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Original Article

Association Between Pulsed-Wave Velocity and Coronary Artery Calcification in the Iranian Population

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ABSTRACT

Background: Albeit coronary artery angiography is the gold standard of the diagnosis of coronary artery disease (CAD), coronary artery calcification (CAC) is a less invasive diagnostic method. We evaluated pulsed-wave velocity (PWV) as another accessible diagnostic tool to detect early CAD in the Iranian population.

Methods: From March 2016 to March 2017, we enrolled 350 patients referred for an evaluation of CAD to Rajaie Cardiovascular, Medical, and Research Center (Tehran, Iran). The patients underwent coronary artery computed tomography angiography, and their CAC scores were measured simultaneously. The PWV index was defined as the distance between the brachial and dorsalis pedis arteries divided by time, and the correlations between the PWV index and the CAC score and known CAD risk factors were assessed.

Results: From 350 patients, 52.3% were men and the rest were women. The mean PWV was 8.7 ± 2.2 m/s and the mean CAC score was 251 ± 99.52. There was no significant relationship between the CAC score and the PWV index ($P = 0.16$). In the women, the CAC score and the PWV index were meaningfully higher ($P \leq 0.001$ and $P < 0.04$, respectively). The CAC score was significantly different between the patients with and without CAD ($P < 0.001$), whereas there was no difference concerning the PWV index ($P = 0.31$). Among all CAD risk factors, hypertension and diabetes mellitus were significantly correlated with the CAC score ($P = 0.001$ and $P = 0.015$, correspondingly) and the PWV index ($P = 0.001$ and $P = 0.009$, respectively).

Conclusions: In contrast to some recent studies that have shown a significant increase in the PWV index in relation to the CAC score, our results did not prove it. The PWV index, thus, needs further studies if it is to be fully utilized in clinical practice. ***(Iranian Heart Journal 2020; 21(2): 6-12)***

KEYWORDS: Coronary artery disease, Coronary artery calcium score, Pulsed-wave velocity

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Coronary atherosclerosis is the leading cause of death worldwide in both developed and developing countries, and it accounts for the greatest healthcare budget. [1] Progress in the diagnosis and management of coronary artery disease (CAD) is constantly evolving, with coronary angiography still deemed the gold standard of its diagnosis. [2] Unfortunately, this diagnostic modality is far from ideal insofar as not only is it invasive and costly but also it needs experienced staff in fully-equipped hospitals, hence the ongoing search for a safer, cheaper, and more accessible method of diagnosis. [3] One of these recently developed modalities is multi-detector computed tomography (MDCT), which offers a sensitivity of about 90% in detecting significant stenosis and also measuring the coronary artery calcification (CAC) score. [4-6] The inter-relationship between the CAC score and CAD has already been proved, with a higher CAC score denoting a more progressive CAD and a lower CAC score guaranteeing fewer future cardiac events. [7, 8] One emerging thesis in the diagnosis of CAD is the relationship between arterial stiffness and the extent of CAD. [9, 10] In the present study, we measured arterial stiffness using pulsed-wave velocity (PWV), which represents the circulation velocity from the heart to the peripheral arterial branches. In other words, a higher PWV index indicates more arterial stiffness. Ultimately, we assessed the relationship between the CAC score as a noninvasive indicator of CAD and the PWV index as a promising method of CAD diagnosis.

METHODS

The current cross-sectional descriptive study, conducted from March 2016 to March of 2017, enrolled 350 patients diagnosed with CAD based on the latest clinical guidelines in Rajaie Cardiovascular, Medical, and Research Center, affiliated with Iran University of Medical Sciences, Tehran, Iran. The patients were evaluated for known CAD risk factors—comprising hypertension, cigarette smoking history, diabetes mellitus history, addiction, dyslipidemia, and family history of premature CAD. Also assessed was the study population's pretest probability of CAD with the aid of the calculator devised by the American College of Cardiology and the American Heart Association. Complete demographic data were obtained from the subjects, who were fully informed about the study protocol. First, the patients underwent MDCT angiography for the assessment of CAD and the CAC score. Those with contraindications for MDCT and known cases of CAD were excluded from the study. The CAC score was categorized into 3 groups of less than 100, between 100 and 400, and greater than 400. Thereafter, the patients were assessed by PWV so that the results would be compared with the 3 CAC score groups. PWV measurement was another challenging part of the present study because it was defined in accordance with previous articles as the distance between the brachial and dorsalis pedis arteries divided by time. Data analysis was carried out using IBM SPSS, version 18. All the assessments of the demographic data and risk factors, together with their relationship with the CAC score and the PWV index, were analyzed using the correlation test and a *P* value of less than 0.05 was considered statistically meaningful. The study protocol was approved by the institutional ethics committee.

RESULTS

The study population was comprised of 350 patients: 183 (52.3%) male and 167 (47.7%) female. In terms of the 3 CAC score groups, there was no significant relationship between the PWV index and the CAC score (*P*= 0.057) (Table 1).

The patients' CAC score and the PWV index were in the range of 0 to 1596 and 2.6 m/s to 15.4 m/s (median = 8.4 m/s), correspondingly. The subjects were evaluated regarding their gender; the results revealed that while there was no meaningful relationship between the PWV index and the CAC score in the men, the PWV index was statistically significantly higher in the women ($P = 0.05$) (Table 2).

The study population was categorized into 2 groups of premature CAD risk defined as less than 45 and 55 in men and women, respectively, and more than these values as non-premature CAD risk. In the premature CAD risk group, the relationship between age and the PWV index and the CAC score results was statistically significant (Table 3).

In 54 (15.4%) patients, CAD was diagnosed via MDCT. The majority of these patients had single-vessel disease (74%). In the CAD group, the relationship between CAD and the CAC score and the PWV index was nonsignificant ($P = 0.4$) (Table 4).

Table 1: PWV index and CAC score in the men

	PWV				*P* value
	N	Mean ± SD	Minimum	Maximum	
CAC score <100	150	8.2 ± 1.9	2.9	14.5	0.1
100< CAC score <400	18	9 ± 2.1	5.2	12.6	
400< CAC score	15	7.6 ± 0.9	6.6	9.9	
Total	183	8.3 ± 1.9	2.9	14.5	

PWV, Pulsed-wave velocity; CAC, Coronary artery calcium

Table 2: PWV index and CAC score in the women

	PWV				*P* value
	N	Mean ± Std. Deviation	Minimum	Maximum	
CAC score <100	134	9.2 ± 2.3	2.6	15.4	0.05
100< CAC score <400	15	8.4 ± 2.4	3	12.5	
400< CAC score	18	10.4 ± 2.7	5.4	15.8	
Total	167	9.3 ± 2.4	2.60	15.80	

PWV, Pulsed-wave velocity; CAC, Coronary artery calcium

Table 3: PWV index and the CAC score in the non-premature CAD risk group

	PWV				*P* value
	N	Mean ± SD	Minimum	Maximum	
100< CAC score <400	19	8.1 ± 2.3	3.00	12.60	0.1
400< CAC score	14	8.2 ± 1.6	5.40	11.20	
Total	204	8.9 ± 1.6	2.60	15.40	

PWV, Pulsed-wave velocity; CAC, Coronary artery calcium; CAD, Coronary artery disease

Table 4: PWV index and the CAC score in the premature CAD risk group

	PWV				*P* value
	N	Mean ± SD	Minimum	Maximum	
CAC score <100	113	8.2 ± 2	2.90	13.60	0.003
100< CAC score <400	14	9.5 ± 1.8	6.80	12.50	
400< CAC score	19	9.8 ± 2.8	6.80	15.80	
Total	146	8.6 ± 2.2	2.90	15.80	

PWV, Pulsed-wave velocity; CAC, Coronary artery calcium; CAD, Coronary artery disease

Table 5: CAD relationship with the CAC score and the PWV index

	PWV (no CAD)				*P* value
	N	Mean ± SD	Minimum	Maximum	
CAC score <100	235	8.6 ± 2.1	2.90	15.40	0.3
100< CAC score <400	30	8.6 ± 2.1	3.00	12.60	
400< CAC score	31	9.3 ± 2.5	5.40	15.80	
Total	296	8.7 ± 2.2	2.90	15.80	

PWV, Pulsed-wave velocity; CAC, Coronary artery calcium; CAD, Coronary artery disease

Table 6: CAD relationship with the CAC score and the PWV index

	PWV (CAD)				*P* value
	N	Mean ± Std. Deviation	Minimum	Maximum	
CAC score <100	49	9.1 ± 2.4	2.60	14.50	0.4
100< CAC score <400	3	9.5 ± 3.3	5.70	11.70	
400< CAC score	2	7.00	7.00	7.00	
Total	54	9.0 ± 2.4	2.60	14.50	

PWV, Pulsed-wave velocity; CAC, Coronary artery calcium; CAD, Coronary artery disease

The patients were all asked and evaluated about known major CAD risk factors (Fig. 1).

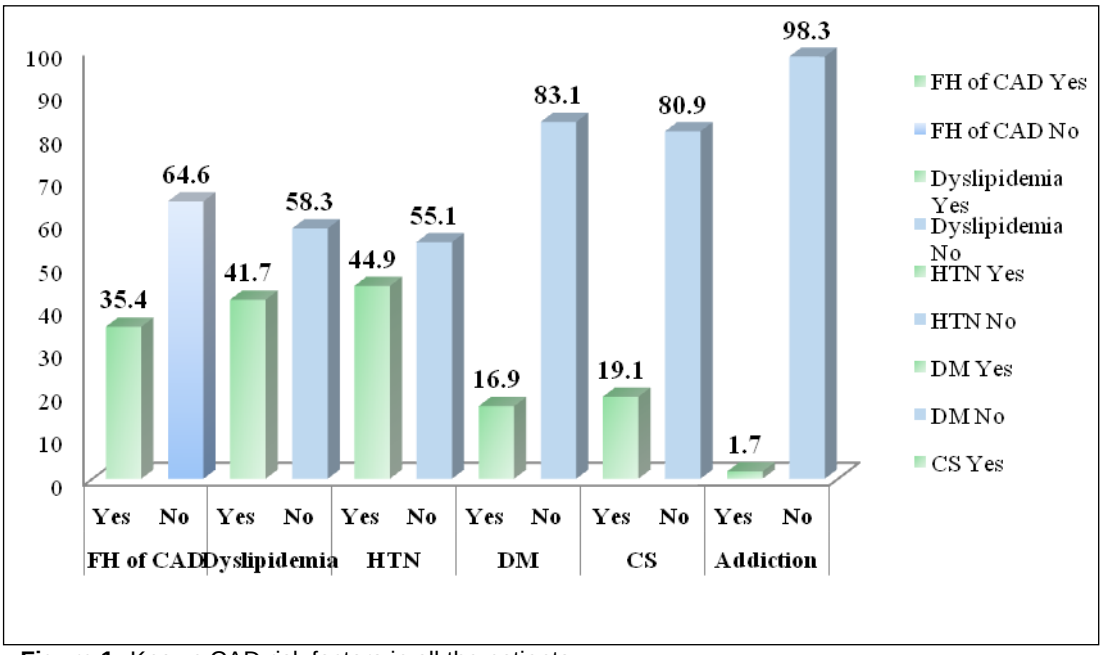

Figure 1: Known CAD risk factors in all the patients

CAD, Coronary artery disease; HTN, Hypertension; DM, Diabetes mellitus; FH, Family history

Subsequently, the inter-relationship between each risk factor and the CAC score was assessed. Interestingly, the relationship between the PWV index and the CAC score was statistically significant only in the group of patients without hypertension ($P = 0.01$ in those without hypertension and $P > 0.05$ in the other categories).

DISCUSSION

The PWV index as a parameter of vessel stiffness was primarily reported in 1930, since which time it has been proven that it increases with age and hypertension. [9, 10] To obtain reproducible data, we assessed the PWV of the brachial artery to the dorsalis pedis artery given the recent reports on its value. [11,12] However, the best method to assess vessel stiffness, according to some previous research, is via an invasive measurement of the elasticity factor. [13] The PWV index measures the distance between 2 points (eg, the brachial artery and the dorsalis pedis artery) and it fails to measure the stiffness in the entire arterial path. Additionally, if there is any tethering in the arterial tree, the PWV index may show totally different numbers and confound the results. [14-16] The PWV index in the general population reportedly ranges from 2 m/s to 15 m/s depending on the presence of intervening conditions; nonetheless, in our study population, the range o this index was between 2.6 m/s and 15.8 m/s. [17-19] In 2012, Iino et al [20] reported that a PWV index of more than 1.6 m/s with a CAC score exceeding 50 represented a good index in CAD diagnosis. Lee et al, [21] in 2015, showed

a meaningful relationship between the PWV index and the CAC score and reported that the male gender and diabetes mellitus affected PWV results. Liu et al [22] evaluated CAD with CT angiography and reported higher CAC scores and PWV indices in their patients with CAD. There are also some reports of a linear relationship between the CAC score and the PWV index in patients with CAD by Torii et al and Seo et al. [23, 24] In our study, we found no meaningful relationship between the CAC score and the PWV index. The mean PWV index was significantly higher in the women, the premature CAD risk group, and the hypertensive group among our patients. In conclusion, our results demonstrated that the PWV index as a noninvasive measure of CAD did not correlate with the CAC score, which is a proven CAD indicator. Further research is, therefore, warranted in this area.

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