Research Related to Rehabilitation

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SUMMARY  Progress in cardiac rehabilitation demands that rehabilitation efforts for the patient after myocardial infarction or aortocoronary bypass surgery be integrated into a comprehensive program of acute and ambulatory cardiac care. To permit a more rapid return of coronary patients to a normal or near-normal lifestyle and role in society, further delineation of the scientific bases for all components of rehabilitation programming and identification of both barriers to and facilitators of rehabilitation are necessary to improve rehabilitative services.

ONE OF THE MOST EXCITING features of the rehabilitative approach to the cardiac patient during the past decade has been its progressive incorporation into the mainstream of traditional medical care. The particular concerns of rehabilitation include the assessment of a patient's functional status and the application of measures designed to enhance function in a variety of spheres — physiologic, psychologic, social, educational, vocational. The ultimate goal is the prompt return of the patient to a normal or near-normal lifestyle and role in society. The care of the patient with coronary atherosclerotic heart disease is cited as a prototype in this paper because coronary disease is, overwhelmingly, the most common cardiovascular problem with significant residual functional impairment.

Today, early ambulation is an accepted practice for patients with uncomplicated myocardial infarction; exercise stress testing is more frequently used to evaluate cardiovascular function objectively, and exercise training programs are instituted to improve the coronary patient's functional capacity. Greater attention is being focused on psychosocial factors affecting the patient after myocardial infarction, since these factors are more often the cause of disability than is physiologic impairment. Patient and family education about coronary disease and its management is emphasized in both the acute and the long-term care of the patient with myocardial infarction. Patient, public and professional education efforts appropriately emphasize that most patients after myocardial infarction can and should return to a normal or near-normal lifestyle. This rehabilitative approach to the patient who has had aortocoronary bypass surgery has also been accepted more often. Recent data derived from a variety of research efforts constitute the scientific bases for and have led to the development of these rehabilitative programs.

Early Ambulation

The pattern of care for the patient with myocardial infarction in the 1970s is characterized by a decrease in immobilization at bed rest and a liberalization of physical activity. Information about the deleterious effects of prolonged bed rest changed the empiric custom of the 1930s of several months of immobilization after myocardial infarction and provided the impetus for early ambulation programs.

The delineation of many of these deleterious or deconditioning effects occurred during investigation of the effects of immobilization on astronauts in the United States aerospace efforts. Research studies have shown that the most marked alteration after immobilization at bed rest is a decrease in physical work capacity, and thus a decrease in maximal oxygen uptake. Also, mobilization after a period of bed rest is accompanied by significant tachycardia and orthostatic hypotension, both due in large part to the hypovolemia that occurs at bed rest. The circulating blood volume has been shown to decrease by 700-800 ml after a week to 10 days at strict bed rest. Another problem is that the plasma volume decreases to a greater extent than does the red blood cell mass, increasing blood viscosity and predisposing to thromboembolism; this occurs in a setting where bed rest obviates the use of the leg muscle pump, adding the risk of venous circulatory stasis to that of increased blood viscosity. A modest decrease in lung volume and vital capacity was documented with bed rest, but appeared of major significance only in the patient with associated pulmonary disease. A negative nitrogen and protein balance has been demonstrated, and surgeons find this disturbing in regard to wound healing in the postoperative patient. Perhaps internists and cardiologists should be as concerned about healing of a necrotic area of myocardium. Finally, research studies have documented a decrease in skeletal muscle mass and in muscular contractile strength and efficiency after strict bed rest. An inefficiently contracting muscle requires more oxygen than an efficiently contracting muscle to perform the same amount of work, and imposes this increased demand on an impaired oxygen transport system and myocardium.

Based on these data, gradually progressive, low-level intensity, early-ambulation programs were designed to avert or lessen the deleterious effects of prolonged immobilization. Criteria have been established to select patients for early ambulation. Such patients are those with uncomplicated myocardial infarction, which means they do not have significant dysrhythmia, heart failure, shock or persistent or recurrent chest pain. Guidelines have also been iden-
ified and tested for physical activity surveillance, e.g., a heart rate response no greater than 120 beats/min, no chest pain or dyspnea, no dysrhythmia, no change in ST-segment displacement on the ECG or monitor as evidence of ischemia and no decrease of greater than 15-20 mm Hg in systolic blood pressure. (The systolic blood pressure normally increases slightly in response to exercise and, in the clinical setting of myocardial infarction, a fall in systolic blood pressure usually signifies inadequate cardiac output to meet the demand.)

Several controlled studies from medical centers throughout the world have documented the safety of early ambulation for appropriately selected and monitored patients after acute myocardial infarction.\textsuperscript{15-22} There is no alteration in morbidity and mortality and no increase in cardiac complications — specifically, no increase in angina pectoris, heart failure, dysrhythmia, recurrent myocardial infarction, ventricular aneurysm and cardiac rupture. In fact, some studies suggest a more favorable outcome. The documented benefits of early ambulation include this prevention of deconditioning, a decrease in thromboembolic complications, amelioration of anxiety and depression\textsuperscript{23-25} and the economic advantages of permitting a shorter hospitalization and an earlier return to work.

**Cardiac Conditioning (Exercise Training) Programs**

Physiologic studies have delineated the response to exercise training in normal subjects and in patients with cardiovascular disease, including patients after myocardial infarction.\textsuperscript{26-30} This response is characterized by a decrease in resting heart rate and systolic blood pressure and a lesser increase in heart rate and systolic blood pressure at any level of submaximal work. These parameters — the rate-pressure product, or double product — are major determinants of myocardial oxygen demand. Thus, the exercise-training effect is best described as a muting of the heart rate and blood pressure response to any given level of activity, and, in turn, a decrease in myocardial oxygen demand. An additional physiologic advantage of exercise training is an increase in maximal oxygen uptake, which is related to an augmented blood supply to exercising muscle and to an increased extraction of oxygen from the circulating blood. Studies have also suggested that training may improve myocardial function and myocardial oxygen supply, but these aspects are controversial.

Sensible guidelines have emerged to identify patients after myocardial infarction who are suitable candidates for cardiac conditioning programs. Major contraindications to exercise training include unstable angina pectoris, uncontrolled hypertension or heart failure, significant dysrhythmias, especially those which increase with exercise, and gross cardiac enlargement.\textsuperscript{31}

Central to a cardiac conditioning program is the concept of prescribed, individualized exercise, with prior multilevel exercise stress testing required for the safety and the accuracy of exercise prescription.\textsuperscript{32-36} Accumulating evidence indicates that to achieve the training effect, patients should exercise at least two to three times weekly, preferably on nonconsecutive days, for 20-30 minute sessions, which include a warm-up and cool-down period. Exercise should be of an intensity to attain 70-85\% of the maximal heart rate response safely achieved at prior exercise stress testing. Although somewhat arbitrary, these recommendations are generally accepted as effective; further evaluation is required to determine whether a lower intensity and duration of exercise can achieve a training effect. In general, increased exercise duration has been shown to compensate for a lesser exercise intensity; however, an increase in exercise duration has been documented to result in poorer adherence and in an increase in orthopedic complications. Research studies have also identified that not all patients after myocardial infarction can improve their exercise tolerance, even when appropriately selected and correctly trained. This lack of training effect may be due to the development of left ventricular dysfunction or overt heart failure at higher levels of activity or to a progression of the underlying coronary disease during the training period.

Physiologic studies have also identified that dynamic (isotonic) exercises — exercises involving repetitive movements of large muscle groups — are necessary for cardiovascular training. Both arm and leg exercises are needed, since arm and leg training effects have been shown not to be interchangeable.\textsuperscript{37} Furthermore, although continuous training can more effectively increase endurance, interval training has been demonstrated to be more appropriate for cardiac patients, since under these conditions a significant oxygen debt and high blood lactate levels can be avoided.

Benefits other than physiologic (i.e., a decrease in myocardial oxygen demand for the same amount of external work) also result from exercise training programs for patients after myocardial infarction. Psychologic research studies\textsuperscript{38-40} have shown that patients who exercise and become physically fit feel better, have an improved self-image, have lessened anxiety, depression and dependency scores (as measured by standardized psychometric tests), and appear better able to tolerate life stresses. Physical activity programs also appear to aid patients in renouncing the sick role and in returning to a normal lifestyle, including return to work. Exercise aids in weight control (important for many postinfarction patients), provides an incentive for cessation of cigarette smoking and is important as a modality that is prescribed rather than proscribed for the patient after myocardial infarction or after aortocoronary bypass surgery.

Equally important is the identification of inappropriate expectations from exercise training.\textsuperscript{41} Exercise does not appear to alter the development of a coronary collateral circulation in the patient after myocardial infarction, at least not collateral vessels that can be detected angiographically. An increase in
the coronary collateral circulation appears related only to the progression of the underlying atherosclerotic disease. No information is available about alterations of blood flow through existing coronary collateral vessels, a parameter that cannot be measured angiographically but may be elucidated with myocardial scintigraphic studies. The crucial question — whether the institution of physical activity after myocardial infarction can alter the natural history of the illness — is unanswered and requires further research. The National Exercise and Heart Disease Project,\(^6\) a multicenter study of postinfarction patients randomly assigned to exercise and control groups, may provide some important information.

**Patient and Family Education**

Recent studies\(^6\) have confirmed that patients and their families who understand coronary disease and its management are more likely to adhere to medical recommendations for care. Organized patient education programs, both in the hospital and in ambulatory care settings, have effected significant changes in patients' knowledge of their disease, their medications, their diet, and so on, and have produced beneficial changes in adherence to prescribed therapy. Counseling patients who were poor adherers to medication regimens had been documented to produce a significant and sustained improvement in medication-taking. Similar results have occurred with intensive community educational efforts.

**Research Needs in Cardiac Rehabilitation**

In 1974 the National Heart and Lung Institute convened an expert task force to evaluate the needs and opportunities for rehabilitating the coronary heart disease patient. The report of the task force\(^4\) emphasized that many current rehabilitative techniques and methods are based on limited numbers of scientific studies and that future improvement in the effectiveness of these programs depends on the attainment of more information in several areas.

The optimal mode of delivery of available rehabilitative services must be determined. Relevant considerations for research studies designed to arrive at this decision include the availability of community resources (facilities and personnel), the funding patterns for medical care, disability determination and its funding, opportunities for vocational retraining or selective placement in industry and legislation concerning cardiac patients.

The effects of early ambulation on myocardial contractility, on infarct size, and on hemodynamic parameters warrant additional study with newer and, often, noninvasive techniques. The role of early exercise stress testing for the patient after myocardial infarction — before discharge from the hospital — must be investigated to define its safety, its indications and contraindications, its value in altering medical/surgical management, its contribution to early identification of patients with significant impairment and its role in defining more precisely the effects of early ambulation and other acute care measures. The use of traditional exercise stress testing to determine the pattern of medical care and as a guide to return to work and vocational placement must be established and correlated with information obtained from the routine clinical evaluation of the patient. The role of health care personnel (and their requisite training) requires delineation in exercise testing and training programs and in coronary risk modification and other counseling programs.

Factors that determine the differences in the ability of patients after myocardial infarction or aortocoronary bypass surgery to return to work, such as age, occupation, organization of the job, occupational hazards, severity of the infarction, associated diseases and psychosocial factors, require delineation. Methods of job retraining are particularly applicable to the more impaired coronary patient, whether physiologically or emotionally impaired, and their efficacy must be demonstrated. The value and role of new diagnostic techniques — ambulatory on-the-job cardiac monitoring and exercise myocardial scintigraphy, for example — require assessment in the more seriously ill patients.

More basic investigation is needed to define the effects of exercise training on the natural history of coronary atherosclerotic heart disease. Does exercise alter the progression of atherosclerosis, coronary collateral flow, myocardial perfusion? Does it alter the recurrence of myocardial infarction or the occurrence of sudden cardiac death? Delineation of the mechanisms that produce a training effect — the improvement in physical work capacity and cardiovascular performance — may permit the design of more optimal exercise training programs.

Identification of the determinants of successful and unsuccessful rehabilitation (physiologic, psychosocial, vocational and institutional determinants), and characterization of patient subgroups more likely to require rehabilitative services, are prerequisite to feasible, acceptable and cost-effective rehabilitation programs.

**References**

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Circulation. 1979;60:1636-1639
doi: 10.1161/01.CIR.60.7.1636
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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the World Wide Web at:
http://circ.ahajournals.org/content/60/7/1636

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