

Utilization of Risk Scores for Coronary Heart Disease Diagnosis in Rural China

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Objective: The current study was to design a cardiovascular risk score for the diagnosis of coronary heart disease (CHD) in the rural area of China and the sensitivity and specificity of this score would be assessed.

Methods: A total of 520 patients were enrolled and based on the results from coronary artery angiography, patients were divided into three groups: CHD group (coronary artery $\geq 50\%$ stenosis), atherosclerosis group (coronary artery $< 50\%$ stenosis) and normal groups (without stenosis). Between-group differences were evaluated and the sensitivity and specificity of cardiovascular risk score were evaluated.

Results: Compared to the normal and atherosclerosis groups, patients in the CHD group were older, had higher body mass index, and more likely to be smoking and obese, and had dyslipidemia, hypertension and diabetes, and had higher cardiovascular risk score (4.05 ± 2.15 vs 2.94 ± 1.90 vs 2.54 ± 1.59). Patients in the CHD group were more likely to have cardiovascular risk scores ≥ 2 (90.2% CHD group vs 74.2% atherosclerosis group vs 76.1% normal group, $P < 0.05$). The area under the ROC was 0.673, with 95% confidence interval was 0.623–0.722 ($P < 0.001$), and the sensitivity and specificity were highest when the cardiovascular risk score was 4, indicating that the value of cardiovascular risk score of 4 was a good cutoff point for CHD diagnosis.

Conclusion: Using cardiovascular risk score can improve CHD diagnosis which may help to reduce health disparities between rural and urban area.

Keywords: coronary heart disease, cardiovascular risk score, sensitivity, specificity

Introduction

Coronary heart disease (CHD) is a leading cause of morbidity and mortality in the developed countries.^{1–3} In the past decades, with increasing prevalence and incidence of hypertension, diabetes, dyslipidemia, as well as endemic of sedentary lifestyle and smoking,^{4–6} the prevalence and incidence of CHD in China is increased dramatically.^{7,8} Due to the profound differences in economic development between the urban and rural areas of China, the health resources, diagnostic equipment and therapeutic approaches for CHD are quite different, which result in significantly poorer prognosis and higher mortality rates of CHD in patients of rural area than urban area.^{9–11}

Notably, besides typical clinical symptoms, electrocardiogram (ECG), sensitive cardiac biomarkers such as high-sensitivity cardiac troponin-I (Hs-CTnI), cardiac computed tomography (CT) and angiography are the important avenues for increasing the diagnostic accuracy of CHD.^{12–14} However, in rural areas of China, other than ECG, the commonly used sensitive diagnostic approaches are not always readily available which lead to delayed diagnosis and missed the timing for reperfusion of occluded coronary artery with fibrinolysis or percutaneous coronary intervention.

Huizhou, a city located in the southeast part of China, is a relatively well-developed urban city, which is surrounded by many rural areas wherein health resources are scarce. In order to improve the managements of suspected CHD patients in the local rural areas of Huizhou city, the Huizhou Institute of Health initiates a program in order to help improve the diagnosis of CHD in these rural areas, and as one of the leading cardiovascular centers in Huizhou, we designed a cardiovascular risk score for CHD diagnosis and then to evaluate the sensitivity and specificity of this score

for CHD diagnosis. Our results indicate that this score has a good predictive value for CHD diagnosis in Huizhou rural area. Hopefully, this score derived from our study can be further corroborated in other population groups which in turn can improve prognosis of CHD patients in the rural area.

Methods

Participants' Enrollment

The current study was approved by the Clinical Research Ethic Committee of the Third People's Hospital of Huizhou. Informed consent was obtained before participant's enrollment. All the performances were conducted in accordance with the Declaration of Helsinki. Current study was conducted between January of 2017 to December of 2017. The inclusion criteria were: patients with suspected CHD and underwent coronary angiography; the exclusion criteria were: missed data of clinical risk factors; could not finish ECG, echocardiography or carotid artery ultrasound examination; documented acute heart failure or acute myocardial infarction; or had end stage liver, renal, lung disease or malignancy. A total of 520 patients were enrolled and based on the results from coronary artery angiography, patients were divided into three groups: CHD group (coronary artery $\geq 50\%$ stenosis), atherosclerosis group (coronary artery $< 50\%$ stenosis) and normal groups (without stenosis).

Data Collection

The factors including into the cardiovascular risk scores were as follows: 1) presence of any of these risk factors (male ≥ 45 years old or female ≥ 55 years old; hypertension or with antihypertensive treatment; dyslipidemia or with statins treatment; smoking; body mass index ≥ 28 kg/m², or male waist circumference > 90 cm and female waist circumference > 85 cm; diabetes or with anti-diabetic treatment or abnormal fasting or postprandial blood glucose level); 2) ECG changes (no ST-T abnormality; ST-T depression and/or T wave flat or inversion); 3) echocardiography change (normal wall motion or focal or diffuse wall motion abnormality); 4) carotid artery ultrasound (normal; carotid intima-media thickness [CIMT] > 1.0 cm; presence of carotid plaque; carotid stenosis $< 50\%$ or $\geq 50\%$); 5) clinical symptoms (chest pain, dyspnea, short of breath or palpitation; duration of symptoms; activity related; relieved by rest or nitroglycerin); 6) coronary angiography (coronary artery $\geq 50\%$ stenosis, $< 50\%$ stenosis or without stenosis). Based on the presence of these factors, a score from 0 to 4 was signed into each individual variable (Table 1).

Statistical Analysis

We used statistical software SPSS24.0 to perform statistical analysis. Using the chi-square test for comparison of categorical variables and analysis of variance for continuous variables. Coronary artery angiography was used as the standard diagnostic criteria and the cardiovascular risk score was compared with the angiography to evaluate the accuracy of the score. The point allocation to each variable was based on the coefficient of the logistic regression analysis which was described previously. In specific, in the first step, univariate regression analysis was performed and factors with P-value < 0.1 were entered into multivariable regression models. In the second step, factors independently associated with CHD were selected. In addition, factors which were clinically important were also selected although without statistical significance. In the third step, based on the value of the coefficient, a score from 0 to 4 was assigned.

The receiver operating curve (ROC) was constructed to evaluate the performance of this score for CHD diagnosis; and the sensitivity and specificity of different scores for diagnosing CHD were calculated. $P < 0.05$ was considered as statistically significant;

Results

Baseline Characteristics Comparisons

As presented in Table 2, compared to the normal and atherosclerosis groups, patients in the CHD group were older (63.8 ± 11.2 vs 61.8 ± 11.7 vs 58.3 ± 12.9 years old), had higher BMI (26.5 ± 5.8 vs 25.8 ± 5.7 vs 25.3 ± 5.2 kg/m²), and more likely to be smoking (58.1% vs 29.9% vs 44.4%) and obese (30.6% vs 17.5% vs 11.1%), and had dyslipidemia (30.6% vs 17.5% vs 11.1%), hypertension (60% vs 48.5% vs 31.7%) and diabetes (30.3% vs 14.4% vs 12.7%), and had higher

Table 1 Variables of Cardiovascular Risk Score

Variables	Descriptions	Score	
		Yes	No
Age	Male ≥ 45 years old, Female ≥ 55 years old	1	0
Smoking	≥ 10 years and ≥ 10 cigarette/day	1	0
Blood pressure	$\geq 140/90$ mmHg or anti-hypertensive treatment	2	0
Blood glucose	Fasting ≥ 7.0 mmol/L, 2h- postprandial ≥ 11.1 mmol/L, or anti-diabetic treatment	3	0
Lipid profiles	Total cholesterol ≥ 5.72 mmol/L, LDL-C ≥ 3.64 mmol/L, or statins treatment	1	0
BMI	BMI > 28 kg/m ² , or male waist circumference ≥ 90 cm, female ≥ 80 cm	1	0
ECG	Without ischemia change	0	-
	Diffuse ST depression and/or T wave flat or inversion	1	-
	Corresponding ST depression and/or T wave flat or inversion	2	-
	ST-T dynamic change in line with ischemia	4	-
ECHO	No abnormality of wall motion	0	-
	Diffuse abnormality of wall motion	2	-
	Segmental abnormality of wall motion	4	-
Carotid artery ultrasound	Normal	0	-
	IMT > 1.0 mm but without plaque	0.5	-
	Has plaque but without stenosis	1	-
	Has plaque and stenosis $< 50\%$	2	-
	Has plaque and stenosis $\geq 50\%$	4	-
Clinical presentation	Chest pain but none specific	1	-
	Chest pain with compress feeling	2	-
	Chest pain symptoms last more than 30 seconds and less than 15 minutes	3	-
	Symptoms are related to exercise, diet and cold et al.	3	-
	Symptoms released with nitroglycerin	3	-

cardiovascular risk score (4.05 ± 2.15 vs 2.94 ± 1.90 vs 2.54 ± 1.59). In addition, compared to the normal group, patients in the atherosclerosis group were also older, and more likely to be obese, and had dyslipidemia and hypertension and had higher cardiovascular risk score, but less likely to be male and smoking.

Distribution of Cardiovascular Risk Scores Among Three Groups

As presented in Table 3, compared to the normal and atherosclerosis groups, patients in the CHD group were more likely to have cardiovascular risk scores ≥ 2 (90.2% CHD group vs 74.2% atherosclerosis group vs 76.1% normal group, $P < 0.05$) and no significant differences in atherosclerosis group and normal group was observed in patients with cardiovascular risk scores ≥ 2 . However, compared to patients in the normal group, patients in the atherosclerosis group were more likely to have cardiovascular risk scores ≥ 3 (58.7% vs 42.9%, $P < 0.05$).

Table 2 Baseline Characteristics and Cardiovascular Risk Score Comparisons

	Normal Group	Atherosclerosis Group	CHD Group
n	63	97	360
Age (years)	58.3 ± 12.9	61.8 ± 11.7 [#]	63.8 ± 11.2*
Male, n (%)	47 (74.6)	53 (54.6) [#]	273 (75.8)
BMI (kg/m ²)	25.3 ± 5.2	25.8 ± 5.7	26.5 ± 5.8*
Obese, n (%)	7 (11.1)	17 (17.5) [#]	110 (30.6)*
Smoking, n (%)	28 (44.4)	29 (29.9) [#]	209 (58.1)*
Dyslipidemia, n (%)	7 (11.1)	17 (17.5) [#]	110 (30.6)*
Hypertension, n (%)	20 (31.7)	47 (48.5) [#]	216 (60)*
Diabetes, n (%)	8 (12.7)	14 (14.4)	109 (30.3)*
Scores	2.54 ± 1.59	2.94 ± 1.90 [#]	4.05 ± 2.15*

Notes: *P < 0.05 vs normal group and atherosclerosis group; [#]P < 0.05 vs normal group.

Table 3 Distribution of Cardiovascular Risk Scores Among Three Groups

	CHD Group (%)	Atherosclerosis Group (%)	Normal Group (%)	Total (%)
n	360	97	63	520
0	2 (0.6)	5 (5.2)	1 (1.6)	8 (1.5)
1	33 (9.2)	20 (20.6)	20 (33.3)	73 (14.0)
2	74 (20.6)	15 (15.5)	14 (22.2)	103 (19.8)
3	52 (14.4)	31 (32.0)	13 (20.6)	96 (18.5)
4	75 (20.8)	10 (10.3)	7 (11.1)	92 (17.7)
5	33 (9.2)	5 (5.2)	5 (7.9)	43 (8.3)
6	18 (5)	4 (4.1)	1 (1.6)	23 (4.4)
7	40 (11.1)	4 (4.1)	2 (3.2)	46 (8.8)
8	31 (8.6)	3 (3.1)	0 (0)	34 (6.5)
9	2 (0.6)	0 (0)	0 (0)	2 (0.4)

Sensitivity and Specificity of Cardiovascular Risk Score to Predict CHD

Using coronary angiography as standard diagnostic criteria, the sensitivity and specificity of cardiovascular risk score were evaluated by the ROC. As presented in Figure 1, the area under the ROC was 0.673, with 95% confidence interval was 0.623–0.722 (P < 0.001), and as presented in Table 4, the sensitivity and specificity was highest when the cardiovascular risk score was 4, indicating that the value of cardiovascular risk score of 4 was a good cutoff point for CHD diagnosis.

Discussion

To our knowledge, our current study for the first time shows that in the rural area of China, cardiovascular risk scores, which include parameters of clinical symptoms, comorbidities, ECG, echocardiography and carotid artery ultrasound, can

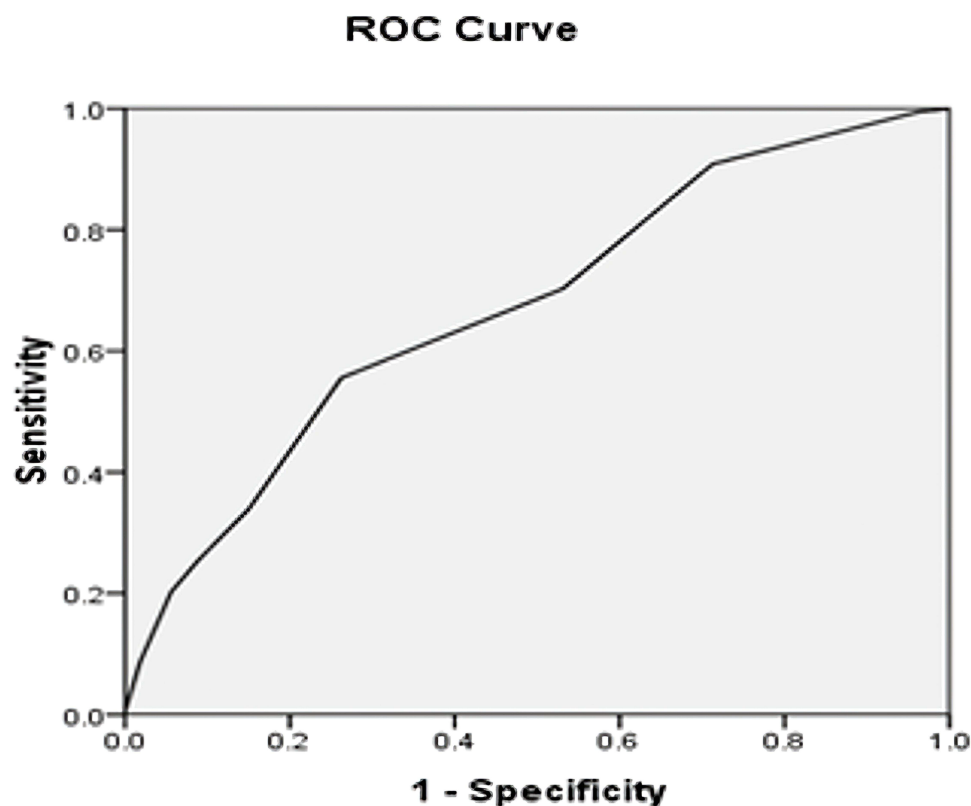


Figure 1 Performance of risk score. The area under the ROC was 0.673, with 95% confidence interval was 0.623–0.722 ($P < 0.001$).

be used to diagnose CHD. When compared to coronary artery angiography, cardiovascular risk scores of four have the best sensitivity and specificity for CHD diagnosis. Further studies of other geographic areas and population groups should be conducted to corroborate our findings.

Major and profound growth of economy have occurred in China in the past decades. Unfortunately, the risk factors (eg, diabetes) and unhealthy lifestyle (eg, smoking) also concurrently increase,^{15,16} which result in dramatic increase in atherosclerotic cardiovascular disease.^{17,18} In the last decade, the treatment of CHD has improved in China especially in the urban area.⁸ However, national survey indicates that the diagnosis and treatment of CHD in the rural area are still poor and the underlying mechanisms are multifactorial and can be attributed to the lacking of health resources such as coronary artery computed tomography and coronary angiography.^{19,20} For example, Yan et al¹⁹ conducted an epidemiological study recruiting participants from high-, medium- and low-income regions of China, and their study indicates that there was an inverse trend between risk-factor burden and cardiovascular disease prevalence in urban and rural

Table 4 Sensitivity and Specificity of Cardiovascular Risk Score for CHD Diagnosis

Cardiovascular Risk Score	Sensitivity	Specificity
1	0.994	0.038
2	0.908	0.288
3	0.703	0.469
4	0.556	0.738
5	0.339	0.850
6	0.253	0.912
7	0.203	0.944
8	0.089	0.981
9	0.006	1

communities. They concluded that such asymmetry might be attributed to the interregional differences in residents' awareness, quality of healthcare, and availability and affordability of medical services. Wan et al²¹ conducted a study to evaluate the mortality trend of ischemic heart disease (IDH) in China from 1991 to 2009. They reported that in rural areas, the mortality rate with annual percentage change increasing from 3.52% in 1991–2000 to 9.02% in 2000–2009, which was much higher than in urban areas (1.05%). These results collectively indicate that it is a priority to improve the management of CHD in the rural areas of China otherwise the health and economic expenditure could not be reduced despite improvement of CHD prognosis has been achieved in urban area of China.

As a cardiovascular health improvement initiative of Huizhou City, our center conducted a pilot study to evaluate whether combining traditional risk factors can improve CHD diagnosis in rural area of Huizhou. Our study demonstrated that when combining risk factors, ECG change and clinical symptoms, the diagnostic sensitivity and specificity of cardiovascular risk score could be as high as 55.6% and 73.8%, respectively. These findings have several significant clinical implications, especially in rural area of China. First of all, our results stress the importance of collecting basic clinical information in terms of the features of patients' clinical symptoms and ECG. Second, using cardiovascular risk score can help physicians to evaluate a suspected CHD in a comprehensive and integrated pattern. Third, with a high specificity, our current cardiovascular risk score can help local physician to better rule out CHD which result in reduced unnecessary economic expenditure. Last but not the least, our study indicates that despite less well developed than urban area, the prevalence of cardiovascular risk factors and comorbidities remained high in these rural areas. Further studies are needed to evaluate the underlying mechanisms so as to improve the overall health for the people in these rural areas.

Notably, ECG remains an irreplaceable tool in the management of the patients with CHD. Among these ECG parameters, ST-segment change has been commonly used to identify CHD. Nevertheless, in recent decades, accumulative evidence has suggested that other than ST-segment change, other parameters such as QTc and Tp-e can also be used to screen and identify the possibility of CHD²². In the current study, we only used the ST-segment change which has also shown a good predictive value. However, it is clinically relevant to evaluate whether other ECG parameters can improve CHD diagnosis in the absence of ST-segment change in the future.

The impacts of this risk score in daily clinical practice can be depicted in three aspects. First, in rural areas where health resources and specialists are limited, using this risk score can help improve the diagnosis of CHD. Second, this risk score can help to rule out those with unlikely to have CHD, which in turn can avoid unnecessary further examination and expenditure. Third, this risk score can facilitate general practitioner to screen those with suspected CHD and determine whether prevention therapy is needed.

Strength and Limitation

The strength of current study is that this should be the first study to use the easily available parameters to construct the risk score for predicting CHD in rural China. In addition, several parameters with detailed information were recorded, which help to improve the discriminative performance of the risk score. There are also some limitations of our current study needed to be addressed. First, since current study was conducted only in Huizhou area and findings from our study may not be extrapolated to other areas. However, our study provides insight into the usefulness of cardiovascular risk score for CHD diagnosis in areas without advanced diagnostic instrument (eg, cardiac CT). Second, since this was a cross-sectional study and we do not know whether using this cardiovascular risk score can improve patients' long-term outcome or not. Further studies are needed to answer this question. Third, we only recorded ST change and other ECG parameters (QTc and Tp-e) were unavailable. Further studies are needed to collect these parameters and to evaluate whether adding these parameters would improve the predictive value. Lastly, in the cardiovascular risk score, we have only included several traditional risk factors and whether including cardiac biomarker such as Hs-CTnI or cardiac kinase-MB can further improve the diagnostic accuracy deserves evaluation in the future.

Conclusion

In conclusion, our study for the first time shows that using cardiovascular risk score can improve CHD diagnosis in rural area of China which may help to reduce health disparities between rural and urban area. Future studies are warranted whether this score can improve patients' outcome.

Abbreviation

CHD, Coronary heart disease; ECG, Electrocardiogram; Hs-CTnI, High-sensitivity cardiac troponin-I; CT, Computer tomography; CIMT, Carotid intima-media thickness.

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Disclosure

The authors report no conflicts of interest in this work.

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