.00780	
LCC Dimeter (Diastole)	**Male**	45	.2882	.06790	.01012	0.001
	Female	90	.2449	.07016	.00740	
RCC Diameter (Diastole)	**Male**	45	.2802	.06963	.01038	0.036
	Female	90	.2541	.06628	.00699	
RCC Stiffness	**Male**	45	283.8676	224.20991	33.42324	0.660
	Female	90	267.2553	196.67605	20.73148	
LCC Stiffness	**Male**	45	306.0976	185.01312	27.58013	0.409
	Female	90	273.1051	232.89242	24.54902	

Discussion:

Our study aims to investigate the differences in carotid artery stiffness among adults living in urban and rural areas of Punjab. Cardiovascular health is a topic of significant concern, with artery stiffness being an essential factor in predicting and understanding cardiovascular diseases. Carotid artery stiffness is a crucial factor linked to cardiovascular health. Research indicates that stiffness in the carotid artery differs between hypertensive and non-hypertensive adults, particularly in those older than 40 years [7]. Carotid stiffness has associations with the development and progression of carotid artery disease, being an independent factor for stroke and dementia [8]. Current study showed the mean RCC stiffness higher at urban areas (324.13) as compared to



Graph 1: *Box-plot Shows RCC stiffness mean between urban and rural areas of Punjab*



Graph 2: *Box-plot Shows LCC stiffness mean between urban and rural areas of Punjab*

the rural population's (222.20). Similarly, the LCC stiffness in urban adults showed a higher mean of 329.52, while rural adults showed a lower mean of 239.34. A study was conducted on 52 healthy children living in a small town on the Amalphitan Coast. A statistically significant difference was found in carotid arterial stiffness between children living closer to the main street and other children, both those living between 330 and 730 meters from the main street and those living more than 750 meters from the main street. This showed that long-term residential exposure to fine particulate matter is associated with the thickness of the intimal and media layers, which is another marker of early vascular atherosclerosis [9]. Another study shows a significant arterial stiffness difference in children living closer to the main street and those living away. The complex mixture of substances that make up gaseous and particle phases of air pollution is mostly caused by the combustion of fossil fuels in modern urban centers. Blacher et.al has shown that increased carotid artery stiffness, indicated by higher CIMT, is strongly associated with adverse cardiovascular outcomes and overall mortality. Arterial stiffness is often considered a reflection of underlying vascular damage, atherosclerosis, and reduced arterial compliance [10].These environmental factors may be Pollution due to traffic. Populations residing in rural areas often exhibit a heightened burden of carotid plaque, coronary artery disease, and cardiovascular risk factors compared to their urban counterparts [11]. This suggests a potential disparity in cardiovascular health between rural and urban communities. A cross-sectional study on rural Chinese adults found significantly higher carotid arterial stiffness parameters, including Dd, PWV, α, and β, particularly in individuals with diabetes [1]. This emphasizes the impact of specific health conditions on arterial stiffness in rural settings. Compared to people living in cities, people in rural areas had a higher prevalence of cardiovascular risk factors and carotid plaque coronary artery disease [12,13]. However, there is not enough data available for estimating the worldwide prevalence of carotid atherosclerosis in rural areas [14]. Although carotid plaques and increased intima-media thickness are well-established markers for subclinical and clinical carotid artery disease, screening for the condition in the general public is still debatable [15,16]. The assessment of carotid plaque burden, progression, risk stratification, and evaluation of new risk factors have all benefited from the use of other ultrasonography modalities, such as 3D ultrasound imaging [17].

Sex differences play a crucial role in cardiovascular risk factors, influencing arterial stiffness and related conditions. Traditional cardiovascular disease (CVD) risk factors, including aging, hypertension, diabetes, and obesity, have been associated with elevated arterial stiffness [18]. Obesity, specifically overweight and obesity, contributes to arterial stiffness, emphasizing the impact of body weight on cardiovascular health [19]. Additionally, hypertension and obesity are linked, as self-reported hypertension increases the risk of renal cell carcinoma, particularly in women and men, highlighting the intricate connection between these

risk factors [20]. Gender-related differences in the progression of carotid stiffness have been observed, with specific relationships noted in women between carotid stiffness and pulse pressure [21]. Furthermore, female gender is associated with higher susceptibility to arterial stiffening in obesity, potentially predisposing individuals to hypertension development [22].

Conclusion:

Urban populations exhibited significantly higher RCC and LCC stiffness compared to rural counterparts. Additionally, urban individuals demonstrated larger RCC diameters during systole and diastole. Hypertension did not significantly impact carotid stiffness, while individuals with hypertension exhibited larger RCC and LCC diameters during systole. Obesity did not show a significant association with carotid stiffness, but obese individuals had larger RCC and LCC diameters during systole and larger LCC diameter during diastole. Gender differences were observed in carotid diameters during systole and diastole, but carotid stiffness did not differ significantly between males and females. These insights contribute to understanding the complex interplay of demographic factors in determining carotid artery health, emphasizing the importance of considering urban-rural distinctions and individual health conditions in cardiovascular research **R**

References

1. Wei Y, Wang M, Gui Y, et al. Carotid artery stiffness in rural adult Chinese: a cross-sectional analysis of the community-based China stroke cohort study. BMJ open. 2020;10(10).
2. Petrova M, Gavino A, Li Y, McLachlan CS. Comparison of Parameters for Assessment of Carotid Stiffness and Their Association with Carotid Atherosclerosis in Rural Australian Adults: A Pilot Study. Journal of Clinical Medicine. 2023 Apr 18;12(8):2935.
3. Zhang J, Sang H, Zhang X, et al. Comparison of the characteristics and risk factors of carotid atherosclerosis in high stroke risk populations between urban and rural areas in North China. Frontiers in Neurology. 2020 Nov 9;11:554778.
4. Xu X, Wang B, Ren C, et alAge-related impairment of vascular structure and functions. Aging and disease. 2017 Oct;8(5):590.
5. Phillips AA, Chan FH, Zheng MM, et al. Neurovascular coupling in humans: physiology, methodological advances and clinical implications. Journal of Cerebral Blood Flow & Metabolism. 2016 Apr;36(4):647-64.
6. Ren L, Cai J, Liang J, Li W, Sun Z. Impact of cardiovascular risk factors on carotid intima-media thickness and degree of severity: a cross-sectional study. PloS one. 2015 Dec 4;10(12): e0144182.
7. Chen W-W, Gao R-L, Liu L-S, et al. China cardiovascular diseases report 2015: a summary. J Geriatr Cardiol 2017;14:1–10.
8. Mikael, L.D.R.; de Paiva, A.M.G.; Gomes, M.M.; Sousa, A.L.L.; Jardim, P.C.B.V.; Vitorino, P.V.D.O.; Euzebio, M.B.; de Moura Sousa, W.; Barroso, W.K.S. Vascular Aging and Arterial Stiffness. Arq. Bras. Cardiol. **2017**, 109, 253–258.
9. Iannuzzi A, Verga MC, Renis M, et al. Air pollution and carotid arterial stiffness in children. Cardiology in the Young. 2010 Apr;20(2):186-90.
10. Blacher J, Pannier B, Guerin AP, Marchais SJ, Safar ME, London GM. Carotid arterial stiffness as a predictor of cardiovascular and all-cause mortality in end-stage renal disease. Hypertension. 1998 Sep;32(3):570-4.
11. Petrova M., Kiat H., Gavino A., McLachlan C.S. Carotid ultrasound screening programs in rural communities: A systematic review. J. Pers. Med. 2021;11:897.
12. Alston L., Allender S., Peterson K., Jacobs J., Nichols M. Rural Inequalities in the Australian Burden of Ischaemic Heart Disease: A Systematic Review. Heart Lung Circ. 2017;26:122–133.
13. Kapral M.K., Austin P.C., Jeyakumar G. et al. Rural-Urban Differences In Stroke Risk Factors, Incidence, And Mortality In People With And Without Prior Stroke. Circ. Cardiovasc. Qual. Out-

comes. 2019;12: e004973.
14. Huang X.Z., Wang Z.Y., Dai X.H., Yun-Zhang Zhang M. Velocity Vector Imaging of Longitudinal Mechanical Properties of Upstream and Downstream Shoulders and Fibrous Cap Tops of Human Carotid Atherosclerotic Plaque. Echocardiography. 2013;30:211–218.
15. Urbina E.M., Williams R.V., Alpert B.S., et al. Noninvasive assessment of subclinical atherosclerosis in children and adolescents: Recommendations for standard assessment for clinical research: A scientific statement from the American Heart Association. Hypertension. 2009; 54:919–950.
16. Song P., Fang Z., Wang H., et al. Global and regional prevalence, burden, and risk factors for carotid atherosclerosis: A systematic review, meta-analysis, and modeling study. Lancet Glob. Health. 2020;8: e721–e729.
17. López-Melgar B., Varona J.F., Ortiz-Regalón R., et al. Carotid Plaque Burden by 3-Dimensional Vascular Ultrasound as a Risk Marker for Patients with Metabolic Syndrome. J. Cardiovasc. Transl. Res. 2021;14:1030–1039.
18. DuPont JJ, Kenney RM, Patel AR, Jaffe IZ. Sex differences in mechanisms of arterial stiffness. British journal of pharmacology. 2019 Nov;176(21):4208-25.
19. Eikås JG, Gerdts E, Halland H, Midtbø H, Cramariuc D, Kringeland E. Arterial Stiffness in Overweight and Obesity: Association with Sex, Age, and Blood Pressure. High Blood Pressure & Cardiovascular Prevention. 2023 Sep;30(5):435-43.
20. Shen T, Shu XO, Xiang YB, et al. Association of hypertension and obesity with renal cell carcinoma risk: a report from the Shanghai Men's and Women's Health Studies. Cancer Causes & Control. 2015 Aug;26:1173-80.
21. Łoboz-Rudnicka M, Jaroch J, Kruszyńska E, et al. Gender-related differences in the progression of carotid stiffness with age and in the influence of risk factors on carotid stiffness. Clinical Interventions in Aging. 2018 Jun 27:1183-91.
22. Zuo J, Chao H, Tang B, et al.Female gender is associated with higher susceptibility of weight induced arterial stiffening and rise in blood pressure. Journal of Clinical Medicine. 2021 Aug 6;10(16):3479.

READY - MADE CITATION

Raheej Akhtar, Syed Muhammad Yousaf Farooq, Sidra Maryam, Areej Akhtar, Amna Rafique, Sania Maheen, Aruj Latif, Zeshan Haider, Syeda Moazza Ali. Carotid Artery Stiffness In Adults Belonging To Urban And Rural Areas Of Punjab, Pakistan: A Comparative Study. *Hell J Radiol* 2024; 9(3): 37-44.