Review Article

Cardiac rehabilitation past, present and future: an overview

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Abstract: Cardiac Rehabilitation has evolved over the past decades from a simple monitoring for the safe return to physical activities to a multidisciplinary approach that focuses on patient education, individually tailored exercise training, modification of the risk factors and the overall well-being of the cardiac patients. It has been proven to be an effective tool for the care of the patients with heart disease. Recent research in cardiac rehabilitation has demonstrated that tremendous benefits can be derived from the optimal use of cardiac rehabilitation in patients with various cardiac pathologies including ischemic heart disease, heart failure and post heart surgery. The benefits of cardiac rehabilitation include mortality reduction, symptom relief, reduction in smoking and improved exercise tolerance, risk factors modification and the overall psychosocial wellbeing. Unfortunately, cardiac rehabilitation remains considerably underutilized mainly because of referral problems and poor enrollment. The development of alternate approaches and the use of transtelephonic and other means of monitoring and surveillance will help expand the utilization of cardiac rehabilitation.

Key Words: Cardiac rehabilitation; exercise training; secondary prevention

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Cardiac rehabilitation programs have become an integral part of the standard of care in modern cardiology. Their scope has shifted from the emphasis on exercise therapy to comprehensive secondary prevention strategies managing risk factors, nutritional, psychological, behavioral and social factors that can affect patient outcomes.

While the importance of primary prevention measures aimed at delaying or preventing the onset of cardiovascular disease is obvious and cannot be emphasized enough, cardiac rehabilitation is mainly involved with secondary prevention which relies on early detection of the disease process and application of interventions to prevent the progression of disease. These interventions include education, counseling and behavioral strategies to promote lifestyle change and modify risk factors. Clinical trials have proven that strategies for the detection and the modification of risk factors can slow, stabilize or even modestly reverse the progression of atherosclerosis and reduce cardiovascular events.

In most current guidelines of cardiovascular societies worldwide, cardiac rehabilitation is a class I recommendation (1-4).

The aim of this paper is to present an overview of cardiac rehabilitation as a tool for secondary prevention of cardiovascular disease and its current status as a performance measure in the care of patients with cardiac disease.

Historical background

In 1772, four years after his magnificent description of angina pectoris, Heberden reported a case of a patient who improved by working in the woods half an hour per day. Despite some evidence of the benefits of physical activity, mobility restriction was imposed on patients with acute coronary events, often leading to serious deconditioning problems, decline in functional capacity, prolonged hospital stay and increased morbidity and mortality. This incorrect attitude was reinforced after the description of myocardial infarction by Herrick in 1912. In the 1930s, patients with acute coronary events were advised to observe 6 weeks of bed rest. Chair therapy was introduced in the 1940s (5). In

the early 1950s, a very short daily walk of 3 to 5 minutes was allowed 4 weeks after the coronary events. Gradually, it was recognized that early ambulation prevented many of the complications of bed rest, and that it did not increase the risk.

Early cardiac rehabilitation pioneers like Levine and Lown experienced very strong opposition for advocating early mobilization of patients. However the cumulating evidence of the benefits of early ambulation and physical activity in general helped convince the skeptics. In 1953, Morris' study showed that the bus drivers in London had a higher rate of coronary events compared to ticket sellers (6). This was attributed to the fact that ticket sellers were more active going up and down the double-deck buses while drivers sat behind the wheels. Further proofs of the detrimental effects of prolonged immobilization were provided by the training of the candidates for space flight (7).

In 1968, Saltin *et al*. published the Dallas Bed Rest and Exercise Study which, though small, provided a very powerful proof of the importance of exercise and the detrimental effect of prolonged bed rest (8). The works of Braunwald, Sarnoff, Sonnenblick, Hellerstein, Naughton and many others helped establish the physiologic basis of exercise benefits and led to the development of Cardiac rehabilitation programs as a multidisciplinary approach to help cardiovascular patients recover and optimize their functional and mental status (9,10).

Since that time, this approach has been proven to have undeniable morbidity and mortality benefits, and has been recommended as an important therapeutic tool in modern cardiology by most cardiovascular professional societies (3,4). Unfortunately, the early success of this discipline did not translate in a large endorsement by the cardiology community, as many young cardiologists were attracted by new technologies like echocardiography and coronary angiography. The development of new and more powerful drugs like beta-blockers, calcium-blockers and thrombolytics made it difficult for cardiac rehabilitation to become a standard therapeutic tool as cardiologists focused on immediate and short-term results.

In recent years, a better understanding of the natural history of many cardiac pathologies and the fact that, despite tremendous advances, heart disease remains the number one killer have led to a renewed interest in cardiac rehabilitation.

Objectives and indications of cardiac rehabilitation

Cardiac rehabilitation has evolved over the last four decades from a simple monitoring program for the safe return to physical activities to a multidisciplinary program including post-operative patient care, the optimization of medical treatment, nutritional counseling, smoking cessation, risk stratification, stress management, hypertension management and the control of diabetes or dyslipidemia. The World Health Organization offered a definition of cardiac rehabilitation that summarizes very well its objectives: the sum of activities required to influence favorably the underlying cause of the disease, as well as to ensure the patient the best possible physical, mental and social conditions, so that they may, by their own efforts, preserve or resume when lost, as normal a place as possible in the life of the community (World Health Organization, 1993).

Objectives

Historically, the first objective of cardiac rehabilitation was to help the patients regain autonomy and improve regular physical activities. The positive impact of regular physical activities on mortality after myocardial infarction has been confirmed by many prevention studies such as the study by Wannametthee and INTERHEART Study (11,12).

Regular physical activity improves HDL-cholesterol, decreases visceral fat and reduces glycemia as well as blood pressure.

Another objective of cardiac rehabilitation is to control the modifiable risk factors. This involves not only smoking cessation and the optimization of medication for blood pressure, diabetes and cholesterol control, but also the therapeutic education that emphasizes the importance of the measures of therapeutic life changes.

Therapeutic education is a structured teaching program using workshops to educate the patients about their conditions. The ultimate goal is to allow the patients to become responsible and autonomous for their medical treatment and lifestyle changes.

Lastly, helping manage psychosocial and professional problems of the cardiac patients is also an objective of cardiac rehabilitation. Psychiatric troubles like anxiety and depression are quite frequent following coronary events and are associated with lower exercise capacity, fatigue and a reduced quality of life and sense of well being. In cardiac rehabilitation centers, patients learn stress management and other self-control tools which in return will affect the control of the risk factors.

Indications

There are differences in the provision and organization of cardiac rehabilitation in different countries which have to do with health policies and politics. Different countries allocate different resources into cardiac rehabilitation.

Obviously, countries with a higher income level are more likely to put more resources into cardiac rehabilitation. The indications for cardiac rehabilitation can therefore vary between countries.

The generally accepted indications for cardiac rehabilitation include: acute myocardial infarction, stable angina pectoris, coronary artery bypass graft surgery, heart valve repair or replacement, percutaneous transluminal coronary angioplasty and heart transplantation or heart-lung transplantation (13,14).

Until recently, exercise restriction was imposed on patients with heart failure. The inclusion of heart failure as an indication for cardiac rehabilitation is fairly recent, and the work by Sullivan had a major contribution (15). In this high risk group, only stable class II and class III heart failure patients without complex arrhythmias should be referred for exercise training (16).

Heart transplant patients benefit from exercise training in individualized protocols that take into account their particular physiologic characteristics: denervated myocardium, increased plasma norepinephrine, lower peak heart rate, lower peak stroke volume, delayed slowing of heart rate in recovery, elevated systolic and diastolic blood pressures and attenuated increase in heart rate during submaximal work (17).

Exercise training in these patients can be very helpful even before heart transplantation to mitigate the impact of the decreased strength and skeletal muscle abnormalities that develop prior to transplantation.

Patients with peripheral artery disease (PAD) can also benefit from individualized exercise training since PAD often coexists with coronary artery disease. Half of patients with PAD have coronary artery disease, and one-third of patients with known coronary artery disease have coexisting PAD (18). Pande *et al*. suggested in their study that millions of patients with PAD are not receiving secondary prevention therapies (19). Referring these patients to a cardiac rehabilitation program will ensure that they get adequate secondary prevention interventions.

Contraindications

Contraindications to cardiac rehabilitation only concern the exercise aspect of the program. All the other components of the program can be pursued. Most patients referred for cardiac rehabilitation are eligible to participate in the program.

Contraindications include unstable angina, decompensated heart failure, complex ventricular arrhythmias, pulmonary arterial hypertension greater than 60 mmHg, intracavitary thrombus, recent thrombophlebitis with or without pulmonary embolism, severe obstructive cardiomyopaties, severe or symptomatic aortic stenosis, uncontrolled inflammatory or infectious pathologies and any musculo-skeletal condition that prohibits physical exercise (20).

Components and organization of cardiac rehabilitation

The development of structured and physician-supervised rehabilitation programs came out of concerns about the safety of unsupervised exercise in patients with acute coronary events. Hellerstein's multidisciplinary approach for comprehensive rehabilitation of patients recovering from acute cardiac event presented in the 1950s has been adopted by cardiac rehabilitation programs worldwide (9).

Traditionally, cardiac rehabilitation is divided into three phases (21). All phases of cardiac rehabilitation aim to facilitate recovery and to prevent further cardiovascular disease.

Phase I or inpatient phase is initiated while the patient is still in the hospital. It consists of early progressive mobilization of the stable cardiac patient to the level of activity required to perform simple household tasks. The shorter hospital stay with modern cardiology makes it difficult to conduct formal inpatient education and training programs. Thus inpatient cardiac rehabilitation programs are mostly limited to early mobilization to make self care possible by discharge, and brief counseling about the nature of the illness, the treatment, risk factors management and follow-up planning.

In most countries, phase II is a supervised ambulatory outpatient program of 3 to 6 months duration which consists of outpatient monitored exercise and aggressive risk factor reduction. In some countries, especially in Europe, residential programs of 3 to 4 weeks duration are offered.

Phase III is a lifetime maintenance phase in which physical fitness and additional risk-factor reduction are emphasized. It consists of home-or gymnasium-based exercise with the goal of continuing the risk factor modification and exercise program learned during phase II.

The American Heart Association, the American College of Cardiology Foundation and the American Association of Cardiovascular and Pulmonary Rehabilitation have outlined the core components of contemporary cardiac rehabilitation and secondary prevention programs and produced guidelines for detection, management and prevention of cardiovascular disease. These core components include patient assessment, exercise training, physical activity counseling, tobacco cessation, nutritional counseling, weight management, aggressive coronary risk-factor management

and psychosocial counseling (1,3,22). Other subjects often raised by patients discussed during cardiac rehabilitation visits include sexual dysfunction, alcohol consumption and stress management.

Some of these guidelines have been recently updated as important evidence emerged from clinical trials to support the benefits of intensive risk-reduction therapies in cardiovascular patients (23,24).

Patient assessment

In order to guide the patient through the different aspects of cardiac rehabilitation, to meet his individual needs and to optimize his benefits, a risk profile of the patient needs to be established through a complete physical and mental evaluation done at the initiation of the cardiac rehabilitation program.

The goal is to insure a safe environment for the patient and to facilitate patient care with minimal risk. This evaluation will help set the goals of cardiac rehabilitation for the patient.

Before the exercise training, a symptom-limited exercise test is undertaken for prognostic, diagnostic, and therapeutic purposes (25).

At the end of the participation, some centers routinely perform another evaluation to verify if the goals have been met and to find ways to ensure a continued patient progress in the long term.

Exercise training

The scientific data clearly establish that exercise training results in improvements in exercise tolerance. Appropriately prescribed and conducted exercise training is therefore a key component of cardiac rehabilitation. Meyers *et al*. showed that improvement of 1 metabolic equivalent in functional capacity imparts a 12% reduction in all-cause mortality (26).

More recently, Jolly *et al*. showed that abnormal heart rate recovery, which is a predictor of mortality, can be normalized with exercise training with improvement in mortality (27).

Exercise protocols should include not only endurance but also resistance training, as improvement in muscle strength could benefit patients' performance of activities of daily living.

A variety of material is used for patients' endurance and resistance training. These include treadmills, steppers, weights, rowers, elliptical trainers, exercise bikes, dumbbells etc. Swimming pools can be very helpful for the training of highly debilitated patients.

A baseline symptom-limited exercise test is used to stratify patients' risk for cardiac events before exercise training. An exercise prescription is developed based on the result of the exercise test and includes the type, the intensity, the duration, and the frequency of the exercise.

While most programs in North America are ambulatory, residential programs are quite common in European countries like France or Germany. The duration of outpatient programs varies depending on the funding available.

In the United States of America, patients covered by health insurance, Medicaid or Medicare are offered exercise training at a frequency of three times weekly for 8 to 12 weeks. Exercise training sessions are usually of 45 minutes duration (28).

In Canada, programs are typically offered for 6 to 8 weeks. Residential programs that are mostly offered in Europe are brief and intensive, lasting for 3 to 4 weeks.

In an effort to address the problem of discrepancies in response to cardiac rehabilitation and the increasing rate of obesity in cardiac rehabilitation participants, exercise modalities other than the traditional moderate-intensity protocols have been studied recently. High-intensity interval aerobic exercise program and high-calorie-expenditure exercise program are two such modalities.

High-intensity interval aerobic exercise training programs have shown greater improvements in exercise performance and hemodynamic benefit when compared to moderate-intensity exercise training in patients with stable CAD and heart failure with no significant increase in complications (29,30). Exercise protocols for this modality vary. In one study, the exercise program consisted of a 10-minute warm-up period at 50 to 60 percent of VO_{2max} followed by four 4-minute intervals at 90 to 95 percent peak heart rate (Rate of Perceived Exertion 17±1), with intervals separated by three minute periods of walking at 50 to 70 percent of peak heart rate (31).

Ades *et al*. developed another variation called high-calorie-expenditure exercise training which they compared to the standard cardiac rehabilitation exercise in participants who were overweight or obese and who had ischemic heart disease. This program achieved a much higher exercise-related energy expenditure (3000-3500 kcal/week) compared to the usual care (700-800 kcal/week) with patients walking at lower intensities (50-60% peak VO_2) for longer durations and more often. They showed a significantly greater weight loss with improvement in insulin resistance and lipid profiles (32).

Physical activity counseling

Regular physical activity has been shown to have many cardiovascular benefits including weight loss, blood pressure reduction, glycaemic control and lipid profile improvements.

A meta-analysis of 11 exercise rehabilitation randomized trials including 2285 patients showed that regular exercise was associated with a significant 28% reduction in all-cause mortality (6.2% versus 9.0%, risk ratio 0.72, 95% CI 0.54-0.95) and a possible but nonsignificant 24% reduction in recurrent myocardial infarction (risk ratio 0.76, 95% CI 0.57-1.01) (33).

Most guidelines recommend that exercise should be performed for a minimum of 30 minutes per day at least five days per week and preferably daily, should involve moderately intensive (target heart rate of 60 to 75 percent of the average maximum heart rate or the perception of moderate exercise 12 to 14 on the Borg scale) aerobic activity such as brisk walking and should be supplemented by an increase in daily lifestyle activities (e.g., walking breaks at work, gardening, and household work) (23,34,35).

There seems to be a dose-response relation between physical activity and Health in general and coronary heart disease in particular. A meta-analysis by Sattlemair *et al*. found that "some physical activity is better than none" and "additional benefits occur with more physical activity (36)".

Tobacco cessation

Smoking cessation is the most important and the most cost-effective of all the lifestyle modifications recommended to prevent cardiovascular disease. Several large observational studies and a meta-analysis showed a substantial reduction in mortality [RR: 0.64 (CI: 0.58-0.71)] in patients with a history of MI, CABG, angioplasty, or known CHD, who quit smoking compared with patients who continued to smoke (37). javascript:showrefcontent('refrencesla yer'); The overall mortality risk of smokers who quit decreases by 50% in the first couple of years and tends to approach that of nonsmokers in approximately 5-15 years of cessation of smoking (38). Nevertheless, smoking cessation is often challenging, as tobacco dependence is a complex phenomenon that includes not only physical and psychological addiction but also social and behavioral components. A personalized consultation with an emphasis on both smoking history and the exposure to second-hand smoke is offered to smokers to enable and consolidate smoking cessation. Many tools are used for smoking cessation and they include pharmacologic assistance (nicotine substitutes, bupropion, varenicline), counseling, education and group support (39).

Nutritional counseling

The aim of nutritional counseling in cardiac rehabilitation is to help patients understand the impact of food on one's health and make healthy food choices. For that reason, baseline daily caloric intake and dietary information are gathered by the dietician. Recommendations are given to patients tailored on their individual diet profile. Dieticians organize practical workshops to teach patients healthy eating habits, label reading and cooking demonstrations. General dietary recommendations for cardiac patients include a reduced intake of saturated fats (<7% of total calories) and cholesterol (<200 mg/d), increased intake of polyunsaturated (about 10% of total calories) and monounsaturated fats (20% of total calories), an adequate repartition of calorie sources (about 50-60% of total calories for carbohydrates, 15% for protein and 25-35% for fat) and increased fiber intake (about 20-30 g/d). Based on recent studies in nutrition and cardiovascular disease, there has been specific recommendations for patients with heart disease that emphasize moderation and plant-based food (22).

Weight management

The negative effects of overweight and obesity on physical activity and the incidence of hypertension, cholesterol and diabetes have been confirmed in many studies. Anthropometrics measurements are taken during visits at cardiac rehabilitation centers. Patients are instructed on their specific weight issues and on methods that can help achieve a healthy body weight through a combination of decreased caloric intake and increased caloric expenditure (40). All the other aspects of cardiac rehabilitation will also have an impact on weight improvement and maintenance. The American Heart Association released a Scientific Statement in 2011 regarding weight management strategies for busy ambulatory settings (41).

The goal of weight management is body mass index of 18.5-24.9 kg/m^2 and waist circumference of <40 inches in men and <35 inches in women. The initial goal of weight loss therapy should be to reduce body weight by approximately 10% from baseline. With success, further weight loss can be attempted if indicated through further assessment.

Lipid management

Hypercholesterolemia is the risk factor with the highest percentage of attributable risk post myocardial infarction (12). Yusuf *et al*. showed that every 1 mmol/L (38.7 mg/dL) decline in LDL cholesterol results in a 21% decrease in cardiovascular events (42). Unfortunately this risk factor is often overlooked. Euroaspire studies have shown that

this risk factor is not well controlled and that there have only been weak improvements in the percent of patients attaining target LDL-cholesterol values (33% to 41%) (43). Many aspects of cardiac rehabilitation will contribute to improve patients' lipid profile. These include physical exercise, nutritional counseling and weight management.

Pharmacologic treatment is often added to therapeutic lifestyle changes to achieve LDL-cholesterol targets (44).

Blood pressure management

High blood pressure is very prevalent among patients referred for cardiac rehabilitation. A decrease in systolic blood pressure by 10 mmHg can decrease cardiovascular mortality by 20-40% and a reduction of diastolic blood pressure by 5-6 mm Hg results in a reduction of stroke risk by 42% and Coronary heart disease events by 15% (45,46).

For many patients at cardiac rehabilitation centers, medications for high blood pressure will be a new reality they are dealing with because those medications would have been introduced only a few weeks earlier at the time of their cardiac event. During cardiac rehabilitation sessions, they will learn the importance of blood pressure control, the medications and their side effects, the measures of therapeutic life changes that will have an impact on their blood pressure and the use of blood pressure devices.

Understanding of the disease and its treatment will certainly improve patients' compliance and reduce the risk associated with high blood pressure (47).

Diabetes management

About 26% of patients referred to cardiac rehabilitation have diabetes. These patients have a particularly high cardiovascular risk profile. The majority (93%) will have another associated risk factor (smoking 16%, hypertension 54%, hypercholesterolemia 51%, overweight 40%, obesity 34%)(48). Therapeutic education is a very important tool that helps improve diabetes control. Because of their multidisciplinary approach and the use of therapeutic education tools, cardiac rehabilitation programs can help achieve a better glycemic control. This has been shown to reduce cardiovascular morbidity and mortality (49).

The goal of diabetes management is to maintain glycosylated hemoglobin (HbA1c) concentration of <7%.

Management of Psychosocial and professional issues

Patients with heart disease are often confronted with psychological and social problems that can affect both morbidity and mortality. Depression, anxiety, and denial occur in up to 20% of patients following myocardial infarction (50). During cardiac rehabilitation follow-up, patients undergo a routine screening to identify anxiety, depression, substance abuse and familial or other social problems. The social workers and others professionals involved in the multidisciplinary team in cardiac rehabilitation centers provide patients with the information and the help they need to plan for their return to work and to a normal life.

Medical, psychological and social interventions tailored to individual problems are offered and have been shown to improve outcomes (51,52).

The INTERHEART Study quite clearly demonstrated that stress was the third most important risk factor for coronary events, following lipids and smoking, and accounts for approximately 30% of the population's attributable risk of acute MI (12). Psychosocial stress affect cardiovascular disease process through the increase in blood pressure, blood glucose, lipid levels and body weight. It also promotes the progression of atherosclerosis, inflammation and endothelial dysfunction (53).

Exercise training has been associated with reductions in stress and its related mortality (54,55).

Many cardiac rehabilitation programs also offer stress management workshops to help patients identify, avoid and deal with stressful situations (56).

Cardiac rehabilitation is therefore an important therapeutic tool for distressed cardiac patients. Besides exercise training, many cardiac rehabilitation centers offer other stress reduction techniques training including meditation, relaxation breathing, yoga etc.

Sexual counseling

Sexual dysfunction is common in patients with cardiovascular disease. This is due to the side effects of medications (beta-blockers in particular), the coexistence of other risk factors (diabetes, dyslipidemia, smoking and hypertension) and the psychological factors (depression, anxiety and the fear of triggering a heart attack during intercourse etc.).

Sexual activity is an important component of quality of life. It's therefore important to provide sex counseling to patients during cardiac rehabilitation sessions (57).

Alcohol drinking

Moderate alcohol consumption (1-2 drinks per day) is associated with a reduced cardiovascular and all-cause mortality compared with both abstinence and heavy drinking

(58). In a pooled estimate from five prospective cohort studies of patients with coronary heart disease, patients who consumed small to moderate amounts of alcohol daily had a 20 percent reduction in cardiovascular mortality (relative risk 0.80, 95% confidence interval [CI] 0.78-0.83) compared to nondrinkers (59). A meta-analysis by Costanzo *et al*. found J-shaped curves for alcohol consumption and mortality, with a significant maximal protection against cardiovascular mortality with consumption of approximately 26 g/d and maximal protection against mortality from any cause in the range of 5-10 g/d (60). The pattern and amount of alcohol intake appears to be more important than the type. Possible explanations for moderate alcohol consumption benefits include: HDL increase by stimulating the hepatic production of apo A-I and A-II, fibrinogen levels reduction, fibrinolysis stimulation, inflammation reduction and inhibition of platelet activation (61-65).

Benefits and risks of cardiac rehabiliation

Benefits of cardiac rehabilitation

The benefits achieved with cardiac rehabilitation are the result of the combination of all its components. Approximately half of the mortality reduction achieved by exercise-based cardiac rehabilitation (28%) can be attributed to reductions in major risk factors, particularly smoking (66). Other factors may also contribute to the benefits of cardiac rehabilitation. These include a reduction in inflammation (a decrease in serum C-reactive protein concentration that is independent of weight loss and other medical therapies), ischemic preconditioning, improved endothelial function and a more favorable fibrinolytic balance (67). Other important benefits of cardiac rehabilitation include an increase of tolerated metabolic equivalents by 33% and of maximal oxygen consumption by 16%. This improvement in exercise performance is associated with beneficial effects on the quality of life and cardiovascular events.

Patients life quality benefits are also achieved through the improvement of symptoms (lessening of chest pain, dyspnea and fatigue), stress reduction and the enhancement of the overall sense of psychosocial well-being (68).

The benefits of cardiac rehabilitation in patients with coronary disease are summarized in two recent meta-analyses. One meta-analysis of 63 randomized trials with a total of 21,295 patients showed a 17% reduction of recurrent myocardial infarction at 12 months and a 47% reduction of mortality at 2 years with cardiac rehabilitation (33).

Another meta-analysis of 48 randomized trials with a total of 8,940 patients with coronary disease showed that cardiac rehabilitation was associated with a significant reduction in all-cause mortality (odds ratio [OR] =0.80; 95% [CI] 0.68 to 0.93) and cardiac mortality (OR =0.74; 95% CI 0.61 to 0.96). There were no significant differences in the rates of nonfatal myocardial infarction and revascularization (69).

In a recent study of more than 600,000 Medicare patients hospitalized for acute coronary syndrome, percutaneous coronary intervention, or coronary artery bypass graft surgery, 73,049 patients (12.2%) participated in cardiac rehabilitation. After 1 yr, there was a 2.2% mortality rate for cardiac rehabilitation participants *vs.* 5.3% for nonparticipants. This benefit was sustained at 5 yrs with a mortality rate of 16.3% for participants *vs.* 24.6% for nonparticipants. There was a dose–response relationship with cardiac rehabilitation. Patients who attended 25 or more sessions had a 20% lower 5-yr mortality rate than those who attended less than 25 sessions (70).

The first studies showing the benefits of cardiac rehabilitation in heart failure patients were small, monocentric with results that were disputed (71). ExtraMatch, a meta-analysis of 9 randomized studies, confirmed a 35% decrease in mortality for heart failure patients (72). A large randomized controlled trial of exercise training in heart failure (HF-ACTION) involving 2331 patients with an ejection fraction of 35% or less showed that exercise training can achieve significant reductions (15%) in all-cause and cardiovascular mortality and heart failure hospitalization. It should be noted that the initial analysis in intention to treat did not show a difference between the exercise training and the standard treatment groups. The positive result was obtained after adjustment of pre-specified prognostic criteria (73).

Risks of cardiac rehabilitation

In the past decades cardiac rehabilitation has evolved as a result of evidence-based research, as the understanding of atherosclerosis and the role of risk factors has advanced. In a contemporary study of over 25,000 patients participating in 65 cardiac rehabilitation centers in 2003, there was one cardiac event for every 8484 exercise tests performed, one cardiac event for every 50,000 patient hours of exercise training, and 1.3 cardiac arrests for every million patient hours of exercise (74).

The 2007 American Heart Association scientific statement on exercise and acute cardiovascular events estimated that the risk of any major cardiovascular complication (cardiac arrest, death or myocardial infarction) is one event in 60,000 to 80,000 patient-hours of supervised exercise (75).

Patients most at risk are those with residual ischemia, complex ventricular arrhythmia and severe left ventricular

dysfunction (ejection fraction of less than 35%), especially NYHA III or IV. The respect of indications and contraindications and proper risk stratification are key to the safety of cardiac rehabilitation.

Overall, modern cardiac rehabilitation is safe and well tolerated with a very low rate of major complications such as death, cardiac arrest, myocardial infarction or serious injuries.

Cardiac rehabilitation cost and effectiveness

Recent studies show that cardiac rehabilitation is not only clinically effective, but also cost-effective and compares favorably with other medical interventions performed commonly in patients with coronary heart disease. Ades *et al*. showed that cardiac rehabilitation was more cost-effective following myocardial infarction, compared to lipid lowering drugs, thrombolytics and CABG. Only smoking cessation was more cost effective than cardiac rehabilitation (76). A study by Levin in Sweden showed that cardiac rehabilitation participation following MI or bypass surgery (with a 5-year follow-up) decreased rehospitalizations from 16 to 11 days, increased the rate of return to work from 38% to 53% and resulted in an overall cost savings of $12,000 per patient (77).

Another study by Oldridge *et al*. showed that a 12-weeks participation in cardiac rehabilitation reduces medical costs by 739$ per patient after only 21 months follow-up (78).

Cardiac rehabilitation referral and participation

Underutilization of cardiac rehabilitation

Despite its proven benefits, cardiac rehabilitation referral and participation rates have been low compared to other evidence-based performance measures. Earlier studies from multiple countries reported an average referral rate of approximately 30% in Canada, the United States and the United Kingdom and a little higher at around 50% in the rest of Europe. Differences in healthcare policies and delivery systems between countries may explain, at least in part, this variability (79).

In an analysis of recent data from 156 hospitals participating in the Get with the Guidelines (GWTG) Program published recently, Brown *et al*. found that 56% of patients hospitalized for MI, percutaneous coronary intervention (PCI) or coronary artery bypass graft (CABG) surgery were referred to cardiac rehabilitation at discharge (80).

Barriers to cardiac rehabilitation referral and participation

Recent studies have found that various social, psychological, medical and demographic variables have an impact on cardiac rehabilitation referral and participation. These factors include age, sex, race, physician recommendation, patients' beliefs about their illness, patient's expectation about cardiac rehabilitation, feelings of self-efficacy, mood and coping style (81,82).

Studies have also shown that there are inequalities in cardiac rehabilitation referral and participation against women, elders and minorities.

Sex differences are found to impact cardiac rehabilitation participation with women having poorer participation rates than men (81).

Barriers to women's participation include the lack of financial resources, transportation difficulties, and the lack of social or emotional support (83).

Although studies have shown that the elderly might have greater needs for cardiac rehabilitation and that they achieve excellent outcomes with a low risk of adverse events, older individuals are less likely to be referred to and to participate in cardiac rehabilitation (70,84).

Studies have also shown that racial and ethnic minority populations have higher rates of cardiovascular disease and related risk factors but have limited participation to cardiac rehabilitation programs due to lack of accessibility to program sites, lack of insurance coverage and low patient referral rates (85-87).

Strategies to improve cardiac rehabilitation referral and participation

Recent studies suggest that automated referral systems and patient education by physicians and other healthcare providers regarding cardiac rehabilitation benefits may be the most effective strategies to improve cardiac rehabilitation referral and participation rates. Physician endorsement was found to be one of the strongest predictors of cardiac rehabilitation participation (80).

Home-based cardiac rehabilitation programs as an alternative to hospital-based cardiac rehabilitation have also been recommended as another method to improve participation rate. A recent meta-analysis showed that the effect of home-based cardiac rehabilitation is similar to hospital-based cardiac rehabilitation. The Birmingham Rehabilitation Uptake Maximization (BRUM) Study involving 525 participants following MI or coronary revascularization compared home-based cardiac rehabilitation with center-based cardiac rehabilitation from four hospitals and found no difference in risk factor control, self-reported physical activity and the distance walked on the incremental shuttle walk test (88).

Although cardiac rehabilitation programs are mostly run

by cardiologists, primary care physicians' involvement is thought to improve access and retention in the long term.

Other cited barriers to patients' participation are: illness, transportation difficulties, distance, work, sickness, embarrassment about group activities and the lack of understanding, motivation, interest and time (89).

The use of modern technologies (internet, phone and other communication tools) offers interesting prospects for the delivery and expansion of cardiac rehabilitation programs beyond the setting of supervised, structured, and group-based rehabilitation, and will help to increase enrolment, reduce risk factors and improve benefit-cost ratio (90).

Recently an advisory panel from the AHA produced a statement with recommendations for enhancing the quality of and participation in cardiac rehabilitation programs (91). If implemented, these recommendations will certainly make a difference in the lives of many cardiac patients by giving them the opportunity to benefit from cardiac rehabilitation programs.

Conclusions

Cardiac rehabilitation has been proven to be safe and effective in improving cardiovascular patients` life quality and reducing morbidity and mortality.

Despite the evidence of its benefits, cardiac rehabilitation remains underused.

More patients would benefit from this cost-effective tool by improving referral and participation to cardiac rehabilitation programs and individualizing services taking into account the patients' profile.

New research areas include exploring new ways of cardiac rehabilitation delivery to improve referral and participation rates as well as developing new exercise regimens that are more effective and versatile and that incorporates new technologies in cardiac rehabilitation to maximize its benefits.

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