·Original Paper·

Cardiovascular responses between post myocardial infarction patients with different levels of ST segment depression during exercise

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Abstract **Objective:**To investigate selected cardiovascular responses of post myocardial infarction patients(PMIP) during exercise within the context of different levels of ST segment depression. **Method:** Forty-six male recent PMIP performed a graded exercise test on a motorized treadmill during which time blood pressure and heart rate were measured and a 12 lead electrocardiogram (ECG) was monitored continuously. They were then subdivided into those ST segment depression <1.0 mm at exercise stage II (group 1) and those who had ST segment depression >1.0 mm at this stage (group 2). **Result:** The results showed that the patients with a larger degree of ST segment depression at the given work load exhibited higher a value of rate-pressure product (RPP).**Conclusion:** RPP may be of particular value in estimating the clinical response to exercise when ECG monitoring is not available.

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Key words post myocardial infarction patients;cardiovascular responses;ST segment depression;rate-pressure product; exercise

ST segment depression can be induced by exercise and has come to be regarded as the clinical marker of subendocardial ischemia [4].However,critical ST segment depression will not necessarily occur in all post myocardial infarction patients (PMIP) when they exercise at a given workload during rehabilitation. The variation in response can be ascribed to the patients' different coronary status and general health. This can be examined by observing the difference in cardiovascular variables such as heart rate(HR) and blood pressure between patients with and without distinctive ST segment depression during exercise. Another variable,rate-pressure product (RPP),has a high correlation with myocardial oxygen consumption[10]. These results should,therefore,provide greater understanding of the relationships between electrical activity of the heart as one indicator of myocardial oxygen demand and physiological measures purporting to reflect the same mechanism.

MATERIAL AND METHODS

Subjects

Forty six male recent PMIP undertook a graded exercise test on a motorized treadmill (Marquette,Manchester,UK). For the purpose of this analysis they were then subdivided into those ST segment depression <1.0mm at exercise stage II (Group 1,N=28) and those who had ST segment depression >1.0 mm at this stage (Group 2,N=18). None of the patients was treated by beta-blockade therapy. The details of this study were described to the subjects and their written,informed consent was obtained. Ethical approval was provided by the Wirral and West Cheshire Community Healthcare Trust.

Methods

Test protocol

The modified Bruce treadmill protocol was used for the graded exercise test. The criteria to end the exercise test followed the American College of Sports Medicine guidelines [1] and included any abnormal electrocardiogram(ECG), reaching the age-predicted heart rate maximum,any abnormal blood pressure readings,a rating of perceived exertion of 17 and a respiratory exchange ratio of above 1.15. The patients were questioned throughout the study and could stop the exercise at any time,even if the above criteria were not evident.

Measurements

Both systolic and diastolic blood pressure (SBP and DBP) were measured during the last minute of every exercise stage (i.e. every 3 minutes) using a mercury sphygmomanometer (Baum,Copiague,USA). A 12-lead electrocardiogram(Marquette,Centra,Manchester,UK) was observed continuously by a clinician and summary recordings which included ST segment levels (ST) and HR made every three minutes. A four level angina and dyspnea scale[2] was also presented immediately after the blood pressure measurement to establish whether the subjects were experiencing any chest pain or breathing difficulties. They were required to point to

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the appropriate descriptors on the scale should either of these occur. RPP was calculated by multiplying HR by systolic blood pressure and divided the product by 100[6].

Statistics analysis

The results were expressed as means and standard deviations (SD). A one-way analysis of variance(ANOVA) was used for variables comparison between two groups. A probability of $P<0.05$ was regarded as statistically significant. A two-tailed test was used throughout.

RESULTS

The general information of the 46 male subjects is shown in Table 1. All patients in the study completed a minimum of exercise stage II on the modified Bruce treadmill protocol, and showed non significant differences for age, height, body mass and time since the myocardial infarction.

The values for the physiological and clinical variables at rest are shown in Table 2. There is a non-significant difference between the groups for each variable.

Table 3 shows the physiological response at exercise stage II. It can be seen that the only non-significant difference between the groups is for diastolic blood pressure, in spite of having 5 mmHg higher value in the group with the ST segment depression above 1 mm.

Figures 1 to 3 show the changes of selected physiological variables from exercise stage I to exercise stage II. It can be seen that for each variable the group with the higher ST segment depression not only starts with a higher physiological value, but increases it relatively more as the exercise progresses. This is indicated by the steeper inclination of the slope for Group 2 compared with Group 1. Figure 4 shows the changes of ST segment levels during exercise for the two groups.

Table 1 The general information of the 46 male subjects ($\bar{x}\pm s$)

	N	ST depression at stage II (mm)	Age(yr)	Height (cm)	Body mass (kg)	Time since MI (months)
Group 1	28	<1.0	62.7±6.3	174.8±7.9	75.8±7.9	3.8±0.8
Group 2	18	>1.0	61.6±6.4	172.1±9.0	77.1±9.4	3.7±0.9

Table 2 The values of physiological and clinical variable at rest ($\bar{x}\pm s$)

	HR (beats·min^{-1})	Systolic (mmHg)	Diastolic (mmHg)	RPP (beats·mmHg·10^{-2})	ST(mm)
Group 1	86.8±10.4	137.4±19.0	80.3±10.7	118.9±22.9	0.0±0.1
Group 2	83.0±12.4	134.4±16.3	77.4±8.4	111.5±21.8	0.0±0.1

Table 3 The values of selected physiological variables at exercise stage II ($\bar{x}\pm s$)

	HR (beats·min^{-1})	Systolic (mmHg)	Diastolic (mmHg)	RPP (beats·mmHg·10^{-2})
Group 1	105.3±13.6	155.3±16.9	74.0±9.6	163.4±27.1
Group 2	121.5±15.3②	164.8±13.7①	79.2±10.1	200.4±29.2③

compared with Group 1. ①$P<0.05$, ②$P<0.01$, ③$P<0.001$

Figure 1 Changes of HR during exercise for both groups

Figure 2 Changes of SBP during exercise for both groups

Figure 3 Changes of RPP during exercise for both groups

Figure 4 Changes of ST segment levels during exercise for both groups

DISCUSSION

Relevant ST segment depression in the electrocardiogram (ECG) occurs when myocardial demand exceeds the ability of the narrow coronary arterial bed to increase blood flow in the context of an increased external workload [14]. In addition an enlarged myocardial demand would lead to increased left ventricular volume or increased contractility associated with increased sympathetic drive [13]. This is the basis to investigate the association between myocardial work load and cardiac anoxia. The justification for subdividing the two groups was because 1 mm of ST segment depression is commonly applied as the threshold for acute ischaemia [5,7]. There was no a priori reason to select exercise stage II as the criterion for comparison. Patients who only achieved exercise stage I on the modified Bruce protocol would be in a very poor cardiovascular state and by stage III only about 80% of the subjects would still be exercising. Thus, stage II represents a compromise between compliance and cardiac status.

It can been seen from Figures 1 to 4 that Group 1 had lower values for HR, SBP and RPP at both exercise stages I and II. ST segment depression at stage II was, of course, the criterion for the group selection, but at stage I there was already a clear difference. These data provide clear evidence for the severity of myocardial ischaemia to be related to the degree of cardiovascular response at a given work load. This was reinforced by the fact that the patients in Group 1 also showed a less inclined slope for HR, SBP, RPP increases and ST segment depression from stage I to stage II.

The heart is normally controlled by neural, hormonal, and intrinsic factors and these factors can be stimulated by exercise resulting in feedback to the cardiac regulatory centres, rising catecholamine level in blood and increasing cardiac response [9]. Thus heart rate has been reported to increase almost instantaneously when exercise starts [12]. This is because during exercise the heart has to pump more blood to maintain energy supply. Increased cardiac output can also cause a greater systolic blood pressure which consequently results in an increased RPP value.

The RPP is important because it has a high correlation with myocardial oxygen consumption [10]. A higher RPP at a given level of work indicates an inefficient cardiovascular system which is causing the heart to make a greater effort and at more oxygen cost to meet the demands of the work load[3]. Once myocardial demand exceeds the ability of the coronary arterial bed to increase blood flow in the context of an increased external workload,the ischaemic threshold is exceeded,producing ST segment depression [11,14]. Thus a low RPP value at a given workload is desirable when PMIP undertake exercise.

Table 3 showed that the difference between groups in RPP was much more significant than that of HR and SBP. This could simply be attributed to RPP being the product of HR and SBP. Hermida and Eng have previously shown a close relationship between myocardial oxygen demand and RPP in both healthy people and patients with coronary heart disease during exercise [6,8]. This study has extended this because it has shown that RPP differentiates between groups with different levels of myocardial insufficiency as represented by ST segment depression. RPP was the most sensitive index of all those measured,showing no different at rest,yet a highly significant difference (P<0.001) during exercise. This demonstrates that for the health professional it is well worth the effort of calculating RPP,a simple procedure once HR and SBP are known. This is because clinically those who show ischemia are of concern and should not exercise further or should exercise with caution. This study has shown that HR,SBP and RPP can all distinguish these two groups. The unifying aspect could be general fitness or cardiovascular status reflected in a variety of measures. As every subject is doing an identical amount of work(i.e. stage II treadmill) and body mass is the same,the muscular activity must be similar between the two groups. Thus cardiovascular condition as illustrated by all the measures is clearly different between the two groups. So this study basically shows that specific cardiac anoxia as measured by ST segment depression is reflected by general cardiovascular status (HR,SBP and especially RPP). Thus the practitioner should be aware that if RPP shows any sudden increase,200 at stage II of the modified Bruce treadmill protocol for example,it might be related to underlying myocardial insufficiency. Armed with this information a precautionary approach would be to limit exercise to this level until further ECG evidence was available. It is recognised that few cardiac rehabilitation programmes monitor clinical ECGs regularly during exercise and thus an alternative,easily accessible indication of myocardial oxygen consumption such as RPP will be invaluable.

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运动中ST段下移程度不同的心肌梗死后患者的心血管反应/刘洵,Brodie DA,Bundred PE,等.//中国康复医学杂志, 2006, 21(8):700—702

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摘要 **目的**:对运动中ST段下移程度不同的心梗后患者(PMIP)的心血管反应进行探讨。**方法**:46名男性PMIP在跑台上进行递增负荷运动实验,其间测量每级负荷时的血压、心率并连续监测12导联心电图(ECG)。根据跑台第Ⅱ级负荷时的ST段下移程度将其分为两组,第一组ST段下移<1.0mm,第二组ST段下移>1.0mm。**结果**:定量负荷工作时ST段下移程度大的患者其心率-血压乘积(RPP)也高。**结论**:当不便进行ECG监测时,RPP可能是评价患者对运动的临床反应的特效指标。

关键词 心肌梗死;心血管反应;ST段下移;心率-血压乘积;运动

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