The Association between Visceral Adipose Tissue and Coronary Atherosclerosis in Thai Postmortem Cases

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ABSTRACT

Objective: To determine the correlation between visceral adipose tissue (VAT) and degree of coronary artery stenosis in the Thai population.

Materials and Methods: This prospective cross-sectional study was conducted in 220 Thai postmortem cases. Sex, age, weight, height, waist and hip circumferences were recorded for each case. The intra-abdominal VAT weight of each site was assessed during the autopsy procedure, and degrees of stenosis for three coronary arteries (left anterior descending artery (LAD), right coronary artery (RCA) and left circumflex artery (LCX)) were evaluated in histological examination. Descriptive statistics, bivariate correlation, and multivariate linear regression were used to determine the correlations between VAT and degrees of coronary artery stenosis.

Results: There were 108 female and 112 male subjects with a mean age of 45.95 years old. Waist circumference, waist-hip ratio and VAT in the male subjects were significantly higher than in the female subjects ($p<0.001$). VAT was well correlated with waist circumference and waist-hip ratio ($p<0.001$). VAT weights were positively correlated with degrees of LAD, RCA and LCX stenosis, with coefficient correlations (r) of 0.561, 0.453 and 0.451, respectively ($p<0.001$). Mesenteric and peri-renal adipose tissues produced better correlations than the other sites. Multivariate linear regression showed that sex and age were correlated with stenosis in all three coronary arteries ($p<0.001$), and mesenteric and peri-renal adipose tissues had strong correlations with LAD stenosis ($p<0.001$).

Conclusion: VAT weights from all sites were correlated with degrees of coronary artery stenosis. Mesenteric and peri-renal adipose tissues produced better correlations than the other sites.

Keywords: Visceral adipose tissue; coronary atherosclerosis; Thai; obesity (Siriraj Med J 2024; 76: 304-312)

INTRODUCTION

Coronary artery disease (CAD) is the leading cause of death in patients who die from sudden cardiac death.[1] Risk factors for CAD were categorized into traditional risk factors, and non-traditional risk factors such as ankle-brachial index, high-sensitivity C-reactive protein level, and coronary artery calcium score.[2] Traditional risk factors included sex, age, high blood pressure or hypertension, impaired fasting plasma glucose or diabetes mellitus, high blood lipid profiles, obesity (high body mass index (BMI) and waist circumference), and smoking.[3] Some of the traditional risk factors, namely, hypertension, diabetes mellitus, dyslipidemia, and obesity, can be classified as metabolic syndrome. The prevalence of metabolic syndrome as a risk factor for CAD in 107,933 Thai police officers was 39.24%, and males had a higher

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prevalence than females.[4] This figure indicated that the number of Thai people at risk for CAD was relatively high. Common cardiovascular risk prediction models in clinical practice, such as the Framingham Risk Score (FRS), Systematic Coronary Risk Evaluation (SCORE) and the World Health Organization/International Society of Hypertension (WHO/ISH) models, still use traditional risk factors to evaluate high-risk people.[3] One of these risk factors is being overweight or having obesity. Being overweight and having obesity in the Asian population have been defined as a BMI between 23.5-25 kg/m^2 and greater than 25 kg/m^2, respectively.[3] Being overweight and having obesity leads to increased visceral adipose tissue (VAT), and this VAT could escalate risks of coronary artery stenosis.[5,6] Previous studies have suggested that VAT secretes some vasoactive substances and adipocytokines that could increase inflammation and alter glucose and lipid metabolism, leading to increased risks of CAD.[5,6] In clinical practice, BMI, waist circumference, and waist-hip ratio could be used for assessing risks of CAD because these parameters are related to VAT.[5,6]

Previous studies on the Thai population have suggested that being overweight and having obesity are also associated with increased risks of CAD.[7,8] However, there is scarce evidence of the association between VAT and CAD in the Thai population. Jongjirasiri S et al. indicated that the volume of VAT, as assessed by computerized tomography (CT) of the whole abdomen, was positively associated with coronary artery calcium scores in Thai living people.[9] This finding is in accordance with a study on Chinese living people in Singapore by Ei Ei Khaing N et al., which also showed that VAT measured by CT of the whole abdomen was positively correlated with coronary artery calcium scores.[10] There have been some studies that have conducted assessments of VAT and CAD in cadavers. Edston E showed that there was a positive association between the weight of VAT and degree of coronary artery stenosis (r = 0.31) in Swedish cadavers.[11] A positive correlation between the amount of VAT and degree of coronary artery stenosis was also demonstrated in dead bodies in Brazil, and it was also found that age had an effect on this correlation.[12]

As there is still scarce information about the association between VAT and CAD in Thai people, the authors aim to study the association between VAT and degree of coronary artery stenosis. In addition, the authors also consider the effect of VAT in each area on the degree of coronary artery stenosis to determine the significant area of VAT that principally affects the degree of coronary artery stenosis. This information will be fundamental data for further studies on CAD in the Thai population.

MATERIALS AND METHODS

Study design and data collection

A prospective cross-sectional study was performed for medico-legal cases sent for autopsy at the Department of Forensic Medicine, Siriraj Hospital, Mahidol University. The inclusion criteria were as follows: Deceased Thai people who were at least 18 years old at the time of death and sent for autopsy at the Department of Forensic Medicine, Siriraj Hospital, Mahidol University between February 14, 2023, and November 30, 2023. The exclusion criteria were as follows: decomposed bodies, bodies which presented with abnormal fluid or blood in abdominal cavities, bodies which presented with cardiac injuries, bodies with fractures of lower extremities, bodies with underlying diseases related to metabolic syndrome and bodies with evidence of cardiac surgeries. This study was approved by the Siriraj Institutional Review Board, Faculty of Medicine Siriraj Hospital, Mahidol University (COA no. Si 120/2023, SIRB protocol No. 947/2565 (IRB3)).

Sex, age, weight, height, waist circumference, hip circumference, and cause of death were recorded for each case. All anthropometric measurements were assessed on all cadavers lying on stainless steel autopsy tables without clothes in supine positions. Body weights were measured in kilograms (kg) to one decimal place on a Tiger® digital balance model TI-01SS. Body heights were assessed in centimeters (cm) from vertex to heel using a stainless steel tape measure. Waist and hip circumferences were measured in centimeters (cm) using a non-elastic measuring tape. The landmarks for measurement of waist circumference and hip circumference were at the mid-position between the lowest rib and the iliac crest and at the point of maximum extension of the buttocks, respectively. Body mass index (BMI) was calculated by using weight (kg) divided by height (m) squared, and waist-hip ratio was calculated by dividing waist circumference (cm) by hip circumference (cm).

Evaluation of visceral adipose tissue (VAT)

The autopsy was performed in each case using the Letulle method, or "en masse" evisceration, and all organs were removed as one block.[13] Briefly, when skin on the anterior trunk was incised by using a Y-incision, the thorax and abdominal cavity were exposed and visceral fat tissue could be examined. First, omentum was removed from the transverse colon. Then, the small bowel and large bowel were removed from the position just distal to the ligament of Treitz to the area between the sigmoid colon and proximal rectum. After the small bowel and large bowel were removed, the transverse and sigmoid mesocolon were removed from the transverse colon and sigmoid colon. Next, all of the mesentery was removed from the small intestine (Fig 1.1). Then, blunt dissection of both sides of each ureter was performed, and pelvic organs (including the bladder and prostate in males or the bladder and uterus and both ovaries in females) were identified and removed from the pelvic floor together with both ureters. After this procedure was completed, evisceration was performed by removing the tongue out of the floor of the mouth so that all of neck organs could be pulled down. Then, the vessels at the thoracic inlet were incised so that all of the thoracic organs could be pulled down. Next, both diaphragms were cut from the internal surface of the thoraco-abdominal wall. After the liver, spleen, both kidneys, including peri-renal adipose tissue, and abdominal vessels, including inferior vena cava and abdominal aorta, were dissected from all attachments, the organ block could be pulled down to the pelvic cavity and it could be removed from the body by cutting both sides of the internal and external iliac vessels. After the organ block had been removed, it could be dissected separately into a thoracic block, hepato-biliary block and genito-urinary block. In the genito-urinary block, both sides of the peri-renal adipose tissue were dissected and removed from both kidneys (Fig 1.2). Then, all of the organ blocks were dissected by following the standard procedure to determine the cause of death. According to this procedure, the omentum, mesocolon, mesentery and both sides of the perinephric fat tissue could be collected for weighing on a Sunford® digital balance, model FEH5000, which covered weights from 1-5,000 grams. The amount of adipose tissue taken from each site was recorded, and all adipose tissue weights were used in statistical analysis.

Assessment of coronary artery stenosis

Three coronary arteries, which were the left anterior descending artery (LAD), left circumflex artery (LCX) and right coronary artery (RCA), were evaluated as percentage of stenosis according to the serial section of each coronary artery, with around 3-5 millimeters taken from each section. After serial cutting, all of the coronary sections were taken for histology and microscopic evaluation of the percentage of luminal diameter reduction, which was performed on the internal elastic lamina of each side of the coronary artery, was carried out (Fig 2). The maximal point of stenosis of each coronary artery was recorded for statistical analysis.

Statistical analysis

Statistical analysis was performed using IBM SPSS® Statistics for Windows version 25. Descriptive statistics, including the mean, median and standard deviation (SD), were calculated. Kolgomorov-Smirnov test was performed

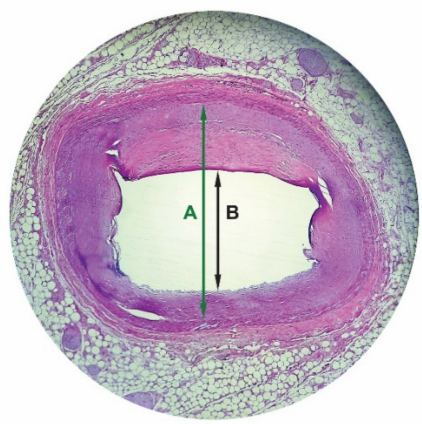

Fig 2. Assessment of degree of coronary artery stenosis in histological examination (degree of coronary artery stenosis = [(A-B)/A] x 100)

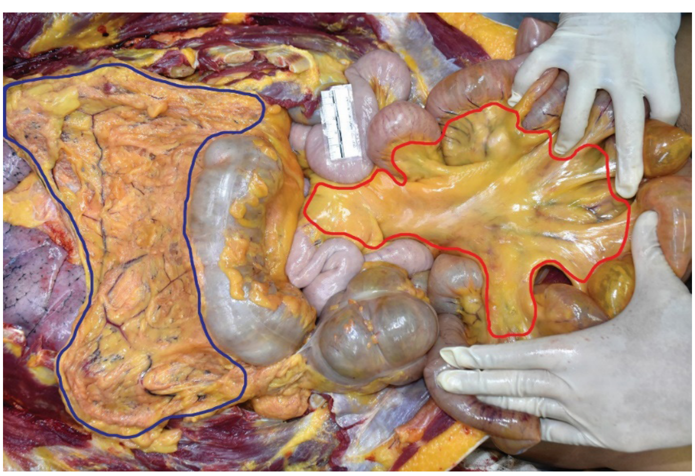

Fig 1.1. Sites for dissection of the omentum (blue circle) and mesentery (red circle).

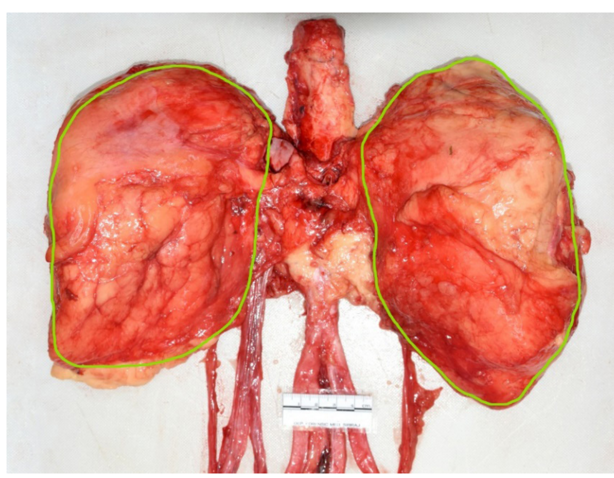

Fig 1.2. Sites for dissection of peri-renal adipose tissue from both kidneys (green circles).

Fig 1. Assessment of VAT during the autopsy procedure (Fig1.1 shows the omentum and mesentery, and Fig 1.2 shows the peri-renal adipose tissue.)

to determine normality testing for descriptive data, anthropometric parameters and degree of coronary artery stenosis and it was found that they were not normally distributed. Thus, comparisons of descriptive data were performed using the Mann-Whitney U test. Correlations between anthropometric parameters and coronary artery stenosis were evaluated by using Spearman's correlation. Multivariate linear regression and multicollinearity testing were performed for anthropometric parameters and VAT levels, with the variance inflation factor (VIF) converged to 1.

RESULTS

There were 220 cases recruited in this study, consisting of 108 females (49.09%) and 112 males (50.91%). The mean age of all subjects was 45.95 years old, whereas the mean ages of female and male subjects were 45.60 and 46.29 years old, respectively. All anthropometric parameters and VAT values were compared between female and male subjects, and results are shown in Table 1. Waist circumference and waist-hip ratio in male subjects were much more statistically significant than in female subjects (p<0.001). In addition, the amount of VAT in each area and total amount of VAT in male subjects were significantly higher than in female subjects (p<0.001). In addition, male subjects had a higher degree of coronary stenosis than female subjects in all three coronary arteries (p<0.001).

Table 2 shows that both the amount of VAT taken from each site and the total amount of VAT was positively correlated with all of three anthropometric parameters (p<0.001). Looking in detail, it was found that waist circumference generated the highest coefficient correlation (r) with VAT, followed by waist-hip ratio and BMI, respectively, in both genders and all cases except for correlation between peri-renal adipose tissue and anthropometric parameters in male subjects, where the waist-hip ratio produced a higher coefficient correlation (r) than waist circumference and BMI. This finding suggested that waist circumference and waist-hip ratio were better than BMI for indicating VAT amounts.

Table 3 shows the number of subjects who had a degree of coronary artery stenosis ≥50%, classified by age group. The threshold of 50% was used because this

TABLE 1. Comparison of demographic data in female and male subjects in this study.

Parameters	Female (N = 108)		Male (N = 112)		p-value
	Mean ± SD	Range	Mean ± SD	Range	
Age (years)	45.60 ± 12.92	18-74	46.29 ± 12.33	21-76	0.753
BMI (kg/m^2)	24.84 ± 4.11	17.69-36.44	25.98 ± 3.57	18.17-35.48	0.019
Waist (cm)	82.97 ± 11.21	62-108	88.46 ± 8.90	71-112	<0.001
Waist-hip ratio	0.88 ± 0.06	0.75-0.99	0.94 ± 0.04	0.83-0.99	<0.001
Omentum (g)	207.44 ± 148.40	47-972	336.42 ± 160.02	64-860	<0.001
Mesocolon (g)	111.90 ± 89.25	20-717	157.95 ± 94.19	31-553	<0.001
Mesentery (g)	237.26 ± 153.35	48-764	374.69 ± 179.18	81-989	<0.001
Peri-renal (g)	264.44 ± 206.34	43-1294	420.08 ± 273.64	53-1548	<0.001
Total adipose tissue (g)	821.05 ± 512.98	195-2886	1289.13 ± 604.67	289-3053	<0.001
Log (omentum)	2.23 ± 0.27	1.67-2.99	2.47 ± 0.23	1.81-2.93	<0.001
Log (mesocolon)	1.95 ± 0.30	1.30-2.86	2.12 ± 0.25	1.49-2.74	<0.001
Log (mesentery)	2.29 ± 0.29	1.68-2.88	2.52 ± 0.23	1.91-3.00	<0.001
Log (peri-renal)	2.32 ± 0.30	1.63-3.11	2.53 ± 0.30	1.72-3.19	<0.001
Log (total adipose)	2.84 ± 0.26	2.29-3.46	3.06 ± 0.22	2.46-3.48	<0.001
LAD (% stenosis)	34.14 ± 26.39	0-92.28	58.40 ± 27.25	0-92.32	<0.001
RCA (% stenosis)	27.15 ± 23.70	0-91.86	45.22 ± 27.22	0-94.67	<0.001
LCX (% stenosis)	18.57 ± 20.45	0-93.75	34.88 ± 27.32	0-96.25	<0.001

TABLE 2. Bivariate correlations between VAT and anthropometric parameters.

Parameters		BMI		Waist circumference		Waist-hip ratio	
		r	p-value	r	p-value	r	p-value
Log (omentum)	Female	0.602	<0.001	0.718	<0.001	0.607	<0.001
	Male	0.472	<0.001	0.675	<0.001	0.577	<0.001
	Total	0.550	<0.001	0.723	<0.001	0.676	<0.001
Log (mesocolon)	Female	0.519	<0.001	0.630	<0.001	0.566	<0.001
	Male	0.450	<0.001	0.682	<0.001	0.554	<0.001
	Total	0.506	<0.001	0.679	<0.001	0.613	<0.001
Log (mesentery)	Female	0.625	<0.001	0.711	<0.001	0.551	<0.001
	Male	0.469	<0.001	0.647	<0.001	0.489	<0.001
	Total	0.565	<0.001	0.711	<0.001	0.617	<0.001
Log (peri-renal)	Female	0.619	<0.001	0.688	<0.001	0.526	<0.001
	Male	0.344	<0.001	0.583	<0.001	0.655	<0.001
	Total	0.506	<0.001	0.668	<0.001	0.626	<0.001
Log (total visceral tissue)	Female	0.653	<0.001	0.763	<0.001	0.619	<0.001
	Male	0.469	<0.001	0.715	<0.001	0.660	<0.001
	Total	0.577	<0.001	0.761	<0.001	0.700	<0.001

TABLE 3. Number of subjects with a degree of coronary artery stenosis ≥50%, classified by age.

Age group	N	LAD ≥50% (N)	RCA ≥50% (N)	LCX ≥50% (N)
<30 years	28	3 (1.4%)	1 (0.5%)	1 (0.5%)
30-39 years	43	13 (5.9%)	9 (4.1%)	5 (2.3%)
40-49 years	52	28 (12.7%)	15 (6.8%)	10 (4.5%)
50-59 years	68	44 (20.0%)	32 (14.5%)	17 (7.7%)
≥60 years	29	20 (9.1%)	15 (6.8%)	11 (5.0%)
Total	220	108 (49.2%)	72 (32.7%)	44 (20.0%)

cut-off is still conventionally used to define obstructive coronary artery stenosis in clinical settings.[14] Based on this cut-off, it was found that the number of subjects who had coronary arteries with a degree of stenosis ≥50% tended to increase when the ages of subjects in both genders increased until the age of 60 years old. The number of subjects who presented with LAD stenosis ≥50% was significantly higher than the number of subjects who had RCA and LCX stenosis ≥50% ($p<0.01$ and $p<0.01$), respectively.

Correlations between VAT and degree of coronary artery stenosis were analyzed, and the results are shown in Table 4. Virtually all correlations between sites of VAT and the percentage of coronary stenosis were significant positive correlations except for the correlation between the omentum and LCX stenosis in male subjects. Almost all correlations between sites of VAT in female subjects and the degree of coronary stenosis were higher than in male subjects except for the correlation between peri-renal adipose tissue and LAD stenosis. In addition, it

TABLE 4. Bivariate correlations between VAT and degree of coronary artery stenosis.

Parameters		% stenosis					
		LAD	p-value	RCA	p-value	LCX	p-value
Log (omentum)	Female	0.452	<0.001	0.416	<0.001	0.409	<0.001
	Male	0.334	<0.001	0.198	0.036	0.179	0.059
	Total	0.504	<0.001	0.404	<0.001	0.377	<0.001
Log (mesocolon)	Female	0.436	<0.001	0.321	<0.001	0.410	<0.001
	Male	0.327	<0.001	0.210	0.026	0.302	0.001
	Total	0.460	<0.001	0.339	<0.001	0.408	<0.001
Log (mesentery)	Female	0.490	<0.001	0.430	<0.001	0.438	<0.001
	Male	0.375	<0.001	0.253	0.007	0.311	0.001
	Total	0.530	<0.001	0.428	<0.001	0.442	<0.001
Log (peri-renal)	Female	0.443	<0.001	0.443	<0.001	0.387	<0.001
	Male	0.471	<0.001	0.343	<0.001	0.339	<0.001
	Total	0.531	<0.001	0.457	<0.001	0.424	<0.001
Log (total adipose tissue)	Female	0.495	<0.001	0.450	<0.001	0.454	<0.001
	Male	0.446	<0.001	0.292	0.002	0.314	0.001
	Total	0.561	<0.001	0.453	<0.001	0.451	<0.001

was indicated that mesentery and peri-renal adipose tissue produced higher correlations with the degree of coronary stenosis than the other two sites of VAT.

As seen in the aforementioned results, age, sex, waist circumference, waist-hip ratio, and VAT in the mesentery and both kidneys produced higher correlation coefficients compared with other parameters. However, waist circumference and waist-hip ratio produced similar variables to VAT, and this research aimed to concentrate on the effect of VAT on coronary artery stenosis. Thus, age, sex, and mesenteric and peri-renal adipose tissues were considered for multivariate linear regression with coronary artery stenosis (Table 5). Age and sex showed statistically significant positive correlations with increasing stenosis of all three coronary vessels ($p<0.001$). However, the mesentery and peri-renal adipose tissue produced only positive correlations with statistical significance with LAD stenosis ($p=0.026$ and $p=0.022$, respectively). In addition to such correlations with LAD stenosis, the mesentery produced a positive correlation with statistical significance with increasing stenosis of LCX ($p=0.046$).

In addition, the cut-off for significant stenosis of coronary vessels as ≥70% for indicating disease status in clinical setting was applied to define single LAD disease,

TABLE 5. Multivariate linear regression with statistical significance between age, sex (male), log (mesentery) and log (peri-renal) and degrees of coronary artery stenosis.

Parameters	LAD		RCA		LCX	
	b	p-value	b	p-value	b	p-value
Age (years, 5-unit)	3.934	<0.001	4.206	<0.001	3.552	<0.001
Sex: Male	16.238	<0.001	13.017	<0.001	10.928	<0.001
Log (mesentery)	17.437	0.026	7.259	0.346	14.990	0.046
Log (peri-renal)	16.028	0.022	13.076	0.057	6.570	0.323

single RCA disease, multi-vessel disease and triple vessel disease following the previous guideline.[15] LAD disease and multi-vessel disease were identified as variables that significantly affected the complexity of CAD.[15] Prevalences of single LAD disease, single RCA disease, and multi-vessel disease including triple vessel disease comprised 17.73% (39/220), 4.55% (10/220), 14.09% (31/220), respectively and the overall prevalence of coronary artery disease in this study was 36.36% (80/220). The prevalence of triple vessel disease was separately defined as 5.91% (13/220). However, when age group ≥30 and ≥35 years old were applied, overall prevalences of coronary artery disease were 40.63% (78/192) and 43.60% (75/172), respectively. Then, mesenteric VAT and peri-renal VAT were compared among those three disease conditions with non-disease group and results were shown in Table 6.

Table 6 shows that mesenteric and peri-renal adipose tissues in all categories of CAD were significantly higher than those in non-disease group. Single LAD disease and multi-vessel disease including triple vessel disease groups produced high statistical significance. However, single RCA disease had less statistical significance compared with single LAD disease and multi-vessel disease both in mesenteric and peri-renal adipose tissues.

DISCUSSION

This study showed that virtually all VAT was significantly correlated with degrees of stenosis in three coronary arteries in both genders of the Thai population. This finding was consistent with previous studies that indicated correlations between the amount of VAT and severity of coronary atherosclerosis both in non-Asian populations[11,12] and Asian populations.[9,16,17] Compared with a previous study of autopsy cases that produced a correlation coefficient (r) of 0.31 between VAT and coronary artery stenosis[11], our data had r values of 0.561, 0.453 and 0.451 between the total amount of VAT and LAD, RCA and LCX stenosis, respectively. However, when sex was considered, Thai female subjects had higher correlations between VAT and the degree of coronary artery stenosis than Thai male subjects, and this difference has not been mentioned in any previous studies. Current data only shows that sex hormones, including estrogen and androgens, play an important role in adipose tissue function leading to linkage with metabolic syndrome and might have different effects on the fat distribution and cardiovascular involvement of males and those of females.[6] In addition, adipocyte characteristics, including low density lipoprotein (LDL) and high density lipoprotein (HDL) particle sizes, in females were different from males.[6] These two reasons might partially explain the different r-values between Thai females and males. Further study should be conducted to ascertain the effect of gender on correlations between VAT and coronary atherosclerosis in the Thai population.

Of all the sites of VAT, the mesentery and peri-renal adipose tissue were found to have higher significant correlations with degrees of coronary stenosis in all

TABLE 6. Comparison of VAT between different categories of CAD status.

Comparison among different groups			Log (mesentery) Mean ± SD	p-value	Log (peri-renal) Mean ± SD	p-value
1	Non-disease	N=140	2.32 ± 0.28	<0.001	2.31 ± 0.29	<0.001
	Single LAD disease	N=39	2.59 ± 0.22		2.65 ± 0.27	
2	Non-disease	N=140	2.32 ± 0.28	0.037	2.31 ± 0.29	0.007
	Single RCA disease	N=10	2.51 ± 0.17		2.56 ± 0.17	
3	Non-disease	N=140	2.32 ± 0.28	<0.001	2.32 ± 0.28	<0.001
	Single vessel disease (both LAD and RCA)	N=49	2.57 ± 0.22		2.63 ± 0.25	
4	Non-disease	N=140	2.32 ± 0.28	<0.001	2.31 ± 0.29	<0.001
	Multi-vessel disease	N=31	2.53 ± 0.29		2.62 ± 0.26	
5	Non-disease	N=140	2.32 ± 0.28	0.002	2.31 ± 0.29	<0.001
	Triple vessel disease	N=13	2.58 ± 0.17		2.61 ± 0.21	

three vessels compared with other sites of VAT. This finding suggested that the mesentery and peri-renal adipose tissue could be practically used for evaluation of VAT correlation with coronary artery stenosis in the Thai population. A previous study showed that VAT that was associated with metabolic syndrome arose from mesothelial cells, which was proven by lineage tracing analysis, and these sites of VAT included the omentum, the mesentery, peri-renal adipose tissue, retroperitoneal fat mass, gonadal adipose tissue and epicardial fat tissue.[18] Regarding mesenteric fat, there has been some evidence indicating that mesenteric adipose tissue is associated with metabolic syndrome leading to cardiovascular risks.[19,20] Regarding peri-renal adipose tissue, previous studies showed that the amount of peri-renal adipose tissue was correlated with hypertension and dyslipidemia leading to increased cardio-metabolic risks.[21,22] However, our data from multivariate linear regression only showed that mesenteric and peri-renal adipose tissues had positive correlations with LAD stenosis ($p<0.001$), whereas the correlations with RCA were not statistically significant ($p>0.05$), and the correlations with LCX stenosis were statistically significant only with mesenteric adipose tissue ($p=0.046$). This finding might result from the predominance of LAD stenosis compared with that of RCA and LCX in both genders in this study, as described in Table 3. Another previous study suggested that LAD was affected more by local hemodynamic effects, including turbulent flow and wall shear stress, than RCA and LCX.[23] Thus, LAD was found to be the most prevalent artery for coronary stenosis, and our data was also found to be consistent with this finding. Thus, a larger sample size is required for further study to elucidate the effect of VAT on RCA and LCX stenosis compared with LAD stenosis. When CAD categories based on the previous guideline were applied[15], mesenteric and peri-renal adipose tissues in both single vessel disease (both LAD and RCA) and multi-vessel disease (including triple vessel disease) were significantly higher than those in non-disease group and this finding supported that mesenteric and peri-renal adipose tissues were also associated with CAD in clinical setting. When considering statistical figures, single RCA disease had less statistical significance than single LAD disease and multi-vessel disease. This finding implied that the impact of mesenteric and peri-renal adipose tissues was more prominent on single LAD disease and multi-vessel disease than single RCA disease. However, the number of subjects in single RCA disease group was small and this could affect the statistical analysis. Further study with greater subjects should be conducted to prove the impact of VAT on single RCA disease.

In addition to VAT, increased age and male sex were the other independent factors that had an influence on coronary stenosis, and this effect was statistically significant for all three coronary arteries, as described in Table 5 ($p<0.001$). Previous studies indicated that increased age and male sex were associated with the presence of coronary atherosclerosis from cardiac imaging.[9,10,17] In addition, this study showed that waist circumference and waist-hip ratio were more associated with VAT than BMI, and VAT was strongly correlated with the percentage of coronary artery stenosis. Thus, it was suggested that waist circumference and waist-hip ratio might be useful for prediction of coronary artery stenosis, and this finding was consistent with a previous study that used waist circumference for evaluation of metabolic syndrome in Thai police officers.[4]

The main limitation of this study was the reliability of histories of underlying diseases in autopsy cases. Their relatives might not have any information about their underlying diseases because some cases did not have a history of medical check-ups, or they did not recognize their medical conditions. Thus, there might be possible that some subjects who had some underlying diseases and their relatives did not know were included in this study and this might contribute to confounding factors to the statistical analysis. The other limitation was the disproportionate number of subjects in some age groups, particularly in the <30 years old and ≥60 years old groups. Interpretation of coronary artery stenosis in the group aged ≥60 years old should be carefully performed.

CONCLUSION

VAT weights from all sites were positively correlated with degrees of coronary artery stenosis, particularly with that of LAD stenosis, and the degrees of significant correlations were higher in female subjects than in male subjects. Of all the sites of VAT, mesenteric and peri-renal adipose tissues produced better correlations with coronary artery stenosis than the other sites and showed significant correlations with the degree of LAD stenosis.

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Conflict of interest

None

Author's contributions

PW and PP contributed to study conceptualization, literature review and study design. PW contributed to data collection, data analysis, and data interpretation. PW drafted the manuscript and PP performed critical revision. All authors read and approved the final version of this manuscript that was submitted for publication.

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