



A Study on the Correlation between Abdominal Subcutaneous Fat Area and Aortic Dissection Based on Quantitative CT

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Abstract

Objective: To explore the correlation between abdominal Visceral Fat (VAT) area, Subcutaneous Fat (SAT) area and Aortic Dissection (AD) based on Quantitative CT (QCT). **Methods:** A total of 99 patients with AD diagnosed by CT angiography from January 2019 to April 2023 were retrospectively collected as the dissection group. The subjects were frequency-matched by age and gender. From the patients who underwent whole abdominal CT plain scan for non-specific abdominal pain, routine physical examination or other non-cardiovascular emergencies during the same period, 85 subjects without AD were selected as the control group. Their absence of aortic disease was confirmed by reviewing the imaging data and medical records. Collect the general clinical data of the two groups, and measure the liver fat fraction (Fat%-QCT) and the area of abdominal VAT and SAT at the L2/3 intervertebral space level based on QCT. Conduct a multivariate Logistic regression analysis to identify the independent factors associated with the occurrence of AD. **Results:** Univariate analysis showed that the proportions of smoking history, drinking history, and hypertension in the dissection group were significantly higher than those in the control group (all $P < 0.05$), as were Fat%-QCT, VAT area, and SAT area. Spearman rank correlation analysis showed that smoking history, drinking history, hypertension, Fat%-QCT, SAT area, and VAT area were positively correlated with AD occurrence ($R = 0.349, 0.366, 0.427, 0.185, 0.276, 0.227$). Multivariate Logistic regression analysis showed that smoking history, drinking history, hypertension, and SAT area ($OR = 0.238, 0.150, 0.138, 1.010$) were independent risk factors for AD occurrence (all $P < 0.05$), while VAT area ($P = 0.486$) and Fat%-QCT ($P = 0.105$) were not independent influencing factors.

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Conclusion: An increase in abdominal subcutaneous fat area is independently associated with the occurrence of aortic dissection and is a new independent risk indicator in addition to traditional risk factors (smoking, drinking, and hypertension). Controlling body weight and reducing abdominal subcutaneous fat accumulation may help reduce the risk of AD.

Subject Areas

Radiology & Medical Imaging

Keywords

Quantitative CT, Aortic Dissection, Subcutaneous Fat, Visceral Fat, Risk Factors

1. Introduction

Aortic Dissection (AD) is a cardiovascular emergency with rapid onset, rapid progression, and extremely high mortality [1]. Its pathological basis lies in the degeneration or damage of the middle layer structure of the aortic wall under the influence of multiple factors such as hypertension, atherosclerosis, and genetic diseases, leading to intimal tear and the formation of true and false lumens in the aortic wall [2]. Atherosclerosis is an important pathological basis for AD, which can increase the fragility of the aortic wall [2]. Adipose tissue, especially abdominal fat, as an active endocrine organ, plays a key role in the development of atherosclerosis by releasing various inflammatory factors and adipokines [3]. Abdominal fat is mainly divided into Visceral Adipose Tissue (VAT) and Subcutaneous Adipose Tissue (SAT), and there are differences in their metabolic activity and impact on the cardiovascular system.

Quantitative Computed Tomography (QCT) is an imaging technique that can accurately and reproducibly quantify body composition, including fat area and liver fat content [4]-[6]. Currently, the specific association between different abdominal fat distributions and the risk of AD is not clear. This study aims to utilize QCT technology to precisely measure the abdominal VAT area, SAT area, and liver fat fraction, and explore their correlation with the occurrence of AD, with the expectation of providing new imaging evidence for the risk assessment and primary prevention of AD.

2. Materials and Methods

2.1. Study Subjects

This study was a single-center retrospective study. The subjects were divided into the following two groups. The dissection group: patients who were consecutively included from January 2019 to April 2023, presenting with symptoms such as chest and back pain and diagnosed with acute or subacute Aortic Dissection (AD)

by full aortic CT angiography in our hospital. A total of 99 cases were included, among which 78 were in the acute phase (onset ≤ 14 days) and 21 were in the subacute phase (onset 15 - 90 days); according to the Stanford classification, 42 were type A and 57 were type B. The control group: patients who underwent full abdominal CT plain scan due to non-specific abdominal pain, routine physical examination or other non-cardiovascular emergencies during the same period were selected based on the age distribution (matched within ± 5 years) and gender of the dissection group. To ensure that the control group had no aortic disease, two radiologists jointly reviewed their abdominal CT plain scan images (window width and window level suitable for observing large blood vessels) and reviewed their medical records to exclude any individuals with signs of aortic lesions such as aortic widening, calcification, ulceration, intramural hematoma or dissection. Inclusion criteria: 1) Age ≥ 18 years; 2) Image quality met the requirements for QCT measurement. Exclusion criteria: 1) Severe motion or metal artifacts in CT images; 2) Missing clinical data (such as smoking history, blood pressure, and blood lipids); 3) Previous history of aortic surgery; 4) Coexisting malignant tumors or long-term chemotherapy or glucocorticoid treatment. Ultimately, 99 patients were included in the dissection group and 85 subjects in the control group.

2.2. Collection of Clinical Data

The following data were collected through the electronic medical record system: 1) Demographic characteristics: gender, age; 2) Lifestyle: smoking history (defined as cumulative smoking ≥ 100 cigarettes), drinking history (defined as regular drinking with an ethanol intake ≥ 30 g/d for more than one year); 3) Medical history: hypertension (based on medical history or multiple blood pressure measurements $\geq 140/90$ mmHg after admission), diabetes (based on medical history or fasting blood glucose ≥ 7.0 mmol/L or glycated hemoglobin $\geq 6.5\%$); 4) First fasting lipid profile upon admission: total cholesterol, triglycerides, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol.

2.3. CT Scanning and QCT Measurement

2.3.1. CT Scanning

The Siemens SOMATOM Definition dual-source 64-slice CT machine was used. The parameters for total aortic CT angiography: tube voltage 120 kV, automatic tube current modulation (reference mAs: 200 - 350), detector collimation 128×0.6 mm, pitch 0.8, rotation time 0.5 s, reconstruction layer thickness 1.5 mm, and slice spacing 1.5 mm. All images were reconstructed using the standard vascular reconstruction algorithm to ensure the comparability of CT values.

2.3.2. QCT Measurement

The plain scan DICOM images were imported into the QCT (Mind-ways Company) measurement and analysis software. Abdominal fat measurement: Two radiologists with over 10 years of abdominal imaging diagnostic experience and standardized QCT training independently operated. At the L2/3 intervertebral

disc center level [7], the Total Abdominal Fat (TAT) area was manually delineated along the abdominal wall contour using the tissue composition analysis module. The software automatically identified and segmented the VAT area (with the abdominal wall muscles and spine as the inner boundary), and the SAT area was obtained by subtracting the VAT area from the TAT area. The results of the two measurements were recorded and averaged. Liver fat measurement: At the level of the right branch of the portal vein, circular Regions Of Interest (ROIs) with an area of approximately 300 mm² were placed in the right anterior lobe, right posterior lobe, and left medial lobe of the liver, avoiding large bile ducts, intrahepatic vessels, and liver fissures. The average value of the three ROI measurements was taken as Fat%-QCT. Consistency test: 30 images were randomly selected, and the two radiologists repeated the measurements after a two-week interval. The Intra-class Correlation Coefficient (ICC) of abdominal VAT area, SAT area, and Fat%-QCT was calculated to assess the intra- and inter-observer consistency. The results showed that the ICC of all indicators was greater than 0.95, indicating excellent measurement consistency.

2.4. Statistical Analysis

SPSS 25.0 software was used. For the measurement data that followed a normal distribution, they were expressed as $\bar{x} \pm s$, and the comparison between groups was conducted using the independent sample t-test; for the non-normal distribution data, they were represented as M (P25, P75), and the comparison between groups was performed using the Mann-Whitney U test. For the count data, they were expressed as the number of cases (percentage), and the comparison between groups was conducted using the χ^2 test or Fisher's exact test. Spearman's rank correlation was initially used to preliminarily analyze the correlation between each factor and AD (assigned as 1 = yes, 0 = no). Variables from the univariate analysis with $P < 0.1$ and variables with clear clinical significance (such as age, gender) were included in the multivariate binary Logistic regression to analyze the independent related factors of AD occurrence. In the Logistic regression model, categorical variables such as smoking history, drinking history, and hypertension were all regarded as the reference category as "no". The results were expressed as Odds Ratio (OR) and its 95% Confidence Interval (CI). Before conducting the regression analysis, collinearity diagnosis was performed on continuous independent variables (SAT area, VAT area, Fat%-QCT), and the Variance Inflation Factor (VIF) was all less than 5, indicating the absence of severe multicollinearity. As P value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of General Data and Fat Parameters between the Two Groups

There was no statistically significant difference in age and gender composition between the dissection group and the control group ($P > 0.05$), and the matching was

successful. The proportions of smoking history, drinking history, and hypertension in the dissection group were significantly higher than those in the control group (all $P < 0.001$). In terms of lipid indicators, there was no statistically significant difference in total cholesterol, triglycerides, high-density and low-density lipoprotein cholesterol levels between the two groups (all $P > 0.05$). In terms of imaging parameters, the Fat%-QCT, VAT area, and SAT area in the dissection group were significantly higher than those in the control group ($P = 0.012, <0.001, 0.002$). See **Table 1**.

Table 1. Comparison of baseline data and fat parameters between the dissection group and the control group.

Clinical characteristics		Dissection group (n = 99)	Control group (n = 85)	χ^2/z	P
Gender [n (%)]	Male	84 (84.8)	64 (75.3)	2.653 ^a	0.103
	Female	15 (15.2)	21 (24.7)		
Age		56.00 (46.00, 67.00)	58.00 (53.00, 67.00)	-1.418 ^b	0.156
Smoking history [n (%)]	Yes	43 (43.4)	10 (11.8)	22.367 ^a	<0.001
	No	56 (56.6)	75 (88.2)		
Drinking history [n (%)]	Yes	38 (38.4)	6 (7.1)	24.665 ^a	<0.001
	No	61 (61.6)	79 (92.9)		
Hypertension [n (%)]	Yes	68 (68.7)	22 (25.9)	33.543 ^a	<0.001
	No	31 (31.3)	63 (74.1)		
Diabetes [n (%)]	Yes	3 (3.0)	4 (4.5)	0.021 ^a	0.886
	No	96 (97.0)	85 (95.5)		
Total cholesterol		4.16 (3.26, 4.80)	4.04 (3.48, 4.48)	-0.533	0.594
Triglycerides		1.14 (0.80, 1.77)	0.95 (0.73, 1.36)	-1.423 ^b	0.155
High-density lipoprotein		1.25 (1.08, 1.48)	1.37 (1.14, 1.57)	-1.377 ^b	0.168
Low-density lipoprotein		2.28 (1.58, 2.75)	2.36 (1.94, 2.80)	-1.259 ^b	0.208
Fat%-QCT		12.20 (10.10, 15.400)	8.20 (10.90, 13.75)	-2.499 ^b	0.012
Visceral fat area		154.40 (101.50, 218.10)	113.00 (64.75, 165.2)	-3.738 ^b	<0.001
Subcutaneous fat area		109.00 (79.80, 152.20)	86.30 (53.80, 126.65)	-3.071 ^b	0.002

Note: a represents χ^2 test or Fisher's exact test; b represents Mann-Whitney U test.

3.2. Correlation Analysis of Various Factors with Aortic Dissection

Spearman rank correlation analysis revealed that smoking history, drinking history, hypertension, Fat%-QCT, SAT area, and VAT area were all positively correlated with the occurrence of AD (correlation coefficient R values ranged from 0.185 to 0.427, all $P < 0.05$), among which hypertension had the strongest correlation ($R = 0.427, P < 0.001$). See **Table 2**.

Table 2. Spearman correlation analysis of various factors with the occurrence of aortic dissection.

Influencing factors	Correlation coefficient R	P
Smoking history	0.349	<0.001
Drinking history	0.366	<0.001
Hypertension	0.427	<0.001
Fat%-QCT	0.185	0.012
Visceral fat area	0.277	0.002
Subcutaneous fat area	0.276	<0.001

3.3. Multivariate Logistic Regression Analysis of Risk Factors for Aortic Dissection

The variables with significant results from the univariate analysis (smoking history, drinking history, hypertension, Fat%-QCT, VAT area, SAT area) and age and gender were included in the multivariate Logistic regression model. The collinearity diagnosis revealed that the Variance Inflation Factors (VIF) for all continuous variables were all less than 2, indicating that there were no serious multicollinearity issues in the model. The results showed that, after controlling for other factors, smoking history, drinking history, hypertension and SAT area were independent risk factors for AD. See **Table 3**.

Table 3. Multivariate logistic regression analysis of risk factors for aortic dissection.

Influencing factors	OR (95 % CI)	P
Smoking history	0.238 (0.087, 0.653)	0.005
Drinking history	0.150 (0.049, 0.459)	0.001
Hypertension	0.138 (0.061, 0.311)	<0.001
Fat%-QCT	1.089 (0.982, 1.206)	0.105
Subcutaneous fat area	1.010 (1.001, 1.019)	0.029
Visceral fat area	0.998 (0.991, 1.004)	0.486

4. Discussion

This study, based on QCT technology, systematically evaluated the association between abdominal fat distribution and AD occurrence. The main finding was that an increase in abdominal SAT area was an independent influencing factor for AD, while VAT area and liver fat content did not show independent predictive value in multivariate analysis. This result suggests that SAT may be a more specific fat depot to focus on when assessing the risk of obesity-related AD.

Hypertension, smoking, and alcohol consumption are well-recognized traditional risk factors for AD [8] [9]. The results of this study once again confirmed this, as all three showed a strong correlation with AD (Spearman $R > 0.3$) and

were independent influencing factors. The mechanisms may be related to direct damage to the aortic wall from long-term elevated blood pressure, oxidative stress and endothelial dysfunction induced by tobacco and alcohol [10]. The core role of these traditional factors in the occurrence of AD is beyond doubt.

Unlike previous studies that focused more on VAT [3], this study found that SAT area had independent predictive value. This finding may have important pathophysiological significance. The traditional “visceral obesity hypothesis” holds that VAT is metabolically active and the main contributor to cardiovascular risk. However, SAT is not only an energy storage depot; when it expands excessively, it can lead to fat cell dysfunction, hypoxia, and chronic low-grade inflammation [11]. More importantly, SAT has a limited storage capacity. When SAT capacity is saturated, excess lipids will “spill over” and deposit in ectopic sites, including perivascular adipose tissue [12]. Abnormal accumulation and inflammation of perivascular adipose tissue have been shown to directly promote aortic wall inflammation, matrix metalloproteinase activation, and extracellular matrix remodeling through paracrine and adventitial effects, thereby weakening the strength of the vascular wall and increasing the risk of dissection [13] [14]. Therefore, the independent correlation of SAT area in this study may reflect this “spillover” state and the resulting perivascular pathological changes. While VAT itself has a high level of inflammatory factor secretion, its impact may be more reflected in systemic metabolic disorders and insulin resistance, and its direct local effect on the aortic wall may be less than that of SAT at the “spillover” critical point.

This study did not find significant differences in lipid profiles between the two groups, which may be related to the acute stress state of AD and the early admission affecting lipid levels, and is consistent with some research results [15]. Liver fat content (Fat%-QCT) was associated with AD in univariate analysis, but the correlation disappeared after adjusting for smoking, alcohol consumption, hypertension, and abdominal fat area. This indicates that the risk of liver steatosis for AD may be mainly mediated by its collinearity with systemic obesity and metabolic disorders, rather than an independent effect.

This study has the following limitations: Firstly, as a retrospective study, it is impossible to establish a causal relationship between SAT area and AD. Secondly, the sample size is relatively small and the data are from a single center, which may affect the generalizability of the results. Thirdly, QCT measurement only selects a single section of L2/3; although it is a gold standard method [7], it cannot fully reflect the fat distribution throughout the body. Fourthly, the interstitial group in this study includes patients of different types and stages, and their pathophysiological processes are different, which may have potential impacts on the research results. However, due to the small sample size of the subgroups, no stratified analysis was conducted. Fifthly, this study failed to collect the patients' Body Mass Index (BMI), family history of aortic diseases, history of hereditary connective tissue diseases (such as Marfan syndrome), as well as the use of antihypertensive drugs and lipid-lowering drugs. These known predisposing factors or confound-

ing factors for AD were not included in the model for adjustment, which may cause certain bias in the interpretation of the results.

5. Conclusion

This study, using QCT as a precise quantification tool, reported for the first time that abdominal subcutaneous fat area is an independent influencing factor for aortic dissection. This finding expands our understanding of the relationship between obesity and aortic diseases and suggests that in clinical practice, in addition to controlling traditional risk factors, the assessment and management of abdominal subcutaneous fat may also become a new entry point for preventing aortic dissection. Future research should be forward-looking and based on large sample sizes, and should incorporate more comprehensive adipose function indicators to further clarify the underlying mechanisms.

Conflicts of Interest

The authors declare no conflicts of interest.

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