https://doi.org/10.4082/kjfm.17.0027 • Korean J Fam Med 2018;39:284-289

KJFM
Korean Journal of Family Medicine

eISSN: 2092-6715

■ Original Article

The Cutoff Pericardial Adipose Tissue Volume Associated with Metabolic Syndrome

Dong Sun Kim[1], Eun Jeong Ok[1], Beom Hee Choi[2], Nam-Seok Joo[1,*]

[1]Department of Family Practice and Community Health, Ajou University School of Medicine, Suwon, Korea
[2]CHA Anti-aging Institute, CHA University, Seoul, Korea

Background: Metabolic syndrome (MS) is a well-known risk factor of cardiovascular diseases that is focused on central obesity. Recent studies have reported the association between pericardial adipose tissue (PAT) volume and MS. However, no studies have demonstrated the cutoff PAT volume that represents the best association with MS.
Methods: The data of 374 subjects were analyzed cross-sectionally to compare PAT, measured on coronary multidetector computed tomography, and various metabolic parameters according to MS. After PAT volumes were divided into tertiles, various metabolic parameters were compared among tertiles; furthermore, the odds ratio for developing MS was calculated. Finally, we demonstrated the cutoff PAT volume that represented the best association with MS by using the receiver-operating characteristic curve.
Results: We found that 27.5% of the subjects had MS, and the mean PAT volume was 123.9 cm^3. PAT showed a significant positive correlation with body mass index, waist circumference, and levels of glucose, triglyceride, high-sensitivity C-reactive protein, uric acid, and homocysteine, but a negative correlation with high-density lipoprotein cholesterol. Furthermore, after dividing into tertiles, PAT volume was also significantly associated with various metabolic parameters. The odds ratio for having MS was 4.19 (95% confidence interval, 2.27–7.74) in the top tertile of PAT volumes after adjusting for age, sex, and smoking. The cutoff PAT volume that represented the best association with MS was 142.2 cm^3.
Conclusion: PAT was significantly associated with MS and various metabolic parameters. The cutoff PAT volume of 142.2 cm^3 showed the best association with MS.

Keywords: Metabolic Syndrome; Adipose Tissue; ROC Curve; Pericardial Fat

Received: March 2, 2017, Revised: August 29, 2017, Accepted: October 12, 2017
*Corresponding Author: **Nam-Seok Joo** https://orcid.org/0000-0001-5895-1800
Tel: +82-31-219-5324, Fax: +82-31-219-5218, E-mail: jchcmc@hanmail.net

INTRODUCTION

Metabolic syndrome (MS) involves multiple medical conditions, including central obesity, high blood pressure, hyperglycemia, hypertriglyceridemia, and low high-density lipoprotein (HDL) level.[1] Therefore, MS threatens human health by increasing the risks of cardiovascular disease (CVD) and diabetes mellitus.[2,3] In Korea, the prevalence of MS is increasing owing to the westernization of eating patterns and physical inactivity.[4,5] To date, the most convincing pathogenesis of MS is the result of increased insulin resistance due to excessive visceral fat accumulation.[6,7]

The pericardial adipose tissue (PAT) is located in the pericardium and is a type of visceral fat that has attracted much attention from many researchers in recent years.[8,9] Several studies on PAT have focused on the relationship between PAT volume and heart disease.[10-12] In addition, some studies have shown that PAT volume is associated not only with CVD but also with metabolic diseases.[13-15] These results indicate that the correlation between PAT volume and MS was studied in multiple areas. One of these studies was the ARIRANG study, which showed that the incidence of MS was significantly increased with increasing PAT thickness in Korean men.[16] However, domestic studies that focus on the relationship between PAT volume and MS are still lacking. Furthermore, no cutoff PAT volume has been reported yet in relation to MS. The purpose of this study was to clarify the association between PAT volume and MS, and to cross-sectionally demonstrate the cutoff PAT volume in relation to MS.

METHODS

1. Subjects and Data Collection

We included the data of 405 subjects with available cardiac computed tomography (CT) scans collected in the Samsung branch office of Chaum Health Promotion Center between 2010 and 2014. We excluded the data of 31 subjects who had CVDs (cardiac arrest, coronary artery disease, ischemic heart disease, stroke, and other definite diseases of cardiovascular origin). We analyzed the data of the remaining 374 subjects. The data included age, height, smoking, metabolic parameters (waist circumference [WC]; blood pressure; levels of cholesterol, glucose, uric acid, high-sensitivity C-reactive protein [hsCRP], and homocysteine; visceral fat area [VFA]), and PAT volume. This study was approved by the Institutional Review Board of Ajou University and Boondang-CHA Hosptial after informed consent (AJIRB-MED-MDB-16-268, CHAMC 2016-10-020).

2. Measurement

1) Definition of metabolic syndrome

MS is defined as a clustering of at least three of the following five metabolic alterations: central obesity, high blood pressure, hyperglycemia, hypertriglyceridemia, and low HDL level. Metabolic alteration, which was included in the criteria for diagnosis of MS, was determined on the basis of the criteria set out in the National Cholesterol Education Program.[17]

2) Body proportion and blood samples

The data included medical history and lifestyle habits, which were obtained using a self-administered questionnaire. In case of females, menopausal status was also documented, which was defined as natural cessation of menstruation for >12 months or cessation of menstruation by hysterectomy. Physical examinations, including body weight, height, and WC, were performed by a trained examiner who followed a standardized procedure (measured in the standing position, without shoes). Blood pressure was also measured after resting for 10 minutes in a sitting position by using an automatic sphygmomanometer. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters. Current smokers were defined as those who had smoked >5 packs of cigarettes during their lifetimes and were currently smoking; past smokers, as those who had smoked in the past but had quit; and non-smokers, as those who had no history of smoking. Blood samples for assessing fasting glucose and lipids, hsCRP, uric acid, and homocysteine levels were drawn from the antecubital area in the morning. Serum samples were stored at 4°C and analyzed within 1 day of sampling. VFA was also measured using Bio Impedance Analysis (Inbody 720; Biospace Ltd., Seoul, Korea).

3) Measurement of pericardial adipose tissue

Epicardial fat was defined as any adipose tissue located within the pericardium; and paracardial fat, as any adipose tissue situated on the external surface of the parietal pericardium. Pericardial fat was defined as epicardial fat plus paracardial fat. For the measurement of PAT, a 128-slice CT scanner (GE Light Speed VCT; GE Imatran, San Francisco, CA, USA) was utilized. The scan parameters were as follows: 25-mm slice thickness, 120-kV tube voltage, and 120-mAs tube current. To define PAT volume, –190 to –30 HU measured using the CT scanner was applied. The superior cutoff point in the axial slices was the bifurcation of the pulmonary artery. Inferiorly, the volume analyzed was segmented up to the intra-abdominal adipose tissue. The anterior border was defined using the anterior chest wall; and the posterior border, by the esophagus and descending aorta. The region of interest containing the heart and surrounding adipose tissue was assessed using manual tracing of the axial images. Measurement of PAT was performed by counting the number of pixels in these areas. Tissue with mean attenuation plus or minus 2 standard deviation (SD)s was considered to be the VFA.[18-20]

3. Statistical Analyses

The general characteristics of the study subjects, including age, height, weight, WC, metabolic parameters (blood pressure, fasting glucose, lipids, hsCRP, uric acid, and homocysteine levels, and VFA), and PAT volume, are described as mean±SD. For evaluating the correlation between PAT volume and the other metabolic parameters, the partial correlation method was used after adjustment for sex. The skewed data (TG, hsCRP, and homocysteine levels) were log transformed.

https://doi.org/10.4082/kjfm.17.0027

Analysis of variance was used to compare the difference in metabolic parameters according to the tertiles of PAT volumes. Significant metabolic parameters were then further analyzed using post hoc analysis. To determine the odds ratio (OR) for having MS according to PAT tertile, logistic regression was performed. Finally, we used the receiver operating characteristic (ROC) curve to calculate the cutoff PAT volume associated with the presence of MS. All statistical analyses were performed via SPSS ver. 11.0 for Windows (SPSS Inc., Chicago, IL, USA), and statistical significance was considered at P-values of <0.05.

RESULTS

Of the 374 subjects, 72 were female (19.3%) and 27.5% had MS. The patients' mean age, BMI, WC, and PAT volume were 54.1 years, 24.9 kg/m^2, 88.4 cm, and 123.9 cm^3, respectively (Table 1).

PAT volume was positively associated with age; height; weight; BMI; WC; levels of glucose, triglyceride, hsCRP, uric acid, and homocysteine; and VFA. PAT volume showed a negative correlation with HDL-cholesterol level (Table 2). After the PAT volumes were divided into tertiles, various metabolic parameters, which showed significant correlation among themselves, were compared. According to the increase in PAT tertile, age, height, weight, BMI, WC, triglyceride level, uric acid level, homocysteine level, and VFA were significantly higher than those in the low PAT volume tertile. By contrast, HDL-cholesterol level was significantly lower in the higher PAT volume tertile (Table 3). To clarify the further association, we calculated the OR for developing MS according to PAT tertile after adjustment for age, sex, and smoking. Without adjustment, the OR (95% confidence interval [CI]) for developing MS was 3.55 (1.98–6.35) in the top tertile as compared with the first PAT volume tertile. After adjustment, the OR (95% CI) was 4.19 (2.27–7.74) in the top tertile. However, after additional adjustment for BMI, the OR (95% CI) was 1.82 (0.91–3.63) and showed no significant difference (Table 4).

Finally, we calculated the cutoff PAT volume according to the presence of MS by using the ROC curve. The ROC curve showed maximum association between a PAT volume of 142.2 cm^3 and MS (sensitivity, 0.495 and 1-specificity, 0.218) (Figure 1, Supplement Table 1).

DISCUSSION

On evaluating the association of PAT volume and various metabolic parameters with MS, we found that PAT volume showed a significant

Table 2. Correlation between pericardial adipose tissue and other metabolic syndrome-related factors

Factors	r*	P-value
Age (y)	0.184	0.001
Height (cm)	0.159	0.004
Weight (kg)	0.459	<0.001
Body mass index (kg/m^2)	0.459	<0.001
Waist circumference (cm)	0.535	<0.001
Glucose (mg/dL)	0.153	0.006
Systolic blood pressure (mm Hg)	0.019	0.742
Diastolic blood pressure (mm Hg)	0.000	0.999
Total cholesterol (mg/dL)	−0.032	0.575
Triglyceride† (mg/dL)	0.313	<0.001
Low-density lipoprotein cholesterol (mg/dL)	−0.033	0.562
High-density lipoprotein cholesterol (mg/dL)	−0.234	<0.001
High-sensitivity C-reactive protein† (mg/dL)	0.195	<0.001
Uric acid (mg/dL)	0.222	<0.001
Homocysteine† (μmol/L)	0.174	0.002
Visceral fat area (cm^3)	0.362	<0.001

*Partial correlation coefficient after sex adjustment. †Values from after log transformation.

Table 1. General characteristics of the study group (n=374)

Characteristic	MS(–) (n=271)	MS(+) (n=103)	P-value
Age (y)	54.7±10.2	52.8±8.7	0.100
Females	53 (19.6)	19 (18.4)	0.808
Height (cm)	167.2±7.9	170.0±7.8	0.002
Weight (kg)	68.1±11.3	77.4±11.0	<0.001
Body mass index (kg/m^2)	24.3±2.8	26.6±2.6	<0.001
Pericardial adipose tissue volume (cm^3)	116.9±38.0	142.3±47.2	<0.001
Waist circumference (cm)	86.4±7.7	93.6±7.4	<0.001
Glucose (mg/dL)	93.1±20.3	112.4±26.2	<0.001
Systolic blood pressure (mm Hg)	122.0±11.6	128.4±10.4	<0.001
Diastolic blood pressure (mm Hg)	79.7±8.8	84.3±8.5	<0.001
Total cholesterol (mg/dL)	203.5±35.0	208.0±37.6	0.278
Triglyceride (mg/dL)	118.6±58.6	218.6±88.5	<0.001
Low-density lipoprotein cholesterol (mg/dL)	128.7±31.1	126.0±31.6	0.468
High-density lipoprotein cholesterol (mg/dL)	53.6±12.3	43.2±9.1	<0.001
High-sensitivity C-reactive protein (mg/dL)	0.15±0.33	0.13±0.12	0.601
Uric acid (mg/dL)	5.6±1.3	5.9±1.4	0.057
Homocysteine (μmol/L)	11.3±4.6	10.8±2.6	0.334
Visceral fat area (cm^3)	90.6±28.7	109.5±25.3	<0.001

Values are presented as mean±standard deviation or number (%).
MS, metabolic syndrome.

Table 3. Comparison of the MS-related factors among the 3 PAT tertile groups

Variable	T1 (n=127)	T2 (n=125)	T3 (n=122)	P-value
PAT volume (cm^3)	81.8±15.6	119.8±10.6	171.8±30.7	<0.001
MS cases	22 (5.9)	29 (7.8)	52 (13.9)	<0.001
Age (y)	52.4±9.2	54.8±9.5	55.4±10.4*	0.034
Height (cm)	166.5±7.8	167.4±8.0	170.2±7.5*,†	<0.001
Weight (kg)	65.1±11.0	70.3±11.0‡	76.8±10.8*,†	<0.001
Body mass index (kg/m^2)	23.4±2.7	24.9±2.6‡	26.4±2.6*,†	<0.001
Waist circumference (cm)	83.6±7.2	88.3±6.9‡	93.5±7.5*,†	<0.001
Glucose (mg/dL)	94.6±19.5	99.5±26.6	101.4±24.0	0.061
Triglyceride (mg/dL)	124.3±75.8	144.1±80.4	170.9±82.0*,†	<0.001
High-density lipoprotein cholesterol (mg/dL)	55.1±13.1	50.2±11.8‡	46.8±10.8†	<0.001
High-sensitivity C-reactive protein (mg/dL)	0.11±0.15	0.14±0.19	0.19±0.44	0.065
Uric acid (mg/dL)	5.3±1.2	5.6±1.2	6.1±1.5*,†	<0.001
Homocysteine (μmol/L)	10.2±3.0	11.3±3.7	12.1±5.3*	0.002
Visceral fat area (cm^3)	85.0±28.1	95.4±26.5‡	107.6±28.1*,†	<0.001

Values are presented as mean±standard deviation or number (%). P-values were obtained using analysis of variance.
MS, metabolic syndrome; PAT, pericardial adipose tissue.
The superscripted letters indicate the groups with higher values and P-values of <0.05 in the post hoc analysis: *comparison between T1 and T3; †comparison between T2 and T3; and ‡comparison between T1 and T2.

Table 4. ORs of the prevalence of metabolic syndrome among the 3 pericardial adipose tissue tertile groups

Variable	OR1 (95% CI)	OR2 (95% CI)	OR3 (95% CI)
T1 (36.1–101.9)	1	1	1
T2 (102.5–138.3)	1.44 (0.78–2.68)	1.59 (0.80–2.31)	1.09 (0.55–2.15)
T3 (138.7–301.8)	3.55 (1.98–6.35)	4.19 (2.27–7.74)	1.82 (0.91–3.63)

OR1, crude OR; OR2, adjusted for age, sex, and smoking; OR3, adjusted for age, sex, smoking, and body mass index.
OR, odds ratio; CI, confidence interval.

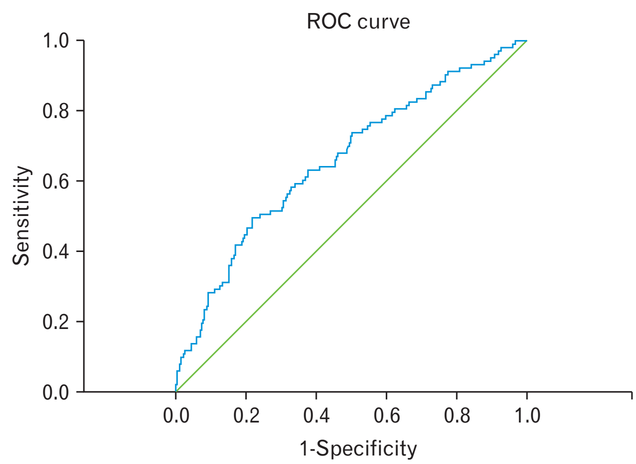

Figure 1. ROC curve of pericardial adipose tissue volume according to the presence of metabolic syndrome. This ROC curve shows the maximum association between pericardial adipose tissue volume (142.2 cm^3, P<0.001) and metabolic syndrome at the point of sensitivity (0.495) and 1-speicificity (0.218). ROC curve, receiver operating characteristic curve.

positive association with metabolic parameters and MS, except HDL-cholesterol level. Furthermore, we calculated the cutoff PAT volume to be 142.2 cm^3, which showed the best association with MS.

Many of the previous studies focused on the risk of CVD according to PAT volume in people with preexisting MS.[21-23] However, several studies have addressed the direct link between PAT volume and MS. The ARIRANG study measured epicardial adipose tissue (EAT) thickness on echocardiography.[16] The incidence of MS increased significantly with increasing EAT thickness in men after adjusting for various confounding variables, but no clear correlation was found in women. However, this study showed that EAT thickness measured on echocardiography could be used as an index for predicting the incidence of MS in men.

Park et al.[13] discussed the relationship between PAT volume and MS by using echocardiography for measuring EAT thickness. The result of their study showed that EAT thickness was significantly greater in patients with MS than in those without MS, but the ability of EAT thickness to predict MS was found to be strong only in the group that had a BMI of <27 kg/m^2. The relationship between EAT thickness and MS was also demonstrated in the ROC curve, but the cutoff value was not discussed in the study.

Another study, by Ormseth et al.,[24] also found a connection between PAT volume and MS in patients with rheumatoid arthritis. This study calculated EAT volume and calcium score for the carotid artery on CT. They showed that EAT volume was associated with multiple factors (insulin resistance, triglyceride level, current smoking, and homocysteine level), which have already been shown to be strongly associated with MS.

Various studies have consistently shown that PAT volume is associated with MS.[25-28] The result of our research was in line with those of the previous studies. In our study, we demonstrated that PAT volume significantly correlated with the prevalence of MS after adjusting for confounding variables. In addition, we determined a significant cutoff PAT volume for a possible relationship with MS. This is the main difference between our study and the previous studies, which only showed

https://doi.org/10.4082/kjfm.17.0027

the relationship between PAT volume and MS.

One of the strengths of our research is the method of measuring PAT volume. In most studies, echocardiography was used to measure PAT volume owing to its convenience and low cost.[28-30] However, the measurement of PAT thickness on ultrasonography has a limitation in obtaining total PAT volume accurately.[31] Nevertheless, our study accurately measured the total PAT volume on CT; therefore, we could calculate the PAT volume for evaluating its association with MS. Analysis of data from the general population, though not relatively large enough, is another strong point of this study as compared with other studies. Most existing studies had limitations in representing the general population because they were performed in special populations of subjects with preexisting CVDs or other diseases.

However, our research has some limitations. One limitation is that the causal relationship between PAT volume and MS could not be inferred because of the cross-sectional design of our study. Second, our study data were not large enough to represent the association in the general population. Third, various confounding factors were not adjusted for in this study. In addition, the OR of developing MS in the top PAT tertile group showed no statistical significance (OR, 1.82; 95% CI, 0.91–3.63) after adjusting for age, sex, smoking, and BMI. Even though our results had no statistical significance, we carefully considered their marginal significance. BMI critically impacts PAT volume but did not show statistical significance after additional BMI adjustment. Finally, the conclusion is limited to clinical application because of the cost-effectiveness, radiation exposure, and convenience of CT. Nonetheless, this is the first study to evaluate the cutoff PAT volume in subjects with MS.

In conclusion, PAT volume was significantly associated with MS and various metabolic parameters, including BMI, WC, and triglyceride and HDL levels. In addition, the cutoff PAT volume of 142.2 cm^3 showed the best association with MS. Further prospective well-designed studies are needed in the near future to reveal the exact association between PAT and MS.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

SUPPLEMENTARY MATERIALS

Supplementary materials can be found via https://doi.org/10.4082/kjfm.17.0027. Supplementary Table 1. The sensitivity and 1-specificity values based on the ROC curve and area under the ROC curve.

REFERENCES

1. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation 2005;112:2735-52.
2. Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. Circulation 1983;67:968-77.
3. Meigs JB, Wilson PW, Fox CS, Vasan RS, Nathan DM, Sullivan LM, et al. Body mass index, metabolic syndrome, and risk of type 2 diabetes or cardiovascular disease. J Clin Endocrinol Metab 2006;91:2906-12.
4. Yamaoka K, Tango T. Effects of lifestyle modification on metabolic syndrome: a systematic review and meta-analysis. BMC Med 2012;10:138.
5. Shin A, Lim SY, Sung J, Shin HR, Kim J. Dietary intake, eating habits, and metabolic syndrome in Korean men. J Am Diet Assoc 2009;109:633-40.
6. Tatsumi Y, Nakao YM, Masuda I, Higashiyama A, Takegami M, Nishimura K, et al. Risk for metabolic diseases in normal weight individuals with visceral fat accumulation: a cross-sectional study in Japan. BMJ Open 2017;7:e013831.
7. Usui C, Asaka M, Kawano H, Aoyama T, Ishijima T, Sakamoto S, et al. Visceral fat is a strong predictor of insulin resistance regardless of cardiorespiratory fitness in non-diabetic people. J Nutr Sci Vitaminol (Tokyo) 2010;56:109-16.
8. Arpaci D, Gurkan Tocoglu A, Yilmaz S, Ergenc H, Tamer A, Keser N, et al. The relationship between epicardial fat tissue thickness and visceral adipose tissue in lean patients with polycystic ovary syndrome. J Ovarian Res 2015;8:71.
9. Ghaderi F, Eshraghi A, Shamloo AS, Mousavi S. Assosiation of epicardial and pericardial fat thickness with coronary artery disease. Electron Physician 2016;8:2982-9.
10. Matloch Z, Kotulak T, Haluzik M. The role of epicardial adipose tissue in heart disease. Physiol Res 2016;65:23-32.
11. Rosito GA, Massaro JM, Hoffmann U, Ruberg FL, Mahabadi AA, Vasan RS, et al. Pericardial fat, visceral abdominal fat, cardiovascular disease risk factors, and vascular calcification in a community-based sample: the Framingham Heart Study. Circulation 2008;117:605-13.
12. Kim TH, Yu SH, Choi SH, Yoon JW, Kang SM, Chun EJ, et al. Pericardial fat amount is an independent risk factor of coronary artery stenosis assessed by multidetector-row computed tomography: the Korean Atherosclerosis Study 2. Obesity (Silver Spring) 2011;19:1028-34.
13. Park JS, Ahn SG, Hwang JW, Lim HS, Choi BJ, Choi SY, et al. Impact of body mass index on the relationship of epicardial adipose tissue to metabolic syndrome and coronary artery disease in an Asian population. Cardiovasc Diabetol 2010;9:29.
14. Chen O, Sharma A, Ahmad I, Bourji N, Nestoiter K, Hua P, et al. Correlation between pericardial, mediastinal, and intrathoracic fat volumes with the presence and severity of coronary artery disease, metabolic syndrome, and cardiac risk factors. Eur Heart J Cardiovasc Imaging 2015;16:37-46.
15. Pierdomenico SD, Pierdomenico AM, Cuccurullo F, Iacobellis G. Meta-analysis of the relation of echocardiographic epicardial adipose tissue thickness and the metabolic syndrome. Am J Cardiol 2013;111:73-8.
16. Lee JH, Kim JY, Kim KM, Lee JW, Youn YJ, Ahn MS, et al. A prospective study of epicardial adipose tissue and incident metabolic syndrome: the ARIRANG study. J Korean Med Sci 2013;28:1762-7.
17. National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in

Adults (Adult Treatment Panel III). Third report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. Circulation 2002;106:3143-421.
18. Sjostrom L, Kvist H, Cederblad A, Tylen U. Determination of total adipose tissue and body fat in women by computed tomography, 40K, and tritium. Am J Physiol 1986;250(6 Pt 1):E736-45.
19. Kvist H, Chowdhury B, Sjostrom L, Tylen U, Cederblad A. Adipose tissue volume determination in males by computed tomography and 40K. Int J Obes 1988;12:249-66.
20. Yoshizumi T, Nakamura T, Yamane M, Islam AH, Menju M, Yamasaki K, et al. Abdominal fat: standardized technique for measurement at CT. Radiology 1999;211:283-6.
21. Aydin H, Toprak A, Deyneli O, Yazici D, Tarcin O, Sancak S, et al. Epicardial fat tissue thickness correlates with endothelial dysfunction and other cardiovascular risk factors in patients with metabolic syndrome. Metab Syndr Relat Disord 2010;8:229-34.
22. Sengul C, Cevik C, Ozveren O, Oduncu V, Sunbul A, Akgun T, et al. Echocardiographic epicardial fat thickness is associated with carotid intima-media thickness in patients with metabolic syndrome. Echocardiography 2011;28:853-8.
23. Sengul C, Duman D. The association of epicardial fat thickness with blunted heart rate recovery in patients with metabolic syndrome. Tohoku J Exp Med 2011;224:257-62.
24. Ormseth MJ, Lipson A, Alexopoulos N, Hartlage GR, Oeser AM, Bian A, et al. Association of epicardial adipose tissue with cardiometabolic risk and metabolic syndrome in patients with rheumatoid arthritis. Arthritis Care Res (Hoboken) 2013;65:1410-5.
25. Yorgun H, Canpolat U, Hazirolan T, Ates AH, Sunman H, Dural M, et al. Increased epicardial fat tissue is a marker of metabolic syndrome in adult patients. Int J Cardiol 2013;165:308-13.
26. Momesso DP, Bussade I, Epifanio MA, Schettino CD, Russo LA, Kupfer R. Increased epicardial adipose tissue in type 1 diabetes is associated with central obesity and metabolic syndrome. Diabetes Res Clin Pract 2011;91:47-53.
27. Iacobellis G, Sharma AM. Epicardial adipose tissue as new cardiometabolic risk marker and potential therapeutic target in the metabolic syndrome. Curr Pharm Des 2007;13:2180-4.
28. Iacobellis G, Ribaudo MC, Assael F, Vecci E, Tiberti C, Zappaterreno A, et al. Echocardiographic epicardial adipose tissue is related to anthropometric and clinical parameters of metabolic syndrome: a new indicator of cardiovascular risk. J Clin Endocrinol Metab 2003;88:5163-8.
29. Pierdomenico SD, Pierdomenico AM, Neri M, Cuccurullo F. Epicardial adipose tissue and metabolic syndrome in hypertensive patients with normal body weight and waist circumference. Am J Hypertens 2011;24:1245-9.
30. Mazur A, Ostanski M, Telega G, Malecka-Tendera E. Is epicardial fat tissue a marker of metabolic syndrome in obese children? Atherosclerosis 2010;211:596-600.
31. Sicari R, Sironi AM, Petz R, Frassi F, Chubuchny V, De Marchi D, et al. Pericardial rather than epicardial fat is a cardiometabolic risk marker: an MRI vs echo study. J Am Soc Echocardiogr 2011;24:1156-62.

https://doi.org/10.4082/kjfm.17.0027

Supplement Table 1. The sensitivity and 1-specificity values based on the ROC curve and area under the ROC curve
<Coordinates of the curve; test result variable(s): PAT>

Positive if greater than or equal to	Sensitivity	1-Specificity
35.145	1.000	1.000
40.102	1.000	0.996
45.596	1.000	0.993
48.082	1.000	0.989
49.546	1.000	0.985
50.280	1.000	0.982
50.510	1.000	0.978
51.212	1.000	0.974
54.064	1.000	0.970
57.481	1.000	0.967
58.797	0.990	0.967
58.926	0.990	0.963
59.256	0.990	0.959
59.524	0.981	0.959
60.100	0.981	0.956
60.852	0.981	0.952
61.366	0.981	0.948
61.933	0.981	0.945
62.484	0.981	0.941
63.055	0.981	0.937
63.643	0.981	0.934
64.971	0.981	0.930
66.391	0.981	0.926
66.992	0.971	0.926
67.253	0.971	0.923
67.348	0.971	0.919
67.392	0.961	0.919
68.261	0.961	0.915
69.200	0.961	0.911
69.420	0.961	0.908
69.570	0.951	0.908
70.143	0.951	0.904
71.076	0.951	0.900
71.779	0.951	0.897
72.093	0.942	0.897
72.311	0.942	0.893
72.980	0.942	0.889
73.657	0.942	0.886
74.152	0.942	0.882
74.440	0.942	0.878
74.750	0.932	0.878
75.285	0.932	0.875
75.597	0.932	0.871
75.691	0.932	0.867
75.737	0.932	0.863
76.071	0.932	0.860
76.712	0.932	0.856
77.141	0.932	0.852
77.362	0.932	0.849
77.601	0.932	0.845
77.946	0.932	0.841
78.509	0.922	0.841
78.916	0.922	0.838
79.726	0.922	0.834
80.493	0.922	0.830
80.910	0.922	0.827

(Continued to the next page)

Supplement Table 1. Continued

Positive if greater than or equal to	Sensitivity	1-Specificity
81.540	0.922	0.823
81.946	0.922	0.819
82.955	0.922	0.815
83.810	0.922	0.812
83.831	0.922	0.808
84.000	0.913	0.808
84.525	0.913	0.804
85.179	0.913	0.801
85.791	0.913	0.797
86.178	0.913	0.793
86.404	0.913	0.790
86.608	0.913	0.786
86.864	0.913	0.782
87.394	0.913	0.779
87.921	0.913	0.775
88.191	0.903	0.775
88.453	0.903	0.771
88.850	0.903	0.768
89.077	0.893	0.768
89.208	0.883	0.768
89.347	0.883	0.764
89.533	0.883	0.760
89.689	0.883	0.756
89.745	0.883	0.753
90.122	0.874	0.753
90.782	0.874	0.749
91.306	0.874	0.745
92.332	0.874	0.742
93.169	0.874	0.738
93.262	0.874	0.734
93.397	0.874	0.731
93.470	0.864	0.731
93.627	0.864	0.727
93.770	0.854	0.727
93.803	0.854	0.723
93.860	0.854	0.720
94.158	0.854	0.716
94.608	0.854	0.712
94.867	0.845	0.712
94.950	0.835	0.712
95.091	0.835	0.708
95.381	0.835	0.705
95.845	0.835	0.701
96.340	0.835	0.697
96.551	0.835	0.694
96.643	0.835	0.690
96.780	0.835	0.686
97.160	0.825	0.686
97.506	0.825	0.683
97.748	0.825	0.679
98.031	0.825	0.675
98.156	0.825	0.672
98.342	0.825	0.668
98.532	0.825	0.664
98.840	0.816	0.664
99.129	0.816	0.661
99.285	0.816	0.657
99.402	0.806	0.657

(Continued to the next page)

Supplement Table 1. Continued

Positive if greater than or equal to	Sensitivity	1-Specificity
99.413	0.806	0.653
99.515	0.806	0.649
99.768	0.806	0.646
99.979	0.806	0.642
100.051	0.806	0.638
100.161	0.806	0.635
100.300	0.806	0.631
100.470	0.806	0.627
100.729	0.806	0.624
100.870	0.796	0.624
100.971	0.796	0.620
101.395	0.796	0.616
101.818	0.786	0.616
102.208	0.786	0.613
102.506	0.786	0.609
102.520	0.786	0.605
102.559	0.786	0.601
102.862	0.786	0.598
103.267	0.777	0.598
103.432	0.777	0.594
103.688	0.777	0.590
103.929	0.777	0.587
104.113	0.767	0.587
104.426	0.767	0.583
104.618	0.767	0.579
104.709	0.767	0.576
104.822	0.767	0.572
104.989	0.767	0.568
105.112	0.767	0.565
105.396	0.767	0.561
105.823	0.767	0.557
105.994	0.767	0.554
106.201	0.757	0.554
106.463	0.757	0.550
107.145	0.757	0.546
107.818	0.748	0.546
107.879	0.748	0.542
107.916	0.748	0.539
108.112	0.748	0.535
108.348	0.748	0.531
108.508	0.738	0.531
108.689	0.738	0.528
109.060	0.738	0.524
109.372	0.738	0.520
110.189	0.738	0.517
111.016	0.738	0.513
111.211	0.738	0.509
111.997	0.738	0.506
112.726	0.738	0.502
112.896	0.728	0.502
113.020	0.728	0.498
113.239	0.718	0.498
113.486	0.709	0.498
113.571	0.709	0.494
113.624	0.699	0.494
113.793	0.699	0.491
114.142	0.689	0.487
114.654	0.680	0.487

(Continued to the next page)

Supplement Table 1. Continued

Positive if greater than or equal to	Sensitivity	1-Specificity
115.119	0.680	0.483
115.349	0.680	0.480
115.503	0.680	0.476
115.631	0.680	0.472
115.920	0.680	0.469
116.291	0.680	0.465
116.575	0.680	0.461
117.263	0.670	0.461
117.989	0.670	0.458
118.288	0.660	0.458
118.457	0.660	0.454
118.890	0.650	0.454
119.330	0.641	0.454
119.455	0.641	0.450
119.495	0.641	0.446
119.612	0.641	0.443
119.863	0.641	0.439
120.070	0.641	0.435
120.280	0.641	0.432
120.686	0.641	0.428
120.995	0.641	0.424
121.051	0.641	0.421
121.305	0.641	0.417
122.298	0.641	0.413
123.053	0.641	0.410
123.089	0.631	0.410
123.199	0.631	0.406
123.668	0.631	0.402
124.072	0.631	0.399
124.175	0.631	0.395
124.413	0.631	0.391
124.914	0.631	0.387
125.354	0.631	0.384
125.551	0.631	0.380
125.727	0.631	0.376
125.885	0.621	0.376
126.468	0.612	0.376
126.968	0.612	0.373
127.319	0.612	0.369
128.046	0.602	0.369
128.489	0.602	0.365
128.597	0.602	0.362
128.666	0.592	0.362
128.715	0.592	0.358
128.770	0.592	0.354
128.884	0.592	0.351
129.068	0.592	0.347
129.229	0.592	0.343
129.323	0.592	0.339
129.546	0.583	0.339
129.759	0.583	0.336
129.830	0.583	0.332
129.956	0.583	0.328
130.197	0.573	0.328
130.403	0.573	0.325
130.555	0.563	0.325
130.916	0.563	0.321
131.191	0.563	0.317

(Continued to the next page)

Supplement Table 1. Continued

Positive if greater than or equal to	Sensitivity	1-Specificity
131.347	0.553	0.317
131.611	0.553	0.314
131.764	0.544	0.314
131.893	0.544	0.310
132.118	0.544	0.306
132.315	0.534	0.306
132.773	0.524	0.306
133.211	0.524	0.303
133.283	0.515	0.303
133.361	0.515	0.295
133.529	0.515	0.292
133.730	0.515	0.288
134.243	0.515	0.284
134.992	0.515	0.280
135.685	0.515	0.277
136.258	0.515	0.273
136.508	0.515	0.269
137.231	0.505	0.269
137.959	0.505	0.266
138.162	0.505	0.262
138.526	0.505	0.258
138.952	0.505	0.255
139.547	0.505	0.251
140.113	0.505	0.247
140.424	0.505	0.244
140.616	0.505	0.240
140.955	0.495	0.240
141.302	0.495	0.236
141.412	0.495	0.232
141.757	0.495	0.229
142.125	0.495	0.225
142.173	0.495	0.221
142.242	0.495	0.218
142.504	0.485	0.218
142.722	0.476	0.218
142.805	0.466	0.218
143.078	0.466	0.214
143.918	0.466	0.210
144.657	0.466	0.207
145.299	0.466	0.203
146.157	0.447	0.203
146.522	0.447	0.199
146.764	0.447	0.196
147.125	0.437	0.196
147.341	0.437	0.192
147.443	0.427	0.192
147.501	0.427	0.188
147.760	0.417	0.188
148.241	0.417	0.185
148.691	0.417	0.181
149.021	0.417	0.177
149.443	0.417	0.173
149.798	0.417	0.170
150.107	0.408	0.170
150.646	0.398	0.170
150.961	0.388	0.170
151.111	0.388	0.166
151.635	0.379	0.166

(Continued to the next page)

Supplement Table 1. Continued

Positive if greater than or equal to	Sensitivity	1-Specificity
152.246	0.379	0.162
152.560	0.379	0.159
153.004	0.369	0.159
153.501	0.359	0.159
154.370	0.359	0.155
155.348	0.359	0.151
155.977	0.350	0.151
156.357	0.340	0.151
156.488	0.330	0.151
156.616	0.320	0.151
156.708	0.311	0.151
156.778	0.311	0.148
156.862	0.311	0.140
157.185	0.311	0.137
157.490	0.311	0.133
157.738	0.301	0.133
158.072	0.301	0.129
158.375	0.301	0.125
159.027	0.291	0.125
160.127	0.291	0.122
160.954	0.291	0.118
161.860	0.291	0.114
163.114	0.291	0.111
163.805	0.282	0.111
164.063	0.282	0.107
165.580	0.282	0.100
166.979	0.282	0.096
167.802	0.282	0.092
168.799	0.272	0.092
169.315	0.262	0.092
169.926	0.252	0.092
170.475	0.243	0.092
171.046	0.243	0.089
171.955	0.233	0.089
172.602	0.233	0.085
174.025	0.233	0.081
175.441	0.223	0.081
175.502	0.214	0.081
175.567	0.204	0.081
175.712	0.204	0.077
176.385	0.194	0.077
177.109	0.194	0.074
177.410	0.184	0.074
177.580	0.175	0.074
178.126	0.175	0.070
179.037	0.165	0.070
179.694	0.155	0.070
180.102	0.155	0.066
181.285	0.155	0.063
182.876	0.155	0.059
184.170	0.146	0.059
185.279	0.136	0.059
186.264	0.136	0.055
187.002	0.136	0.052
188.166	0.136	0.048
189.778	0.136	0.044
191.362	0.126	0.044
193.813	0.117	0.044

(Continued to the next page)

Supplement Table 1. Continued

Positive if greater than or equal to	Sensitivity	1-Specificity
195.574	0.117	0.041
196.043	0.117	0.037
197.548	0.117	0.033
199.273	0.117	0.030
200.392	0.117	0.026
201.508	0.107	0.026
203.073	0.107	0.022
205.011	0.097	0.022
206.586	0.097	0.018
208.232	0.097	0.015
210.946	0.087	0.015
218.130	0.078	0.015
225.005	0.078	0.011
227.510	0.068	0.011
230.264	0.058	0.011
232.223	0.058	0.007
232.796	0.058	0.004
235.837	0.049	0.004
240.185	0.039	0.004
244.493	0.029	0.004
248.083	0.019	0.004
255.601	0.019	0.000
281.908	0.010	0.000
302.764	0.000	0.000

The test result variable(s): PAT has at least one tie between the positive actual state group and the negative actual state group. The smallest cutoff value is the minimum observed test value minus 1, and the largest cutoff value is the maximum observed test value plus 1. All the other cutoff values are the averages of two consecutive observed test values.
ROC, receiver operating characteristic; PAT, pericardial adipose tissue.