

# Diagnostic Value of a New Modified HEART Score for Fatal Chest Pain Risk Stratification in Emergency Department

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## Research Article

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# Abstract

## Background

Because of the establish and maintain green channel for patients with acute chest pain, the mortality of fatal chest pain such as myocardial infarction has decreased. There are still some patients with chest pain, such as acute pulmonary embolism(PE) and acute aortic dissection(AAD), which is very easy to miss diagnosis and misdiagnosis. Therefore we establish a new modified HEART score for fatal chest pain risk stratification in emergency department to judge the prognosis of patients.

## Methods

There were 541 patients enrolled in Yixing people's Hospital from November 2018 to June 2020 at Department of Cardiology, Yixing people's hospital. All patients were detailed medical history, years old, risk factors, hypertension and were detected by blood pressure, ECG, troponin, cardiac function, D-dimer. All patients with chest pain were scored by using HEART score and a new modified HEART score.

## Results

A total of 317 patients with non fatal chest pain were divided into low-risk group, medium-risk group and high-risk group according to HEART score and modified HEART score. The results showed that the proportion of three groups were no significant difference. In 224 cases of fatal chest pain patients, according to the HEART score and modified HEART score, they were divided into three groups: low-risk group, medium risk group and high-risk group. The results showed that the proportion of low-risk group was no significant difference. The proportion of patients diagnosed as medium risk group was significant difference(36.16% vs 12.50%,  $p < 0.05$ ). The proportion of high-risk group was significant difference(57.59% vs 82.59%,  $p < 0.05$ ). The area under Receiver Operating Characteristic curve(ROC) evaluate new modified HEART score for the prognosis of fatal chest pain. The area under ROC curve of new modified HEART score were 0.975 (95%CI 0.964–0.987,  $p < 0.001$ ), the best cut-off point was 5 scores, sensitivity and specificity were 90.7% and 93.3%.

## Conclusion

Our study demonstrated that a new modified HEART score can effectively and rapidly distinguish fatal chest pain and can play an important role in the prognosis of patients with chest pain in emergency department.

## 1. Introduction

Acute nontraumatic chest pain (CP) is one of the common symptoms in emergency department. Because of many clinical causes, it is often unable to judge the severity of the disease in time and may delay the treatment. It is found that chest pain is the main manifestation of cardiovascular diseases, such as acute myocardial infarction [1, 2]. The incidence rate and mortality rate of acute myocardial infarction in China are increasing. The in-hospital mortality rate of ST-segment elevation myocardial infarction (STEMI) has not reduced in the past 10 years [3]. According to the summary of China cardiovascular disease report 2017, the number of cardiovascular disease patients is about 290 million, including about 11 million patients with coronary heart disease. In order to improve the treatment efficiency, integrate and optimize resources, and reduce mortality, the Chinese Medical Association vigorously advocated the construction of chest pain center. However, in the actual clinical diagnosis and treatment process, in addition to acute coronary disease (ACS) patients, there are still some patients with chest pain, such as acute PE and AAD, who can not be treated in time, resulting in poor prognosis [4].

How to quickly and accurately identify high-risk fatal chest pain patients and treat them in time, while shunting other low-risk chest pain patients, is the focus and difficulty in clinical practice. The key of clinical diagnosis and treatment is to optimize the management and risk stratification of patients with acute chest pain. Early and rapid diagnosis and treatment of ACS, AAD, PE and other fatal diseases, striving for the best rescue opportunity, improving the clinical prognosis of patients, and reasonable diversion of ACS low-risk population and other non fatal chest pain as soon as possible, to avoid unnecessary examination and treatment, is one of the great challenges faced by emergency physicians.

In the emergency department and the cardiovascular intensive care unit, many risk scores are used to identify ACS and high-risk patients with adverse events, so that patients can benefit from early active treatment. Among them, the risk scores of thrombolysis in myocardial infarction (TIMI) and global registration of acute coronary events (GRACE) are widely used [5, 6]. However, the above scores are all applied to the evaluation of acute ischemic heart disease, and there is no evaluation effect on the chest pain caused by non-invasive non myocardial ischemic death. Therefore, some scholars have proposed the HEART score (composed of 5 indexes, such as history, ECG, age, risk factors, troponin I) and HEARTs3 score (HEART and gender, ECG change and cTnI change) [7, 8].

Although HEART score and HEARTs3 score have some emphasis on the diagnosis of ACS, they have not significantly improved the diagnosis of PE and AAD. However, PE and AAD are not rare in emergency department. Based on the above scores, we further improved the heart score, so as to make a rapid and effective diagnosis of fatal chest pain, including ACS, PE, AAD.

## **2. Materials And Methods**

### **2.1 Patients and study design**

There were 543 patients enrolled in Yixing People's Hospital from November 2018 to June 2020 at Department of Cardiology, Yixing people's hospital. All patients were detailed medical history, years old, risk factors, hypertension and were detected by blood pressure, ECG, troponin, cardiac function, D-dimer.

All patients with chest pain were scored by using HEART score and a new modified HEART score (Table 1). HEART score included history, ECG, Age, risk and troponin. All major adverse cardiovascular events were recorded within one month. This study was performed in accordance with the 1964 Declaration of Helsinki and was approved by Human Ethics Committees of Yixing People's Hospital. All patients involved in this study have signed informed consent. This sample size was calculated with the MedSci software (MedSci Sample Size tools, MSST).

Table 1

A new modified HEART score. Risk factors include: dyslipidemia, smoking, diabetes, past history of coronary heart disease, obesity and a variety of ischemic vascular disease. Low risk:0-3, moderate risk: 4-7, high-risk:  $\geq 8$ .

Variables	stratification	score
history	no suspected fatal chest pain	0
	moderate suspected fatal chest pain	1
	highly suspected fatal chest pain	2
ECG	normal	0
	nonspecific ST-T changes	1
	Significant ST segment elevation, ST segment depression, T wave inversion and other ECG manifestations such as newly found left bundle branch and right bundle branch block, and specific S1QIIITIII	2
Age(yrs old)	$\leq 50$	0
	$>50$	1
risk	no risk factors	0
	1 or 2 risk factor(s)	1
	$\geq 3$ risk factors	2
troponin T	normal	0
	within 3 times of normal range	1
	more than 3 times higher than normal range	2
walking test	able to walk	0
	unable to walk	1
hypertension	without hypertension	0
	with hypertension and normal blood pressure	1
	with hypertension and SBP $\geq 160$ mmHg or $\leq 90$ mmHg;DBP $\geq 100$ mmHg	2
D-dimer	normal	0
	within 3 times of normal range	1
	more than 3 times higher than normal range	2

## 2.2 Electrocardiography(ECG)

In all patients, a 12-lead ECG was recorded before, immediately after PCI, and in the case of the occurrence of symptoms that were interpreted as a postprocedural ischemic event. All patients received continuous ECG monitoring using wireless technology after PCI during hospitalization.

### **2.3 Laboratory measurements**

The samples for cTNT and plasma D-dimer were collected immediately at emergency department. The cTNT levels were measured by chemiluminescence (ACCESS2 and reagents, Beckman Kurt, USA). The plasma D-dimer levels were measured by immunoturbidimetry (Ningbo primber Biotechnology Co., Ltd).

### **2.4 Statistics**

All data were statistically analyzed by SPSS software (SPSS 16 for Windows, SPSS Inc., Chicago, Illinois). The independent samples t test or Mann Whitney U test was used to compare the continuous variables between two groups. The chi-square test was employed for the statistical analysis of the categorical variables. ROC(receiver operator characteristic) curve was used to evaluate the predictive value of two scoring systems for fatal chest pain. P values < 0.05 were considered statistically significant.

## **3. Results**

### **Baseline Characteristics**

543 patients enrolled in Yixing People's Hospital from November 2018 to June 2020, including 8 patients with pulmonary embolism, 2 with pneumothorax, 8 with aortic dissection, 203 with acute myocardial infarction, 5 with sudden death, and 317 with chest pain (including unexplained chest pain, heart failure, stable angina, etc.). Pneumothorax is a special type of chest pain, therefore this study does not include patients with pneumothorax. Finally, 541 patients with chest pain entered the study. (Fig. 1)

#### **Comparison of HEART score and new modified HEART score in the diagnosis of non fatal chest pain**

A total of 317 patients with non fatal chest pain were divided into low-risk group, medium-risk group and high-risk group according to HEART score and modified HEART score. The results showed that the proportion of low-risk group was 83.28% vs 81.70%,  $p > 0.05$ , The proportion of patients diagnosed as medium-risk group was 16.09% vs 16.72%,  $p > 0.05$ , there was no significant difference. The proportion of high-risk group was 0.63% vs 1.58%,  $p > 0.05$ , there was no significant difference. (Fig. 2)

#### **Comparison of the diagnostic value of HEART score and new modified HEART score in fatal chest pain**

In 224 cases of fatal chest pain patients, according to the heart score and modified heart score, they were divided into three groups: low-risk group, medium risk group and high-risk group. The results showed that the proportion of low-risk group was 6.25% vs 4.91%,  $p > 0.05$ , there was no significant difference. The proportion of patients diagnosed as medium risk group was 36.16% vs 12.50%,  $p < 0.05$ , there was significant difference. The proportion of high-risk group was 57.59% vs 82.59%,  $p < 0.05$ , there was

significant difference. Compared with heart score, new modified HEART score is superior to HEART score in the evaluation of fatal chest pain. (Fig. 3)

### **The Predictive Value Of New Modified Heart Score In Fatal Chest Pain**

The area under Receiver Operating Characteristic curve(ROC) evaluate new modified HEART score for the prognosis of fatal chest pain. The area under ROC curve of new modified HEART score were 0.975 (95%CI 0.964–0.987,  $p < 0.001$ ), the best cut-off point was 5 scores, sensitivity and specificity were 90.7% and 93.3%. (Fig. 4)

## **4. Discussion**

In our paper, we found that compared with heart score, new modified HEART score is superior to HEART score in the evaluation of fatal chest pain. The area under ROC curve of new modified HEART score were 0.975 (95%CI 0.964–0.987,  $p < 0.001$ ), the best cut-off point was 5 scores, sensitivity and specificity were 90.7% and 93.3%. According to the risk factors and prognosis, acute non traumatic chest pain can be divided into ACS, fatal non myocardial ischemic chest pain (PE, AAD, acute tension pneumothorax) and other chest pain (gastroesophageal reflux, costochondritis, herpes zoster, etc.)[9]. There are some problems in the clinical diagnosis and treatment of acute chest pain in China. Firstly, the differential diagnosis of acute nontraumatic chest pain lacks standardized process. Secondly, patients with ACS have over treatment or insufficient treatment. Finally, unable to quickly identify high-risk and low-risk chest pain, patients stay in the emergency department for a long time. It is difficult for emergency physicians to immediately determine the cause of acute non traumatic chest pain[10]. It is important to carry out early diagnosis, differential diagnosis and risk stratification for patients with acute chest pain. How to quickly identify the cause of acute chest pain and reduce high-risk mortality of chest pain patients have become the focus of our attention.

In the emergency department, many risk scores are used to identify high-risk patients with ACS and adverse events, so that patients can benefit from early treatment[11]. Among them, TIMI risk score and GRACE risk score system are widely used. However, these scoring systems are all used in the evaluation of acute ischemic heart disease, and lack of evaluation function for chest pain caused by non myocardial ischemia[12]. Up to 6.3% of emergency department patients are related to chest pain. And less than 25% will have an ACS of all chest pain patients[13]. If patients at low risk for ACS could be recognized early in the diagnostic process, it has the potential to reduce patient burden, length of stay at emergency department, frequency of hospitalization and costs. Therefore, some scholars have proposed the HEART score and HEARTs3 score to assess the risk of acute chest pain.

HEART score can be applied to patients with chest pain caused by non ischemic heart disease, however there are still deficiencies in the evaluation of patients with acute chest pain[14–16]. Firstly, the proportion of all kinds of scores is not weighted analysis, the elevation of troponin is equal to over 65 years old, which weakens the role of troponin in the diagnosis of myocardial infarction; Secondly, gender score is not included, and more and more studies have found that gender difference exists in patients

with coronary heart disease; Thirdly, There was no dynamic monitoring of ECG and myocardial injury markers. The above shortcomings make the sensitivity of HEART score in identifying high-risk chest pain patients decreased and will bring adverse effects to clinical diagnosis and treatment. Fesmire M *et al* improved the HEART scoring system and proposed HEARTs3 scoring system, based on the HEART scoring system, three items including gender, electrocardiogram and troponin measured again after 2 hour. They compared 315 patients with ACS within 30 days and 1833 patients without ACS. The results showed that the ROC area was 0.985 vs. 0.825,  $P < 0.05$ , HEARTs3 score system greatly improved the ability to identify high-risk patients with chest pain[17]. Although the HEARTs3 scoring system has strengthened the ability to identify chest pain in high-risk ACS, it also has some problems. At first, this score need to dynamically observe the cTnI index of electrocardiograph, it has relatively prolonged the diagnosis time of high-risk chest pain patients. Secondly, the diagnostic efficiency of PE, AAD and tension pneumothorax was not improved. Based on the above reasons, we propose to divide acute chest pain into two categories: non lethal chest pain and fatal chest pain according to the serious consequences of chest pain, and improve HEART score to quickly identify fatal chest pain and non fatal chest pain. The modified HEART score includes three items: cardiac function, hypertension and D-dimer. Through preliminary trials, we found that modified HEART score can effectively and quickly identify fatal chest pain patients, and provide a new diagnosis and treatment strategy for emergency department.

In the emergency department, there are still many difficulties in the differential diagnosis of chest pain, especially in patients with atypical ACS, acute aortic dissection and pulmonary embolism[18]. Modified HEART score system does not put forward higher requirements for hospital experimental conditions, and its scoring items and data are easy to obtain, which is more suitable for extensive promotion in primary hospitals. It helps to promote the implementation of individualized treatment balance resource allocation to avoid high-risk patients unable to get timely treatment, or low-risk patients receiving over treatment and repeated examination, so as to save medical costs. Modified HEART score system can play a role in the rapid identification of high-risk fatal chest pain and exclusion of low-risk chest pain, which has great clinical application value.

## 5. Conclusion

Our study demonstrated that a new modified HEART score can effectively and rapidly distinguish fatal chest pain and can play an important role in the prognosis of patients with chest pain in emergency department.

## Abbreviations

PE  
pulmonary embolism  
AAD  
acute aortic dissection  
CP

chest pain  
STEMI  
ST-segment elevation myocardial infarction  
ACS  
acute coronary disease  
TIIMI  
thrombolysis in myocardial infarction  
GRACE  
global registration of acute coronary events  
cTNT  
cardiac troponin T

## **Declarations**

### **Availability of data and materials**

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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None.

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### **Contributions**

SY and YJY conceived and wrote the manuscript. MZ and JDJ collected the data. LX and YJY did the experiment, YCC reviewed the manuscript. All authors read and approved the final manuscript.

Corresponding author

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## Ethics declarations

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by Human Ethics Committees of Yixing People's Hospital. Verbal informed consent was obtained from all patients.

## Consent for publication

None

## Competing interests

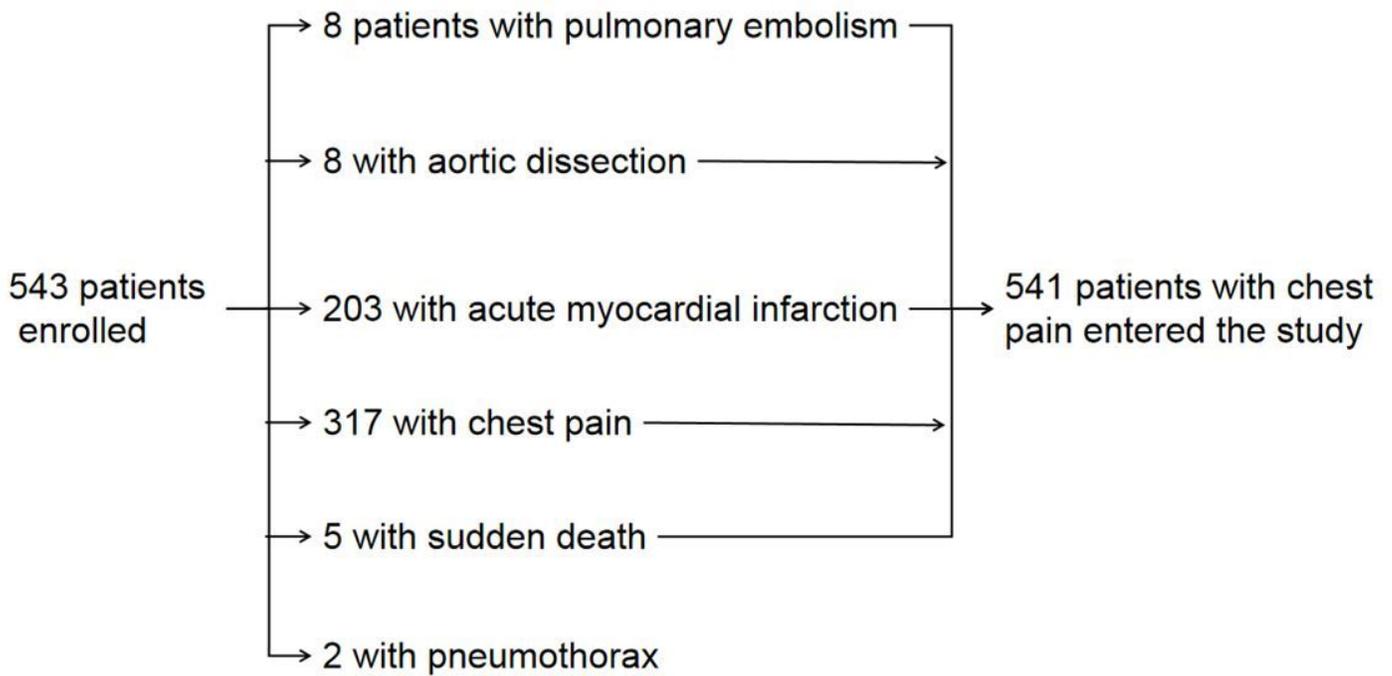
The authors declare that they have no competing interests.

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## Figures



**Figure 1**

**Baseline Characteristics**

543 patients enrolled, including 8 patients with pulmonary embolism, 2 with pneumothorax, 8 with aortic dissection, 203 with acute myocardial infarction, 5 with sudden death, and 317 with chest pain (including unexplained chest pain, heart failure, stable angina, etc.). Finally, 541 patients with chest pain entered the study.

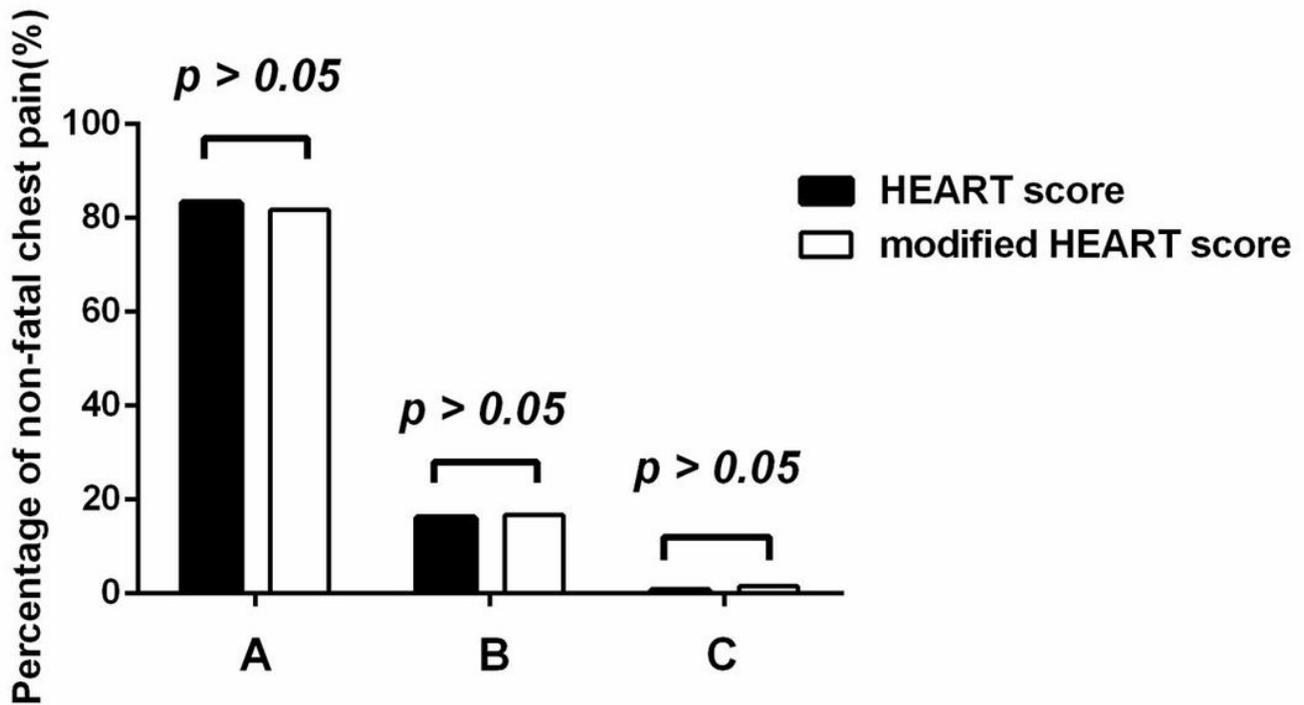


Figure 2

**Comparison of HEART score and new modified HEART score in the diagnosis of non-fatal chest pain**

group A, B, C means low-risk group, medium-risk group and high-risk group. A total of 317 patients with non fatal chest pain were divided into low-risk group, medium-risk group and high-risk group according to HEART score and modified HEART score. The results showed that the proportion of low-risk group was 83.28% vs 81.70%,  $p > 0.05$ , The proportion of patients diagnosed as medium-risk group was 16.09% vs 16.72%,  $p > 0.05$ , there was no significant difference. The proportion of high-risk group was 0.63% vs 1.58%,  $p > 0.05$ , there was no significant difference.

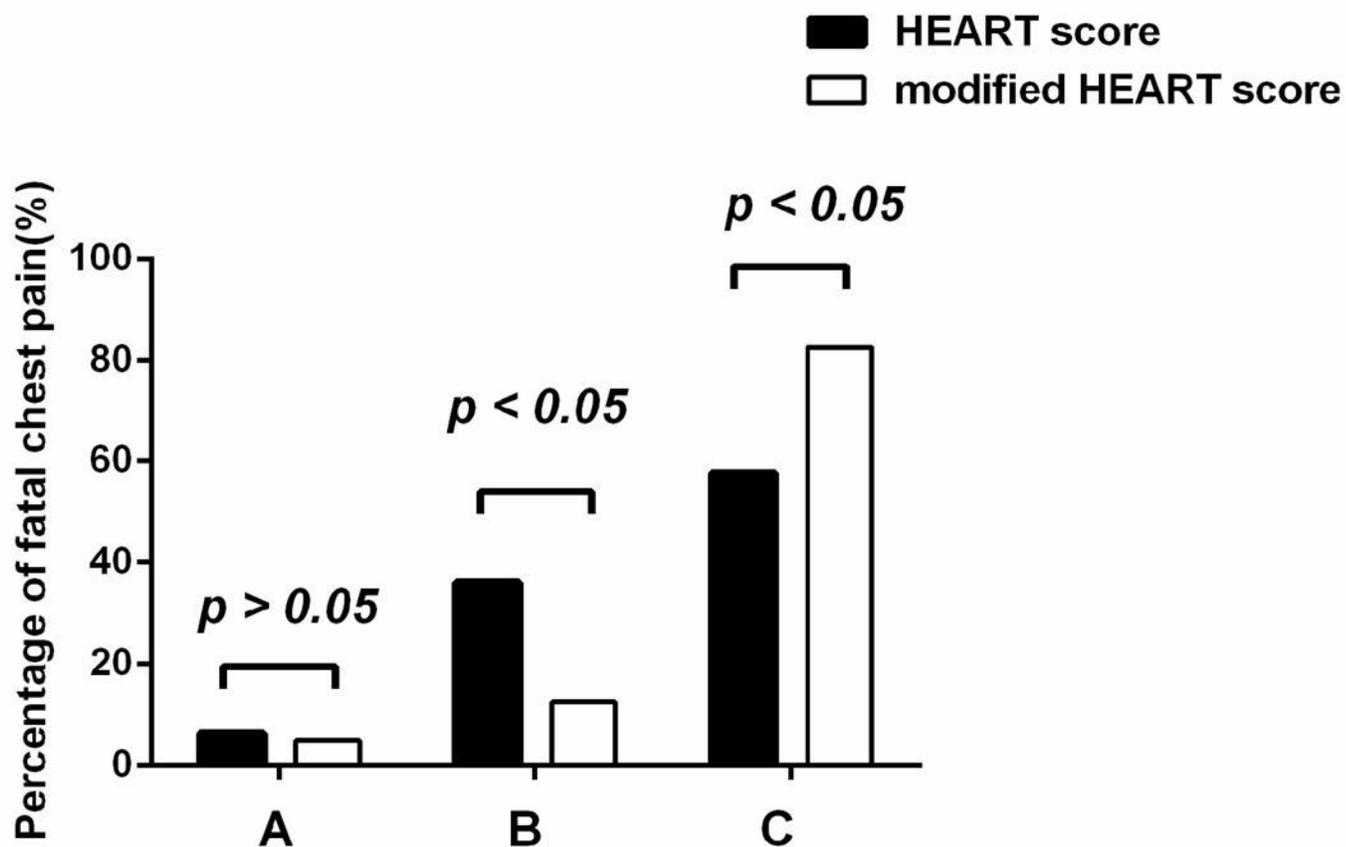
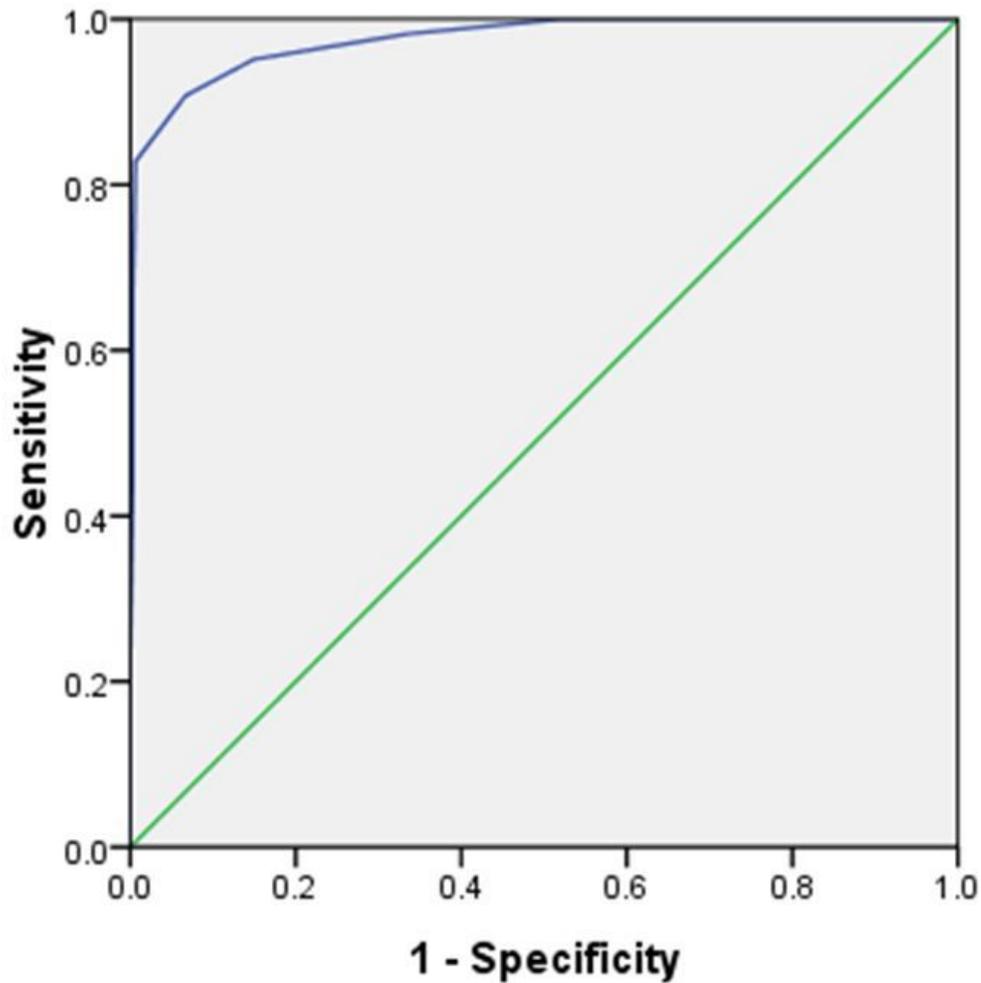


Figure 3

### Comparison of HEART score and new modified HEART score in the diagnosis of fatal chest pain

group A, B, C means low-risk group, medium-risk group and high-risk group. In 224 cases of fatal chest pain patients, according to the heart score and modified heart score, they were divided into three groups: low-risk group, medium risk group and high-risk group. The results showed that the proportion of low-risk group was 6.25% vs 4.91%,  $p > 0.05$ , there was no significant difference. The proportion of patients diagnosed as medium risk group was 36.16% vs 12.50%,  $p < 0.05$ , there was significant difference. The proportion of high-risk group was 57.59% vs 82.59%,  $p < 0.05$ , there was significant difference.



**Figure 4**

**The predictive value of new modified HEART score in fatal chest pain**

The area under Receiver Operating Characteristic curve(ROC) evaluate new modified HEART score for the prognosis of fatal chest pain. The area under ROC curve of new modified HEART score were 0.975 (95%CI 0.964-0.987 ,  $p < 0.001$ ), the best cut-off point was 5 scores, sensitivity and specificity were 90.7% and 93.3%.