Original Article

The Impact of Aortic Stiffness on the Development of Coronary Artery Disease Using Echocardiography

Impact of Aortic Stiffness on Coronary Artery Disease

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ABSTRACT

Objective: To correlate to the echocardiographic data with coronary angiographic finding, investigate the relation of aortic stiffness with coronary artery disease using echocardiography.

Study Design: A case control study

Place and Duration of Study: This study was conducted at the Cardiac Care Unit, Baghdad Teaching Hospital, Iraq from 1st November 2023 to 1st July 2024.

Methods: A total of 100 adult people, 50 patients with coronary artery disease and other 50 healthy participants matched with case group in age and gender were enrolled. The collected data of all patient's information including history blood pressure measurement and pulse measurement. We used transthoracic echocardiography to measure the dimension of ascending aorta, thickness of the wall, maximum systolic and diastolic aortic dimension depending on reference points on the patient ECG which was connected to the echocardiography. Then the patient was admitted to the catheterization lab for coronary angiography. After that, we compared the results of the measures from the transthoracic echo study with the report on coronary angiography.

Results: The blood pressure measurements and aortic dimensions along with wall thickness measurements were significantly higher in coronary artery disease patients with catheterization when compared to control subjects. The measurements of aortic wall thickness revealed statistically significant positive relationships between blood pressures that measured systolic and diastolic pressure values as well as aortic diameter measurements in both their systolic and diastolic states.

Conclusion: A significant correlation found between aortic stiffness and coronary artery disease.

Key Words: Coronary artery disease, Aortic stiffness, Transthoracic echocardiography

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INTRODUCTION

Coronary artery disease (CAD) which goes by the alternative name ischemic heart disease (IHD) functions as the principal fatal condition together with the cause leading for the disability-adjusted life years (DALYs) worldwide.[1-3] The disease advances because of atherosclerosis in coronary arteries although some individuals show no indications of the condition. Patients with CAD show three important presentations, acute coronary syndrome (ACS) in addition to silent myocardial ischemia (MI) and stable angina.

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The American Heart Association (AHA, 2019) reports that CAD affects 31% of elderly male population while 25.4% of elderly females experience the condition.[4]

Cardiovascular disorders (CVD) are thought to be mostly caused by atherosclerosis. IHD and ischemic stroke are two of the principal effects of atherosclerotic cardiovascular disease on the heart and brain.[5] The leading and fifth causes of death worldwide, respectively, are IHD and stroke. Atherosclerosis can affect arteries anywhere in the body, even though it is frequently associated with heart problems.[6] In arteries, a strong cushioning effect is typically provided by systemic conduit arteries, allowing the microvasculature to have practically constant flow even in the face of periodic left ventricular (LV) ejection.[7] The artery stiffness compromises this cushioning function, which has a number of negative effects that significantly affect cardiovascular health.[8] The extent to which an elastic structure opposes change in its size defines its stiffness rating. Doctors do not directly measure arterial wall stiffness inside the body but use parameters including arterial pulse wave velocity (PWV) to evaluate stiffness indirectly by studying arterial pressure changes in volume and cross-sectional area and diameter.[9] Medical professionals use pulse wave velocity and pulse wave analysis as their main tools for assessing arterial stiffness at present.[10] Outpatient screening purposes exclude the use of angiography due to its risks together with limitations that limit its utility beyond specialized clinical evaluation. The assessment of cardiovascular risk would be more effective with non-invasive solutions that measure coronary artery wall thickness.[11]

Echocardiography which is regularly used to inspect cardiac structure, and function has evolved substantially to provide precise examination of arterial structures while assessing their functions and hemodynamics.[12] Current TTE technology with its advanced high-resolution probes enables medics to perform accurate wall thickness measurements of the left main coronary artery (LMCA).[13] The measurement for cardiovascular risk shows direct relevance to carotid intima-media thickness (C-IMT) assessments that doctors currently use as the standard non-invasive marker for cardiovascular risk. In this research, echocardiographic assessment was used to examine the relationship between aortic stiffness and coronary artery disease.

METHODS

This is a case control study performed at Cardiac Care Unit (CCU), Baghdad Teaching Hospital, during a period of eight months from 1st November 2023 to 1st July 2024. This study included 100 adult people divided into two groups: **Case group:** Included 50 patients have complaints as dizziness, dyspnea, fatigue, chest or epigastric pain, and elevated blood pressure. They were diagnosed with CAD and admitted to the CCU for elective cardiac catheterization or patients with symptomatic acute coronary syndrome (ACS) confirmed by ECG. **Control group:** Included 50 healthy volunteers participants matched with cases in age and gender.

Obese patients with poor window, poor imaging diagnostic, and sever aortic stiffness that impact the measurements of wall diameter through the cardiac cycle, patients with history of chronic renal failure (CRF) or liver failure (LF), those who had history of coronary artery bypass graft (CABG) or percutaneous coronary intervention (PCI) procedure, and those who refused to be part of this study were excluded.

The data was collected by a well-designed questionnaire including socio-demographic and clinical characteristics. The blood pressure of Systolic and diastolic and heart beats were measured. The body mass index (BMI) was calculated by the same scale for all the subjects (kilograms/square meters).[16] The participants were classified as follows:

- Normal (18.5 – 24.9 kg/m2).
- Overweight (25 – 29.9 kg/m2).
- Obese (≥ 30 kg/m2).

✓ We used 2d echocardiography technique to measure the dimension of ascending aorta, thickness of the wall, maximum systolic and diastolic dimension depending on reference points on the patient's ECG which was connected to the Echo device.

✓ Then the patient was admitted to the theater for catheterization.

✓ After that, we compared the results of the measures from the Echo study with the report of cardiac CATH.

The echocardiography machine is a digital device (vivid E9, with XDclear, made in japan, probe M5Sc-D). It was used to measure the dimensions of the ascending aorta as shown in figure 1.

Technique

❖ Attached the standard lead ECG to the participant to monitor the heart's electrical activity.

❖ The participant was lied in a left lateral decubitus position, as this help improve access to the heart for imaging, which helps to bring the heart closer to the chest wall for optimal imaging.

❖ If necessary, the participant was asked to slightly turn onto his left side to allow better access to the heart.

❖ The chest area was exposed, ensuring that the area where the transducer was placed is fully visible.

❖ A thin layer of ultrasound gel was applied to the participant's chest. This gel serves as a medium for sound wave transmission and helps eliminate air pockets between the skin and the ultrasound probe. The gel also helps improve the quality of the images by facilitating better sound wave penetration into the body.

❖ After the participant was comfortable, we asked him to hold his breath when required for clear imaging.

❖ An echocardiography machine was used with a phased-array transducer (5 MHz) to acquire clear images of the ascending aorta

❖ B-mode (Brightness Mode) Imaging was used to generate cross-sectional images of the heart's structures, including the aorta. The B-mode displays tissue interfaces and is essential for measuring the dimension of the ascending aorta.

The statistical analysis used SPSS-26. To analyze the numeric variables with normal distribution between groups the student's t-test was utilized while the Mann–Whitney test served for variable comparison when distribution was not normal. Statistical analysis of categorical differences occurred using the Pearson's Chi-square test (χ^2). The Pearson correlation analysis calculated statistical relationships between two numeric variables by producing correlation coefficient (r) outcomes which indicated direct positive or inverse negative statistical strength. The correlation levels wherein less than 0.3 factors no relationship and the range of 0.3 to 0.5 represented weak correlation and 0.5 to 0.7 marked moderate correlation and over 0.7

indicated strong correlation. Statistical significance when p value reached below 0.05.

RESULTS

No statistically significant differences between study groups in age, gender, and BMI. The comparison of aortic measurements between the two groups revealed that the study patients had significantly higher SBP (154.9 mmHg vs 115.4 mmHg, P=0.001), higher DBP (96.63 mmHg vs 76.61 mmHg, P=0.001), larger systolic diameter (34.89 mm vs 29.21mm, P=0.001) and larger diastolic diameter (33.02 mm vs 28.45 mm, P=0.001) than the controls. Further, the aortic wall thickness was significantly larger in the cases compared to the controls (4.06 mm vs 2.40 mm, P=0.001). On the other hand, the heart rate was not significantly different between the two studied groups (P≥0.05) [Table 1].

The Pearson correlation analysis showed a significant, positive correlation between aortic wall thickness and SBP (r=0.609, P= 0.001), DBP (r= 0.611, P=0.001), systolic diameter (r=0.365, P=0.009), and diastolic diameter (r=0.598, P=0.001) while it was not significantly correlated with BMI and heart rate. Further, no significant correlation was detected between BMI and each systolic and diastolic diameter (Table 2).

Figure No. 1: Echocardiography device

Table No.1: Comparison between study groups by certain parameters

Characteristics	Case (n= 50)	Control (n= 50)	P value
Age (Year)	44.21±8.7	46.49±1.3	0.412
Male	29 (58%)	35 (70%)	0.211
BMI (kg/m^2)	27.32±4.2	26.55±6.1	0.412
SBP (mmHg)	154.9±11.87	115.4±10.73	0.001
DBP (mmHg)	96.93±7.13	70.61±6.51	0.001
Heart rate (bpm)	79.2±12.96	75.43±11.82	0.131
Aortic systolic diameter (mm)	34.89±4.78	29.21±3.16	0.001
Aortic diastolic diameter (mm)	33.02±5.04	28.45±4.27	0.001
Aortic wall thickness (mm)	4.06±0.91	2.40±0.49	0.001
SBP (mmHg)	154.9±11.87	115.4±10.73	0.001

Table No.2: Correlations between aortic measurements

Aortic measurement	Aortic thickness (mm)		BMI (kg/m^2)	
	Correlation (r)	P - Value	Correlation (r)	P - Value
BMI (kg/m^2)	0.046	0.653	-	-
Aortic systolic diameter (mm)	0.365	0.009	0.093	0.231
Aortic diastolic diameter (mm)	0.598	0.001	0.137	0.098
SBP (mmHg)	0.609	0.001	-	-
DBP (mmHg)	0.611	0.001	-	-
Heart rate (bpm)	0.192	0.344	-	-

DISCUSSION

The diameter of the aorta enlarges progressively as life progresses while adapting to increased cardiac output during childhood development until pathological obesity in adulthood leads to further growth. Different diseases that damage blood vessels become usable through combined structural and functional assessments in standard clinical procedures.[15]

Both blood pressure numbers and measurements of aortic diameter and wall thickness stood at higher levels in study patients than in control subjects. The results match those discovered by Li et al[16] through their research which found both systolic and diastolic blood pressure measurement variability necessary to detect early coronary artery disease. Liu et al[17] determined that arteriosclerosis exists as an independent factor which affects blood pressure control in hypertensive patients for both systolic and diastolic measurements. Brandts et al[18] discovered that both elevated blood pressure and aortic wall thickness showed marked connections especially within the hypertensive population. According to Iwata et al[19], high systolic blood pressure values specifically linked to complex plaques forming in the aortic arch areas of patients with severe arterial narrowing.

Numerous studies have shown that CAD and CVD are associated with thicker artery walls. Plaque build-up and CAD can thicken artery walls, which when paired with changes in blood pressure can cause stiffness to gradually grow. Although aortic stiffness and greater artery wall thickness were linked to hypertension and higher DBP, respectively, no overt CVS symptoms were seen.[20,21] It is acknowledged that one of the main causes of elevated systolic and pulse pressure with aging is arterial stiffness, which also plays a significant role in myocardial infarction and stroke. Arterial stiffness has been linked to a variety of illnesses, such as ischemic heart disease and heart failure, in addition to aging and high blood pressure.[22]

Results of this research demonstrated that aortic wall thickness established positive relationships with systolic blood pressure (SBP), diastolic blood pressure (DBP), and systolic along with diastolic aortic diameters. This research showed that body mass index (BMI) and heart rate values failed to produce significant correlations. According to Ergul et al[23], strong positive correlation relationship between left ventricular wall thickness and aortic diameter measurements as well as systolic and diastolic diameters.

The advancement of arteriosclerosis during aging occurs due to different contributing factors. Structural arterial remodeling cause's thickness increases in the intima-media layer throughout the aging process. As individuals age the vascular media shows mechanical property alterations that include harmful deposits of collagen fibers. Pulse wave velocity shows an intense connection to increasing patient age regardless of whether they have coronary artery disease because this vascular condition persists during advanced years when coronary artery disease is not present. Long-term exposure to vascular risk factors particularly diabetes mellitus plays a major role in causing age-dependent increases in arterial stiffness.[24]

It is recommending routinely assessment of aortic stiffness in high-risk populations, such as individuals with hypertension, diabetes, or a family history of cardiovascular diseases. Echocardiography could be employed as a cost-effective and non-invasive screening tool. Further larger longitudinal studies with larger sample size are needed to confirm the temporal relationship between aortic stiffness and the development of CAD. Enhanced imaging techniques and standardized protocols for assessing aortic stiffness should be developed to increase the clinical utility of this tool. A general idea about physicians' knowledge and attitude toward patient were confidentiality.

CONCLUSION

Aortic stiffness may serve as an early indicator or predictor for CAD in individuals, particularly in high-risk populations. Echocardiography has proven to be an effective tool in diagnosing the presence of aortic stiffness despite its failure to evaluate the severity of the lesion. The ability of echocardiography to evaluate aortic stiffness parameters, such as aortic diameter, reinforces its potential in clinical settings for early detection and risk stratification of CAD. Assessing aortic stiffness may allow for earlier intervention and prevention strategies for individuals at high risk of CAD. By monitoring aortic stiffness, clinicians could identify those at increased risk before significant coronary damage occurs, facilitating timely therapeutic interventions such as lifestyle changes or pharmacologic treatment.

Author's Contribution:

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Drafting or Revising Critically:	Ghazi Farhan Haji
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