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The Relationship Between Coronary Collateral Circulation and Visceral Fat

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Abstract

Objectives: Collateral circulation is assumed to prevent myocardial ischemia in healthy subjects and in patients with coronary artery disease. Visceral adipose tissue is an active component of total body fat, which holds some biochemical characteristics that have impact on several normal and pathological processes in the human body. In this study, we investigated the relationship between visceral fat ratio and coronary collateral circulation (CCC).

Materials and Methods: Totally 148 patients with stable angina pectoris were recruited to the study and all patients' heights and weights were recorded after the coronary angiography. The study subjects were divided into two groups as those between 1 and 9, and those >10 by classifying their visceral fat ratio with bioelectrical impedance analysis method. Patients were classified as poor CCC group (grade 0 and 1) and good CCC group (grade 2 and 3) based on the Rentrop's classification of CCC.

Results: In the analysis in accordance with collateral classification, visceral fat percentage (13.7±4.7 versus 10.1±4.0, p=0.01) and body mass index (28.2±2.4 versus 27.3±2.3, p=0.040) were found significantly higher in the poor collateral group. Diabetes mellitus was significantly higher in patient with high visceral fat ratio. In multivariate logistic regression analysis for collateral growth, visceral fat percentage [odds ratio (OR): 0.740, %95 confidence interval (CI): 0.602-

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Abstract

0.909, p=0.040] and coronary stenosis percentage (OR: 1.220, %95 CI: 1.070-1.390, p=0.003) were found meaningful, independent from the other factors. In ROC analysis, increase in visceral fat level decreased collateral growth with 72.7% sensitivity and 58.5% specificity.

Conclusion: The increase in visceral fat seems an independent factor for poor collateral development.

Keywords: Coronary artery disease, collateral vessel, visceral fat, coronary artery disease risk factor

Introduction

Coronary artery disease (CAD) is a progressive, systemic and inflammatory disease with atherosclerosis in its etiology[1]. Coronary collateral circulation (CCC) is defined as vascular structures those present non-functional in the normal heart, becomes activated upon a serious stenosis or complete obstruction, disrupts blood circulation as an adapting response between the sections of the same coronary artery or different coronary arteries in order to provide blood flow into the ischemic myocardial area[2]. Collateral circulation is quite crucial since it is a potential alternative source upon any insufficiency in coronary arteries for providing blood circulation. Anti-ischemic effects, reducing myocardial infarction frequency, limiting infarct area, preventing the formation of aneurysms, maintaining ventricular functions, antiarrhythmic effects, and decreasing coronary mortality are the benefits of CCC[3-6]. It is a fact that the status of the collaterals is different even between individuals even with the same level of artery disease[7]. Visceral fat is a unique part of the total body fat and possesses several biochemical functions. Visceral fat is associated with a constellation of various metabolic abnormalities, including insulin resistance, hyperinsulinemia, type 2 diabetes, dyslipidemia, inflammation, and altered cytokine profile. Such metabolic abnormalities may have an effect on the endothelial tissue which is in the cornerstone point of development of new vessels in injured or ischemic tissues.

In our study, we have tried to show the relationship between visceral fat percentage, which is one of the factors considered to be efficient in coronary collateral vessel development, and CCC development.

Materials and Methods

Study Population

Our patients were selected from the cases who applied to our center due to chest pain and were hospitalized in our clinic after receiving coronary angiography indication with stable angina pectoris diagnosis after routine examinations. All patients were informed preceding the study.

Coronary angiography images, which were performed in our cardiology angiography laboratory, were scanned, and post-procedure hospital records were examined for patients with at least 90% and above critical stenosis in at least one of their coronary arteries. Baseline demographic data and laboratory results were obtained from the cases and hospital database system. Echocardiographic examination and electrocardiography were performed in all patients during the hospital stay. Left ventricular ejection fraction was measured using the Modified Simpson Method.

Among 200 patients who were eligible for the study criteria, patients with acute coronary syndrome requiring intervention in the first 72 hours, cancer, hematological disease, hypothyroidism, serious valvular heart disease, decompensated heart failure, severe liver disease, autoimmune disease, chronic kidney disease, inflammatory and infectious disease, corticosteroids or cytotoxic drug use, bedbound patients with a history of bleeding diathesis, patients weighing above 150 kg or

below 40 kg, patients whose height was above 180 cm or below 140 cm, and patients under 18 or over 80 years old were excluded from the study. Our study included 148 patients who were eligible according to inclusion criteria.

Coronary Angiography

By using right and left femoral approach, selective coronary angiography was performed to patients with the Judkins method by using 6F or 7F catheters. Coronary angiography images were evaluated by two experienced cardiologists who had no knowledge on the clinical characteristics and laboratory data of patients. The levels of stenosis in coronary arteries were determined depending on the projection with the highest stenosis. Collateral development was evaluated according to the Rentrop classification. The grades of the evaluation according to the Rentrop classification were as follows: Rentrop grade 0: No collateral fill, Rentrop grade 1: very weak collateral flow, but no filling in epicardial arteries, Rentrop grade 2: Partial filling, presence of contrast material on epicardial arteries but no complete filling, Rentrop grade 3: Complete perfusion, contrast material determined to fill epicardial vessels completely. Rentrop Grades 0 and 1 were evaluated as poorly developed collateral circulation, while Rentrop grades 2 and 3 were evaluated as well-developed collateral circulation[8].

Visceral Fat Percentage, Body Mass Index and Waist Circumference Measurement

Body weight in kilograms and height in centimeters were measured and recorded before the discharge of patients. Body mass index (BMI) was obtained by dividing body weight in kg to the square of the height in meters. Body fat tissue percentage (%) and visceral fat percentage (%) were measured with the Omron HBF-500 Digital Body Analysis Scale that worked with Bioelectrical Impedance Analysis method[9].

Statistical Analysis

All analyses were performed with SPSS version 18.0 (SPSS Inc., Chicago, Illinois, USA). The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to determine whether the distribution of continuous variables fit in normal. Descriptive statistics were expressed as mean ± standard deviation for continuous variables, and case number and (%) for nominal variables. The continuous variables showing normal distribution were compared with the Student's t-test, while continuous variables with no normal distribution were compared by using the Mann-Whitney U test. The chi-square test or Fischer's Exact test were used in the comparison of categorical variables. Statistical significance was assumed for p-value <0.05. The Pearson correlation test was used in the evaluation of the relationship between parameters with normal distribution, while the Spearman's rho correlation test was used to examine the relationship between parameters that did not show normal distribution. Multivariate logistic regression analysis was used for evaluating independent markers on collateral use during analysis. Receiver operating characteristic (ROC) analysis was performed in order to determine the sensitivity and specificity of estimating the negative effect of visceral fat tissue, BMI and increase in waist circumference on coronary collateral development.

Results

A total of 148 patients were included in our study, consisting of 64 females (43.2%) and 84 males (56.8%) aged between 41 and 80 years with the mean age of 62±8.8 years.

From an angiographic aspect, 66 patients were classified in the good collateral group, and 82 patients were in the poor collateral group. Patients with good collaterals and poor collaterals were compared according to their demographic and clinical characteristics (Table 1).

Patients who were included in the study were separated in two groups according to visceral fat percentage. Those with values between 1% and 9% were placed in group 1 while those with values above 10% were placed in group 2. Ninety-three of those had high visceral fat percentage

and remaining 55 patients were determined to have low visceral fat percentage.

Visceral fat percentage level of patients in the poor collateral group varied between 5% and 24%, and the mean visceral fat percentage was determined as 13.7%±4.7%. Meanwhile, visceral fat percentage level of patients in the good collateral group varied between 6% and 20%, and the mean visceral fat percentage was determined as 10.1±4.0%. This difference was determined to be statistically significant (p=0.011).

Laboratory results of the patients are shown in Table 2. The comparison of coronary angiographic and echocardiographic characteristics of the groups is presented in Table 3. Upon analyzing the relationship between the CCC and visceral fat percentage, linkage analyses are shown in Figure 1 according to the distinction of good and poor collateral and Rentrop classification.

A weak negative correlation was determined upon performing correlation analysis between collateral level and visceral fat percentage, and despite being modest, it was found to be statistically significant (r=-0.415, p<0.001). A very weak correlation was found upon performing correlation analysis between collateral development and BMI (r=-0.211, p=0.010) and waist circumference (r=-0.203, p=0.013), and it was also determined to be statistically significant. There was a very weak correlation between collateral development and diabetes mellitus (DM) and it was found to be statistically significant (r=0.184, p=0.025). There was also a moderately positive but statistically significant correlation between stenosis percentage and collateral development (r=0.548, p<0.001).

The patients included in the study were divided into two groups: those with visceral fat ratio between 1 and 9 and those above 10. In 93 of these, visceral fat ratio was above 10 (high), and in the remaining 55 patients, it was observed between 1 and 9 (low). 52.7% of patients with low visceral fat ratio were male, and 59.1% of those with high ratio were male. However, no statistically significant difference was found (p=0.447). The mean age of the patients with low visceral fat ratio was 63.5±9.6 years,

Table 1. Demographic and clinical characteristics of patients

Demographic and clinical characteristics		Poor collateral (n=82)	Good collateral (n=66)	p
Age, years		61.2±9.3	63.0±8.2	0.233
Gender, (%)	**Male**	43 (52.4%)	41 (62.1%)	0.237
	Female	39 (47.6%)	25 (37.9%)	
BMI, (kg/m²)		28.2±2.4	27.3±2.3	**0.040**
Waist circumference, (cm)		98.9±8.4	96.4±8.8	0.081
Visceral fat	**Between 1-9**	23 (28.0%)	32 (48.5%)	**0.011**
	10 and above	59 (72.0%)	34 (51.5%)	
HT, s (%)		53 (64.6%)	39 (59.1%)	0.489
DM, s (%)		33 (40.2%)	18 (27.3%)	0.099
Dyslipidemia, s (%)		62 (75.6%)	47 (71.2%)	0.546
Smoking, s (%)		33 (40.2%)	21 (31.8%)	0,290
Family history, s (%)		26 (31.7%)	19 (28.8%)	0.701
Antiplatelet agents, s (%)		50 (36.1%)	36 (54.5%)	0.431
Beta blockers, s (%)		49 (59.8%)	37 (56.1%)	0.651
ACE inh/ARB, s (%)		43 (52.4%)	28 (42.4%)	0.225
Statin, s (%)		30 (36.6%)	27 (40.9%)	0.591

BMI: Body mass index, HT: Hypertension, DM: Diabetes mellitus, ACE inh: Angiotensin converting enzyme inhibitors, ARB: Angiotensin receptor blockers, n: Number
Important p-values shown as bold

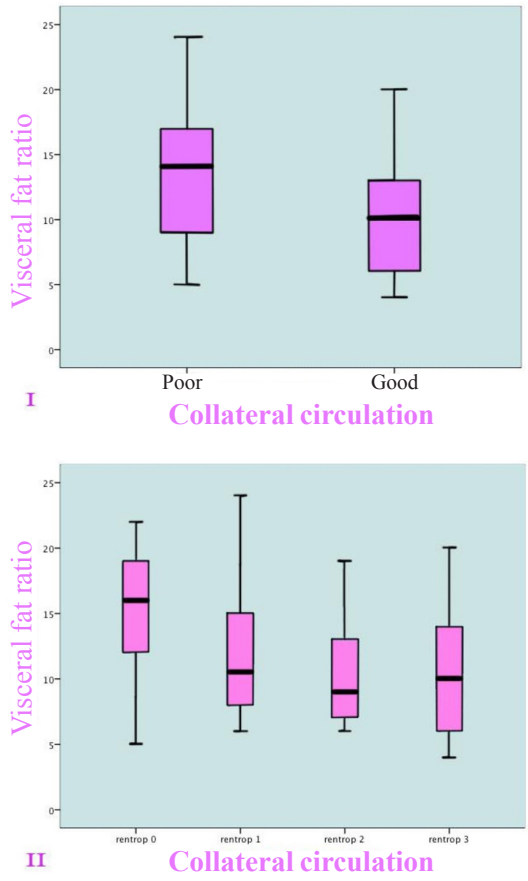

Figure 1. Linkage analyses between coronary collateral circulation and visceral fat percentage: (I) According to the distinction of good and poor collateral, (II) According to Rentrop classification

and the ratio was 61.1±8.2 in those with high ratio. There was no statistically significant relationship (p=0.108). We compared visceral fat ratio with each of the cardiovascular risk factors. Those with high visceral fat were found to be higher than those with low visceral fat; DM (40 vs 11 patients, p=0.004), hypertension (HT) (61 vs 33 patients, p=0.495), dyslipidemia (71 vs 38 patients, p=0.333), smoking (35 vs 19 patient, p=0.706), family history of CAD (31 vs 14 patients, p=0.314). However, except DM, there was no statistically significant difference (Table 4).

Visceral fat ratio was found to be significantly higher in those with higher BMI and waist circumference (p<0.001). The mean BMI was found to be 26.0±1.7 in those with low visceral fat, while it was found to be 28.8±2.2 in those with high visceral fat. Waist circumference was 92.6±7.6 in those with low visceral fat, while it was 100±7.7 in those with high visceral fat. In addition, In laboratory parameters compared with low and high visceral fats, respectively, triglyceride (170±82.9 vs 201±92.3, p=0.042) and cholesterol (179±42.6 vs 195±47.9, p=0.037, respectively) were higher. This was statistically significant (Table 4).

Very weak negative and positive correlations were determined in the correlation analysis of other parameters that might affect collateral development, and no statistically significant difference was determined between the groups

Table 2. Laboratory results of study groups

Laboratory results	Poor collateral (n=82)	Good collateral (n=66)	p
WBC, (x10³ µL)	8.6±1.4	8.2±1.9	0.139
Neutrophil	5.3±1.5	4.7±1.6	**0.016**
Lymphocyte	2.2±0.69	2.0±0.71	0.044
Hemoglobin, g/dL	13.6±1.7	13.8±1.7	0.465
MCV	84.2±4.4	85.4±4.7	0.110
Platelet (x10³ µL)	280±85.0	262±61.5	0.147
Glucose, mg/dL	153±55.5	142±51.6	0.215
Creatinine, mg/dL	0.89±0.2	0.90±0.19	0.798
LDL, mg/dL	112.3±40.7	109.8±35.0	0.693
HDL, mg/dL	40.5±7.2	40.4±8.8	0.989
Triglycerides, mg/dL	200±95.7	175±80.6	0.091

WBC: White blood cells, MCV: Mean corpuscular volume, LDL: Low-density lipoprotein, HDL: High-density lipoprotein, n: Number
Important p-values shown as bold

(Table 5). In the correlation between and cardiovascular risk factors, a statistically significant positive correlation was determined between visceral fat percentage and DM (r=0.314, p<0.001).

A high positive correlation with BMI (r=0.704, p<0.001) and a moderate positive correlation with waist circumference (r=0.592, p<0.001) were determined upon performing correlation between BMI and waist circumference and visceral fat percentage, and they were determined to be statistically significant.

In the correlation between triglyceride and cholesterol levels and visceral fat percentage, a statistically significant

Table 3. Coronary angiographic and echocardiographic characteristics of groups

		Poor collateral (n=82)	Good collateral (n=66)	p
Critical coronary vessel	LAD	38 (46.3%)	29 (43.9%)	0.360
	Cx	21 (25.6%)	12 (18.5%)	
	RCA	23 (28.0%)	25 (37.9%)	
Rentrop collateral grade	Rentrop 0	46 (56.1%)	0	-
	Rentrop 1	36 (43.9%)	0	
	Rentrop 2	0	25 (37.9%)	
	Rentrop 3	0	41 (62.1%)	
Stenosis percentage, (%)		93.5±4.4	97.1±4.3	0.033
Lesion location	Proximal	33 (40.2%)	35 (53%)	0.121
	Distal	49 (59.8%)	31 (47%)	
LVEF, (%)		54.1±9.6	54.7±7.6	0.675

LAD: Left anterior descending artery, Cx: Circumflex, RCA: Right coronary artery, LVEF: Left ventricular ejection fraction, n: Number

Table 4. The comparison of visceral fat percentage and clinical and demographic characteristics

Visceral fat		Between 1 and 9 (n=55)	10 and above (n=93)	p
Age, years		63.5 ± 9.6	61.1 ± 8.2	0.108
Gender, (%)	Male	29 (52.7%)	55 (59.1%)	0.447
	Female	26 (47.3%)	38 (40.9%)	
BMI, (kg/m²)		26.0 ± 1,7	28.8 ± 2,2	**<0.001**
Waist circumference, (cm)		92.6 ± 7.6	100 ± 7.7	**<0.001**
HT, (%)		33 (60%)	61 (65.6%)	0.495
DM, (%)		11 (20%)	40 (43%)	**0.040**
Dyslipidemia, (%)		38 (69.1%)	71 (76.3%	0,333
Smoking, (%)		19 (34.5%)	35 (37.6%)	0,706
History of CAD, (%)		31 (56.4%)	61 (65.6%)	0.263
Family history, (%)		14 (25.5%)	31 (33.3%)	0.314
Triglycerides, mg/dL		170 ± 82.9	201 ± 92.3	**0.042**
Cholesterol, mg/dL		179 ± 42.6	195 ± 47.9	**0.037**
HDL, mg/dL		41.7± 9.5	39.7 ± 6,8	0.131
LDL, mg/dL		103.8 ± 34.4	115 ± 36.9	**0,038**

BMI: Body mass index, HT: Hypertension, DM: Diabetes mellitus, CAD: Coronary artery diseases, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, n: Number
Important p-values shown as bold

Table 5. Correlation analysis for collateral development

	r	p
Age, years	0.097	0.242
Gender	0.146	0.077
Visceral fat	**-0.415**	**<0.001**
BMI	-0.211	**0,010**
Waist circumference (cm)	-0.203	**0.013**
Stenosis percentage	0.548	**<0.001**
Lesion location	-0.096	0.244
Number of critical vessels	-0.136	0.100
HT, (%)	-0.098	0.234
DM, (%)	-0.184	**0.025**
CAD	-0.094	0.255
Family history, (%)	-0.029	0.726
Smoking	-0.127	0.124
Dyslipidemia, (%)	-0.053	0.522
Neutrophil	-0.150	0.070
Lymphocyte	-0.157	0.056
Platelet, (x10³ µL)	-0.106	0.200
Glucose, mg/dL	-0.159	0.053
CRP	-0.154	0.122
Triglycerides, mg/dL	-0.144	0.080
Cholesterol, mg/dL	-0.113	0.172
LDL, mg/dL	-0.028	0.735

BMI: Body mass index, HT: Hypertension, DM: Diabetes mellitus, CAD: Coronary artery diseases, CRP: C-reactive protein, LDL: Low-density lipoprotein, n: Number
Important p-values shown as bold

Table 6. Correlation analysis about visceral fat level

	r	p
Age, years	0.143	0.082
Gender	0.019	0.821
Collateral circulation	-0.415	**<0.001**
BMI	0.704	**<0.001**
Waist circumference, (cm)	0.592	**<0.001**
HT, (%)	0.106	0.199
CAD	0.106	0.198
DM, (%)	0.314	**<0.001**
Smoking	0.131	0.111
Family history, (%)	0.060	0.470
Triglycerides, mg/dL	0.168	**0.041**
Cholesterol, mg/dL	0.216	**0.008**
LDL, mg/dL	0.184	**0.025**

BMI: Body mass index, HT: Hypertension, DM: Diabetes mellitus, CAD: Coronary artery diseases, CRP: C-reactive protein, LDL: Low-density lipoprotein
Important p-values shown as bold

weak positive correlation was determined with triglyceride (r=0.168, p=0.041), cholesterol (r=0.216, p=0.008) and low-density lipoprotein (r=0.184, p=0.025) levels. Although a very weak positive correlation was determined in the correlation analysis between other cardiac risk factors and visceral fat percentage level, these correlations were not statistically significant (Table 6).

In the multivariate logistic regression analysis performed to determine the factors affecting collateral development, visceral fat tissue and coronary stenosis percentage were determined to be statistically significant independent factors among the variables. Accordingly, it was determined that the increase in coronary stenosis percentage and the decrease in visceral fat percentage were independent predictors of good collateral artery development (Table 7).

Collateral development and visceral fat percentage, BMI, and waist circumference were compared in the ROC analysis of data. There was a statistically significant negative correlation between visceral fat level, BMI and collateral development. With 72.7% sensitivity and 58.5% specificity, a decrease was predicted in collateral

Table 7. Evaluation of the predictors of collateral development with multivariate logistic regression analysis

Parameter	OR	95% CI	p
Age, years	0.948	0.874-1.028	0.948
Gender	0.851	0.203-3.560	0.851
Visceral fat	0.740	0.602-0.909	**0.040**
BMI, (kg/m²)	0.989	0.631-1.549	0.960
Waist circumference, (cm)	1.040	0.941-1.153	0.430
HT, (%)	0.380	0.099-1.454	0.158
DM, (%)	0.344	0.048-2.460	0.289
Dyslipidemia, (%)	0.308	0.048-1.976	0.214
Smoking, (%)	0.440	0.127-1.530	0.197
Family history, (%)	3.716	0.798-1730	0.094
Stenosis percentage	1.220	1.070-1.390	**0.003**
Lesion location	0.409	0.116-1.437	0.163
Statin, (%)	0.450	0.116-1.749	0,249
Glucose, mg/dL	0.994	0.976-1.012	0.494
Creatinine, mg/dL	2.540	0.107-6020	0.564
CRP	0.620	0.336-1.114	0.126
Triglycerides, mg/dL	0.993	0.975-1.011	0.450
Cholesterol, mg/dL	1.016	0.937-1.101	0.699

OR: Odds ratio, CI: Confidence interval, BMI: Body mass index, HT: Hypertension, DM: Diabetes mellitus, CRP: C-reactive protein
Important p-values shown as bold

Table 8. ROC analysis

	AUC	95% CI	Cut-off	Sensitivity	Specificity	p
Visceral fat	720	638-801	125	72.7%	58.5%	<0.001
BMI, (kg/m²)	600	508-692	28.3	72.7%	51.2%	0.370
Waist circumference, (cm)	587	495-679	101.5	66.7%	47.6%	0.690

ROC: Receiver operating characteristic curve, BMI: Body mass index, AUC: Area under the curve, CI: Confidence interval
Important p-values shown as bold

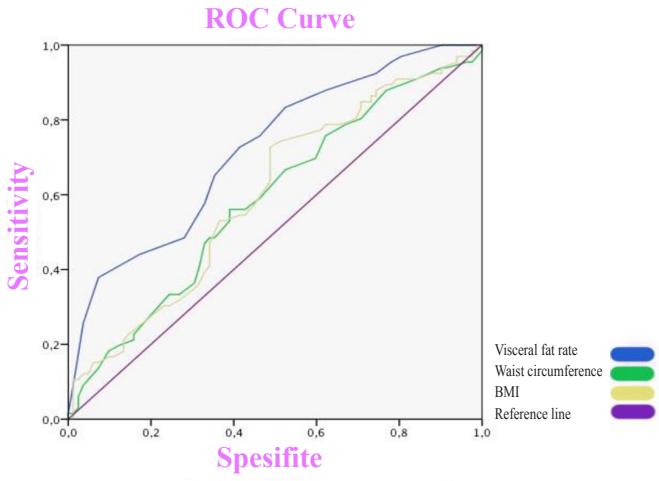

Figure 2. ROC analysis, comparison of the relation between collateral development and visceral fat percentage, BMI (body mass index), waist circumference with ROC analysis

ROC: Receiver operating characteristic

development at 12.5 cut-off level for visceral fat percentage (Table 8, Figure 2).

Discussion

It is considered that the development of coronary collateral vessels in human heart is processed through the combined development of two different types of adaptation mechanisms, angiogenesis and arteriogenesis[10]. Endothelial functions are known to have a crucial role in the maturation process of collateral vessels[11,12]. The interpersonal difference in collateral development level is suggested to be caused by endothelial dysfunction. Fat tissues do not only store fatty acids, they also play a central role in glucose and lipid metabolism. Numerous hormones such as tumor necrosis factor alpha (TNF-α), interleukin-6 (IL-6), adiponectin and leptin are produced in adipose tissue and increase in adipose tissue mass directly increases systemic inflammation[13]. In the current study population, visceral fat percentage was significantly higher in the poor collateral group compared to the good collateral group (p=0.011). A significant negative relation was determined between visceral fat percentage and Rentrop flow upon separating the patients into sub-groups according to the Rentrop classification (p=0.003). High visceral fat percentage was determined to be a negative predictor for coronary collateral development in logistic regression analysis. In our study, we showed that the increase in visceral fat percentage was an independent factor in terms of poor collateral development. Regarding other cardiovascular risk factors, apart from visceral fat tissue, there is no significant difference between the subjects with good and poor collateral development.

Among cardiovascular risk factors, diabetes, HT, hyperlipidemia, smoking and family history of CAD were observed to be more common in the group with high visceral fat percentage; however, no statistically significant difference was determined in the risk factors other than diabetes. The frequency of other factors was more prominent in the group with high visceral fat percentage, albeit not statistically significant.

The measurement of waist circumference reveals abdominal obesity[14]. However, it does not distinguish visceral fat from subcutaneous fat tissue. The reason for that is visceral fat tissue is not affected from skin and muscle layers as in waist circumference measurement. We determined higher waist circumference and BMI in people with high visceral fat percentage (p<0.001). Although a positive correlation was determined between visceral fat percentage with waist circumference and BMI, visceral fat percentage was determined to be a determinant on collateral development with higher sensitivity and specificity compared to other factors. Although a statistically significant negative correlation was determined between collateral development and visceral fat percentage and BMI, no statistically significant difference was determined between those and waist circumference despite a negative correlation. Accordingly, it was determined that the effect of visceral fat tissue on coronary collateral development was stronger compared to BMI and waist circumference.

There is a positive correlation between body mass and peripheral leukocyte count. It was shown in a high number of studies that inflammatory proteins in circulation (CRP, IL-6, PAI-1, P-selectin, vascular cell adhesion molecule-1,

fibrinogen, angiotensinogen, SAA3) are increased with an increase in body mass[15].

Coronary collaterals are potential vascular structures presenting in normal heart and emerge in the presence of serious CAD and work for the protection of myocardial vitality. It is well-known that the presence of collateral vessels and increased collateral circulation level are associated with left ventricular function status[16,17]. Studies have demonstrated that collateral circulation reduces myocardial ischemia, decreases infarct area, positively increases left ventricular function, decreases ventricular aneurysm formation, and most importantly, increases survival[18,19]. However, left ventricular systolic functions were statistically similar between the groups of good and poor collateral development in our analysis. This difference may be determined more accurately in studies of patient follow-up after discharge.

While collateral vessel development is formed as a response to severe coronary stenosis, the factors that affect collateral development level in the presence of severe CAD may not be clearly determined[20]. Stenosis in the artery providing the collateral flow (donor artery) is another important factor in collateral vessel development. It has been indicated that stenosis rate should be ≥90% and collateral vessel diameter should be above 100 μm for angiographic imaging[21]. Arteriogenesis is induced in the result of increased "shear stress" after serious artery obstructions[22]. It is suggested that MCP-1 (monocyte chemotactic protein-1) is effective on this mechanism[10]. While there is maximum shear at the beginning, this is gradually reduced with the increasing diameter of collateral vessels[23]. Assuming that hypertension will play a facilitating role in this mechanism, it can be considered to affect collateral development positively. In the result of some studies investigating the relationship between the presence of coronary collateral in hypertension and left ventricular hypertrophy in CAD, it has been determined that hypertensive patients have better developed collateral, and a positive relationship has been demonstrated between coronary collaterals and left ventricular wall thickness[24,25]. Although studies on humans and animals have shown that epicardial coronary arteries are dilated in hypertrophic ventricle, it is now clear why left ventricular hypertrophy increases CCC; it may be associated with myocardial ischemia. While the hypertension incidence was higher in the poor collateral group compared to the good collateral group in our study, no significant difference was determined between the two groups. We have attributed this result to the fact that HT was under control due to drug therapy in our patients.

In type II DM, in which insulin resistance plays a significant role, deaths are largely associated with cardiovascular diseases[26]. There are various opinions on the effect of DM on collateral development. Abaci et al.[27] have shown that collateral development is weaker in DM due to the fact that endothelial function, which plays a large role in collateral development, is impaired in diabetics. Melidonis et al.[28] have determined higher coronary collateral vessel development rate in diabetics compared to the non-diabetics. Zbinden et al.[29] did not determine a significant difference between the two groups with regard to collateral flow in their study in which they compared patients with or without DM. As in diabetic retinopathy, DM is known to induce angiogenesis but inhibits arteriogenesis[30]. In our study, 51 of 148 patients had diabetes, and DM prevalence was not determined to be statistically significant even though it was higher in the poor collateral group, which might be due to low diabetic case number.

Study Limitations

Although no collateral was observed with angiographic method, the recovery in left ventricular function with revascularization is attributed to the fact that capillary collateral flow that could not be imaged in angiography protects myocardial function in a hibernated manner[10]. Considering that we can detect collaterals above 100 μm, the presence of collateral flow at an angiographically

invisible level may have prevented the development of infarction in some cases with poor collaterals. The use of angiography in the evaluation of collateral flow and this limitation in the collateral evaluation of angiography may have affected the results.

Conclusion

Despite the advancements in treatment modalities, cardiovascular diseases are still the first underlying reason of morbidity and mortality around the world. This study reveals that one of the components of obesity, increased visceral fat percentage, may negatively affect coronary collateral development in metabolic syndrome. In addition, cardiovascular diseases are increased in parallel with the increase in visceral fat tissue. The cardiovascular risk factors and the development of cardiovascular diseases may be prevented with visceral fat percentage follow-up and treatment. For this reason, ensuring weight loss, regular exercise and healthy diet poses utmost importance in these patients.

Ethics

Ethics Committee Approval: Ethics committee approval of our study was obtained from Dicle University Faculty of Medicine Clinical Research Ethics Committee on 25.12.2015 with the decision number 139.

Informed Consent: The study was designed retrospectively. All patients have been informed preceding the study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: A.A., Bu.A, Concept: M.Ö., M.D., Design: R.K., B.A., Data Collection or Processing: A.A., Analysis or Interpretation: A.A., T.G., Literature Search: A.A., Bu.A., Writing: A.A., T.G.

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