Association between C-reactive protein, carotid intima-media thickness and P-wave dispersion in obese premenopausal women: an observational study

Premenapozal şişman kadınlarda P dalga dispersiyonu karotis intima-media kalınlığı ve C-reaktif protein arasındaki ilişki; Gözlemsel bir çalışma

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ABSTRACT

Objective: The aim of the present study was to evaluate P-wave dispersion (PWD) in obese women, and to investigate the relationship between P-wave measurements, high sensitive C-reactive protein (hsCRP), carotid intima-media thickness (CIMT) and echocardiographic findings.

Methods: Forty-four patients with obese premenopausal women and 30 females with normal weight were enrolled this cross sectional, observational study. Results of anthropometric measurements, laboratory assays, electrocardiographic and echocardiographic findings were recorded for each participant. Student t, Mann-Whitney U and Pearson Chi-square tests, and Spearman correlation analysis were used for statistical analysis. Multiple regression analysis was used to identify independent factors associated with PWD development.

Results: The obese group had significantly higher values for PWD (41.8±11.8 ms vs. 28.5±9.3 ms; p<0.001) as well as for P max (105.2±14.3 ms vs. 89.0±13.3 ms; p<0.001). Correlation analyses revealed the presence of a positive correlation between PWD and each of insulin, systolic blood pressure, diastolic blood pressure, hsCRP, CIMT, left atrial diameter (LAD), waist circumference, waist to hip ratio and body mass index in obese participants. The only significant association that was observed on multiple linear regression analysis, after adjustments for confounding risk factors, was between LAD and PWD (β=4.290, 95% CI: 1.870-9.720, p=0.032).

Conclusion: We found that increased PWD values in obese patients are correlated positively with hsCRP, CIMT and abdominal obesity. However, independent and significant association was found only between LAD and PWD.

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Key words: Obesity, subclinical inflammation, P-wave dispersion, atherosclerosis, regression analysis

ÖZET

Amaç: Çalışmamızın amacı, premenapozal obez kadınlarda P dalga dispersiyonunun incelenmesi, P dalga ölçümleri ile yüksek duyarlılıklı C-reaktif protein (hsCRP), karotis intima-media kalınlığı (KIMK) ve ekokardiyografi bulguları arasındaki ilişkilerin değerlendirilmesidir.

Yöntemler: Kırk dört premenapozal obez kadın ve 30 normal kilolu, sağlıklı, gönüllü, kesitsel gözlemsel çalışmaya dahil edildi. Tüm katılımcılarda, antropometrik ölçümlerden sonra açlık kan şekeri, insülin düzeyi, insülin direnci (HOMA-IR), hsCRP, lipit parametreleri ve KIMK ölçüldü, elektrokardiyografik ve ekokardiyografik parametreler değerlendirildi. İstatistiksel analizde Student t, Mann-Whitney U ve Pearson Ki-kare testleri, ve Spearman korelasyonu analizi kullanıldı. Çoklu doğrusal regresyon analizi ile P dalga dispersiyonu gelişimini etkileyen bağımsız belirleyicileri araştırıldı.

Bulgular: Premenapozal obez kadınlar ile sağlıklı kontrol grubu arasında P dispersiyonu ve maksimum P dalga süresi açısından anlamlı farklılık vardı (sırasıyla, 41.8±11.8 ms'ye karşı 28.5±9.3 ms, p<0.001 ve 105.2±14.3 ms'ye karşı 89.0±13.3 ms, p<0.001). P dalga dispersiyonu ile insülin, HOMA-IR, sistolik kan basıncı, diyastolik kan basıncı, hsCRP, KIMK, sol atriyum çapı, bel çevresi, bel-kalça oranı ve vücut kitle indeksi arasında pozitif korelasyon vardı. Lineer regresyon analizinde ise P dalga dispersiyonu ile sadece sol atriyum çapı arasında anlamlı ilişki vardı (β=4.290, %95 GA: 1.870-9.720, p=0.032).

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Sonuç: Obez hastalardaki artmış P dalga dispersiyonu ile abdominal obezite, KIMK, hsCRP ve sol atriyum çapı arasında pozitif korelasyon bulduk. Bununla birlikte P dalga dispersiyonu ile sadece sol atriyum çapı arasında anlamlı ilişki mevcuttu.
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Anahtar kelimeler: Obezite, subklinik enflamasyon, P dalga dispersiyonu, ateroskleroz, regresyon analizi

Introduction

Obesity, which is an important public health problem especially in developed countries (1), has also been identified as an independent risk factor for the development of atrial fibrillation (AF) (2). Previous studies have reported advanced age, diabetes mellitus, hypertension, and cardiovascular diseases to be associated with an increased risk for developing AF (3, 4), all of which are conditions closely linked with obesity. Various explanations have been put forth in an attempt to identify the mechanisms behind the development of AF in obese individuals. The presence of underlying atherosclerosis, hypertension, left atrial dilatation (LAD), left ventricular hypertrophy and filling abnormalities, abnormal autonomic control of the heart and impaired heart rate variability in patients with obesity have all been implicated as possible contributing factors for the development of AF (3, 5, 6).

Although the actual cause of AF is yet to be completely elucidated, evidence from both laboratory and epidemiological studies suggests that subclinical inflammation and atherosclerosis may play a role (7). Adipose tissue serves as an endocrine organ, secreting a host of inflammatory cytokines including IL-6, which stimulates hepatic production of C-reactive protein (CRP) (8). Indeed, measures of obesity are among the strongest correlates of CRP levels, which is suggestive of a close relationship between inflammation and obesity (8). Among the non-invasive indicators of low grade inflammation and atherosclerosis, high-sensitive CRP (hsCRP) and carotid intima-media thickness (CIMT) are the most widely used in clinical practice (9).

However, there are no studies on relationship between subclinical inflammation, atherosclerosis and AF in obese premenopausal women. We hypothesized that the relation between obesity and AF may be mediated by the influence of subclinical inflammation and atherosclerosis on myocardial structure.

P-wave dispersion (PWD) is defined as the difference between the maximum and the minimum P-wave durations measured on a 12-lead surface electrocardiogram (ECG). P-wave dispersion is considered to reflect the discontinuous and inhomogeneous propagation of sinus impulses and the prolongation of atrial conduction time. Increased PWD and maximum P-wave duration are well established predictors for impending AF (10, 11).

The aim of this study was to evaluate the effects of obesity on PWD, and to investigate the presence of a possible relationship between P-wave measurements and echocardiographic findings, hsCRP and CIMT.

Methods

Study design and sample size estimation

This cross sectional, observational study was undertaken in the Department of Endocrinology and Metabolism of Ankara Numune Research and Education Hospital with the approval of the local Ethics Committee.

The primary aim of this study was to compare obese and normal weight groups by means of PWD levels. Allocation ratio was assumed as 1.5 and a total sample size of 70 cases (42 for obese, 28 for normal weight) was required to detect at least 10 msec (SD=3.36) difference with a power of 90% at the 5% significance level using a two-sided Mann-Whitney U test assuming that the actual distribution is double exponential. The difference of 10 msec was taken from both pilot study and clinical experience.

Patients selection

Patients who were diagnosed with obesity between January 2008 and March 2009 were approached for enrollment in this study and consenting patients were screened for eligibility.

A detailed medical history was obtained for all participants and those with a known history of diabetes mellitus, hyperlipidemia, hypertension, coronary or valvular heart disease, heart failure or a thyroid disorder were excluded. Those taking medications that may affect ECG findings such as antiarrhythmic agents, tricyclic antidepressants, antipsychotics, and antihistamines were also excluded from the study. In addition, individuals with an underlying condition or on any medication that may affect serum lipids, hsCRP levels such as acetylsalicylic acid, smoking, chronic liver or kidney disorder, history of trauma or an infection within 1 month from presentation, or a chronic inflammatory disorder (collagen tissue diseases, inflammatory intestinal diseases) were excluded.

Anthropometric and clinical assessment

After initial screening, participants were subjected to a careful physical examination, including blood pressure measurements obtained following a resting period of 10 minutes. Anthropometric parameters such as weight, height, waist circumference (WC), waist-to-hip ratio (WHR) and body mass index (BMI) were recorded for each participant. Body weight was measured to the nearest 0.1 kg with an electronic scale (Seca, Germany), whereas measurements of height were made to the nearest 1 mm using a portable measuring device (Seca, Germany). Both measurements were made with participants wearing light indoor clothes and without shoes. Body mass index was calculated by dividing weight in kilograms by the square of the height in meters. We analyzed BMI as a continuous variable, and divided into the WHO Categories for normal, overweight and obesity (18.5-25 kg/m^2 Normal, 25-29.99 kg/m^2 Overweight, $\geq$ 30 kg/m^2 Obese) (12). As per study design, subjects with a BMI $\geq$ 30 kg/m^2 made up the obese group, whereas the control group was comprised of participants of normal

weight, with a BMI between 18.5-25 kg/m^2. Individuals with a BMI between 25-30 (overweight), or underweight participants (BMI <18.5 kg/m^2) were not included in the final analysis.

Laboratory assays

Venous blood samples were obtained for all patients from the antecubital region between 8.00-9.00 am after an 8-12 hour overnight fast. Fasting blood glucose (FBG) levels were measured by the glucose oxidation method using the original reagents on an autoanalyzer (UniCel DxC 800 System, Beckman Coulter Inc., USA) and plasma insulin concentrations were determined by chemiluminescent immunoassay on a Unicell DXI 800 immunoassay analyzer (Beckman Coulter Inc., USA). The homeostasis model assessment (HOMA-IR) was used to estimate insulin resistance [(HOMA-IR (mmol/LxμU/ml)=fasting glucose (mmol/L)xfasting insulin (μU/ml)/405]. Fasting serum CRP levels were determined using the Behring BN100 and the N high-sensitivity CRP reagents (Dade-Behring, Mississauga, Ontario, Canada). Serum total cholesterol (TC) was measured by the cholesterol oxidation method, triglyceride (TG) levels by the GPO-PAP method, and after precipitation of sera with phosphotungstic acid, HDL cholesterol (HDL-C) levels were measured by the supernatant cholesterol oxidation method, all of which were performed with Randox kits on an Olympus AU 2700 analyzer (Olympus, Japan). Serum LDL-cholesterol (LDL-C) levels were calculated with the Friedewald Formula.

Assessment of 12-lead ECG

A 12-lead surface ECG was obtained for all participants in the supine position after a rest period of 10 minutes. Two consecutive cycles were recorded at a speed of 50 mm/sec and with an amplitude of 10mm/mV. All ECGs were analyzed by a designated cardiologist blinded to patient details. To improve accuracy, measurements were made using calipers and magnifying lens. Only participants with normal sinus rhythm on ECG were included in the final analysis. The onset of the P-wave was defined as the junction between the isoelectric line and the beginning of the P-wave deflection. The offset of the P-wave was defined as the junction between the end of the P-wave and isoelectric line. P-wave duration was defined as the time measured from the onset to the offset of the P-wave. The Pmax and the Pmin were measured in all 12-lead surface ECGs, although leads in which the onset and offset of the P-wave were indiscernible were excluded. The PWD was defined as the difference between the Pmax and the Pmin. Intra-observer variability was found to be 4.3% for Pmax, and 4.2% for PWD.

Echocardiographic analysis

Two-dimensional echocardiography was performed on all participants by an experience cardiologist using a 2.5 MHz transducer on a Vivid 7, GE-Vingmed (Vingmed Ultrasound AS, Horten, Norway) ultrasound device. Subjects were examined in the left lateral decubitus position after a standard period of rest. Parasternal long and short axis as well as apical two and four-chamber views were obtained. The maximal diameter of left atrium was measured as the distance between the leading edge of the posterior aortic wall and the leading edge of the posterior wall of the left atrium at end-systole. Internal dimensions of the left ventricle (LV) were measure at end-diastole (LVDD) and end-systole (LVSD), whereas end-diastolic wall thicknesses was measured by M-mode echocardiography as recommended by the American Society of Echocardiography (13). Recorded echocardiographic findings were reviewed by an independent physician who was blinded to patient details.

Assessment of carotid intima-media thickness

Measurements of CIMT were made by a previously designated and experienced radiologist who was blinded to patient histories and results of laboratory assays. Evaluations were performed on high resolution ultrasound images obtained using a Logic 3 system (GE Medical Systems, Milwaukee, WI) with a 11 MHz transducer. Each patient was placed in the supine position with his/her neck extended and the neck turned opposite to the side to be evaluated. After examination of transverse and longitudinal planes of the carotid arteries, CIMT measurements were performed at 2 points, 1 cm proximal and 1 cm distal to the dilated carotid bulb dilatation, and the average of the two measurements was recorded as the CIMT. Plaque thickness was not taken into consideration when determining mean CIMT. Gray-scale measurements were obtained for CIMT, with the first echogenic layer of the vessel wall adjoining the lumen identified as the intima and the next weakly echogenic layer representing the media. The presence of a plaque, whether calcified or not, was accepted as a local inward increase in CIMT towards the lumen of the blood vessel. The average of 10 measurements (5 measurements from the right and 5 from the left common carotid artery) was recorded as the final CIMT for each subject (14). Intra-observer variation was found to be 5%.

Statistical analysis

Data analysis was performed by using SPSS for Windows, version 13.0 (SPSS Inc., Chicago, IL, USA). Whether the distributions of continuous variables were normal or not was determined by using Shapiro-Wilk test. Continuous variables are shown as mean±standard deviation. While, the normally distributed data were compared by Student's t-test, otherwise, Mann-Whitney U test was applied for not normally distributed parameters. Nominal data were analyzed by Pearson Chi-square test. The degrees of associations between continuous variables were calculated by Pearson's "r" correlation coefficient. Multiple linear regression analysis was used in order to analyze the combined effects of variables, which were considered to be effective on PWD as a result of univariate statistical analyses, or risk factors, which were considered to affect of PWD value in terms of clinical aspects. Following variables included in the model: dependent variable (PWD) and independent variables (BMI, WC,

WHR, LAD, HOMA-IR, hsCRP and CIMT). Coefficient of regression and 95% confidence intervals for each variable were also calculated. A p value less than 0.05 was considered statistically significant.

Results

General features of study groups

Of all the patients screened, 44 obese premenopausal female subjects and 30 healthy controls with normal weight, who fulfilled all the criteria, were included in the final analysis. The demographic and clinical features of the participants are summarized in Table 1. There was no difference between obese patients and healthy controls with regard to age, systolic and diastolic blood pressures, fasting blood glucose, TC, LDL-C, HDL-C and TG. Obese patients had significantly higher ($p<0.05$ for all) values for BMI, WC, WHR, fasting insulin, HOMA-IR, hsCRP levels and CIMT compared to healthy controls.

Electrocardiographic and echocardiographic parameters

Results of P-wave measurements are summarized in Table 2. The obese group had significantly higher values for PWD as well as for P max ($p<0.05$ for all). However, the difference between groups in terms of P min was statistically insignificant (Table 2).

Similarly, values for LAD, LVDD, LVSD, interventricular septum thickness (IVST) and left ventricular posterior wall thickness (LVPWT) were significantly higher in obese patients than their healthy counterparts ($p<0.05$ for all) (Table 3).

Results of correlation analyses on obese participants revealed the presence of a positive correlation between PWD and each of insulin, HOMA-IR, systolic blood pressure, diastolic blood pressure, hsCRP, CIMT, LAD, waist circumference, waist to hip ratio and BMI ($p<0.05$ for all) (Table 4).

All of the variables in Table 4 (BMI, WC, WHR, LAD, HOMA-IR, hsCRP and CIMT) were included in a multiple regression analysis model as independent variables to determine which of the factors was mostly responsible for the change in PWD. The only significant association that was observed, after adjustments for confounding risk factors, was between LAD and PWD ($\beta=4.290$, 95% CI:1.870-9.720, $p=0.032$) (Table 5).

Discussion

In this study, we managed to demonstrate significantly longer PWD in obese premenopausal women compared to their non-obese counterparts. Correlation analyses also revealed the presence of a significant correlation between PWD and each of abdominal obesity (waist circumference, waist to hip ratio), BMI, subclinical inflammation and atherosclerosis (hsCRP, CIMT) and LAD. Linear regression analyses only showed a significant association between LAD and PWD.

Recent studies have shown obesity to be an important modifiable risk factor for AF, as well as being associated with

Table 1. Clinical and laboratory features of study population

Variables	Obese (n=44)	Control (n=30)	p*
Age, years	43.3±7.6	42.0±3.8	0.126
BMI, kg/m^2	42.65±8.27	22.05±2.09	<0.001
WC, cm	117.0±15.0	79.7±3.5	<0.001
WHR	0.86±0.06	0.76±0.02	<0.001
SBP, mmHg	120.7±12.0	116.3±12.0	0.170
DBP, mmHg	76.5±6.9	74.0±5.5	0.264
FBG, mg/dl	86.4±9.5	80.3±8.5	0.151
FI, µU/ml	15.3±8.6 (2.5-52.5)	6.4±4.4 (1.3-20.0)	<0.001
HOMA-IR	3.4±2.2 (0.5-12.4)	1.3±0.9 (0.2-4.0)	<0.001
hsCRP, mg/dl	4.9±3.0 (0.2-10.2)	1.5±1.4 (0.07-4.80)	<0.001
TC, mg/dl	180.5±33.7	171.0±33.3	0.783
LDL-C, mg/dl	116.8±31.1	104.4±27.9	0.394
HDL-C, mg/dl	43.3±9.4	49.0±14.3	0.654
TG, mg/dl	112.4±46.2	102.7±54.4	0.751

Data are presented as mean±standard deviation
Student's t-test, Mann-Whitney U test
BMI - body mass index, DBP - diastolic blood pressure, FBG - fasting blood glucose, FI - fasting insulin, HDL-C - high-density lipoprotein cholesterol, HOMA-IR - homeostasis model assessment for insulin resistance, hsCRP - high sensitive c-reactive protein, LDL-C - low-density lipoprotein cholesterol, NS - not significant, SBP - systolic blood pressure, TC - total cholesterol, TG - triglyceride, WC - waist circumference, WHR - waist-to-hip ratio

Table 2. Comparison of electrocardiographic parameters of obese subjects and healthy controls

Variables	Obese (n=44)	Control (n=30)	p*
HR, bpm	81.8±12.2 (59-112)	78.6±9.0 (59-92)	0.145
P max, ms	105.2±14.3 (80-120)	89.0±13.3 (60-120)	<0.001
P min, ms	63.4±11.9 (40-80)	60.5±9.9 (40-80)	0.109
PWD, ms	41.8±11.8 (20-40)	28.5±9.3 (20-50)	<0.001

Data are presented as mean±standard deviation and median (interquartile range)
Student's t-test, Mann-Whitney U test
bpm - beats per minute, HR - heart rate, NS - not significant, ms - milliseconds, Pmax - maximum P-wave duration, Pmin - minimum P-wave duration, PWD - P-wave dispersion

Table 3. Comparison of echocardiographic parameters and indicators of subclinical atherosclerosis in obese subjects and healthy controls

Variables	Obese (n=44)	Control (n=30)	p*
CIMT, mm	0.60±0.09 (0.5-0.8)	0.51±0.07 (0.40-0.73)	<0.001
LAD, cm	3.8±0.3 (3.3-4.2)	2.8±0.3 (2.3-3.3)	<0.001
LVDD, cm	4.39±0.49 (3.7-5.2)	3.99±0.34 (3.1-4.5)	<0.001
LVSD, cm	2.87±0.40 (2.2-3.5)	2.41±0.29 (1.7-2.9)	<0.001
LVEF, %	63.61±4.86 (56-74)	66.90±6.67 (56-78)	0.617
IVST, cm	1.07±0.20 (0.7-1.4)	0.85±0.12 (0.7-1.1)	<0.001
LVPWT, cm	1.10±0.22 (0.8-1.6)	0.87±0.08 (0.8-1.1)	<0.001

Data are presented as mean±standard deviation and median (interquartile range)
Mann-Whitney U test
CIMT - carotid intima-media thickness, IVST - interventricular septum thickness, LAD - left atrial diameter, LVDD - left ventricular diastolic diameter, LVEF - left ventricular ejection fraction, LVSD - left ventricular systolic diameter, LVPWT - left ventricular posterior wall thickness, NS - not significant

Table 4. Results of correlation analyses for clinical and echocardiographic parameters thought to be associated with P-wave dispersion in obese subjects

Variable	P-wave dispersion, ms	
	r	P[a]
BMI, kg/m^2	0.583	<0.001
WC, cm	0.506	<0.001
WHR	0.275	0.028
SBP, mmHg	0.287	0.021
DBP, mmHg	0.263	0.036
LAD, cm	0.360	0.030
FI, µU/ml	0.269	0.031
HOMA-IR	0.252	0.045
hsCRP, mg/dl	0.346	0.024
CIMT, mm	0.600	<0.001

[a]Spearman correlation analysis
BMI - body mass index, CIMT - carotid intima-media thickness, DBP - diastolic blood pressure, IVST - interventricular septum thickness, LAD - left atrial diameter, LVDD - left ventricular diastolic diameter, LVEF - left ventricular ejection fraction, LVPWT - left ventricular posterior wall thickness, LVSD- left ventricular systolic diameter, SBP - systolic blood pressure, WC - waist circumference, WHR - waist-to-hip ratio

Table 5. Results of multiple linear regression analyses on independent variables though to be associated with PWD in obese subjects

Variables	β (95% CI)	p*
WC, cm	-0.234 (-0.840 to 0.583)	0.638
WHR	0.348 (0.091 to 1.224)	0.602
BMI, kg/m^2	0.386 (0.082 to 1.820)	0.853
HOMA-IR	-1.169 (-2.122 to -0.126)	0.487
LAD, cm	3.290 (1.870 to 9.720)	0.032
hsCRP, mg/dl	2.087 (0.906 to 4.966)	0.357
CIMT, mm	1.419 (0.365 to 4.683)	0.482

Multiple regression analysis: Beta - regression coefficient, CI - confidence interval
Dependent variable P-wave dispersion
Independent variables included in this model are: BMI - body mass index, CIMT - carotid intima-media thickness, HOMA-IR - homeostasis model assessment-insulin resistance index, hsCRP-high -sensitive C - reactive protein, LAD - left atrial diameter, WC - waist circumference, WHR - waist to hip ratio

PWD (2, 15). Significant decreases in max. P-wave duration and PWD after weight loss were reported in earlier studies on obese subjects (16, 17). The exact mechanism behind PWD prolongation in morbidly obese patients remains unknown, although several hypotheses have been postulated. Left atrial enlargement is a well-documented indicator for the development of AF (5), and several changes such as elevated plasma volume, ventricular diastolic dysfunction, and enhanced neurohormonal activation accompany obesity have been implicated as contributory factors for the development of LAD and electrical instability (18, 19). Abnormalities in autonomic control of the heart in obese subjects occur primarily as a result of a shift in autonomic balance, with a predominance of the sympathetic limb over the parasympathetic limb. This imbalance may affect intra-atrial and inter-atrial conduction times, and the ensuing autonomic dysfunction may enhance atrial arrhythmogenicity in obese individuals (20). Our findings regarding the higher LAD values in our group of obese patients compared to age-matched healthy controls with normal weight are consistent with results of previous studies (2, 21, 22).

On another note, numerous studies have reported on elevations in serum levels of hsCRP in association with AF (7, 23). In the Rotterdam study, subclinical atherosclerosis in patients who do not manifest atherosclerotic disease was found to be an independent risk factor for AF (24). In our study, on the other hand, we managed to demonstrate a positive correlation between PWD and each of BMI, waist circumference, waist to hip ratio, hsCRP and CIMT, findings which are highly suggestive of a role for abdominal obesity, subclinical inflammation and atherosclerosis in the pathogenesis of atrial arrhythmias. Adipose tissue serves as an endocrine organ, secreting a host of inflammatory cytokines including interleukin-6 (IL-6), which stimulates hepatic production of CRP. Indeed, measures of obesity are among the strongest correlates of CRP levels, and the close relationship between inflammation and abdominal obesity. Results of previous cross-sectional studies point to the presence of strong associations between markers of inflammation such as IL-6 and tumor necrosis factor-α and indicators of central obesity other than BMI, including abdominal girth or visceral fat area (25-27). In another study, as stronger correlation between abdominal obesity and serum CRP levels was observed in women in comparison to men (28). In a study published in 2009 on healthy non-obese individuals, investigators reported on a relationship between waist-to-hip ratio and hsCRP levels, which was independent of age and BMI (29).

Elevations in circulating levels of inflammatory markers in obese patients increase the likelihood of their binding to ligands in the atrial myocardium thus leading to activation of the complement system (30). Data from recent studies suggests that adiposity may have a direct influence on myocardial structure, perhaps via increased oxidative stress or lipoapoptosis (31, 32). Subclinical atherosclerosis may also be responsible for decreasing blood supply to the sinus node and the atrial tissue (33). Local atrial complement activation, oxidative stress and reduced blood flow then all contribute to the development of tissue injury and fibrosis resulting atrial remodeling (34). The ensuing loss of atrial myocardial mass as well as the manifestation of structural heterogeneity of the atrial myocardium may account for the intra-atrial conduction disturbances and dispersion of the atrial refractory period providing the electrophysiological substrate for the development of AF (35).

Study limitations

One of the main limitations of our study is the small sample size of our study population. Another limitation may be the fact that ECG measurements were performed manually using an x10 magnifying lens instead of with the aid of a computer program.

Conclusion

With this study, we managed to demonstrate higher PWD values in obese patients while also establishing a positive correlation between PWD and several variables such as hsCRP, CIMT and abdominal obesity. However, there was significant association between only LAD and PWD. Of course, there is a need for more comprehensive large-scale studies to help establish the exact association between subclinical atherosclerosis/inflammation and PWD, as well as to help elucidate the pathogenic mechanisms behind PWD in obese patients.

Conflict of interest: None declared.

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DÜZELTME
ERRATUM

Düzeltme: "Diagnostic importance of aVR derivation in exercise stress testing for interpreting of multivessel and proximal LAD disease-Çok damar ve proksimal LAD lezyonlarının tanınması için yapılan egzersiz stres testinde aVR derivasyonunun tanısal önemi"
Anadolu Kardiyoloji Dergisi, 2011, Cilt 11, Sayı 8, sayfa 749-50
Hatem Arı, Yusuf Alihanoğlu, Mehtap Arı, Mehmet Tokaç

Yukarıdaki makalenin Türkçe başlığı aşağıdaki gibidir.
Egzersiz stres testinde aVR derivasyonunun çok damar ve LAD proksimal lezyonu için diyagnostik önemi

Erratum to: "Diagnostic importance of aVR derivation in exercise stress testing for interpreting of multivessel and proximal LAD disease-Çok damar ve proksimal LAD lezyonlarının tanınması için yapılan egzersiz stres testinde aVR derivasyonunun tanısal önemi"
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In the above article's Turkish title should appear as follows:
Egzersiz stres testinde aVR derivasyonunun çok damar ve LAD proksimal lezyonu için diyagnostik önemi