Cardiac Sports Rehabilitation for Patients with Ischemic Heart Disease

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This paper summarizes data gathered from an 8 years sports cardiac rehabilitation program at Kyoto University and satellite hospital (Takeda Hospital). In total, 185 patients were rehabilitated under our original program with no serious cardiac accidents. Compliance was 58.2% after 6 months of this rehabilitation.

In patients selected to evaluate the value of rehabilitation, exercise study with treadmill and ²⁰¹Tl scintigraphic study showed improvement in exercise tolerance (in 58% of patients) and in perfusion on exercise (in 40%). Coronary angiographic study showed regression of arterial narrowing in 16% of the patients studied.

We conclude that in addition to emotional and psychological support, our sports cardiac rehabilitation is safe and effective in improving exercise tolerance and cardiac perfusion.

PATIENTS who have suffered from ischemic heart disease such as angina pectoris or myocardial infarction, are forced to restrict their daily activity for psychological and physical reasons. In cases of myocardial infarction (MI) especially, many physicians emphasize that re-attack could be fatal. This kind of explanation makes the patients restrict their activity even more.

The purpose of exercise rehabilitation with or without drug therapy is to reduce limitations in daily life, and to rehabilitate and re-adapt patients to their normal social life. For this purpose, it is necessary to improve their exercise tolerance to attain emotional stability, hopefully to stop or retard progres-

sion of arteriosclerosis, and to prevent re-attacks of MI.

We chose sports as a means of cardiac rehabilitation because of several advantages in sports for this kind of patients. Properly selected sports will make group activity enjoyable and lessen anxiety. Patients will try to acquire some skills in sports, and sportsmanship will strengthen their will to overcome their disease. We had performed cardiac sports rehabilitation including outdoor games for about 8 years, in this paper we summarize our experience gathered from this unique model of cardiac rehabilitation undertaken in Japan.

MATERIALS AND METHODS

The sports rehabilitation for ischemic heart disease had been undertaken in Kyoto

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Fig.1. A scene of cardiac sport rehabilitation. All patients are requested to be equipped with telemeter ECG.

University since 1982 and Takeda Hospital since 1988. In total, 185 patients were rehabilitated after more than 4 weeks in the program between 1982 and 1989. Male to female ratio was 5.5:1, and average age of the patients was 58.9 ± 10.7 years (range 12–82); 17.3% of all patients were less than 50 years, 37.2% between 50 and 60 years, 28.2% between 60 and 70 years and 17.3% older than 70 years.

Of these, 67% had myocardial infarction (including 13.5% with PTCA and 5.4% with coronary artery bypass graft (CABG)), 13% angina pectoris (including 5.9% with variant angina), 13.5% risk factors for ischemic heart disease and 6.5% syndrome X or chest pain syndrome. Coronary arteriography was performed in 144 patients; 1, 2, 3 and 0 vessel disease were 54.2%, 30.6%, 9.0% and 6.2%, respectively.

Patients who could perform more than first stage of Bruce treadmill test and who did not have complications were permitted to join this program. Exclusion criteria for the program were: (1) heart failure with Forrester subset of III or IV, (2) unstable angina, (3) ventricular premature beats of R on T or short run of ventricular tachycardia (VT) (ventricular premature beat (VPB) itself is not a contraindication of sports rehabilitation if patients do not show a significant increase of VPBs on exercise), (4) advanced A-V block, (5) severe valvular heart disease, (6) main trunk coronary disease, and (7) renal or hepatic insufficiency and other severe

generalized illness. As for patients with low ejection fraction, we admitted them and kept them under careful monitoring during rehabilitation so long as the patient does not have exercise intolerance or heart failure on exercise.

Exercise prescription

Exercise tolerance was evaluated by treadmill according to the Bruce protocol and by the daily jog-walk program. The jog-walk program, consisting of exercise step with graded 10 levels, was used in evaluating the progression of rehabilitation.

Several kinds of sports were used in this program including jogging, walking, free gymnastics, stretching exercise, ping pong, badminton, mini-tennis, volley-ball, kick-ball, swimming in summer, skiing in winter, outing in the field, aerobic dance and steam sauna (Fig. 1).

Initial training heart rate (HR) is determined by the following equation; $(\text{Maximum HR} - \text{Resting HR}) \times \alpha + \text{Resting HR}$, where α is increased gradually from 0.65 at the beginning to final 0.90 or more. The HR is monitored during rehabilitation. Exercise is stopped or reduced when excessive HR continues for more than a few minutes.

The exercise program is of 2 h duration each time. Currently we have morning, afternoon and evening courses, and we recommend the patient to do the exercise at least 3 times a week. Regular rehabilitation program is 3–6 month in duration to attain

Fig.2. The schedule of 2 hours' sports rehabilitation is shown
SP=sports prescription

Fig.3. Compliance of cardiac patients who joined the rehabilitation for one, three and six months is shown.

exercise tolerance of 85—90% of maximum HR.

Schedule of sports cardiac rehabilitation (Fig. 2)

Sports rehabilitation is performed at the Gymnasium of Kyoto University and at Rehabilitation Center of Takeda Hospital. When patients arrive at the gymnasium, the blood pressure, heart rate, body weight and ECG are recorded. A doctor checks person-

al rehabilitation records, clinical cards, and asks patients about their symptoms prior to initiation of the program. Physical examination and resting or exercise ECG recording are performed if clinically indicated.

Three sets of 20 min sports program are undertaken with 10 min rest between them. Warming-up and cooling-down are performed by ample period of time at the beginning and at the end of the program, respectively. Patients record by themselves the blood pressure, heart rate, body weight (BW), and peak heart rate during jog-walk and sports program in their personal record. Specially trained nurses check vital signs before and after programs and observe the patient's condition during rehabilitation, and technicians monitor ECG's and record VPBs or ST changes, if necessary. Athletic coaches supervise the sports program. In the presence of significant complaints or abnormal ECG's during sports rehabilitation, doctors decide whether or not patients will be able to continue rehabilitation and give appropriate orders.

Rehabilitation-staff meeting is held every week to discuss problems and to decide step-up for each patient.

Patients are instructed to calculate the maximum heart rate from the jog-walk prog-

Fig.4. Changes of exercise time and double product on treadmill test, score of ²⁰¹Tl perfusion defect on ergometer exercise and at rest and coronary arterial narrowing during the interval of rehabilitation are shown here (see in the text). Reh=rehabilitated group, Ct=control group

ram or treadmill exercise tests and are permitted to perform sports rehabilitation within this limit. All patients wear ECG monitors or heart rate monitoring wrist-watch.

Assessment of exercise capacity and cardiac circulation

To evaluate exercise tolerance, treadmill exercise tests (Bruce protocol) were done periodically. Exercise capacity was thought to be improved when a patient's tolerance time prolonged more than 1 min or 10% in double products of the control. If a patient showed a reduction in exercise time of more than 1 min or 10% in double products, the patient was judged to have worsened. A range between these limits was thought to be a physiological variation or no change.

Radionuclide studies with ²⁰¹Tl were performed to evaluate cardiac perfusion. The images were visually scored as previously reported! Briefly, transaxial, short axial and long axial images of SPECT (single photon

emission computed tomography) were analyzed. Every slice was divided into 3—5 segments and perfusion defects in each segment were summed up for all slices.

Exercise was done by symptom-limited graded ergometer exercise with recording ECG and blood pressure. At the point of peak exercise, ²⁰¹Tl (2 mCi) was injected and exercise was continued for one more minute with the same work load. Five minutes after completion of exercise, collection of ²⁰¹Tl activity was started by a 180° collection method with a rotating gamma camera. Images were reconstructed three-dimensionally by SPECT.

Three hours after exercise, resting images were taken again to compare with exercise images. If the patient showed a reduction in ²⁰¹Tl defect score of more than 4 points at rest and/or exercise during the rehabilitation period, he was thought to have improved. In case of increase by more than 4 points, the patients was thought to have worsened.

Fig.5. Representative case of cardiac rehabilitation, who had the 99% coronary stenosis at midportion of the left anterior descending artery. After 2 months of sports rehabilitation, exercise time improved from 6 min to 11 minutes, double product from 15900 to 16900, and perfusion with ^{201}Tl improved prominently at the same time as shown in the frontal and transaxial SPECT images.

Coronary angiographic changes of diameter more than 25% were thought to be significant.

For Treadmill exercise test and ^{201}Tl exercise test, a control group with myocardial infarction without any experience of cardiac rehabilitation was selected to compare with the rehabilitated group with matched interval. Intervals of treadmill exercise test were 4.0 ± 2.3 months and 5.5 ± 3.5 month (NS) for rehabilitated group ($n=57$) and control group ($n=17$), respectively. And the interval of ^{201}Tl exercise test was 5.4 ± 2.3 month and 6.3 ± 1.5 months for rehabilitated group ($n=18$) and control group ($n=10$), respectively, as shown in Fig. 4. The interval of CAG performed was 18.4 ± 10.2 months ($n=19$).

Statistical analysis

Statistical differences between the groups were analyzed using the Wilcoxon's method.

RESULTS

Drop-out

On an average, 9.5 patients attended the sports rehabilitation each time.

Within 1 month, 21.8% of the patients dropped out from the rehabilitation program, and 32.7%, 41.8% within 3 and 6 months, respectively. But a significant number of patients had participated in the rehabilitation for years, some for 8 years from the beginning of the program. The major reasons for non-attendance to on a regular basis are:

- (1) Lack of spare time for this cardiac rehabilitation after returning to regular work,
- (2) Inability to play sports mainly due to old age,
- (3) Inconvenient transportation for some to visit the rehabilitation center or gymnasium 3 times a week,
- (4) Erroneous satisfaction after a short period of rehabilitation which contributed to voluntary withdrawal, and

(5) Self training with similar kinds of sports after 2—3 times of attendance in the rehabilitation center.

Complications of cardiac rehabilitation

For 8 years of cardiac rehabilitation, major complications were cerebral infarction (18%), one of which was fatal, unstable angina (2.3%), one of which was treated with emergent A-C bypass surgery, and heart failure (0.9%). The other minor complications were arthritis, myalgia and lumbago which were most frequent during the initial 1—2 weeks after starting the program. During the sports program, transient hypotensive episodes (0.5%), post MI angina (4.1%), serious VPBs to stop the program (2.3%) and contact dermatitis due to electrode patches or tapes were also seen. We had no fatal cardiac problem during the 8-year rehabilitation interval. Fig. 4 shows the summary of treadmill exercise tests, ^{201}Tl exercise tests and coronary angiographic (CAG) results.

Treadmill exercise tests:

Exercise time improved in 58% of the patients, and 36% showed no remarkable change. Compared to the control group (improvement in 29% and no change in 30%), the difference was significant ($p < 0.05$). Double products at peak exercise showed improvement in 35% of patients and no change in 50% without a significant difference compared to the controls.

^{201}Tl exercise test (Fig. 4)

^{201}Tl images showed improvement in 39% of the patients on exercise and in 28% at rest, but these were not significantly different from those of the control group. A representative case with improvement of ^{201}Tl perfusion on exercise and at rest after 2 month of rehabilitation is shown in Fig. 5. In this case, improvement in myocardial perfusion was associated with that of both exercise tolerance time and double products, which suggested a central (cardiac) effect of rehabilitation.

Coronary angiographic findings (Fig. 4):

Out of 19 patients who had CAG 16% of them showed improvement of coronary nar-

rowing after the mean duration of 18.4 months of rehabilitation. Only 16% showed progression of the narrowing during this interval. Because of the difficulties in finding asymptomatic control patients for whom CAG was undertaken, the perfect selection of control subjects was difficult in this study.

DISCUSSION

The purposes of our grouped (cardiac) sports rehabilitation were:

(1) To relieve the patients excess anxiety and to enable them to enjoy their daily life with ease,

(2) To increase exercise capacity, improve myocardial ischemia and decrease mortality due to ischemic attacks.

(3) To make patients feel and realize their exercise or sports capability in daily life which may be very difficult to understand with ergometer or treadmill exercise tests,

(4) To help patients realize the importance of sports in daily life and to make them accustomed to sports at home.

For these purposes, we had been performing sports rehabilitation mainly for ischemic patients for 8 years. In experience, the risk of sports rehabilitation was very low, even if the prescription was grouped sports. A fatal case of cerebral infarct was encountered in our program but it occurred at home on Sunday. The same type of group prescription of sports had also been reported². Current estimates of the overall risks with prescribed exercise are from one in 100,000 to one in 300,000 man-hours of exercise depending on the patient profile³. Musculo-skeletal problems increase with age because of (1) muscle stiffness, (2) less rapid relaxation of antagonistic muscle, (3) loss of elastic tissue, (4) loss of flexibility and degeneration of the joints and (5) clumsiness due to lack of recent exercise and impairment of spatial senses, balance and reflexes². In case of aged people with myocardial infarction, muscle atrophy and stiffness of joints may augment their musculo-skeletal problems, but our cases experienced them only transiently without serious sequela.

Gottheimer reported that the results of sports training in 1103 cardiac patients (548 with MI) as part of cardiac rehabilitation in Israel² with a compliance rate of approx-

imately 60% in 36 months. The other authors pointed out that the drop-out rate is highest in the first three months after recruitment⁴ and that medical problems are infrequent reasons of poor compliance.⁵ Wilhelmsen et al⁶ reported that dropouts blamed lack of transportation (34%), poor motivation (24%), cardiac problems (25%) and other medical problems (17%). Our experience also indicated that transportation, motivation and unavoidable (working) factors rather than medical problems are more important factors for non-compliance.

Treadmill data showed improvement in 58% of patients with regards to exercise time and 36% with regards to double products. Although double products demonstrated no significant difference compared to the controls, exercise time was significantly improved by rehabilitation ($p < 0.05$). Some of them were due to cardiac or central effect with improvement of myocardial perfusion. Improvement of myocardial perfusion may be due to regression of arteriosclerosis,⁷ increased myocardial capillary beds or vascularity,^{7,8} or improved collateral circulation,¹⁰ any of which have not been confirmed.^{11,12}

Visual improvement of myocardial perfusion with ²⁰¹Tl at rest or on exercise was seen in 28% and 40% of the patients, respectively, and did not show statistical difference from the controls, partly due to small number of patients. Deterioration of perfusion in early stage of rehabilitation (average 5.4 months) was found in no more than 10%.

Froelicher was the first to report an evidence of improvement in myocardial perfusion and function.¹³ He showed improvement in both ejection fraction (EF) and exercise thallium imaging in 31% of patients after training with achievement of higher maximal work load and equivalent double products. Tubau¹⁴ also reported improvement in myocardial perfusion with ²⁰¹Tl in 29% of patients by the circumferential method, although he admitted some discrepancies between improvement of ²⁰¹Tl and cardiac function. Verani was unable to show improvement of ²⁰¹Tl scintigraphy.¹⁵ We must be careful to rule out spontaneous improvement of ²⁰¹Tl scintigraphy over the time as reported by Buda.¹⁶

Development of collaterals seems to be

proportional to the degree of coronary narrowing present in experimental trained dogs.¹⁰ Ferguson reported that increased exercise tolerance was not attributable to the development of collateral circulation although some new collateral vessels appeared due to progression of disease. Even if collateral flow augmented with exercise, collaterals may not effectively protect ischemia,¹² but infarcted myocardium may be protected from serious catastrophe and infarct size may become smaller with collateral circulation.¹⁷ We did not evaluate the collateral circulation in detail, but after an average 18.4 months, 16 of selected 19 patients (84%) showed improvement or no progression of coronary arterial stenosis. It may be possible that physical training retards the progression of coronary artery disease.¹¹

Contrary to the central effect, peripheral effects of training are definitely present. Detry¹⁸ reported increased A-V O₂ difference and improved $\dot{V}O_2$ max with training, resulting in enhanced exercise tolerance. Dressendorfer¹⁹ proposed the term "habituation" as improved physical work efficiency. We have also reported improved oxygen pulse with reduced exercise tolerance.²⁰ Central and peripheral effects are sometimes mixed, but exercise tolerance is strongly related to oxygen pulse in patients with low oxygen pulse.

In addition to these findings, we have also reported good psychological effects with this program.²¹

Thus, we think this sports rehabilitation program is safe and highly valuable for cardiac patients.

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