

Predictive value of CT plain scan of pericoronar fat thickness

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A study on the predictive value of CT plain scan of pericoronary fat thickness combined with clinical indicators for young patients with coronary atherosclerotic heart disease

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Abstract

This study aimed to investigate whether chest CT scans could predict the incidence of atherosclerotic heart disease in patients aged ≤ 40 years. Convenience sampling was used to select 296 patients aged ≤ 40 years with Acute Coronary Syndrome (ACS), and their general information and CT data were collected. According to the results of coronary CTA, patients were divided into a diseased group (134) and an untreated group (162). Single and multiple logistic regression were used to analyze variables, and different variable combination models and single variable models were established to analyze the clinical value of different models. The results showed systolic blood pressure, diastolic blood pressure, Thick1 and BMI. There is a statistically significant relationship between fasting blood glucose and the occurrence of coronary artery plaques. After single factor logistic regression analysis, multiple factor logistic analysis was carried out for indicators with P values less than 0.05. The results showed that gender (OR: 2.1, 95% CI: 1.031-4.292, $p=0.04$), systolic blood pressure (OR: 1.02, 95% CI: 1.01-1.036, $p=0.000$), diastolic blood pressure (OR: 1.04, 95% CI: 1.017-1.054, $p=0.000$), Chol (OR: 1.26, 95% CI: 1.056-1.495, $p=0.01$), TG (OR: 1.35, 95% CI: 1.09-1.678, $p=0.01$), FBG (OR: 1.11, 95% CI: 1.009-1.213, $p=0.03$), Thick1 (OR: 1.5, 95% CI: 1.337-1.682, $p=0.000$) and coronary atherosclerosis. The area under the curve of the prediction model based on the thickness of coronal fat (Thick1), as well as the area under the curve of the prediction model based on systolic blood pressure, diastolic blood pressure, and FBG, show that the effectiveness of the Thick1 model is much higher than that of the clinical indicator model. Chest CT scans hold clinical significance in predicting coronary atherosclerosis in patients aged ≤ 40 years with ACS.

Key words: ≤ 40 years old; acute coronary syndrome; coronary artery disease; machine learning; predictive model; blood pressure.

Acute Coronary Syndrome (ACS), as an emergency cardiovascular event, is mainly caused by Coronary Artery Disease (CAD)¹ The incidence of CAD is constantly rising worldwide, and cardiovascular events in Asian countries are more serious than those in Western countries.²⁻³ In recent years, the incidence of CAD among young people has been increasing year by year,

imposing a heavy burden on society and families.⁴ Therefore, the early diagnosis of CAD is crucial for reducing the mortality rate of patients.⁵

At present, the diagnosis of CAD mainly relies on coronary CTA. However, due to factors such as radiation exposure and cost, it is not a routine physical examination item. Moreover, the electrocardiograms of most ACS patients show no abnormalities during the non-onset period. Therefore, many CAD patients cannot be detected in time.⁶ The aim of this study is to attempt to construct a machine learning model using the pericoronary fat diameter measured by plain chest CT scans of the mediastinal window in combination with routine admission items to predict the occurrence of coronary atherosclerosis in patients aged 40 and under.

Materials and Methods

Research population and grouping

Clinical data of 296 patients aged 40 and under with ACS in Huai'an First Hospital Affiliated to Nanjing Medical University from January 2019 to December 2023 were collected, including height, weight, etc. According to the results of CT coronary angiography, the patients were randomly divided into the training set and the test set in a ratio of 7:3.

Inclusion criteria included: i) age ≤ 40 years old; ii) the patient was admitted to the hospital due to ACS; iii) there is no missing result in the patient's CT and general clinical data; iv) CT coronary angiography was performed one week before and after the patient's admission.

Exclusion criteria were: i) ACS accompanied by severe malignant tumors, hematological diseases and autoimmune diseases; 2) suffering from congenital heart disease, having undergone bypass surgery or stent implantation in the past; 3) severe arrhythmia, second-degree type II or above atrioventricular block; 4) those with severe abnormalities in liver, kidney and thyroid functions.

This study was approved by the Research Ethics Committee of Huai 'an First Hospital Affiliated to Nanjing Medical University (No.: KY-2024-045-03).

General information

This includes basic data such as age, gender, Body Mass Index (BMI), systolic blood pressure, and diastolic blood pressure. The thickness of epicardial fat in the free wall of the right ventricle on the mediastinal window of the chest CT scan is Thick1, and Thick2 is measured on the original CTA image.

Statistical analysis

Normal distribution variables are expressed as mean $\pm$ standard deviation, and the independent sample t-test is used to compare continuous data. Categorical variables are expressed by frequency (percentage), and chi-square test or Fisher's exact test is used for the statistics of

categorical variables. Univariate and multivariate logistic regression were used to verify the clinical factors of coronary atherosclerosis in children under 40 years old, and the ROC curve evaluation model was constructed. All data analyses were conducted using R software (version 3.2.0), and a p value <0.05 was considered statistically significant.

Results

Clinical pathological features and patient grouping

A total of 296 cases aged 40 or younger were included in this study and divided into the disease group and the non-disease group. There were significant differences in the general characteristics, basic clinical data and pericoronary fat data between the two groups ($p < 0.05$; Table 1). The results showed that there was statistical significance among systolic blood pressure, diastolic blood pressure, Thick1, BMI, fasting blood glucose and coronary plaque occurrence. After univariate logistic regression analysis, the indicators with P values less than 0.05 were subjected to multivariate logistic analysis. The results are detailed in Figure 1. The paired sample t-test was conducted on Thick1 measured by plain chest CT scan and Thick2 measured on CTA images, and it was found that there was no significant statistical difference between the two ($p=0.121$). The clinical prediction model was constructed using Thick1 measured on the mediastinal window of chest CT.

Construction of a machine model of risk factors for coronary atherosclerosis in young patients aged ≤ 40 years

A total of 296 patients were randomly divided into a training set and a validation set (7:3). In the training set, a model named model1 was constructed based on the single variable Thick1, and the area under the ROC curve was plotted. The results of the training set and the test set were 0.886 and 0.963, respectively (Figures 2a and 2b). The mixed model model2 was constructed based on systolic blood pressure, diastolic blood pressure and FBG. The AUCs in the training set and test set were 0.684 and 0.573 respectively (Figures 2c and 2d). The total score was correlated with the linear predictors and risk predictors of whether coronary atherosclerosis occurred (Figure 3). Calibration curves and clinical impact curves were constructed based on the nomogram data of model1 and model2 in the validation set. The C-indexes of the calibration curves were 0.963 and 0.522, respectively (Figure 4).

Discussion

The incidence and mortality risk of ACS among young people are increasing year by year. Research shows that in the relationship between hypertensive patients of different ages and the occurrence of cardiovascular diseases, the risk of cardiovascular diseases and all-cause mortality in hypertensive patients under 45 years old is significantly higher than that in

hypertensive patients aged 45 and above.⁷ The results of this study show that after grouping based on the CTA results, there are significant statistical differences in both systolic and diastolic blood pressure between the two groups.

Multiple research results have shown that among patients with ACS, obese patients have better in-hospital and long-term prognosis than those with a low Body Mass Index (BMI).⁸ The mechanism behind this "obesity paradox" is not yet fully understood. Other studies have shown that the accumulation of excess fat in the body can increase blood volume, thereby enhancing overall tolerance and cardiac output, leading to hypertrophy of the left and right ventricles, and ultimately resulting in heart failure. In addition, elevated levels of inflammatory cytokines such as leptin and C-Reactive Protein (CRP) are associated with obesity and can exacerbate vascular and myocardial damage.⁹

The results of this study show that the indicators of $BMI \geq 30$ have significant statistical significance, but none of them have significant statistical significance in logistic regression. Therefore, the role of BMI in young patients aged ≤ 40 years needs further exploration. Waist circumference and hip-to-waist ratio are known cardiovascular risk factors.¹⁰ However, when the patient was admitted to the hospital, the body mass index was measured, but the waist circumference and hip circumference were not. Therefore, the mechanism by which obesity affects the cardiovascular system remains to be further explored.

In a study on the factors related to the occurrence of coronary atherosclerosis without age distinction, it was shown that triglycerides and fasting blood glucose levels were positively correlated with the severity of coronary atherosclerosis.¹¹ Foreign research shows that approximately one quarter of adults who visit hospitals due to ACS have a history of diabetes. This also suggests the impact of elevated blood sugar on the cardiovascular system.¹² In the study conducted by Chen et al. involving 1056 patients with CHD and 616 control cases, it was found that triglycerides, fasting blood glucose, etc. were independent risk factors for the occurrence of CHD, while high-density lipoprotein C was a protective factor.¹³ This study found that triglycerides and total cholesterol had no significant statistical significance in the paired t-test, while fasting blood glucose had significant statistical significance ($p=0.004$). The binary logistic regression analysis showed that the effects of triglycerides, total cholesterol and fasting blood glucose on coronary arteries were all statistically significant.

Perivascular Adipose Tissue (PVAT) has been regarded as an independent risk factor for coronary heart disease.¹⁴ Previous studies have shown that PCAT density has significant implications for the progression of coronary atherosclerosis.¹⁵ The differences in fat density and volume around the heart and pericardium can reflect different types of plaques.¹⁶ Chris's research shows that fat density can be used to detect the inflammatory response of patients. A higher pericardial fat density leads to a lower ratio of total vascular volume to myocardium (V/M), which can serve as a warning indicator for Cardiac graft Vascular Disease (CAV).¹⁷

Wrinkles *et al.* found that the AUC of the texture features, angular second moment, deficit moment and entropy of the fat around the pericardium were 0.808, 0.825 and 0.823 respectively, which had significant statistical significance.¹⁸ In this study, the paired sample t-test was used and no significant statistical difference was found between Thick1 and Thick2 ($p=0.121$), indicating that the pericoronary fat thickness measured by plain chest scan mediastinal window was not significantly different from that measured by CTA. It has obvious statistical significance in independent sample t-tests, univariate and multivariate logistic regression analyses. In the model construction where Thick1 was used as an independent predictor, the areas under the ROC curve in the training set and the test set were 0.886 and 0.963 respectively. ROC curves were delineated according to different models, and the results showed that the diagnostic value of the Thick1 model (model1) was superior to that of the combined model group (model2). Decision curve analysis indicates that using the model1 model to predict the occurrence of coronary atherosclerosis in people aged ≤ 40 has greater advantages than the model1 model. The C-index of the calibration curve of Model1 in the validation set is 0.963, indicating that the model has high clinical value. Despite this, our research still has certain limitations. The machine learning model in this study was constructed using single-center data without external validation. In addition, this study only measured the thickness of pericoronary fat and did not further analyze the density of pericoronary fat and the infiltration of adjacent myocardial fat. This will be achieved in our next research.

List of Abbreviations

ACS, Acute Coronary Syndrome.

CAD, Coronary Atherosclerotic Heart Disease.

CT, Computed Tomography.

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Contributions

Lihua Zhang, conceptualization, data curation, writing-original draft; Yang Gu, methodology, formal analysis; Aichao Ruan, supervision, writing-review & editing, project administration. All authors read and approved the final manuscript.

Conflict of interest

The authors declare that there are no conflicts of interest regarding this study.

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. Approval was granted by the Institutional Review Board of Jiangsu Province Huai'an First People's Hospital (Approval No.KY-2024-045-03). Due to the retrospective nature of this study, the Institutional Review Board approved a waiver of informed consent.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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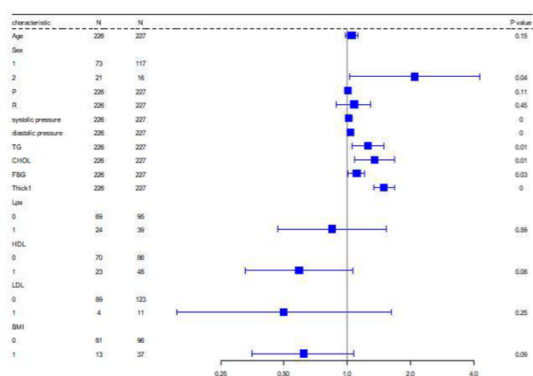
Table 1 General base characteristics of patients.

	Training group (227 people)				Test group (69 people)			
	Group of Patients (1)	Non-diseased group (0)	t/F	P	Group of Patients (1)	Non-diseased group (0)	t/F	P
	(94 people)	(133 people)			(40 people)	(29 people)		
Age (years)	35.40±3.95	34.57±4.04	0.403	0.526	35.82±3.96	33.27±4.08	0.301	0.58
Gender								
Male	73 (77.7)	117 (88.0)	3.13		36 (90)	23 (79.3)		
Female	21 (22.3)	16 (12.0)		0.077	4 (10)	6 (20.7)	1.55	0.184
P	89.51±15.33	86.34±15.84	0.038	0.846	93.03±19.01	88.86±13.60	2.78	0.10
R	18.41±1.63	18.25±1.21	2.185	0.141	18.78±2.34	18.52±1.37	1.04	0.31

Systolic blood pressure	151.10±26.409	139.23±20.808	8.375	0.004	148.85±23.95	143.37±20.55	0.749	0.39
Diastolic blood pressure	96.82±2.384	86.88±14.476	8.606	0.004	95.47±20.07	89.13±13.64	3.389	0.07
Thick1	16.33±6.447	7.53±2.302	55.425	0.000	16.79±5.01	7.32±1.81	11.00	0.001
Thick2	15.99±7.04	7.64±2.50	46.19	0.000	16.76±4.99	28.44±113.59	4.94	0.03
BMI								
0 (BMI<30) (%)	81 (86.2)	96 (72.2)			32 (80)	24 (82.8)		
1 (BMI≥30) (%)	13 (13.8)	37 (27.8)	5.678	0.015	8 (20)	5 (17.2)	0.084	0.772
Lpa								
0 (<300) (%)	69 (74.2)	95 (70.9)			25 (62.5)	22 (75.9)		
1 (≥300) (%)	24 (25.8)	39 (29.1)	0.298	0.585	15 (37.5)	7 (24.1)	1.382	0.24
Triglyceride (TG)								
0 (<1.7mmol/l) (%)	90 (96.8)	121 (90.3)			36 (90)	28 (96.6)		
1(≥1.7mmol/l)	3 (3.2)	13 (9.7)	3.514	0.069	4 (10)	1 (3.4)	0.32	0.389
Total cholesterol (TC)								
0 (<5.2mmol/l)	87 (93.5)	115 (85.8)			34 (85)	26 (89.7)		
1(≥5.2mmol/l)	6 (6.5)	19 (14.2)	3.345	0.067	6 (15)	3 (10.3)	0.042	0.724

Fasting plasma glucose (FPG)	7.235±3.75 8	6.268±2.61 4	8.357	0.00 4	6.70±4.10	6.48±2.63	0.23 9	0.62 6
High-density lipoprotein (HDL)								
0 (<1.8mmol/l)	70 (75.3)	86 (64.2)			39 (97.5)	28 (96.6)		
1(≥1.8mmol/l)	23 (24.7)	48 (35.8)	3.141	0.07 6	1 (2.5)	1 (3.4)	0.00	1
Low-density lipoprotein (LDL)								
0 (<4.3mmol/l)	89 (95.7)	123 (91.8)			38 (95)	26 (89.7)		
1(≥4.3mmol/l)	4 (4.3)	11 (8.2)	1.359	0.28 8	2 (5)	3 (10.3)	0.71 5	0.64 3

a



b

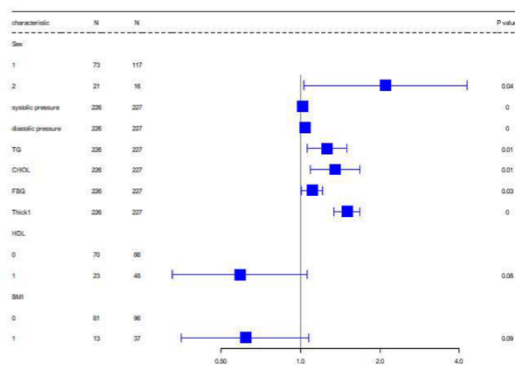


Figure 1. a) Univariate logistic regression forest plot of whether coronary atherosclerosis occurs in patients with acute coronary syndrome; b) Multivariate logistic regression forest plot.

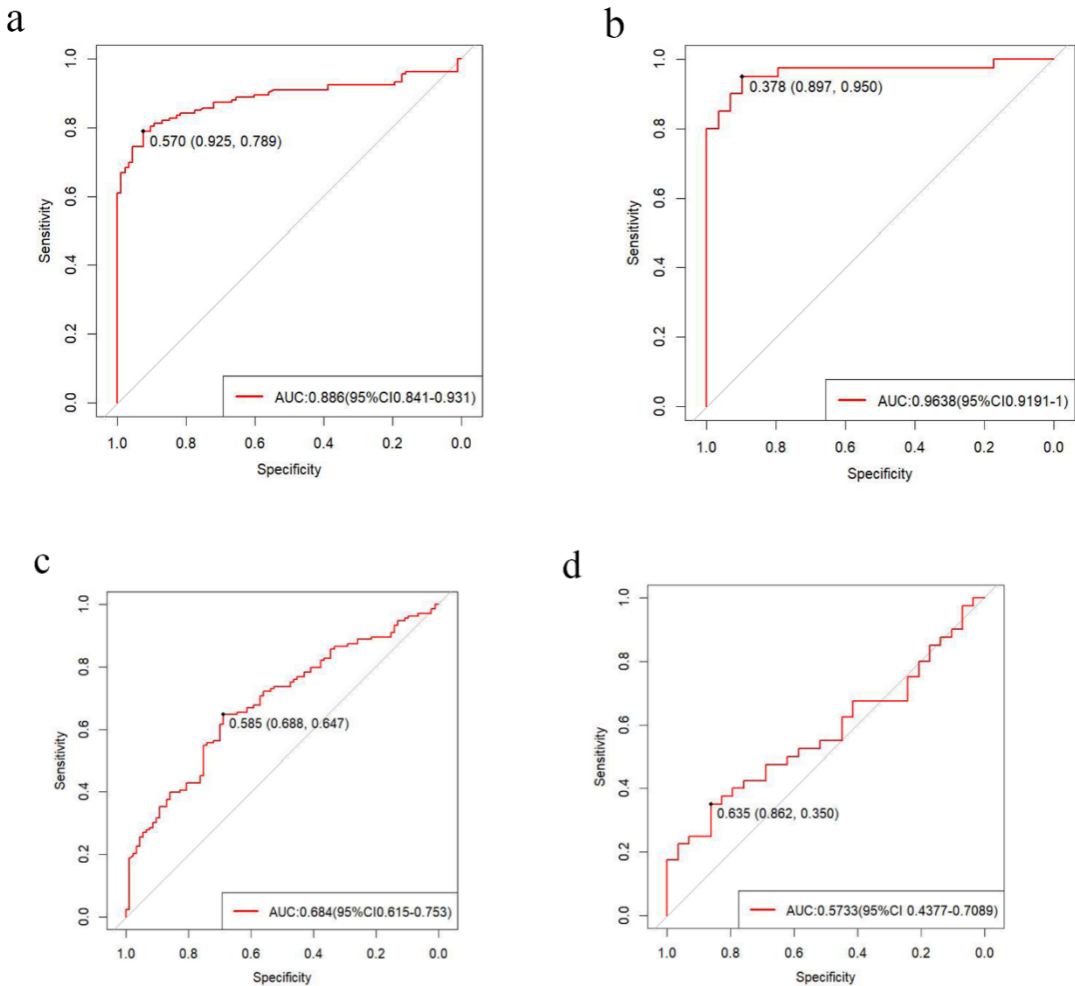


Figure 2.

Single-factor construction model of Thick1 model1. A mixed model model2 was constructed using systolic blood pressure, diastolic blood pressure and FBG. a) model1 training set; b) model1 test set; c) model2 training set; d) model2 test set.

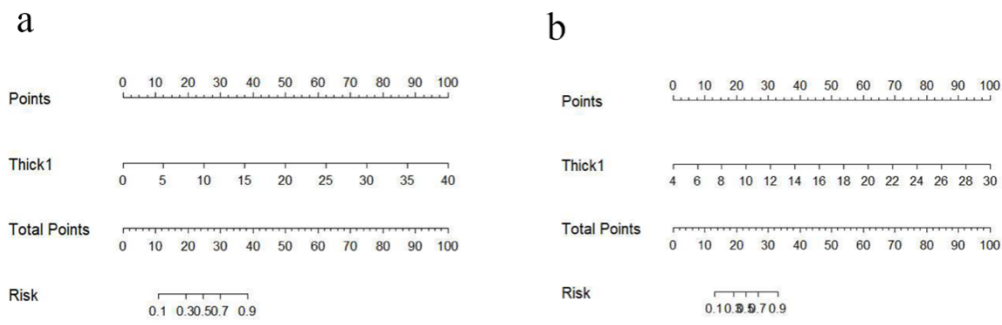


Figure 3. Shows the construction of a nomogram based on model1 variables, with a) training set and b) test set.

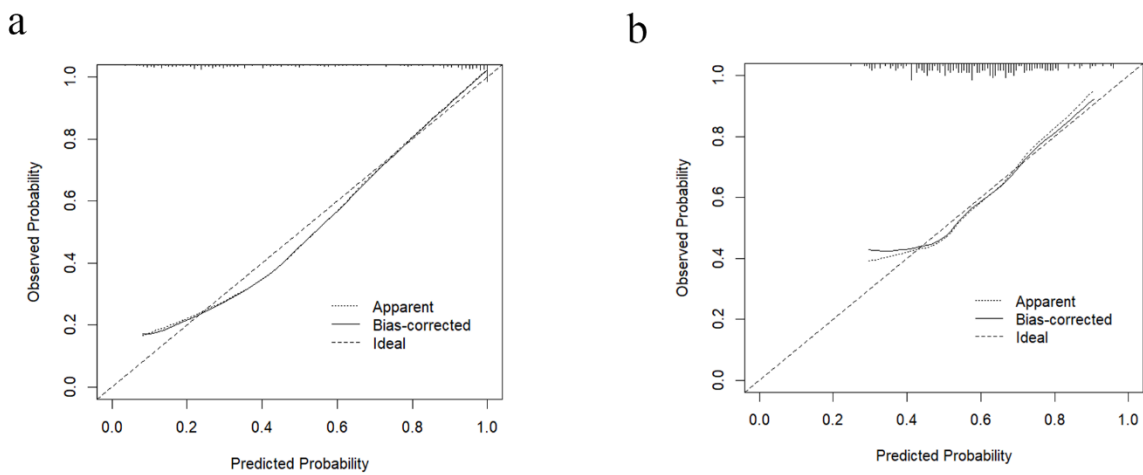


Figure 4. a) Calibration curve of Model model1, with a C-index of 0.963; b) the calibration curve of model2 has a C-index of 0.522.