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Original Article

Aortic Elasticity Parameters and Multivessel Coronary Artery Disease in Young Diabetic Patients

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ABSTRACT

Background: Aortic elasticity has been associated with coronary artery disease (CAD), and increased cardiovascular morbidity and mortality have been linked to aortic stiffness. Diabetes mellitus is well known to be a significant risk factor for the development of coronary heart disease. The primary aim of this study was to determine which of the aortic elasticity indices was a better predictor of CAD severity in young patients with diabetes mellitus and how these indices related to CAD complexity and severity.

Methods: A total of 190 consecutive young patients with diabetes mellitus and CAD, who underwent elective coronary angiography, were prospectively included in this study. Patients were divided into 2 groups: Group I (n = 50, 26.3%) had normal or nonsignificant angiographic results, while Group II (n = 140, 73.7%) demonstrated significant CAD, for which the SYNTAX score was calculated. With echocardiography, aortic elasticity measures, including aortic strain, aortic stiffness index, and aortic distensibility, were determined for each patient in the study.

Results: The results revealed increased aortic stiffness in young diabetic patients with severe CAD and a high SYNTAX score. After adjusting for various factors, aortic distensibility, aortic strain, and aortic stiffness index were identified as independent predictors of a high SYNTAX score (P = 0.006, P = 0.004, and P = 0.003, respectively). The corresponding cutoff values for aortic distensibility, aortic stiffness index, and aortic strain were 4.8, 4.7, and 10.1.

Conclusions: Aortic elasticity parameters obtained from echocardiography may be useful in predicting the complexity and severity of coronary lesions in young diabetic patients, as assessed by the SYNTAX score. ***(Iranian Heart Journal 2024; 25(4): 73-83)***

KEYWORDS: Diabetes, Aortic elasticity, MVD

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Increased aortic stiffness and reduced aortic distensibility, which reflect the aorta's elastic properties, have been demonstrated to be associated with coronary artery disease (CAD) and increased cardiovascular morbidity and mortality. These risk factors have been shown to predict the development of CAD. Aortic

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stiffness has also been postulated as a potential pathogenic mechanism that may underlie the link between diabetes mellitus (DM) and increased cardiovascular risk. [1]

Loss of arterial elasticity is linked to poorer cardiovascular outcomes. Aortic stiffness index and aortic distensibility, the 2 principal measures of aortic elasticity, have both been associated with fatal and nonfatal outcomes of CAD. [2]

Arterial stiffness can be assessed by various invasive and noninvasive techniques, including methods that measure systemic, local, and regional aortic stiffness. Aortic elasticity can be reliably measured by various echocardiography-derived indices, including simple M-mode, color M-mode Doppler, tissue Doppler imaging (TDI), which measures aortic upper-wall velocities, and 2D speckle tracking, which measures radial strain and global circumferential strain of the ascending aorta. [3]

Previous studies have demonstrated a correlation between aortic stiffness indices and the SYNTAX Score, a well-validated measure of coronary atherosclerosis severity. SS is a well-established angiographic scoring system for grading the severity of CAD. It has been demonstrated to predict mortality and morbidity, as well as unfavorable cardiovascular events. [4]

Various aortic strain and distensibility indices have been determined by measuring aortic diameters using M-mode imaging, blood pressure readings, and TDI-derived velocities of the ascending aorta. [5]

The primary objective of the present study was to determine which aortic strain and distensibility indices were more predictive of complicated and severe CAD in young diabetic individuals. This study further aimed to evaluate the correlation between these indices and the presence of significant CAD as well as its complexity as assessed by the SYNTAX score.

METHODS

A total of 190 young patients (35–55 y) with type 2 DM, presenting to the Cardiology Department of Tanta University Hospital between July 2023 and December 2023, were prospectively included in this study. Patients' CAD diagnosis was determined based on the presence of anginal symptoms, positive stress test results, and electrocardiographic evidence of ischemia.

Individuals recommended for elective coronary angiography; patients under 35 years old; and those with hypertrophic cardiomyopathy, renal impairment, decompensated liver disease, severe valvular disease, acute decompensated heart failure, acute coronary syndrome, previous percutaneous coronary intervention or coronary artery bypass graft surgery, and connective tissue illnesses were excluded from the study. Each patient's demographic data, including age, sex, and the presence of CAD risk factors, such as DM, hypertension, smoking, dyslipidemia, and a positive family history, were recorded. Additionally, data regarding the use of medications, including β-blockers, angiotensin-converting enzyme inhibitors (ACEIs), angiotensin receptor blockers (ARBs), and lipid-lowering agents, which may have an impact on the course of the disease, were recorded.

In addition to general examinations (including blood pressure measurement and body mass index [BMI] calculation) and local clinical examinations, each patient's medical record was reviewed and a resting 12-lead surface ECG was performed. For all patients, the following laboratory tests were performed: complete blood count, hematocrit value, estimated glomerular filtration rate, lipid profile, fasting blood glucose, and hemoglobin A1c (HbA1c).

Transthoracic Echocardiographic Evaluation

Transthoracic echocardiography and Doppler studies were performed using the GE Vivid 7

echocardiography machine, equipped with a 2.5 MHz transducer. The modified Simpson's formula was used to assess left ventricular ejection fraction (LVEF). LV wall thicknesses were measured at end-diastole, as well as end-diastolic and end-systolic diameters. The mean LV wall thickness was calculated as the average of the posterior ventricular wall thickness and the thickness of the interventricular septum. A semi-quantitative evaluation was performed to assess the degree of valvular heart disease.

The systolic and diastolic diameters of the ascending aorta were measured in the parasternal long-axis view using M-mode tracing, 3 cm distal to the aortic valve. The aortic diastolic diameter was measured at the peak of the QRS complex on the concurrently recorded ECG, and the aortic systolic diameter was measured at the maximum anterior motion of the aortic valve. These measurements were averaged across 3 successive heart cycles.[6]

Aortic elasticity indices were calculated using the following formulas [7]:

ASI = in (SBP/DBP) [(AoS − AoD)/AoD].

AS (%) =100 × (AoS − AoD)/Ao. AD 1/ 103 × mm Hg = 2 × [(AoS − AoD)/AoD]/PP

SV (mL) = LVOT area × LVOT time − velocity integral

SVi mL/m^2 = SV/BSA

ASI: aortic stiffness index, SBP: systolic blood pressure, DBP: diastolic blood pressure, AoS: aortic systolic diameter, AoD: aortic diastolic diameter, LVOT: left ventricular outflow tract, Svi: stroke volume index, AS: aortic strain, SV: stroke volume, BSA: body surface area

Angiographic Procedure

Coronary artery angiography was performed via conventional methods using either the radial or femoral approach. A lesion was considered significant if the vessel had a diameter of more than 1.5 mm and showed a diameter stenosis exceeding 50%. Patients were classified into 3 groups based on the number of affected vessels: multi-vessel disease, double-vessel disease, and single-vessel disease. The severity of CAD was further evaluated using SS I, a computer-based program that calculates the total points assigned for each coronary lesion of ≥50% luminal obstruction in vessels with a diameter of ≥1.5 mm. Patients were categorized into 3 tertiles based on their SYNTAX scores: low (≤ 22), intermediate (≥ 23 – ≤ 32), and high (≥ 33). [8]

All patients provided written informed consent for data collection. The study was approved by the Tanta University Faculty of Medicine's Ethical Committee. All potential risks and precautionary measures that should be taken to minimize them were explained to the patients. Patient confidentiality was maintained, and both patients and the ethics committee were promptly informed of any unexpected risks that emerged during the course of the study. To protect the privacy of the participants and ensure data confidentiality, the following measures were taken: Each patient was assigned a unique code number, which served as a surrogate for their name and address, and stored in a dedicated file. The identities of the patients were kept confidential in all the study materials.

Statistical Analysis

The IBM SPSS software program, version 20.0 (Armonk, NY: IBM Corp), was used to conduct statistical analyses. The normal distribution of continuous data was checked using the Kolmogorov-Smirnov test. Quantitative data were displayed as mean and standard deviation (SD), while qualitative data were represented by percentages and numbers. One-way analysis of variance (ANOVA) was utilized to assess the results when comparing more than 2 means. A χ^2 test of significance was employed to compare proportions between 2 qualitative factors. To find possible

independent determinants of a high SYNTAX score, a logistic regression analysis was carried out. The ideal cutoff values of the aortic elasticity parameters for forecasting a high SYNTAX score were determined using the receiver operating characteristic (ROC) curve. A *P* value of less than 0.05 was considered statistically significant.

RESULTS

The study included 190 individuals undergoing elective coronary angiography, of whom 50 (26.3%) had normal coronaries or nonsignificant CAD (Group I), while 140 (73.7%) had significant CAD (Group II). Mean age and male sex were significantly higher in Group II than in Group I (Table 1). Compared to Group I, Group II had significantly higher rates of smoking and higher BMI (Table 1). The lipid profile and use of medications (β-blockers, ACEIs/ARBs, and lipid-lowering drugs) were comparable between the groups. Blood pressure measurements (systolic, diastolic, and pulse pressure) were similar in Group I and Group II (Table 1).

Concerning echocardiographic findings among the study population, there were no significant differences in systolic and diastolic LV function parameters between Group I and Group II. The *P* values for EF (%) and E/e' (average) were 0.550 and 0.131, respectively (Table 2). Comparisons of aortic diameters between the groups revealed significantly higher mean aortic systolic and diastolic diameters in Group II than in Group I ($P = 0.001$). Calculations of aortic distensibility and stiffness indices based on M-mode-derived aortic diameters showed that Group II had significantly lower aortic distensibility ($P = 0.006$) and strain (9.24 ± 1.94 vs 10.02 ± 2.01; $P = 0.004$) values than Group I. Conversely, the stiffness index (5.48 ± 1.46 vs 4.70 ± 1.32; $P = 0.003$) and elastic modulus (69.56 ± 18.94 vs 61.41 ± 16.08; $P = 0.0035$) were significantly higher in Group II than in Group I. Comparisons of TDI-derived aortic velocities between the 2 groups showed that Group II had significantly lower systolic aortic and early diastolic aortic velocities than Group I ($P = 0.004$ and $P = 0.006$, respectively (Table 2).

The 140 patients in Group II with significant CAD were classified into 3 groups based on CAD severity as measured by the SYNTAX Score: low, intermediate, and high SYNTAX score groups. Echocardiographic indices of the aortic stiffness of the 3 groups were then analyzed (Table 3). There was no significant difference between the 3 groups regarding aortic diameter in both systole and diastole, aortic peak late diastolic velocity, and aortic peak systolic velocity. Conversely, significant differences were observed between the 3 groups concerning aortic distensibility, aortic strain, and aortic stiffness index, as indicated by the *P* values (Table 3). The post hoc analysis revealed that patients with high SYNTAX scores had a significantly higher aortic stiffness index and a significantly lower aortic distensibility and aortic strain than patients with low and intermediate SYNTAX scores. The *P* values for the aortic stiffness index were 0.001 and 0.001, respectively, for the comparisons between high and low SYNTAX scores and between high and intermediate SYNTAX scores. Similarly, *P* values for aortic distensibility were 0.001 and 0.001, respectively, for the same comparisons. Additionally, there were statistically significant differences regarding these parameters in intermediate and low SYNTAX score groups.

To identify possible predictors of high SYNTAX scores, univariate and multivariable logistic regression models were constructed. The results revealed that aortic distensibility, aortic strain, and aortic stiffness index were independent predictors for high SYNTAX scores ($P = 0.006$, $P = 0.003$, and $P = 0.004$, respectively) (Table 4). In the ROC curve analysis of the previously

mentioned aortic elasticity parameters, the best cutoff values for aortic distensibility, aortic stiffness index, and aortic strain were 4.8, 4.7, and 10.1, respectively. The sensitivity values were 82, 66, and 79, while the specificity values were 48, 64, and 60. The area under the curve values were 0.70, 0.69, and 0.71, respectively (Table 4).

Patients in Group II with significant CAD were classified according to the severity of CAD as measured by the SYNTAX score into 3 groups: low, intermediate, and high SYNTAX score groups. The echocardiographic parameters of the aortic stiffness of these groups were subsequently analyzed (Table 3). No significant differences were observed among the three groups concerning aortic diameter in systole and diastole, aortic peak late diastolic velocity, and aortic peak systolic velocity. On the other hand, a significant difference was observed between the 3 groups in aortic distensibility, aortic strain, and aortic stiffness index (P = 0.001, P = 0.001, and P = 0.004, respectively) (Table 3). Furthermore, the post hoc test showed that patients with a high SYNTAX score had a statistically significant aortic stiffness index and aortic distensibility, along with lower aortic strain, compared to patients with low and intermediate SYNTAX scores. The P values for the aortic stiffness index, aortic distensibility, and aortic strain were all 0.001. There was also a statistically significant difference vis-à-vis these parameters in the low and intermediate SYNTAX score groups. Univariate and multivariable logistic regression models were performed to identify potential predictors of high SYNTAX scores. The results showed that aortic distensibility, aortic strain, and aortic stiffness index were independent predictors of high SYNTAX scores (P = 0.006, P = 0.003, and P = 0.004, respectively) (Table 4).

In the ROC curve analysis of the abovementioned aortic elasticity parameters, the best cutoff values for aortic distensibility, aortic stiffness index, and aortic strain were 4.8, 4.7, and 10.1, respectively. The sensitivity values were 82, 66, and 79, while the specificity values were 48, 64, and 60. The area under the curve values were 0.70, 0.69, and 0.71, respectively (Table 4). Table 5 displays the ROC analysis-derived cutoff points of aortic elasticity indices for the presence of significant CAD. According to these cutoffs, patients with low aortic distensibility, aortic strain, and aortic peak early diastolic velocity, as well as high aortic stiffness index, had a significantly higher SYNTAX score.

Table 1: Clinical Data of the Study Population

Demographic Characteristics	All Individuals (n=190)	Group I (Nonsignificant CAD) (n=50)	Group II (Significant CAD) (n=140)	P value
Age, y	47.23±6.87	45.21±7.02	48.19±6.20	0.001
Male sex, n (%)	120 (63.0)	24 (48.0)	96(68.5)	<0.001
Smoking, n (%)	80 (42.1)	18 (26.0)	62 (44.2)	<0.001
BMI, kg/m^2	29.82±3.52	28.48±2.76	30.05±3.06	0.012
β-blockers, n (%)	150 (80.0)	35 (70.0)	115 (82.1)	0.24
ACEIs/ARBs, n (%)	115 (60.5)	20 (40.0)	95 (67.8)	0.66
Statins, n (%)	155(81.5)	40 (80.0)	115 (82.1)	0.18
Cholesterol, mg/dL	169.82±43.18	170.02±40.10	171.44±42.06	0.940
Triglyceride, mg/dL	143.80±42.64	132.02±34.94	144.86±48.20	0.182
LDL, mg/dL	107.10±34.06	106.04±30.90	104.96±36.44	0.856
HDL, mg/dL	46.04±6.88	46.04±7.00	45.10±6.88	0.440
HR, beats per minute	76.01±9.11	77.04±7.96	75.85±9.04	0.711
SBP, mm Hg	124.0±8.10	126.00±7.80	123.0±8.0	0.940
DBP, mm Hg	76.50±5.2	77.2±4.4	75.94±4.8	0.361
PP, mm Hg	45.8±7.6	46.7±8.2	46.0±7.9	0.768

ACEIs/ARBs: angiotensin-converting enzyme inhibitors/angiotensin receptor blockers, Ao: aorta, BMI: body mass index, CAD: coronary artery disease, DBP: diastolic blood pressure, Diast: diastolic, HDL: high-density lipoprotein, HR: heart rate, LDL: low-density lipoprotein, PP: pulse pressure, SBP: systolic blood pressure, Sys: systolic

Table 2: Echocardiographic Data of the Study Population

Echocardiographic Data	All Individuals (n=190)	Group I (Nonsignificant CAD) (n=50)	Group II (Significant CAD) (n=140)	*P* value
Ejection fraction, %	62.24±8.04	61.92±7.78	63.02±6.84	0.550
E/A ratio	0.96±0.30	1.08±0.18	0.97±0.32	0.034
E/e` (average) ratio	7.42±2.60	7.08±2.08	7.80±2.06	0.131
Ao syst diameter, mm	31.86±2.70	29.98±2.64	32.88±2.68	0.001
Ao diast diameter, mm	30.02±2.14	28.04±2.42	31.08±2.21	0.001
Diameter difference, mm	2.78±0.62	2.86±0.81	2.82±0.42	0.644
Ao distensibility, $cm^2/dyn/10^3$	4.20±1.08	4.58±1.10	4.02±1.02	0.006
Stiffness index, logarithmic	5.28±1.39	4.70±1.32	5.48±1.46	0.003
Stiffness index, non-logarithmic	17.06±4.10	16.64±4.05	18.42±4.60	0.005
Elastic modulus, dyn/cm^2	514.08±140.04	460.07±120.20	532.42±140.90	0.006
Elastic modulus, KPa	67.95±20.02	61.41±16.08	69.56±18.94	0.035
Aortic strain, %	8.99±1.94	10.02±2.01	9.24±1.94	0.004
SAo, cm/s	7.84±2.06	8.28±2.10	7.09±2.12	0.004
EAo, cm/s	9.06±2.24	10.08±2.14	8.98±2.08	0.006
AAo, cm/s	11.96±2.08	12.42±2.52	12.04±2.08	0.179

A: transmitral A wave, Ao: aortic peak late diastolic velocity, E: transmitral E wave, EAo: aortic peak early diastolic velocity, SAo: aortic peak systolic velocity, Sys: systolic

Table 3: Aortic Elasticity Indices in Relation to SS

	Low Score (≤22) (*n*=52)	Intermediate Score (22-32) (*n*=46)	High Score (>32) (*n*=42)	P^1	P^2	P^3
Aortic distensibility, $cm^2/dyn/10^3$	4.82±1.52	4.01±1.06	3.52±1.02	0.003	0.001	0.03
Stiffness index	5.02±1.02	5.60±1.40	6.50±1.82	0.0202	0.001	0.010
Elastic modulus, KPa	62.02±15.98	69.08±18.12	78.02±22.06	0.043	0.001	0.039
Aortic strain, %	9.62±2.04	8.46±1.82	7.68±1.46	0.0039	0.001	0.030
SAo, cm/s	7.42±2.62	7.24±1.96	7.02±1.69	0.704	0.394	0.576
EAo, cm/s	9.80±2.10	8.90±1.78	7.96±1.97	0.025	0.001	0.021
AAo, cm/s	12.89±2.82	12.54±2.62	12.14±2.52	0.527	0.81	0.466

SS: SYNTAX score, P1: significance between low and intermediate SS, P2: significance between low and high SS, P3: significance between intermediate and high SS, AAo: aortic peak late diastolic velocity, EAo: aortic peak early diastolic velocity, SAo: aortic peak systolic velocity

Table 4: Characteristic Analysis of Aortic Elasticity Indices for the Presence of Significant CAD and Their Derived Cutoff Points

	AUC	*P* value	95% CI	Sensitivity	Specificity	Cutoff Point
Aortic distensibility, $cm^2/dyn/10^3$	0.70	0.006	0.56-0.79	82	48	4.80
Stiffness index	0.69	0.004	0.55-0.76	66	64	4.70
Aortic strain, %	0.71	0.003	0.57-0.80	79	60	10.1
SAo, cm/s	0.65	0.01	0.54-0.78	77	54	8.8
EAo, cm/s	0.76	0.001	0.65-0.82	81	67	10.8

CAD: coronary artery disease, AUC: area under the curve, EAo: aortic peak early diastolic velocity, SAo: aortic peak systolic velocity

Table 5: Angiographic Findings for Patients With Significant CAD (n=140) Based on Receiver Operator Characteristic-Derived Cutoff Points of Aortic Elasticity Indices

	Aortic Distensibility (cm2/dyn/103)*		
	Low (≤4.8) (n=100), n (%)	High (>4.8) (n=40), n (%)	*P* value
Aorto-ostial lesion	24 (24.0)	4 (10.0)	0.001
Long lesions	58 (58.0)	21(52.5)	0.317
High SYNTAX score	44 (44.0)	10 (25.0)	0.10
SYNTAX score	22.62±8.24	19.02±7.42	0.015
	Aortic Stiffness Index		
	Low (≤4.7) (n=52), n (%)	High (>4.7) (n=88), n (%)	*P* value
Aorto-ostial lesion	15 (28.8)	24 (27.2)	0.64
Long lesions	28 (53.8)	48 (54.5)	0.97
High SYNTAX score	16 (30.7)	42 (47.7)	0.18
SYNTAX score	19.02±6.92	22.82±8.02	0.005
	Aortic Strain (%)*		
	Low (≤10.1) (n=104), n (%)	High (>10.1) (n=36), n (%)	*P* value
Aorto-ostial lesion	27 (26.4)	7 (19.4)	0.43
Long lesions	54 (51.9)	19(52.7)	0.54
high SYNTAX score	48 (46.1)	8 (22.2)	0.001
SYNTAX score	22.42±7.92	17.64±6.24	0.0013
	TDI Aortic Peak Systolic Velocity (cm/s)*		
	Low (≤8.5) (n=98), n (%)	High (>8.5) (n=42), n (%)	*P* value
Aorto-ostial lesion	30(30.6)	6 (14.2)	0.01
Long lesions	58 (59.1)	20 (47.6)	0.75
High SYNTAX score	45 (46.8)	18 (42.8)	0.81
SYNTAX score	21.82±8.02	20.10±6.72	0.225
	TDI aortic peak early diastolic velocity (cm/s) *		
	Low (≤10.5) (n=110), n (%)	High (>10.5) (n=30), n (%)	*P* value
Aorto-ostial lesion	32 (27.2)	4 (13.3)	0.07
Long lesions	62 (56.0)	15 (50.0)	0.64
High SYNTAX score	50 (45.4)	7 (23.3)	0.04
SYNTAX score	20.92±8.02	15.48±7.48	0.0011

*Variables are categorized into low and high based on the ROC-derived cutoff point of each.

CAD: coronary artery disease, TDI: tissue Doppler imaging, ROC: receiver operator characteristic

DISCUSSION

This study revealed a correlation between a higher SYNTAX score in coronary angiography and M-mode and TDI findings. The SYNTAX score was identified as a significant independent predictor in patients with CAD.

Patients with severe CAD (Group II) exhibited a higher prevalence of conventional CAD risk factors, including male sex, advanced age, smoking, and increased BMI.

Patients with hypertension were excluded from the research due to the potential direct effects of high blood pressure on aortic distensibility and strain, as well as its possible role as a confounding factor in these conditions. The usage patterns of medications known to potentially slow the progression of CAD, such as statins, ACEIs/ARBs, β-blockers, and others, were comparable between the 2 study groups. A notable finding of this study is the correlation between elevated SYNTAX scores, indicative of more severe coronary atherosclerosis, and increased aortic stiffness, as measured by aortic distensibility, aortic strain index, and aortic strain, in young diabetic individuals. This result remained independent of other

established CAD risk factors, including smoking status, BMI, and lipid profile levels, as no statistically significant differences in these parameters were observed between the 2 groups. Furthermore, our multivariate analysis demonstrated that the aforementioned characteristics were independent predictors of a high SYNTAX score after adjustments for various factors known to potentially influence the severity of CAD. In numerous studies, the ankle-brachial index and carotid-femoral pulse-wave velocity (PWV) have been employed as markers of arterial stiffness. [9] These studies have demonstrated that aortic stiffness, particularly in individuals with diabetes, may serve as a predictor for the risk of CAD.

In line with our findings, Karakurt et al [10] also identified a relationship between the severity of CAD and aortic elasticity, aortic strain, and aortic stiffness index.

Research conducted by El-Naggar et al [1] suggested that aortic elasticity indices derived from M-mode imaging might help identify individuals with more advanced and complex CAD. This finding chimes with the results of our study, providing further support for the potential utility of aortic elasticity parameters as markers of CAD severity.

Consistent with our findings, Sen et al [11] also reported significantly reduced aortic strain and aortic distensibility in patients with more advanced CAD. While their study yielded lower mean values of distensibility and strain than our results, the overall conclusions align, further supporting the relationship between aortic stiffness parameters and CAD severity. The discrepancy in mean values of aortic distensibility and strain between our study and the one conducted by Sen and colleagues may be attributed to differences in study design. Notably, the aforementioned authors excluded hypertensive individuals from their study, which could have influenced the aortic parameters under investigation, given the known effects of hypertension on aortic stiffness. This exclusion criterion may have resulted in the lower mean values observed in their study compared with ours.

Concordant with previous studies that assessed aortic strain using carotid-femoral PWV, our study also demonstrated significantly higher aortic stiffness index and elastic modulus values in patients with more advanced CAD. [12]

Chae et al [13] demonstrated an association between brachial-ankle PWV, another method of assessing aortic strain, and the presence of CAD, but not its extent. This finding differs from our results, which showed a correlation between aortic stiffness parameters and CAD severity. The discrepancy between the 2 studies may be attributed to the fact that brachial-ankle PWV reflects regional arterial stiffness rather than central aortic stiffness, which was the focus of our investigation. Central aortic stiffness may be more closely related to CAD severity due to its direct influence on vascular alterations associated with the disease.

In patients with CAD (Group II), aortic diastolic and systolic diameters were significantly larger, with a smaller difference in diameter between the 2 phases. This finding suggests that individuals with more advanced CAD exhibit a trend toward increased aortic diameters coupled with reduced aortic diameter fluctuations throughout the cardiac cycle. These observations imply that greater aortic strain and reduced aortic distensibility are associated with the severity of CAD.

Utilizing pulse-wave TDI, our study revealed significantly lower aortic peak early diastolic velocity and aortic peak systolic velocity in patients with severe CAD (Group II) compared with those with

less advanced disease. In comparison with the study conducted by Gungor et al, [14] our findings demonstrated a statistically significant reduction in aortic peak early diastolic velocity among patients with CAD. In contrast, Gungor and colleagues observed no significant differences in aortic peak late diastolic velocity and aortic peak systolic velocity between patients with and without CAD. Furthermore, they posited that early CAD might be independently predicted by aortic peak early diastolic velocity.

The primary objective of our study was to investigate the potential correlation between various aortic elasticity indices and the severity of CAD as quantified by the SYNTAX score. In our study, we found that patients with intermediate and high SYNTAX scores, indicating more severe CAD, had significantly higher elastic modulus, strain index, and aortic distensibility values than those with low SYNTAX scores. Additionally, patients with intermediate and high SYNTAX scores exhibited significantly lower aortic strain and aortic peak early diastolic velocity. Our findings are in agreement with those reported by Ghaderi et al, [15] who found a significant inverse relationship between the presence and severity of CAD as assessed by the SYNTAX score and aortic strain and aortic distensibility.

Our analysis of ROC-derived cutoff values revealed that patients with high strain index and elastic modulus, low distensibility, strain, and aortic peak early diastolic velocity were more likely to have elevated SYNTAX scores, indicating greater severity and complexity of CAD. Our study found no significant difference in overall coronary lesion severity and complexity, as measured by the SYNTAX score, between patients with low aortic peak systolic velocity and those with a high prevalence of aorto-ostial lesions. This observation suggests that reduced aortic elasticity, indicated by low aortic peak systolic velocity, may be associated with the presence of coronary lesions near the aorta, irrespective of the overall severity of CAD. The superiority of aortic strain over other M-mode-derived aortic indices in our study may be attributed to its direct measurement of aortic elastic properties. In contrast, the assessment of aortic distensibility, stiffness index, and elastic modulus required the consideration of hemodynamic blood pressure, which could have influenced the results, despite the exclusion of hypertensive patients. In our study, M-mode measurements of aortic strain demonstrated a stronger predictive power for the severity of CAD compared with aortic velocities assessed using TDI. This may be due to the fact that TDI-derived aortic velocities can be influenced by the insonation angle, potentially introducing variability into the results. Vitarelli et al [16] demonstrated that aortic strain determined using TDI was a better indicator of aortic compliance than TDI-derived velocities. This could be attributed to the fact that aortic strain measurements capture aortic deformation throughout the entire cardiac cycle.

CONCLUSIONS

Our study demonstrates the utility of both M-mode-derived aortic elasticity indices and TDI-derived aortic elasticity indices in predicting significant CAD. Notably, M-mode-derived indices were found to be particularly effective in predicting CAD severity and complexity. These findings highlight the potential clinical value of incorporating assessments of aortic elasticity into routine practice for improved risk stratification and management of patients with CAD.

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Availability of Data and Materials: The data sets used and or analyzed during the current study are available from the corresponding author upon request.

Ethics Approval and Consent to Participate: This study adhered to the principles outlined in the Declaration of Helsinki. The research protocol was reviewed and approved by the local ethical committee of Tanta University, Faculty of Medicine, with the committee reference number: 35838/9/22. All methods and procedures were carried out in accordance with relevant guidelines and regulations. Informed written consent was obtained from all participating patients before their involvement in the study.

Consent for Publication: Not applicable.

Conflict of Interest: The authors declare that they have no competing interests or potential conflicts of interest related to the content of this study.

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