Early Exercise Training After Mitral Valve Repair*

A Multicentric Prospective French Study

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Background: **Surgical mitral valve (MV) repair is now the best technique to correct mitral regurgitation (MR). However, clinical studies have shown that without exercise training (ET), there is no significant postoperative exercise tolerance improvement. Moreover, healing duration of the MV wound is not well known; thus, the feasibility of an early ET program (ETP) may be discussed.**

Objectives: **To evaluate safety and feasibility of an early ETP after MV repair.**

Methods and results: **All patients hospitalized in 13 postoperative centers after MV repair from September 2002 to June 2003 were included in this prospective study. They underwent an ETP during 3 weeks on average. Transthoracic echocardiography and a cardiopulmonary exercise test were performed before and after the ETP.**

Patients: **Two hundred fifty-one consecutive patients (male gender, 70%; mean age, 59 ± 14 years [± SD]) were included 16 ± 10 days after MV repair. There was no MR occurrence or worsening after the ETP. Left ventricular ejection fraction slightly increased (53 ± 10% vs 55 ± 9%, p = 0.004). Peak oxygen consumption and anaerobic threshold increased from 16.3 ± 4.5 to 20.0 ± 6.0 mL/kg/min (22% increase) and from 12.2 ± 3.8 to 14.2 ± 4.3 mL/kg/min (16% increase) respectively, (p < 0.0001).**

Conclusion: **ET after MV repair does not deteriorate the outcome of recent surgery and seems efficient.**
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Key words: cardiac rehabilitation; exercise training; mitral valve; valvuloplasty

Abbreviations: AF = atrial fibrillation; AT = anaerobic threshold; CABG = coronary artery bypass grafting; CPT = cardiopulmonary exercise test; CRC = cardiac rehabilitation center; ET = exercise training; ETP = exercise training program; LAA = left atrial area; LAD = left atrial diameter; LVEDD = left ventricular end-diastolic diameter; LVEDV = left ventricular end-diastolic volume; LVEF = left ventricular ejection fraction; MR = mitral regurgitation; MV = mitral valve; NYHA = New York Heart Association; TTE = transthoracic echocardiography; $\dot{V}O_2$ = oxygen consumption

The emergence of mitral valve (MV) repair[1] clearly modified cardiac surgery habits. Indeed, valve replacement by either mechanical prostheses or bioprostheses is still associated with a number of problems (*eg*, thrombosis, hemorrhage, degeneration). MV repair has many advantages, including the absence of long-term antithrombotic therapy in patients with sinus rhythm and excellent long-term results.[2,3] This is why, if feasible, this type of reconstructive surgery is increasingly proposed to young patients who sometimes have few symptoms or even are asymptomatic.[4] Modern management of these patients aims at rapid recovery of a near-normal functional capacity. However, as demonstrated by Le Tourneau et al,[5] exercise tolerance measured 6 months after surgery does not significantly improve, despite mitral regurgitation (MR) correction, in the absence of exercise reconditioning. These disappointing results have recently been confirmed in a study[6] in which patients performed their second

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exercise test 1 year after MV repair. One possible explanation of this "paradox" could be peripheral deconditioning induced by both valvular heart disease and postoperative course. Physical training allows, among other effects, improved exercise performance in patients with coronary heart disease[7] and heart failure,[8–10] as well as in those who have undergone aortocoronary bypass grafting[11–13] or prosthetic valve replacement.[14] However, MV healing duration after MV repair is not well known, and only animal data are available. Takamura et al[15] showed (in sheep) that healing of a MV wound requires from 8 to 12 weeks after surgery. This could explain the daily life reluctance of some surgical teams to allow early exercise training (ET) after MV repair, especially in high-risk groups of patients: left ventricular ejection fraction (LVEF) $< 45\%$,[16] age > 70 years,[16] ischemic MR,[17] preoperative New York Heart Association (NYHA) functional class III or IV,[16] anterior or both mitral leaflets repair,[18] and concomitant coronary artery bypass grafting (CABG).[19]

To our knowledge, no assessment of the safety of exercise reconditioning after MV repair has ever been attempted. The main aim of our study was to evaluate the safety and feasibility of early ET in patients after MV repair.

Materials and Methods

Patients

This multicentric prospective study (13 centers) was conducted on behalf of the Working Group of Cardiac Rehabilitation of the French Society of Cardiology. All consecutive patients in whom MV repair had been recently performed ($<$ 60 days before study entry) and who were hospitalized in cardiac rehabilitation centers (CRCs) from September 1, 2002, to June 30, 2003, were included. The only exclusion criteria was the inability to perform exercise testing. Drug treatment was left to the discretion of the investigator.

Assessment Criteria

Clinical, echocardiographic, and ergometric assessments were made before and after completion of the cardiac rehabilitation program. Clinical parameters were assessed at least twice a week, looking for the presence of arrhythmia, thromboembolic or hemorrhagic events, infection, signs of heart failure, and emergence or worsening of MR murmur. Doppler echocardiography was performed in all patients at least on two occasions: before and after the ET program (ETP). Each echocardiographic study was done jointly by two operators. Systolic and diastolic BP and heart rate were measured at the beginning of each session. Left ventricular end-diastolic diameter (LVEDD) was measured on the great axis parasternal plane. Left ventricular end-diastolic volume (LVEDV) and LVEF were measured using the Simpson method.[20] Left atrial diameter (LAD) and left atrial area (LAA) were measured during systole.[21] Mean transmitral gradient was measured by continuous Doppler echocardiography coupled with two-dimensional imaging in the apical position. The importance of residual MR was quoted from I to IV based on the following parameters: left atrial regurgitation flow area determined by color Doppler echocardiography,[22] regurgitating orifice area and regurgitated volume calculated using the proximal isovelocity surface area method,[23,24] and research of pulmonary venous flux inversion.[25] Pulmonary systolic BP was estimated from the tricuspid insufficiency flow.

All patients underwent two cardiopulmonary exercise tests (CPTs) before and after the ETP. CPTs were based on the classical methods and done in the upright position.[26] All patients performed an upright graded symptom-limited cycloergometer exercise with a workload increment of 10 W/min after an initial workload of 30 W. Most of the patients were familiar with the procedure and were regularly encouraged to exercise until maximal exhaustion. In order to stabilize resting gas measurements, subjects were asked to remain still on the bicycle for 3 min before exercising. A standard 12-lead ECG was continuously recorded. Heart rate was followed at each minute, and BP was measured by a mercury sphygmomanometer every 2 min during the exercise test and at the peak of exercise. Oxygen consumption ($\dot{V}O_2$), carbon dioxide production, and the other common ventilatory parameters (minute ventilation, breathing rate) were measured on a breath-by-breath basis. The results were averaged using a moving-average filter every seven breaths, excluding at each breath the highest and lowest values in order to reduce breath-by-breath noises. They were then averaged every 15 s and printed. The respiratory exchange ratio was always > 1 at peak exercise. Peak $\dot{V}O_2$ was defined as the highest $\dot{V}O_2$ obtained at the end of the test, and was expressed in milliliters per minute per kilogram. The anaerobic threshold (AT) was determined using classical methods.[27,28] The oxygen pulse was calculated as the $\dot{V}O_2$/heart rate ratio. At peak exercise, patients were asked to stop pedaling, and measurements were continued for 5 min.

ET

The ETP included calisthenics (started the day after arrival in the CRC) and endurance bicycle training (started after the first CPT) 5 days a week (during 3 weeks on average) for inpatients (84%) and 3 days a week (during 5 weeks on average) for outpatients (16%). Endurance training was performed using a bicycle set at an intensity determined by heart rate measured at the AT or, if not available, at 70% of the maximal heart rate of the first CPT. Each session lasted 40 min, beginning with a 5-min warm-up phase, followed by 30 min of rectangular cycling exercise, and ended by a 5-min cool-down period. The calisthenics consisted of 20 different dynamic and isometric arm and leg exercises during 30 to 40 min at each session. All sessions where held under the supervision of a cardiologist.

Statistical Analysis

Results were expressed as mean $\pm$ SD. A paired t test was used to compare continuous data collected in patients before and after completion of the rehabilitation program. Since multiple comparisons were performed, Bonferroni adjustment was used. Accordingly, statistical significance was achieved for the outcome variables when the p value was < 0.00625. This strategy was used to maintain the type I error rate at the 5% level.

A χ^2 test was used to analyze nominal data. Factors associated with changes observed after the training period were determined by means of logistic regression analysis. All statistical analyses were performed using statistical software (StatView 5.0; SAS Institute; Cary, NC).