Correlation of Arterial Stiffness with Left Ventricular Global Longitudinal Strain and Diastolic Function in Hypertensive Patients

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Abstract

Background: Arterial stiffness is one of the complications of hypertension. It is a hallmark of vascular aging, and when assessed with the carotid–femoral-pulse wave velocity (cf-PWV), it is predictive of outcome regardless of blood pressure components. **Objectives:** To detect subclinical involvement of left ventricular (LV) systolic and diastolic dysfunction in hypertensive patients in whom arterial stiffness is high. **Materials and Methods:** A case–control study with 55 randomly taken hypertensive patients aged 30–60 years old (female = 25 and male = 30) was conducted from December 2022 to June 2023. Their findings were contrasted with those of 55 healthy people. The Sample was collected in Marjan Teaching City, Babylon province, Iraq. Arterial stiffness measured by cf-PWV and wide pulse pressure (PP) results in correlation with LV systolic and diastolic function. The LV systolic function was done by measuring global longitudinal strain, and the diastolic function was done according to the new guideline. **Results:** In comparison to control subjects, hypertensive patients have significant evidence to have subclinical LV systolic dysfunction in whom they have arterial stiffness and demonstrated a strong link (P value <0.001). **Conclusion:** Arterial stiffness measured by cf-PWV and PP highly correlated with subclinical LV abnormality, and there was no significant relationship between arterial stiffness and diastolic function. Subclinical LV abnormalities and arterial stiffness, as measured by cf-PWV and PP, are highly associated. Arterial stiffness and diastolic function are not significantly correlated.

Keywords: Arterial stiffness, echocardiography, hypertension, LV hypertrophy

Introduction

Because of its role in the development of cardiovascular disease, which is the leading cause of death in all industrialized and many developing nations, hypertension has the biggest impact of all the risk factors contributing to mortality and disability globally.[1]

The American[2] and European[3] guidelines' earlier iterations classified hypertension as occurring when the blood pressure (BP) was less than 140/90 mmHg. Prehypertension was described by the Joint National Committee (JNC)VII as BP between 120 and 139 and/or 80 and 89 mmHg. This was based on the hypothesis that these individuals had an extremely high residual risk of developing hypertension, which was in the range of 85%–90%.[4]

According to World Health Organization (WHO) estimates, 1.13 billion individuals worldwide have HTN; the majority of these people (almost two-thirds) reside in low- and middle-income nations, and Iraq is one of these nations. The WHO has set a goal for the world to reduce the prevalence of HTN by 25% by 2025 (baseline 2010) for noncommunicable diseases. WHO estimates that up to 40% of Iraqis under the age of 25 have HTN, and they

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also noted that women are more likely than men to have HTN.[5]

Along with clinical evidence, it appears that high BP is the primary contributor to long-term effects like heart failure, both with and without preserved ejection fraction,[6] atrial fibrillation,[7] valvular heart disease,[8] peripheral arterial disease and aortic syndromes,[7] chronic kidney disease and end-stage renal disease,[9,10] dementia,[11,12] Alzheimer disease,[13] diabetes mellitus,[7] erectile dysfunction,[14] and age-related macular degeneration.[15]

Hypertensive heart disease (HHD) is brought on by systemic hypertension. In order to maintain appropriate wall stress, chronic systemic pressure loading causes left ventricular (LV) hypertrophy. Systolic function is intact in the early stages of hypertension. Systolic function, however, is also hampered in later phases, especially when coronary artery disease (CAD) is present concurrently.[16]

The presence or absence of heart failure (diastolic heart failure, systolic failure, or a combination of the two) is used to further categorize HHD. Diastolic dysfunction was defined as aberrant ventricular stiffness and abnormal ventricular filling during diastole. Systolic dysfunction is characterized by poor LV emptying, which manifests as a lower-than-normal effective ejection fraction (50%).

GLS has been extensively studied in hypertensive patients. Durability of high BP, uncontrolled BP, diabetes, LV hypertrophy, and higher LV filling pressure are all related with impaired GLS.[17] Hypertensive patients had lower resting strains as well as reduced contractile reserve as evaluated by exercise[18] or low-dose dobutamine stress echocardiography.[19]

The earliest abnormality of a hypertensive individual is LV diastolic dysfunction, which may happen in the absence of LV hypertrophy. The Doppler waveforms of transmitral flow velocity (E) to mitral annular tissue Doppler velocity during early diastole (*E′*) ratio is usually used to term patterns of diastolic dysfunction as grade I impaired relaxation, grade II pseudo normal, or grade III restrictive filling which reflecting abnormalities of LV relaxation, diastolic passive stiffness of LV, and left atrial pressure.[6] These measurements are load-dependent. So, they are influenced by left atrial pressure because of its measurement after iso_volumic LV relaxation.

Arterial stiffness is the discipline that emerge to aid in understanding the relationship between the mechanics of continuous media in the artery wall and the fluids held within them. A vital biomarker of vascular health, large artery stiffness is thought to reflect the cumulative effects of aging, exposure of the arterial system to insults, and mechano-chemical stressful events. It has also been repeatedly demonstrated to predict cardiovascular mortality and morbidity in addition to conventional cardiovascular risk factors.[20,21]

Carotid–femoral pulse wave velocity (cf-PWV) is a direct measurement that correlates with the vascular system's generally accepted propagative model and serves as the gold standard for PWV measurement. Among various techniques for assessing arterial stiffness, cf-PWV is the gold standard one due to its ease of measurement, reproducibility, and high reliability; however, independent of established cardiovascular risk factors, there is evidence of its connection with cardiovascular disease and mortality.[22,23]

Since the 2013 European guidelines for HBP, studies like this have supported the inclusion of cf-PWV as one of the criteria considered similar to subclinical organ damage. Elevated cf-PWV (≥10 m/s) is an indication of arterial stiffness, which is independent of established risk variables due to its connection with mortality and severe cardiovascular events.[22] The difference between SBP and DBP (the maximal and smallest pressures reached throughout the cardiac cycle) is known as pulse pressure (PP).[23]

Materials and Methods

Study design and patients

In this case–control study with 55 randomly taken hypertensive patients aged 30–60 years old, the mean age was (47.56 ± 8.71) years (female = 25 and male = 30), with 32 patients of them have wide PP. Their results were compared with the results of 55 healthy individuals. The study included hypertensive patients with primary hypertension on antihypertensive medications. The study was conducted from December 2022 to June 2023. The sample was collected from inpatient and outpatient echocardiographic units in Marjan medical teaching city, Babylon province, Iraq. Athletes, secondary hypertension, arrhythmias, anemia. DM, CMP, valvular heart disease, aortic coarctation, respiratory disease, those with renal failure, Poor imaging on echocardiography examination, CAD, and heart failure with an EF of less than 53% were excluded.

Questionnaire

Our questionnaires were regarding past medical history, personal habits like drugs, smoking, and alcohol consumption, and body surface area BSA was calculated by using the Mosteller method formula = (height [m] × weight [kg] ×3600)/2, At the time of the assessment, BP and heart rate were measured. An ECG was obtained to exclude IHD, arrhythmias, and other abnormalities.

Echocardiographic modalities

Traditional echocardiographic imaging (2D, Doppler study, and TDI) with 2D_ECG guided_speckle tracking imaging was done by using a portable GE VIVID IQ Ultrasound system machine equipped with M5Sc broadband sector array transducer. The images were obtained at breath-hold according to ASE recommendation under the supervision of an echocardiographic specialist in the unit where patients were lying down and in left lateral posture, connected to the single lead ECG, and five views were taken (PLAX, A2C, A3C, A4C, and suprasternal views).

cf-PWV measurement was done by changing the probe to trans-carotid Doppler and guided by ECG as a timing marker, color Doppler taking then pulse wave (sample volume of 2 mm) at right carotid artery and right femoral artery site points, time was measured simultaneously from peak of QRS to the beginning of the wave. A measuring tape was used to determine the distance (L) between the measuring stations, and the equation was applied to measure the velocity:

$$(\mathrm{PWV} = L / \Delta t).$$

Elevated cf-PWV of more than (10 m/s) is a marker indicating arterial stiffening due to its association with mortality and severe cardiovascular events.

Statistical analysis

All values are expressed as mean ± standard deviation. Data were analyzed by SPSS version 27 (SPSS, IBM Company, Chicago, IL) and Microsoft Excel. Categorical variables were analyzed by Chi-square test. The relation between different variables was done by Pearson's correlation coefficient $P < 0.05$ was considered statistically significant.

Ethical approval

The study was conducted in accordance with the ethical principles that have their origin in the Declaration of Helsinki. It was carried out with the patient's verbal and analytical approval before conducting the study. The study protocol, the subject information, and the consent form were reviewed and approved by a local committee on publication ethics at Babil Health Directorate under reference no. 358 on 16 Sep 2022.

Results

This study revealed a significant correlation between arterial stiffness and GLS among hypertensive patients (N = 55, P-value = 0.043), and there was no correlation between diastolic function and arterial stiffness (E/e' average and LAVI). The P value was 0.842 and 0.078, respectively [Table 1, Figures 1 and 2].

Table 1: The mean differences of study variables according to wide pulse pressure among hypertensive patients (N = 55)

Study variables	Wide pulse pressure	N	Mean ± SD	t-Test	P-value
GLS	Yes	32	-14.49 ± 4.31	2.535	0.014*
	No	23	-17.13 ± 2.97		
E/e' average	Yes	32	9.51 ± 2.62	0.201	0.842
	No	23	9.36 ± 2.60		
Left atrium volume index (ml/m^2)	Yes	32	18.14 ± 3.21	1.797	0.078
	No	23	16.43 ± 3.84		

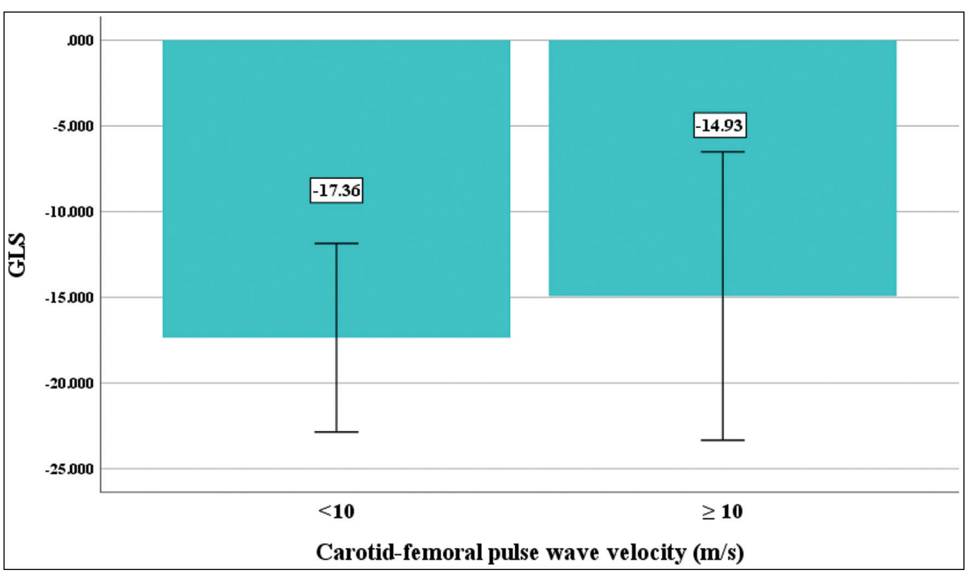

Figure 1: The mean differences of GLS according to carotid–femoral pulse wave velocity (N = 55)

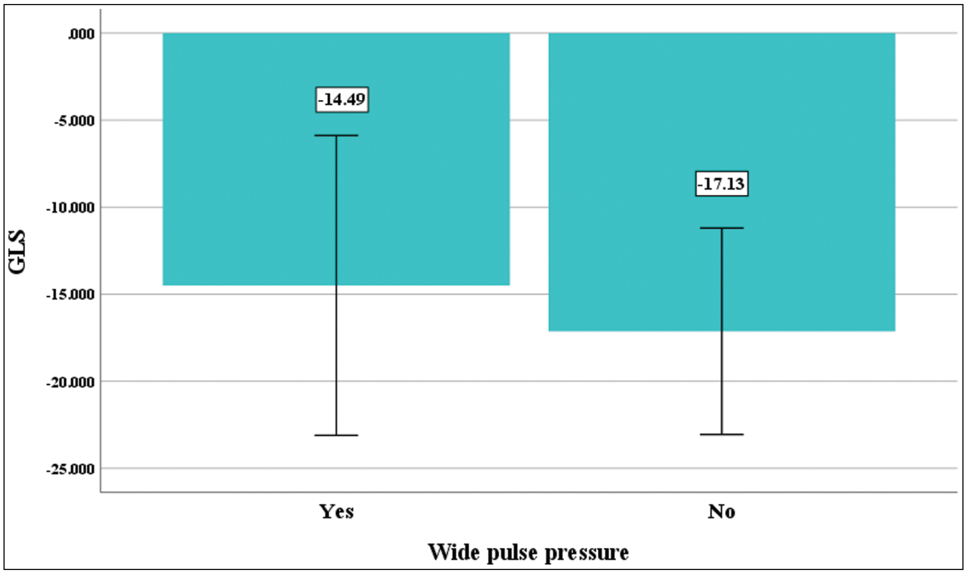

Figure 2: The mean differences of GLS according to wide pulse pressure among hypertensive patients ($N = 55$)

Discussion

In patients with primary hypertension, arterial stiffness has been shown to independently predict cardiovascular morbidity and mortality. Functional modifications were thought to take precedence over structural modifications. During early diastole in people with compliant arteries, whereas late systole in people with stiffer arteries, the arterial wave reflection returns.[24]

There was a significant difference in arterial stiffness of both parameters in hypertension patients and normotensive persons in this study. The average cf-PWV for hypertensive patients was 13.62 ± 6.19, and for normotensive was 8.19 ± 1.71 ($P < 0.001$*). The P-value for wide PP was <0.001*; this was conducted with Ahmed *et al.*[25]

Arterial stiffness was linked to subclinical LV systolic dysfunction, also with reduced LV longitudinal function in patients with hypertension; fortunately, Myung *et al.*[26] discovered carotid arterial stiffness is not associated with LV systolic function in those patients with hypertension.

This difference could be accounted for by demographic disparities among the study subjects, as the subjects in this study were hypertensive patients taking medication with normal LV geometry. Furthermore, additional smoking behaviors, alcohol use, and physical activity, which are regarded as confounding factors, were not considered in our study and may be contributors.

In the current study, there was no significant association between arterial stiffness assessed by cf-PWV and diastolic function (E/e' average and LAVI); the P value was 0.842 and 0.078, respectively. This result was compatible with GaoLan *et al.*[27] in a study of people with hypertension. The arterial compliance measured using applanation tonometry has been shown by Mottram *et al.*[28] to be an independent predictor of diastolic dysfunction.

In several clinical circumstances, the link between artery elastic characteristics and LV diastolic performance has been proven. In 119 hypertensive patients, Sakane *et al.*[29] discovered that the cardio-ankle vascular index was independently associated with the E/A ratio in individuals with normal LV ejection fraction.

A cohort of 188 people (aged 65 years), Abhayaratna *et al.*[30] found a correlation between increasing arterial stiffness measured with applanation tonometry and the degree of LV diastolic dysfunction. According to Vinereanu *et al.*[31] there is an inverse correlation between arterial stiffness and the long-axis LV functions (systolic, early diastolic, mitral annular, and velocities), as well as the velocity of the LV flow propagation.

In this article, arterial stiffness is calculated using cf-PWV, and PP is measured. Because this procedure makes it possible to obtain relatively accurate data and predict other cardiovascular events in order to prevent LV diastolic dysfunction and maintain normal BP, it is essential to focus more on measuring arterial stiffness in people with early-stage hypertension or normal LV mass.

To the best of our knowledge, there is some evidence that people with cardiovascular risk factors, notably those with metabolic syndrome or obesity and those who have apparent arterial disease, have a relationship between arterial stiffness and diastolic function. Information about this association in people with only hypertension and no other disorders is lacking, though.[32,33]

Conclusion

Arterial stiffness is highly correlated with PP in hypertension. The arterial stiffness measured by cf-PWV and PP highly correlated with subclinical LV abnormality. There was no significant correlation between arterial stiffness and diastolic function.

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Conflicts of interest

There are no conflicts of interest.

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