The Change of Resting Heart Rate after Cardiac Rehabilitation in Patients with Coronary Artery Bypass Graft Surgery

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Abstract

Objective. To evaluate the effects of cardiac rehabilitation on the resting heart rate in patients who received coronary artery bypass graft (CABG) surgery.

Method. Twenty-two patients who received CABG were randomly assigned to enter or not to enter a cardiac rehabilitation exercise program (cardiac rehabilitation n = 11; control group n = 11). All subjects underwent cardiopulmonary exercise tests at discharge and 3 months later. Patients in cardiac rehabilitation group received 36 sessions of exercise program, 3 times a week, and the intensity was designed according to individual 60-85% of peak heart rate achieved in cardiopulmonary exercise test.

Results. At follow-up tests, patients in the cardiac rehabilitation group had a significantly lower resting heart rate (75.4 ± 8.1 beats/min) compared to that of control group (P=0.018). There were also significant reductions in resting heart rates in both cardiac rehabilitation (P=0.006) and control groups (P=0.020) compared to their baseline measurements.

Conclusion. Cardiac rehabilitation exercise program had a positive effect on heart rate recovery in CABG patients, and this result was consistent with the autonomic improvement.

Key words : Resting heart rate, cardiac rehabilitation, exercise training

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1. Introduction

Secondary prevention of coronary heart disease and increased exercise tolerance in patients who have received coronary artery bypass graft (CABG) are the main goals of cardiac rehabilitation. Phase II cardiac rehabilitation programs are associated with significant improving exercise tolerance and functional capacity, increasing psychosocial well-being, alleviating activity-related symptoms, reducing disability, and decreasing cardiovascular morbidity and mortality (Ades, 2001; Ryan, 1976; Goldsmith, 2000). Tachycardia, a delegate of activation of sympathetic tone, is a common condition in patients who have just received CABG surgery. This phenomenon may be due to the damage of myocardial tissues, or a stress response to surgery, thus activate sympathetic tone (Robinson, 1966; Cole, 1999; Messinger-Rapport, 2003). The reduced heart rate variability as an evidence of autonomic dysfunction has strong adverse effects on subsequent outcome in patients with ischemic heart disease. Abnormalities of the autonomic nervous system, imbalanced control of both sympathetic and parasympathetic systems which modulate heart rate and heart rate variability, are suspected in the mechanisms of sudden cardiac death. Data from studies of autonomic function during exercise showed that increasing in heart rate is due to the withdrawal of parasympathetic tone first, and then with the activation of sympathetic tone. After exercise, reactivation of the vagal tone causes the fall in heart rate (Cole, 1999; Messinger-Rapport, 2003; Hedback, 2001). A comprehensive cardiac rehabilitation program offered to patients after CABG surgery has been shown to improve the long-term prognosis and reduce the need for hospital care (Messinger-Rapport, 2003; Lucini, 2002; Thomas, 1996; Arthur, 2002). The cardiac rehabilitation is associated with significant improvements in autonomic markers of neural regulation of SA node, such as increase in R-R interval, in its variance, and in overall spontaneous baroreflex (Cole, 1999; Messinger-Rapport, 2003).

A high resting heart rate was regarded as the reflection of abnormalities in the autonomic nervous system, and an increased sympathetic input in subjects with elevated heart rate at rest were confirmed. Jouven and coworkers (2001) assessed the role of an elevated basal heart rate in the occurrence of sudden death in a long-term cohort study and concluded that an elevated heart rate at rest was as an independent risk factor for sudden death in middle-aged men. Hautala and associates (2003) claimed that the high vagal activity and lower resting heart rate at baseline is related to the improvement in aerobic power caused by aerobic exercise training in healthy sedentary subjects. Lucini and colleagues (2002) proposed that the cardiac rehabilitation exercise program is associated with significant improvement in autonomic regulation on SA node, however, the resting heart rate was not addressed in their research. In Hao's recent retrospective and cohort study, the improved resting heart rate after 12 weeks of phase II cardiac rehabilitation were found.

Exercise training has been shown to modify the sympathovagal control of heart rate toward an increase in parasympathetic tone. On the other hand, the improved vagal activity is associated with reduced death risk from cardiac events (Cole, 1999; Messinger-Rapport, 2003; Lucini, 2002; Thomas, 1996; Arthur, 2002; Shi, 1995). Although cardiac rehabilitation exercise program is a standard therapy for patients after a cardiac event especially for people who have received CABG, the relationship between a cardiac rehabilitation exercise program and resting heart rate has not been clearly demonstrated.

The purpose of this study is to investigate if phase II cardiac rehabilitation exercise program has a positive effect on resting heart rate in patients with CABG.

2. METHODS
2.1 Patients

This study involved 22 male patients receiving coronary artery bypass surgery and these patients were randomly assigned to enter or not to enter a phase II cardiac rehabilitation exercise program in the Department of Physical Medicine and Rehabilitation of a medical center. The inclusion criteria were (1) patients without previous CABG surgery, (2) patients without neurological impairments such as stroke, and traumatic brain injury, (3) patients without musculoskeletal diseases such as fracture, (4) uncomplicated clinical course during hospitalization such as severe infection, shock, arrhythmia and prolonged ventilator-dependent. The patients met the following criteria were excluded if (1) β-blockers were used. (2) Patients refused or could not complete the cardiopulmonary exercise test (CPET) at discharge and 3 months later. (3) Uncontrolled dysrhythmias such as atrial flutter, fibrillation, and continuous ventricular tachycardia were observed during exercise testing. (4) Ischemic change in EKG during testing.

The 22 patients were divided into two groups in this study:

Group 1 (phase II cardiac rehabilitation group): 11 patients completed a three-month phase II cardiac rehabilitation program.

Group 2 (control group): 11 patients who did not participate in the cardiac rehabilitation program served as control subjects.

2.2 Exercise testing protocol

Patients were tested by Oxycon Pro with a cycle ergometer [Jaeger Company, Germany] with one-minute incremental protocol (Wasserman,1999; Wilmore, 1996). The 12-lead ECG and blood pressure were continuously obtained with the patient in upright position during the whole exercise testing period. After a three-minute rest period, patients initially cycled for 3 minutes of a 10 watts load for the baseline warm-up. Then an increment of 10 watts per minute protocol was used, and patients were encouraged to continue exercise until peak symptoms were achieved, such as severe dyspnea, dizziness, arrhythmia, abnormal ST segment elevation or depression, and decreased blood pressure over 20 mmHg. Patients were advised to continue to pedal at a slow frequency with a 10 watts load on the ergometer as the recovery phase, and continue to breathe through the mouthpiece at least 3 minutes. The test procedures were fully explained to all patients, and informed consent was obtained. This study was approved by the Human Research Committee of the Taichung Veterans General Hospital, Taiwan.

2.2 Cardiac rehabilitation

Patients who participated in phase II cardiac rehabilitation conducted a 30 to 40 minutes aerobic exercise training session (riding a stationary bicycle or walking on a treadmill) with the intensity of 60-85% peak heart rate achieved in cardiopulmonary exercise test (Lucini, 2002; Wasswerman,1999). There were approximately 10 minutes of stretching and calisthenics for warm up and cool down. The training frequency was three times a week and total 36 training sessions were completed by these patients.

2.3 Statistical Analysis

The resting heart rate at baseline and follow-up were collected for comparison. The variables tested between the two groups were analyzed and compared using analysis of variance (ANOVA). The paired t test was used to calculate for the differences between the pre-training and post-training variables within each group. Continuous variables were expressed as the mean ± standard deviation. Analyses were performed using the Scientific Package for Social Science [version 10.1; SPSS, Chicago, IL, USA]. Statistical significance was considered as P < 0.05.
3. RESULTS

The basic clinical characteristics of the two patient groups were presented in Table 1. The two groups were similar in regards to age, height, weight, body mass index and basic medical history. There were no significant differences between two groups in age, and the mean ages for cardiac rehabilitation and control groups were 63.64 ± 7.66 and 59.18 ± 9.95 years, respectively (P = 0.253).

The descriptive statistics of the resting heart rate and other parameters at baseline and follow-up tests between groups were listed in Table 1. In general, there were no baseline statistical differences between groups and the comparison between cardiac rehabilitation and control groups revealed the significance at follow-up test. Both groups improved their resting heart rate, work load, and maximal O2 consumption at follow-up compared to their baseline data, except for the peak heart rate for the control group (P = 0.080).

At the baseline testing, there were no significant differences in resting heart rate between cardiac rehabilitation (86.8 ± 4.9 bpm) and control groups (87.4 ± 5.9 bpm; P = 0.816). After three months, the cardiac rehabilitation showed a significant lower RHR during the follow-up testing compared to that of control group (75.4 ± 8.1 bpm vs. 82.7 ± 4.8 bpm; P = 0.018).

Comparisons between RHRs across the time interval of two tests demonstrated the significant differences for both cardiac rehabilitation (P = 0.006) and control (P = 0.020) groups and they were illustrated in Figure 1.

4. DISCUSSION

This study shows significant improvements in resting heart rate in CABG patients after a twelve-week cardiac rehabilitation exercise program compared to those in control group.

The reduced heart rate variability has been proposed as a major evidence of autonomic dysfunction, and regarded to have strong adverse effects on subsequent clinical outcome in patients with coronary artery disease (Hedback, 2001; Kavanagh, 2002; Tiukinhoy, 2003). Our subjects demonstrated the higher resting heart rates at the baseline testing for both groups before the cardiac rehabilitation. This observation was close to the result of the Pardo's research (2000), but higher than that of a recent retrospective (Tiukinhoy, 2003). The explanation for the discrepancies may be due to the reason that the higher resting heart rate at patients with coronary heart disease suggested the activation of neurohumoral mechanisms, especially the adrenergic activation from sympathetic activity in early recovery phase from cardiac events (Cole, 1999; Messinger-Rapport, 2003, Pardo, 2000). The subjects in Tiukinhoy's study were evaluated with 6 ± 3 months time interval for the cardiac rehabilitation group as well as 9 ± 3 months for the control group, and without information about the time of baseline testing. The early baseline measurement at discharge in the present study could be attributed to the differences in resting heart rates.

The mean RHR of the cardiac rehabilitation group at the follow-up test in this study was consistent with the prior published studies (Gassner, 2003; Kallio, 1979, Ueno, 2003). The mean RHR at the follow-up test with a significantly lower magnitude in the cardiac rehabilitation group compared to control group was similar to previous published works (Ueno, 2003). This improvement of RHR in the cardiac rehabilitation group may indicate that the long-term endurance training increases the parasympathetic activity and decreases the sympathetic activity directed to the human heart at rest, thus decrease resting heart rate.(Brenner, 1997; Oya, 1999, Gassner, 2003). However, our finding was in contrast to the result of Tiukinhoy et al. and their subjects did not show any improvement in RHR at the follow-up tests. The possible reasons may be due to the nearly normal RHR for the control subjects at baseline and their
long time interval between serial exercise stress tests. Pardo et al. reported that exercise conditioning over a 12-week period improved heart rate variability, reduced the resting heart rate in cardiac patients, and lowered the risk of sudden cardiac death via increased vagal tone.

The improvements of peak heart rate, work load, and maximal O2 consumption at follow-up in cardiac rehabilitation group were consistent with the previously published works. (Lucini, 2002; Lan, 2002; Franklin 2002). The resting heart rates (RHR) were significantly reduced in both groups at follow-up tests when compared to their baseline data in present study. The sympathetic nervous system has been proposed to increase activity during the first 3 weeks after the onset of cardiac event, whereas the parasympathetic nervous system has been regarded to improve gradually during the 3-month period Time was concluded as a factor for the improvement in parasympathetic tone (Cole, 1999; Messinger-Rapport, 2003; Pardo, 2000).

Abnormalities of the autonomic nervous system are related to the mechanisms of sudden cardiac death, and an elevated heart rate at rest is confirmed as an independent risk factor for sudden death in normal middle-aged men. The autonomic dysfunction is known to adversely affect clinical outcome in patients with cardiovascular disease, the improvement in autonomic regulation after cardiac rehabilitation may add to the other proven benefits of exercise training program. Our results may present a clinical implication that CABG patients who received a 3-month comprehensive cardiac rehabilitation exercise program would get more improvement in the reduction of resting heart rate than those who in control group. The sympathetic and parasympathetic systems have been proposed to have the modulation effect on heart rate and heart rate variability. Our results are consistent with the improvement in autonomic regulation toward parasympathetic dominance in CABG patients after the cardiac rehabilitation. The sample size in each group and single patient population may expand and direct to different cardiac patients in the further study. As an independent risk factor for mortality, the resting heart rate may be a good parameter with which to assess the effectiveness of cardiac exercise training, and for risk stratification.

References
9. Lucini D, Richard VM, Costantino G, Carl JL,


Table 1. Basic clinical characteristics of two patient groups

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<tr>
<th></th>
<th>Cardiac rehabilitation</th>
<th>Control</th>
<th>P</th>
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<tr>
<td>Case number</td>
<td>11</td>
<td>11</td>
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<tr>
<td>Age (years)</td>
<td>63.64 ± 7.66</td>
<td>59.18 ± 9.95</td>
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<tr>
<td>Height (cm)</td>
<td>167.18 ± 6.09</td>
<td>170.55 ± 5.59</td>
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<tr>
<td>Weight (kg)</td>
<td>73.82 ± 5.58</td>
<td>71.63 ± 6.14</td>
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<tr>
<td>Body mass index</td>
<td>26.40 ± 1.21</td>
<td>25.26 ± 1.75</td>
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<tr>
<td>Medical history</td>
<td></td>
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<tr>
<td>Diabetic (%)</td>
<td>2 (18.2%)</td>
<td>3 (27.3%)</td>
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<tr>
<td>Hypertension (%)</td>
<td>5 (45.5%)</td>
<td>3 (27.3%)</td>
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<tr>
<td>Hyperlipidemia (%)</td>
<td>2 (18.2%)</td>
<td>1 (9.1%)</td>
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**Resting Heart Rate (bpm)**

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<th></th>
<th>Cardiac rehabilitation</th>
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<tbody>
<tr>
<td>Baseline</td>
<td>86.8 ± 4.9</td>
<td>87.4 ± 5.9</td>
<td>0.816</td>
</tr>
<tr>
<td>Follow-up</td>
<td>75.4 ± 8.1</td>
<td>82.7 ± 4.8</td>
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**Peak Heart Rate (bpm)**

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<tr>
<td>Baseline</td>
<td>121.9 ± 10.1</td>
<td>122.2 ± 11.4</td>
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<td>Follow-up</td>
<td>141.3 ± 8.8</td>
<td>131.6 ± 12.0</td>
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**Work Load (watt)**

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<tr>
<td>Baseline</td>
<td>80.0 ± 14.8</td>
<td>82.5 ± 18.2</td>
<td>0.715</td>
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<tr>
<td>Follow-up</td>
<td>130.8 ± 12.4</td>
<td>115.8 ± 21.5</td>
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**VO2 max (ml/kg/min)**

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<th>Control</th>
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<tbody>
<tr>
<td>Baseline</td>
<td>15.1 ± 3.2</td>
<td>15.9 ± 3.9</td>
<td>0.614</td>
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<tr>
<td>Follow-up</td>
<td>22.7 ± 3.6</td>
<td>18.9 ± 2.9</td>
<td>0.011</td>
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ANOVA (between groups): P < 0.05; Paired t test (within groups): P < 0.05

Figure 1: The resting heart rate (RHR) at baseline and follow-up for two groups. The solid and dot lines are the regression lines to fit the cardiac rehabilitation and control group.
冠狀動脈繞道手術病患心臟復健計劃後休息心跳的改變

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摘要

目的：評估心臟復健計劃對於已接受冠狀動脈繞道手術（CABG）病患之休息心跳的影響。

方法：22位已接受冠狀動脈繞道手術（CABG）病患隨機安排至心臟復健運動計劃組（n = 11）和控制組（n = 11）。所有的病患於出院時和三個月後執行心肺運動測試（cardiopulmonary exercise tests），心臟復健運動計劃組的病患接受每週三次，運動強度為根據心肺運動測試時所到達最大心跳之60-85%，共36次的耐力運動訓練。

結果：於三個月後的心肺運動測試，心臟復健運動計劃組相較於控制組的病患顯現出明顯較低的休息心跳（75.4 ± 8.1 時分，P=0.018）。另外，對於2組病患，相較於其出院時均顯現出明顯較低的休息心跳（心臟復健組P=0.006；控制組P=0.020）。

結論：心臟復健計劃對於接受冠狀動脈繞道手術（CABG）病患之休息心跳有正面的影響，此結果與自主神經系統的改善一致。

關鍵詞：休息心跳、心臟復健、運動訓練

*通訊作者