

Comparison of the Application Value of Treadmill Exercise Test and Dynamic Electrocardiogram in the Diagnosis of Coronary Heart Disease

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Abstract: Objective: To explore the application value of treadmill exercise test and dynamic electrocardiogram in diagnosing coronary heart disease. Methods: A total of 185 patients with suspected coronary heart disease admitted to the Department of Electrocardiography in Wujia District of Central People's Hospital from February 2023 to February 2024 were selected according to the inclusion and exclusion criteria, including 93 males and 92 females, aged from 38 to 75 years, with an average age of (55.86 ± 3.25) years. Treadmill exercise test and dynamic electrocardiogram were performed on all patients, and the results of coronary angiography were used as the gold standard. Results: The results of coronary angiography in 185 patients showed that 148 patients were diagnosed as positive, accounting for 80%. The coronary heart disease detection rate in the treadmill exercise test group was 97.30%, which was significantly higher than that in the Holter group, and the difference was statistically significant ($P < 0.05$). The accuracy, specificity, sensitivity, positive predictive value, and negative predictive value of the treadmill exercise test group were 95.68%, 89.19%, 97.30%, 97.30%, and 89.19%, respectively, which were significantly higher than those of the Holter group ($P < 0.05$). The misdiagnosis rate and missed diagnosis rate of the treadmill exercise test group were 10.81% and 2.70%, which were significantly lower than those of the dynamic electrocardiogram group, and the difference was statistically significant ($P < 0.05$). Conclusion: Both treadmill exercise testing and Holter have unique advantages and limitations. In clinical practice, treadmill exercise testing has a high application value in the diagnosis of coronary heart disease and can effectively reduce the misdiagnosis rate.

Keywords: Treadmill exercise test; Dynamic electrocardiogram; Coronary heart disease; Diagnosis; Value of application

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1. Introduction

Coronary heart disease (CAD) is a common and frequent disease of the cardiovascular system, and its early diagnosis is very important for the prognosis of patients and the formulation of treatment strategies. With the

continuous progress of medical technology, a variety of non-invasive examination methods have been widely used in the diagnosis of coronary heart disease, among which the treadmill exercise test (TET) and 24 h-ECG are two commonly used methods. Treadmill exercise testing involves the patient exercising on a treadmill-like device to gradually increase the load on the heart, thereby inducing possible myocardial ischemia and other problems. Doctors diagnose the heart condition by observing the changes of the electrocardiogram. This method is non-invasive, economical and convenient, and can monitor the electrocardiogram, exercise volume and blood pressure response in real time, which improves the safety^[1,2]. However, Holter requires patients to wear a small recording device to continuously record ECG for 24 hours or even longer, which can capture transient arrhythmia and provide key evidence for diagnosis and treatment^[3,4]. In recent years, there have been more and more studies on treadmill exercise tests and Holter in the diagnosis of coronary heart disease, but the comparison of the application value between the two is still controversial. Therefore, it is necessary to systematically compare and analyze these two methods to provide a more scientific basis for clinical decision-making.

2. Materials and methods

2.1. General information

Patients with suspected coronary heart disease admitted to the Department of Electrocardiography in Wujia District of Central People's Hospital from February 2023 to February 2024 were selected. Inclusion criteria: (1) patients with suspected coronary heart disease symptoms, such as chest pain, chest tightness, etc.; (2) age between 35 and 75 years old, regardless of gender; (3) no severe arrhythmia, acute myocardial infarction or other acute heart disease; (4) Patients agreed to undergo treadmill exercise test and Holter monitoring, and signed the informed consent. Exclusion criteria: (1) patients with unstable conditions such as severe heart failure and acute myocarditis; (2) patients who are weak and unable to complete exercise; (3) patients with pacemakers or other electronic medical devices; (4) patients who are allergic to exercise or have other diseases that are not suitable for exercise. A total of 185 patients with coronary heart disease who met the above inclusion and exclusion criteria were selected as the research objects, including 93 males and 92 females, aged 38–75 years old, with an average age of (55.86 ± 3.25) years old. The study was approved by the ethics committee.

2.2. Methods

2.2.1. Treadmill exercise test

All patients underwent treadmill exercise testing using the standard Bruce protocol. Before the test, the patient's medical history was inquired into in detail, and the basic vital signs such as blood pressure and heart rate were measured. The exercise volume was adjusted according to the patient's age, gender, weight, and other factors, and the exercise load was gradually increased until the target heart rate was reached or the patient developed angina and other symptoms. At the same time, the changes of the electrocardiogram were continuously monitored and recorded to observe the amplitude and duration of ST-segment depression or elevation. The criteria for positive results were as follows: the horizontal or oblique downward shift of the ST segment of the ECG during or after exercise ≥ 0.1 mV, lasting ≥ 2 min, or accompanied by typical angina symptoms^[5].

2.2.2. Dynamic electrocardiogram

All patients underwent continuous ECG monitoring using a 24-hour Holter recorder. During the recording period, patients were asked to maintain normal living habits and avoid strenuous exercise and mood swings. After recording,

the data were uploaded to the computer for analysis, focusing on the frequency, type and duration of myocardial ischemia, arrhythmia and other conditions. Positive results were defined as ST-segment depression ≥ 0.1 mV on ECG, lasting ≥ 1 min, and related to the patient's symptoms or activity [6].

2.3. Observation indicators

The main outcome measures included: the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of treadmill exercise test and 24-hour Holter in the diagnosis of coronary heart disease. The decision criteria were based on the results of coronary angiography as the gold standard. Sensitivity = true positive/ (true positive + false negative) $\times 100\%$; Specificity = true negative/ (true negative + false positive) $\times 100\%$; Positive predictive value = true positive/ (true positive + false positive) $\times 100\%$; Negative predictive value = true negative/ (true negative + false negative) $\times 100\%$; Accuracy = (true positive + true negative)/ total number of cases $\times 100\%$.

2.4. Statistical methods

All the collected data were input into SPSS 26.0 software for statistical analysis. The counting data were recorded as the number of cases and percentage [n(%)), analyzed by χ^2 test and other methods, and the measurement data were recorded as the mean and standard deviation (mean \pm SD), analyzed by t test, and $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparison of the detection rate of coronary heart disease lesions between the two methods

The results of coronary angiography in 185 patients showed that 148 patients were diagnosed as positive, accounting for 80%. The coronary heart disease detection rate in the treadmill exercise test group was 97.30%, which was significantly higher than that in the Holter group, and the difference was statistically significant ($P < 0.05$). See **Table 1** below for details.

Table 1. Comparison of detection rates of coronary artery disease by two methods ($n = 148$)

Group of groups	Treadmill exercise test group	Holter group	χ^2	P
Single vessel disease	70 (47.30)	55 (37.16)	3.116	0.018
Double vessel disease	37 (20.95)	31 (37.16)	9.441	0.002
Multivessel disease	37 (25.00)	25 (16.89)	3.987	0.017
Sum up	144 (97.30)	111 (75.00)	30.832	0.000

3.2. Comparison of the diagnostic efficacy of the two methods for coronary heart disease

The results showed that the accuracy, specificity, sensitivity, positive predictive value and negative predictive value of the treadmill exercise test group were 95.68%, 89.19%, 97.30%, 97.30% and 89.19%, respectively, which were significantly higher than those of the Holter group ($P < 0.05$). The misdiagnosis rate and missed diagnosis rate of the treadmill exercise test group were 10.81% and 2.70%, which were significantly lower than those of the dynamic electrocardiogram group, and the difference was statistically significant ($P < 0.05$). See **Table 2** below for details.

Table 2. Comparison of diagnostic efficacy of the two tests for coronary artery disease

Group of groups	Treadmill exercise test group	Holter group	χ^2	P
Accuracy	95.68 (177/185)	64.32 (119/185)	56.824	0.000
Specificity	89.19 (33/37)	21.62 (8/37)	34.183	0.000
Sensitivity	97.30 (144/148)	75.00 (111/148)	30.832	0.000
Positive predictive value	97.30 (144/148)	79.29 (111/140)	23.006	0.000
Negative predictive value	89.19 (33/37)	17.78 (8/45)	41.419	0.000
Rate of misdiagnosis	10.81 (4/37)	78.38 (29/37)	34.183	0.000
Rate of missed diagnosis	2.70 (4/148)	25.00 (37/148)	30.832	0.000

4. Discussion

Treadmill exercise test, as a non-invasive examination method, evaluates cardiac function and cardiovascular health by allowing patients to exercise with a gradually increasing load on a device similar to a treadmill while monitoring changes in electrocardiogram ^[7]. This method can induce potential myocardial ischemia problems, especially in the diagnosis of occult coronary heart disease. Patients may be “exposed” to myocardial ischemia under exercise stress even if their ECG performance is normal in a quiet state, thus improving the accuracy of early diagnosis of CHD ^[8,9]. Treadmill exercise test can also effectively determine the patient’s exercise tolerance and cardiac response, providing a reliable basis for subsequent rehabilitation exercise ^[10]. However, this method has the possibility of false positives and false negatives, and is not suitable for patients with unstable conditions such as acute myocardial infarction and severe arrhythmia ^[11].

Holter examination provides more comprehensive information of cardiac electrical activity by continuously recording the changes of the electrocardiogram waveform for 24 hours or even longer. It can capture transient episodes of arrhythmia, such as paroxysmal supraventricular tachycardia, premature beats, etc., which may not appear within a few minutes of routine ECG examination ^[12-14]. For cases such as asymptomatic myocardial ischemia and coronary artery spasm, Holter can also provide detailed original records, to provide more comprehensive reference materials for clinical diagnosis, treatment evaluation and prognosis ^[15]. ST-segment change is the most common manifestation of dynamic electrocardiogram in patients with coronary heart disease, and it is also the hallmark change of myocardial ischemia in the early stage, which has good consistency with other methods, such as coronary angiography in the evaluation of myocardial ischemia ^[16]. However, the Holter also has the limitation that it cannot be monitored in real time, and if the patient has serious cardiac discomfort during the wearing period, it cannot be treated immediately ^[17].

The results of this study showed that in 148 patients with positive coronary angiography results, the treadmill exercise test showed higher sensitivity, accuracy, and specificity than Holter ($P < 0.05$). Meanwhile, the positive predictive value and negative predictive value of the former group were better than those of the latter group ($P < 0.05$), and the detection rate of lesions was higher, and the missed diagnosis rate and misdiagnosis rate were lower ($P < 0.05$). The reason is that although dynamic electrocardiogram can monitor heart rate and ST segment changes for 24 hours and assess the state of cardiac ischemia, it is easy to be interfered by factors such as changes in human posture and neurological dysfunction, resulting in difficulties in the identification of ST segment changes and affecting the accuracy of diagnosis. However, the ECG treadmill exercise test makes the diagnosis by allowing the

patient to gradually increase the cardiac load in the state of continuous exercise and observing the location, degree, and duration of the ECG ST segment changes^[18,19]. When the coronary artery stenosis exceeds 50%, the cardiac oxygen consumption increases with the increase of exercise load. If the coronary blood flow cannot meet the demand, symptoms such as angina pectoris and abnormal electrocardiogram will occur, to accurately reflecting the condition^[20].

Conclusion

In summary, treadmill exercise test and Holter have their own unique advantages and limitations. In practical clinical application, treadmill exercise test has a high application value in the diagnosis of coronary heart disease, which can effectively reduce the misdiagnosis rate.

Disclosure statement

The author declares no conflict of interest.

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