Carotid-femoral pulse wave velocity in patients with isolated coronary artery ectasia: an observational study

İzole koroner arter ektazili hastalarda karotis-femoral nabız-dalga hızı: Gözlemsel bir çalışma

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ABSTRACT

Objective: Carotid-femoral pulse wave velocity (PWV), the current "gold-standard" measure of arterial stiffness, has emerged as an important independent predictor of cardiovascular events. The increased PWV is recognized as an indicator of atherosclerosis. The relationship between isolated coronary artery ectasia (CAE) and carotid-femoral PWV has not been well-described. The aim of our study was to assess this relation.
Methods: Thirty-four patients with isolated CAE without any visible coronary stenosis and 24 control subjects with angiographically normal coronary arteries were enrolled to this cross-sectional observational study. Applanation tonometry was applied to assess the carotid-femoral PWV. Statistical analyses were performed by Mann-Whitney U and Chi-square tests. Multiple linear regression analysis was used for the evaluation of the relations of parameters.
Results: The baseline clinical and laboratory parameters of the both groups were similar. Patients with isolated CAE had significantly higher carotid-femoral PWV compared to control subjects (10.5±2.4 vs 9.2±1.7 m/s, p=0.02). In multiple regression analysis, age (beta=0.23, 95% CI=0.001-0.094, p=0.04), number of ectatic vessels (beta=0.24, 95% CI=0.044-1.07, p=0.03), and systolic blood pressure (beta=0.52, 95% CI=0.028-0.1, p=0.001) were found independently related to PWV.
Conclusion: We have shown an association between increased carotid-femoral PWV and isolated CAE, suggesting that atherosclerosis may be involved in the pathogenesis of isolated CAE without any coronary stenosis in the adult population. *(Anadolu Kardiyol Derg 2012; 12: 313-9)*
Key words: Arterial stiffness, pulse wave velocity, coronary ectasia, atherosclerosis, regression analysis

ÖZET

Amaç: Karotis-femoral nabız dalga hızı (NDH) günümüzde arteriyel katılık ölçümünün altın standart yöntemidir ve kardiyovasküler olayların bağımsız öngördürücüsüdür. Artmış NDH aterosklerozun bir göstergesi olarak kabul edilmektedir. İzole koroner arter ektazisi (KAE) ve karotis-femoral NDH arasındaki ilişki tam olarak ortaya konamamıştır. Bu çalışmanın amacı, bu ilişkiyi araştırmaktır.
Yöntemler: Enine-kesitli gözlemsel bu çalışmaya, herhangi bir görünür darlığı olmayan 34 izole KAE'li hasta ve anjiyografik olarak normal koroner arterli 24 kontrol dahil edildi. Karotis-femoral NDH değerlendirmek için aplanasyon tonometrisi kullanıldı. İstatiksel analiz Mann-Whitney U ve Ki-kare testleri ile yapıldı. Parametreler arası ilişkilerin değerlendirilmesi için çoklu lineer regresyon analizi kullanıldı.
Bulgular: Her 2 grubun temel klinik ve laboratuvar parametreleri benzerdi. Karotis-femoral NDH, izole KAE hastalarında kontrol grubuna göre anlamlı olarak daha yüksekti (10.5±2.4 ve 9.2 ±1.7 m/sn, p=0.02). Çoklu regresyon analizinde, yaş (beta=0.23, %95 GA= 0.001-0.094, p=0.04), ektatik damar sayısı (beta=0.24, %95 GA= 0.044-1.07, p=0.03) ve sistolik kan basıncı (beta=0.52, %95 GA= 0.028-0.1, p=0.001) karotis-femoral NDH ile bağımsız ilişkili bulundu.
Sonuç: Artmış karotis-femoral NDH ve izole KAE arasında bir ilişki vardır. Bu ilişki, yetişkin popülasyonda, herhangi bir stenozun olmadığı izole koroner arter ektazisinin patogenezinde aterosklerozun etkisi olduğunu göstermektedir. *(Anadolu Kardiyol Derg 2012; 12: 313-9)*
Anahtar kelimeler: Arteryel katılık, nabız dalga hızı, koroner ektazi, ateroskleroz, regresyon analizi

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Introduction

Coronary artery ectasia (CAE) is defined as localized or diffuse dilation of the coronary arteries with a luminal dilation exceeding the 1.5-fold of normal adjacent segment or vessel diameter (1). Isolated CAE comprises a small portion of the total of CAE cases with an incidence of 0.1-0.79% and coronary artery stenosis, valvular heart disease and other cardiac disorders are not present in this phenomenon (1-4). Although occasionally related to congenital anomalies, inflammatory diseases or coronary interventions, the etiology of CAE is linked to coronary atherosclerosis in most cases (1, 5).

Arterial stiffness (AS) is increasingly being recognized as an important cardiovascular (CV) risk factor and an independent predictor of all-cause and cardiovascular death (6-8). Carotid-femoral pulse wave velocity (PWV) and augmentation index (AIx) are main methods for assessment of the AS. Carotid-femoral PWV which is reported to be a gold-standard measurement of arterial stiffness is a non-invasive measurement of the distensibility of the aorta (9) and is strongly associated with atherosclerosis (10).

Previously, two studies investigated the association of AS and CAE (11, 12). However, these studies included patients with coronary ectasia who have coronary stenosis (significant or not) and measurement of AS was not performed by gold standard method. Therefore, the relationship between isolated CAE and aortic PWV and atherosclerosis has not been well-described in these two studies.

Accordingly, our study was designed to investigate the carotid-femoral PWV to be an indicator of atherosclerosis and to assess the relationship between the number of ectatic vessels and PWV in patients with isolated CAE without any visible coronary stenosis.

Methods

Study design and Subjects

The population of this cross-sectional observational study was selected among 4958 patients who underwent coronary angiography because of presence of anginal chest pain or positive noninvasive tests results between December 2007 and April 2009 at the Cardiology Department of Faculty of Medicine of Karadeniz Technical and Rize Universities and Ahi Evren Cardiovascular and Thoracic Surgery Training and Research Hospital. The study group (group 1) consisted of 34 patients (21 men, 13 women, mean age=56±12 years) with isolated CAE. Group 2 consisted of 24 age-matched patients who were selected in a consecutive manner from the patients who underwent coronary angiography during the same study period and proved to have normal coronary angiograms. To be included in the study, patients needed to have no visible stenotic lesions in the coronary tree (different from other ectasia studies), no valvular heart disease and no wall motion abnormalities with echocardiogra-

phy or ventriculography. Patients and control subjects were evaluated for classic risk factors for coronary artery disease (CAD). Hypertension was considered to be present if the patient was taking antihypertensive drugs at the time of hospital admission or if evidence of ≥140 mmHg systolic blood pressure (BP), ≥90 mmHg diastolic BP, or both was found on examination. Hypercholesterolemia is defined as total cholesterol >200 mg/dL. The study protocol was approved by the local Ethics Committee and informed consent was obtained from all patients and controls.

Coronary angiography

Selective coronary angiography was performed by the Judkins or Sones technique without using of nitroglycerin. Coronary angiograms were analyzed by two experienced observers. CAE was defined as an enlargement of the vessel's lumen above 1.5 times that of an adjacent normal artery or normal parts of the same vessel (1).

Arterial stiffness measurements

Peripheral artery pressure waveforms were evaluated noninvasively using applanation tonometry. The measurement of carotid-femoral PWV was performed with the SphygmoCor system (AtCor Medical, Sydney, Australia) after an overnight fast and 24 hours off of any antihypertensive medications. Subjects were asked to omit caffeine beverages, smoking, and alcohol for at least 12 hours before the assessment. All measurements were performed in a quiet, temperature controlled room. After 10-15 minutes with the participant resting in the supine position, the carotid-femoral PWV was measured by sequential recordings of the arterial pressure waveform at the carotid and femoral arteries with a hand-held micromanometer-tipped probe on the skin at the site of maximal arterial pulsation. Gating of the recordings at these two sites to the electrocardiogram (ECG) allowed the PWV to be measured. The distances from the carotid sampling site to the suprasternal notch and from the suprasternal notch to the femoral artery were measured (13). The carotid-femoral PWV (in meters per second) was calculated automatically as the distance (Δd) between the carotid and the femoral sampling site divided by the time interval (Δt) between systolic R-wave and femoral systolic upstroke minus the time interval between systolic R-wave and carotid systolic upstroke (PWV = $\Delta d/\Delta t$). The carotid-femoral PWV was determined as the mean of at least three consecutive beats recorded during 10 seconds of data acquisition. The augmentation index (AIx) is another arterial stiffness parameter and suggests the difference between early and late pressure peaks divided by central pulse pressure. To measure AIx, an ascending aortic pressure waveform was derived from the radial artery waveforms recorded at the wrist using applanation tonometry with a high-fidelity micromanometer. The aortic augmentation pressure was calculated as the difference between the first and second systolic peaks of the ascending aortic waveform, and AIx was expressed as a percentage of the

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central pulse pressure (the difference between the central systolic and diastolic pressures).

All measurements were performed by the same investigator who was unaware of the clinical and echocardiographic data. For reliable results, only high-quality recordings were included in the analysis. These were defined as an acceptable curves on visual inspection and in-device quality index of >80% derived from an algorithm including average pulse height, pulse height variation, diastolic variation, and the maximum rate of rise of the peripheral waveform.

Study variables

The presence of coronary ectasia and number of ectatic vessels were examined as a predictor variables. Carotid-femoral PWV was primary outcome variable of this study. Systolic and diastolic BP, age, treatment and risk factors for CAD were confounding variables.

Statistical analysis

SPSS software program (SPSS, 10.0, Inc, Chicago, Illinois, USA) was used for statistical analyses. Continuous variables were described as mean±SD and analysed using Student-t test and Mann-Whitney U test when appropriate. Normality of values' distribution was assessed by Kolmogorov-Smirnov test. Chi-squared test was used for analysis of categorical variables.

Univariate correlation analysis was used to assess the relationship between PWV and other parameters. Multiple regression analysis was used to detect the independently related factors to PWV. A p value <0.05 was considered statistically significant.

Results

Baseline and angiographic characteristics

There were 34 patients with isolated CAE out of 4958 cardiac catheterizations (0.68%). There were no statistically significant differences (p>0.05) between the groups in terms of gender, age, cardiovascular risk profile and cardiovascular medical therapy (Table 1). There was no evidence of a collagenosis, connective tissue or inflammatory disease in our patients. Ectasia involved the left anterior descending artery in 24, the left circumflex artery in 15, and the right coronary artery in 14 patients. One vessel, 2 vessel and 3 vessel ectasia were found to be present in 20 (59%), 9 (26%) and 5 (15%) patients, respectively.

Arterial stiffness parameters

Patients with isolated CAE had significantly higher carotid-femoral PWV compared to control subjects with angiographically normal coronary arteries (10.5±2.4 versus 9.2±1.7 m/s, p=0.02, Table 2, Figure 1). However, AIx was similar in both groups (p>0.05).

Table 1. Clinical and laboratory characteristics in isolated CAE patients and controls

Variables	Isolated CAE group (n=34)	Control group (n=24)	*p
Age, years	56±12	54±9	0.56
Male gender, n (%)	21 (62)	10 (42)	0.13
Hypertension, n (%)	17 (50)	11 (48)	0.87
Cigarette smoking, n (%)	6 (18)	6 (25)	0.49
Diabetes mellitus, n (%)	5 (15)	2 (8)	0.46
Family history, n (%)	7 (21)	8 (33)	0.27
LDL, mg/dL	121±36	118±31	0.29
HDL, mg/dL	41±11	44±10	0.32
Triglycerides, mg/dL	194±103	144±76	0.06
Cholesterol, mg/dL	188±45	185±34	0.79
BMI, kg/m^2	30±3.9	29±4.4	0.76
Cardiovascular medication			
ASA, n (%)	16 (47)	9 (37)	0.46
Beta-blockers, n (%)	16 (47)	6 (25)	0.08
Nitrates, n (%)	3 (9)	3 (12)	0.65
ACE inhibitors, n (%)	11 (32)	4 (17)	0.17
Cholesterol-lowering drugs, n (%)	11 (32)	4 (17)	0.17

Data are presented as mean±SD and the number (%) of patients

*Student's test for independent samples and Chi-square test

ACE - angiotensin-converting enzyme, ASA - acetylsalicylic acid, BMI - body mass index, CAE - coronary artery ectasia, HDL - high-density lipoprotein, LDL - low-density lipoprotein
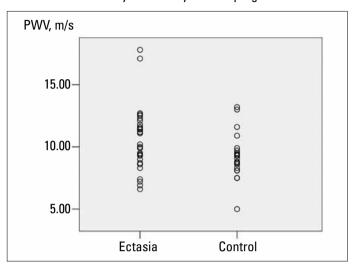
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Relationship between PWV and other variables

In univariate correlation analysis, a relationship was found between PWV and age (r=0.389, p=0.003), number of ectatic vessels (r=0.361, p=0.008), systolic (r=0.470, p<0.001) and diastolic (r=0.347, p=0.008) BPs. Age (beta=0.23, 95% CI=0.001-0.094, p=0.043), number of ectatic vessels (beta=0.24, 95% CI=0.044-1.07, p=0.034) and systolic BP (beta=0.52, 95% CI=0.028-0.1, p=0.001) were found to be independently related to PWV in multiple regression analysis (Table 3).

Discussion

In the present study, we investigated the relationship between carotid-femoral PWV and isolated CAE. We found that patients with isolated CAE have significantly higher carotid-femoral PWV compared to control subjects with angiographically normal coronary arteries. In addition, age, number of ectatic vessel and systolic blood pressure were independently related to PWV.

CAE is a uncommon angiographic finding and generally associated with coronary stenosis. Although that the clinical significance of CAE also remains poorly understood, it can lead to stable angina pectoris and acute coronary syndrome (14). Isolated CAE is a very rare entity and its prognosis is a better
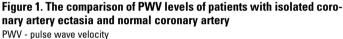

Figure 1. The comparison of PWV levels of patients with isolated coronary artery ectasia and normal coronary artery
PWV - pulse wave velocity

Table 2. Hemodynamic and laboratory characteristics in isolated CAE patients and controls

Variables	Isolated CAE group (n=34)	Control group (n=24)	*p
Peripheral SBP, mmHg	126±18	122±19	0.55
Peripheral DBP, mmHg	76±10	73±15	0.46
Peripheral PP, mmHg	49±14	48±13	0.90
Central SBP, mmHg	114±19	113±19	0.89
Central DBP, mmHg	78±10	75±14	0.43
Central PP, mmHg	36±14	38±12	0.59
Heart rate, beats/min	65±11	64±9	0.60
Ejection fraction, %	65±3.6	66±5.6	0.09
Augmentation index, %	17±14	21±12	0.27
Carotid-femoral PWV, m/sec	10.5±2.4 10.1 (6.6-17.8)	9.2±1.7 9.2 (5-13.2)	0.02

Data are expressed as mean±SD

*Student's t-test for independent samples and Mann-Whitney U test

DBP - diastolic blood pressure, PP - pulse pressure, PWV - pulse wave velocity, SBP - systolic blood pressure

Table 3. Bivariate correlation and multiple linear regression analysis between PWV and other variables

Variables	Bivariate analysis		Multiple regression analysis			
	r	p	β	p	95% CI	
					Lower	Upper
Age	0.38	0.003	0.23	0.04	0.001	0.094
Number of ectatic vessels	0.36	0.008	0.24	0.03	0.044	1.07
Systolic BP	0.47	<0.001	0.52	0.001	0.028	0.1
Diastolic BP	0.34	0.008	-0.91	0.54	-0.072	0.038

PWV is dependent variable in multiple regression model
BP - blood pressure, CI - confidence interval, PWV - pulse wave velocity

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than CAE with stenosis. Valente et al. (15) investigated the clinical significance of CAE and were reported that CAE was associated with acute myocardial infarction in half of cases and acute coronary syndrome in one third of cases. They also reported that acute coronary syndrome caused by isolated CAE is rare and it has a good prognosis. The underlying pathological mechanism of CAE is not completely known. At the present time, CAE is considered to be a variant of CAD, although that 20-30% of cases are associated with collagenosis (16, 17) or connective tissue diseases (18, 19). CAE is commonly coexistent with CAD and there is a relationship between coronary ectasia and several markers of atherosclerosis and inflammation such as leukocyte counts, matrix metalloproteinases, interleukins, uric acid, adiponectin, lipoprotein-associated phospholipase A2, C-reactive protein (CRP), plasminogen activator inhibitor-1 (PAI-1) (20-26).

Arterial stiffness is an independent risk factor for all-cause mortality and cardiovascular death (6-8). In addition, increased aortic stiffness has been shown to predict future cardiovascular events (6). Moreover, PWV is strongly associated with atherosclerosis (10). Several studies reported the various conditions associated with increased arterial stiffness. They include (i) CV diseases such as coronary heart disease (6), congestive heart failure (27), and fatal stroke (28); (ii) CV risk factors such as obesity (29), smoking (30), hypertension (6), hypercholesterolemia (31), impaired glucose tolerance (32), metabolic syndrome (29), and types 1 and 2 diabetes (32, 33). Many methodologies have been applied to assess the arterial stiffness: 1) measuring PWV, 2) relating change in diameter (or area) of an artery to distending pressure, and 3) assessing arterial pressure waveforms. The measurement of PWV is generally accepted as the most simple, noninvasive, robust, reproducible and gold-standard method to determine aortic stiffness (9, 34). To our knowledge, however, there are no published reports concerning the association between carotid-femoral PWV and isolated CAE.

Only two previous studies examined the role of aortic stiffness in patients with CAE. Koşar et al. (11) found impaired distensibility and strain of the aorta in patients with CAE, compared with the control group with angiographically normal coronary arteries. In contrast to our study, aortic stiffness was assessed over the aortic root by means of echocardiography that is a less reliable method than PWV. Moreover, the majority of their patients with coronary ectasia had coexisting nonsignificant stenotic lesions (<50%). However, our patients did not have any stenotic coronary lesions with visual assessment. Tüzün et al. (12) reported impaired aortic stiffness parameters in CAE patients. The assessment of aortic stiffness was performed by echocardiography in their study. In addition, in both studies, isolated CAE patients were not assessed as a different group from the CAE patients with CAD.

In this study, an independent relationship was found between PWV which is an important indicator of atherosclerosis (10) and the number of involved vessels. The inflammation has an important role in arterial stiffness. A large number of inflammatory markers were found to be associated with arterial stiffness and

PWV in various studies (35-38). For example, CRP reported to be associated with PWV in both asymptomatic population (36) and patients with ectasia (25). Likewise, a relationship between PAI-1 and PWV (38) and aortic stiffness (39) was shown. On the other hand, there also are numerous published reports that show a relationship between isolated CAE and inflammation. Kocaman et al. (20) reported increased total and differential leukocyte counts, which are significant inflammation markers in patients with isolated CAE. Şen et al. (22) found increased serum uric acid level which is associated with endothelial function and inflammation which plays an important role in atherosclerosis in isolated CAE patients. Korkmaz et al. (24) reported a relation CAE and increased serum level of the lipoprotein-associated phospholipase A2 which is a specific vascular inflammation marker. In addition, Çiçek et al. (26) reported increased level of PAI-1 in patients with isolated CAE. PAI-1 is a major inhibitor of fibrinolysis and associated with CAD. Thus, it may have been proposed that the development of CAE and increase of PWV result from common etiologic factor such as inflammation that has a central role on development of atherosclerosis. Finally, Aksu et al. (3) proposed that patients who have isolated CAE or CAE with CAD have similar etiopathogenesis because of they have considerably similar risk factors of CAD and clinical presentation. Therefore, we thought that the possible etiology in our patients is coronary atherosclerosis.

On the other hand, AIx is another stiffness parameter suggests wave reflections and arterial stiffness. In this study, AIx was similar in two groups. There are some possible explanations of this situation. For example, PWV and AIx have different determinants. AIx is mainly determined by the magnitude of reflected pressure wave that relies on the tone of the resistance arteries. However, PWV is associated with wall structure of large elastic artery. Therefore, both parameters are not always affected in the same way (40). In addition, AIx is a better indicator of stiffens in young people. Whereas, the number of young subject in our study is a little.

The results of our study have some potential importance: First, this study has included only fully isolated coronary ectasia patients who have no visible coronary stenosis. Also, arterial stiffness was assessed by PWV which is the gold-standard method. Thus, our study differs from the other studies that investigated the relation between AS and CAE. Secondly, our results have supported that the role of atherosclerosis in pathogenesis of isolated coronary ectasia and consistent with prior studies (11, 12). Third, CAE increases the rate of cardiovascular morbidity and mortality by increased incidence of ischemia and myocardial infarction. However, cardiovascular mortality is also increased due to increased arterial stiffness despite lack of significant stenosis in subjects with isolated CAE. Thus, potential benefits of primary prevention in subjects with isolated CAE (even without evident atherosclerotic stenosis) should be evaluated with future prospective studies.

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Study limitations

First, the study population of this study is quite small. In addition, long-term effects of increased PWV in patients with isolated CAE are unknown because of cross-sectional nature of our study design. Second, although the carotid-femoral PWV is a gold-standard measurement of arterial stiffness, its calculation by SphygmoCor system has some potential errors. The measurement of distance between carotid and femoral site should be performed very carefully. Because, small measurement errors may lead to great calculation mistakes, especially, in the persons who have large chest and abdomen circumferences. The caffeine beverages, smoking, alcohol consume and antihypertensive medications should be stopped 12-24 hours before the assessment, because those have affected arterial stiffness measurements. In addition, the records of pulse waves from carotid and femoral sites using SphygmoCor system should be performed at short notice to avoid from heart rate variability and isovolumic period alterations. To avoid these potential errors, all arterial stiffness measurements were performed very carefully and only high-quality recordings defined as in-device quality index of >80% were included in the analysis in this study. Further studies are needed to confirm of our findings.

Conclusion

Carotid-femoral PWV was found to be significantly higher in patients with isolated CAE, suggesting that atherosclerosis may be involved in the pathogenesis of isolated CAE in the adult population.

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References

1. Swaye PS, Fisher LD, Litwin P, Vignola PA, Judkins MP, Kemp HG, et al. Aneurysmal coronary artery disease. Circulation 1983; 67: 134-8. [CrossRef]
2. Al-Harthi SS, Nouh MS, Arafa M, Al-Nozha M. Aneurysmal dilatation of the coronary arteries: diagnostic patterns and clinical significance. Int J Cardiol 1991; 30: 191-4. [CrossRef]
3. Aksu T, Uygur B, Durukan Koşar M, Güray U, Arat N, Korkmaz S, et al. Coronary artery ectasia: its frequency and relationship with atherosclerotic risk factors in patients undergoing cardiac catheterization. Anadolu Kardiyol Derg 2011; 11: 280-4.
4. Sultana R, Sultana N, Ishaq M, Samad A. The prevalence and clinical profile of angiographic coronary ectasia. J Pak Med Assoc 2011; 61: 372-5.
5. Demopoulos VP, Olympios C, Fakiolas CN, Pissimissis EG, Economides NM, Adamopoulou E, et al. The natural history of aneurysmal coronary artery disease. Heart 1997; 78: 136-41.
6. Boutouyrie P, Tropeano AI, Asmar R, Gautier I, Benetos A, Lacolley P, et al. Aortic stiffness is an independent predictor of primary coronary events in hypertensive patients: a longitudinal study. Hypertension 2002; 39: 10-5. [CrossRef]
7. Cruickshank K, Riste L, Anderson SG, Wright JS, Dunn G, Gosling RG. Aortic pulse-wave velocity and its relationship to mortality in diabetes and glucose intolerance: an integrated index of vascular function? Circulation 2002; 106: 2085-90. [CrossRef]
8. Blacher J, Guerin AP, Pannier B, Marchais SJ, Safar ME, London GM. Impact of aortic stiffness on survival in end-stage renal disease. Circulation 1999; 99: 2434-9.
9. Laurent S, Cockcroft J, Van Bortel L, Boutouyrie P, Giannattasio C, Hayoz D, et al. Expert consensus document on arterial stiffness: methodological issues and clinical applications. Eur Heart J 2006; 27: 2588-605. [CrossRef]
10. van Popele NM, Grobbee DE, Bots ML, Asmar R, Topouchian J, Reneman RS, et al. Association between arterial stiffness and atherosclerosis: the Rotterdam Study. Stroke 2001; 32: 454-60. [CrossRef]
11. Koşar F, Sincer I, Aksoy Y, Topal E, Çehreli S. Increased aortic stiffness in patients with coronary artery ectasia. Coron Artery Dis 2005; 16: 499-04. [CrossRef]
12. Tüzün N, Tanrıverdi H, Evrengül H, Kuru DS, Ergene AO. Aortic elastic properties in patients with coronary artery ectasia. Circ J 2007; 71: 506-10. [CrossRef]
13. Mosti G, Iabichella ML, Picerni P. Pulse wave velocity. A new calculation method. Minerva Cardioangiol 2000; 48: 53-9.
14. Antoniadis AP, Chatzizisis YS, Giannoglou GD. Pathogenetic mechanisms of coronary ectasia. Int J Cardiol 2008; 130: 335-43. [CrossRef]
15. Valente S, Lazzeri C, Giglioli C, Sani F, Romano SM, Margheri M, et al. Clinical expression of coronary artery ectasia. J Cardiovasc Med (Hagerstown) 2007; 8: 815-20. [CrossRef]
16. Chaithiraphan S, Goldberg E, O'Reilly M, Jootar P. Multiple aneurysms of coronary artery in sclerodermal heart disease. Angiology 1973; 24: 86-93. [CrossRef]
17. Tang PH, Segal AJ. Polyarteritis nodosa of infancy. Fatal late complication. JAMA 1971; 217: 1666-70. [CrossRef]
18. McKusick VA. Cardiovascular aspects of Marfan's syndrome: heritable disorder of connective tissue. Circulation 1955; 11: 321-42.
19. Befeler B, Aranda MJ, Embi A, Mullin FL, El-Sherif N, Lazzara R. Coronary artery aneurysms: study of the etiology, clinical course and effect on left ventricular function and prognosis. Am J Med 1977; 62: 597-607. [CrossRef]
20. Kocaman SA, Taçoy G, Şahinarslan A, Çengel A. Relationship between total and differential leukocyte counts and isolated coronary artery ectasia. Coron Artery Dis 2008; 19: 307-10. [CrossRef]
21. Doğan A, Tüzün N, Türker Y, Akçay S, Kaya S, Özaydın M. Matrix metalloproteinases and inflammatory markers in coronary artery ectasia: their relationship to severity of coronary artery ectasia. Coron Artery Dis 2008; 19: 559-63. [CrossRef]
22. Şen N, Özcan F, Uygur B, Aksu T, Akpınar I, Çay S, et al. Elevated serum uric acid levels in patients with isolated coronary artery ectasia. Türk Kardiyol Dern Arş 2009; 37: 467-72.

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23. Dağlı N, Öztürk U, Karaca I, Yavuzkır M, Koca S, Akbulut H, et al. Adiponectin levels in coronary artery ectasia. Heart Vessels 2009; 24: 84-9. **[CrossRef]**

24. Korkmaz L, Erkuş E, Kırış A, Ağaç MT, Acar Z, Turan T, et al. Lipoprotein phospholipase A2 in patients with isolated coronary artery ectasia. Clin Res Cardiol 2011; 100: 511-4. **[CrossRef]**

25. Sincer I, Aktürk E, Açıkgöz N, Ermiş N, Koşar MF. Evaluation of the relationship between serum high sensitive C-reactive protein and the elasticity properties of the aorta in patients with coronary artery ectasia. Anadolu Kardiyol Derg 2011; 11: 414-20.

26. Çiçek Y, Durakoğlugil ME, Erdoğan T, Yılmaz A, Uydu HA, Sağlam H, et al. Increased plasminogen activator inhibitor-1 levels in patients with isolated coronary artery ectasia. J Thromb Thrombolysis 2011; 33: 120-3.

27. Giannattasio C, Failla M, Stella ML, Mangoni AA, Turrini D, Carugo S. Angiotensin-converting enzyme inhibition and radial artery compliance in patients with congestive heart failure. Hypertension 1995; 26: 491-6.

28. Laurent S, Katsahian S, Fassot C, Tropeano AI, Gautier I, Laloux B, et al. Aortic stiffness is an independent predictor of fatal stroke in essential hypertension. Stroke 2003; 34: 1203-6. **[CrossRef]**

29. Ferreira I, Henry RM, Twisk JW, van Mechelen W, Kemper HC, Stehouwer CD. The metabolic syndrome, cardiopulmonary fitness, and subcutaneous trunk fat as independent determinants of arterial stiffness: the Amsterdam Growth and Health Longitudinal Study. Arch Intern Med 2005; 165: 875-82. **[CrossRef]**

30. Kool MJ, Hoeks AP, Struijker-Boudier HA, Reneman RS, Van Bortel LM. Short- and long-term effects of smoking on arterial wall properties in habitual smokers. J Am Coll Cardiol 1993; 22: 1881-6. **[CrossRef]**

31. Wilkinson IB, Prasad K, Hall IR, Thomas A, MacCallum H, Webb DJ, et al. Increased central pulse pressure and augmentation index in subjects with hypercholesterolemia. J Am Coll Cardiol 2002; 39: 1005-11. **[CrossRef]**

32. Schram MT, Henry RM, van Dijk RA, Kostense PJ, Dekker JM, Nijpels G, et al. Increased central artery stiffness in impaired glucose metabolism and type 2 diabetes: the Hoorn Study. Hypertension 2004; 43: 176-81. **[CrossRef]**

33. Schram MT, Schalwijk CG, Bootsma AH, Fuller JH, Chaturvedi N, Stehouwer CD. Advanced glycation end products are associated with pulse pressure in type 1 diabetes: the EURODIAB Prospective Complications Study. Hypertension 2005; 46: 232-7. **[CrossRef]**

34. Oliver JJ, Webb DJ. Noninvasive assessment of arterial stiffness and risk of atherosclerotic events. Arterioscler Thromb Vasc Biol 2003; 23: 554-66. **[CrossRef]**

35. van Bussel BC, Schouten F, Henry RM, Schalkwijk CG, de Boer MR, Ferreira I, et al. Endothelial dysfunction and low-grade inflammation are associated with greater arterial stiffness over a 6-year period. Hypertension 2011; 58: 588-95. **[CrossRef]**

36. Duprez DA, Somasundaram PE, Sigurdsson G, Hoke L, Florea N, Cohn JN. Relationship between C-reactive protein and arterial stiffness in an asymptomatic population. J Hum Hypertens 2005; 19: 515-9. **[CrossRef]**

37. Çelik T, Yüksel UC, Demirkol S, Bugan B, İyisoy A, Kabul HK, et al. Relationship between increased systemic inflammation and impaired aortic elasticity in young patients with prehypertension. Blood Press Monit 2011; 16: 55-61. **[CrossRef]**

38. Nishiwaki Y, Takebayashi T, Omae K, Ishizuka C, Nomiyama T, Sakurai H. Relationship between the blood coagulation-fibrinolysis system and the subclinical indicators of arteriosclerosis in a healthy male population. J Epidemiol 2000; 10: 34-41. **[CrossRef]**

39. Van Popele NM, Westendorp IC, Bots ML, Reneman RS, Hoeks AP, Hofman A, et al. Variables of the insulin resistance syndrome are associated with reduced arterial distensibility in healthy non-diabetic middle-aged women. Diabetologia 2000; 43: 665-72. **[CrossRef]**

40. Gedikli O, Öztürk S, Yılmaz H, Baykan M, Kırış A, Durmuş I, et al. Low total antioxidative capacity levels are associated with augmentation index but not pulse-wave velocity. Heart Vessels 2009; 24: 366-70. **[CrossRef]**