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Cardiac rehabilitation of patients with heart failure

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Cardiac rehabilitation (CR) in heart failure (HF) improves exercise capacity and quality of life, reduces rehospitalizations, and prolongs survival. Systematic referral of HF patients to CR, especially during the vulnerable phase after a congestive episode, is strongly recommended. However, CR in HF is still largely underused.
CR is a multidisciplinary approach of complete secondary prevention that can be realized in most HF patients on an outpatient basis in 2-3 months. The CR team includes cardiologists, physiotherapists, dieticians, HF nurses, social workers, and psychologists.
Cardiopulmonary exercise testing (CPX) is a fundamental tool to evaluate the impaired exercise capacity and oxygen uptake of HF patients. The core component of the CR program is individually tailored exercise training (ET) with endurance and resistance training units. During CR, the patients benefit from an efficient adaptation of pharmacotherapy by HF specialists, individual and group-based patient education, dietary counselling, structured tobacco cessation programs, and psycho-social support.
The beneficial effects of ET are both cardiac and peripheral, including reduction of resting heart rate by improved control of autonomic imbalance, increase of the chronotropic reserve, decrease of peripheral vascular resistance, and improved aerobic metabolism of the skeletal muscle resulting in increased endurance and force.
Key unresolved issues remain the low referral rate of HF patients to CR by acute care cardiologists, the limited capacity of CR centers to absorb all referred patients, and especially the difficulties to motivate HF patients to maintain a sufficient level of physical activity after discharge from CR.
Keywords: cardiac rehabilitation, heart failure, cardiopulmonary exercise test, exercise training, secondary prevention

Introduction

The prevalence of chronic heart failure (HF) is rapidly increasing among older adults in developed countries due to the prolonged survival of patients, resulting from spectacular improvements in drug and device therapy. Thus, health care professionals have to provide optimal medical care to a growing number of chronic HF patients presenting exercise dyspnea and recurrent congestive episodes. The main objectives of this care are to limit fluid retention, to stop worsening of the left ventricular (LV) function and remodeling, to improve exercise capacity, to reduce exercise-induced dyspnea, and to reduce mortality.

The cornerstones of HF care, in particular following a congestive episode, are the stepwise optimization of drug treatment (titration), exercise training, patient education, management of uncontrolled risk factors, and if necessary psychosocial support. Cardiac rehabilitation (CR) centers are best suited and qualified to provide this complex, specialized, time-consuming, and multidisciplinary care. Therefore, referral of HF patients to CR has obtained the highest possible level of recommendation in current guidelines (class I, level A) (1). Nevertheless, the implementation of CR in HF is still very low, especially in women and in elderly patients (2).
Patient education is fundamental to avoid or at least delay decompensations, and to reduce their gravity by

early recognition of worsening symptoms allowing for rapid therapeutic intervention, ideally on an outpatient basis. This goal can only be achieved if the patient:

1. becomes an informed and responsible actor of his own pathological condition by understanding the causes of HF;
2. becomes aware of all factors that can favor fluid retention;
3. becomes able to self-monitor his own symptoms and to recognize the precursor signs of an impending decompensation;
4. understands the crucial importance of uninterrupted drug treatment;
5. and becomes able to seek professional help as early as possible. These objectives require a structured and individualized patient education provided by a multidisciplinary team consisting of specialized HF nurses, HF cardiologists, physiotherapists, and dieticians.

Benefits of CR in HF

The most important factor impacting on the quality of life of HF patients is exercise dyspnea, which in turn depends not only on the degree of cardiac dysfunction and the control of volemia and filling pressures, but also on peripheral dysfunctions involving decreased aerobic performance of the skeletal muscle, neurohormonal activation contributing to increase heart rate and peripheral vascular resistance, endothelial dysfunction, and chronic low-grade inflammation.

Exercise training (ET) allows lowering the resting heart rate (3) and consequently to improve the control of LV filling pressures reflected by a significant decrease in natriuretic peptide levels (4). However, the key pathophysiological mechanisms underlying the positive effect of ET are peripheral, by increasing skeletal muscle mass, force, and endurance, by reducing the level of circulating catecholamines and by reducing the activation of the renin-angiotensin- aldosterone system, by improving the endothelium- dependent arteriolar vasodilation, and by limiting pro-inflammatory cytokines. Altogether, these mechanisms contribute to increase the chronotropic reserve, improve heart-rate variability, reduce LV afterload, and optimize oxygen supply and aerobic metabolism of the skeletal muscle.

Physical training in HF patients has indeed been proven to increase peak oxygen consumption (VO2) and exercise duration by approximately 20%. These improvements in exercise capacity are paralleled by a reduction of morbidity-mortality by about 30% (5, 6). There is growing evidence that benefits of CR observed in HF with reduced ejection fraction (EF) are largely reproducible in patients with HF with preserved EF, and that CR should therefore be extended to this population (7).

Cardiopulmonary exercise testing

Historically, HF patients were advised to prolonged bed rest after a large myocardial infarction and/or after a severe congestive episode in order to “preserve” their already “tired” heart. Over the past decades, the revolutionary progress in the understanding of the pathophysiological mechanisms of HF and of the fundamental role of the peripheral musculature have initiated a paradigm shift, encouraging early referral of HF patients to CR. Indeed, prolonged bed rest provokes peripheral deconditioning characterized by a quantitative and a qualitative loss of skeletal muscle mass and function, resulting in amyotrophy, downregulation of key enzymes of muscle oxidative metabolism such as citrate synthase and cytochrome c oxidase, microvascular rarefaction, and increased systemic vascular resistance, all of them contributing to reduce exercise capacity and tolerance in HF patients.

Cardiopulmonary exercise testing (CPX) is a fundamental tool to evaluate the impaired exercise capacity and oxygen uptake of HF patients in CR centers *(Figure 1).* In contrast to standard exercise testing, CPX allows to determine a.o. the first ventilatory threshold (VT1) that indicates transition from oxidative to anaerobic muscle metabolism, and to determine the peak oxygen consumption (VO2), both of them carrying crucial functional and prognostic significance. The interpretation of CPX in HF requires a profound knowledge of cardiovascular, respiratory, and peripheral adaptations to exercise, since it integrates the capacity of the lungs to oxygenate hemoglobin, the capacity of the cardiovascular system to transport oxygenated hemoglobin to the periphery, and the capacity of the skeletal muscle to uptake and metabolize oxygen.

Indeed, CR cardiologists are particularly aware of the fact that pathologically reduced peak VO2 of HF patients can result from both reduced cardiac pump function (central dysfunction) and from reduced muscular oxygen uptake (peripheral dysfunction). Thus, impaired peak VO2 in HF does not necessarily reflects critically reduced cardiac output and catastrophic prognosis, but can at least in part result from profound peripheral deconditioning. On the other hand, peak VO2 can be found relatively preserved in severe HF patients with very low LVEF, which can be explained by preserved skeletal muscle mass and oxidative function as a result of exercise training (ET). In other terms, impaired VO2 in HF patients reliably reflects impaired cardiac pump function only in the absence of significant peripheral deconditioning. Consequently, the measurement of peak VO2 before ET has a limited prognostic value, whereas it is one of the best prognostic markers in HF patients after completion of an individualized ET program (8). Far-reaching therapeutic decisions such as heart transplantation or the need for LV assistance should therefore be based on CPX results obtained after completion of a CR program.

FIGURE 1. Cardiopulmonary exercise testing

Exercise training: a core component of CR in HF

Exercise training constitutes therefore a fundamental element of care of HF patients in CR centers, aimed at increasing aerobic exercise capacity that has been proven not only to improve exercise tolerance and thereby quality of life, but also life expectancy (9). The prescription of an individualized ET program requires, after exclusion of contraindications to exercise such as hemodynamic instability or significant ventricular arrhythmias, a careful and precise evaluation of the exercise capacity at admission by an incremental and maximal (symptom-limited) exercise test, if possible coupled to the measurement of ventilation and gas exchange (CPX). This evaluation allows to estimate the degree of deconditioning, to estimate the minimum number of training sessions needed, and to determine the intensity of the first endurance training units at the aerobic threshold (VT1).
After the initial evaluation of contraindications and exercise capacity by the CR cardiologist, HF patients participate under supervision of experienced physiotherapists in about 20-30 endurance training units of 30-45 min. each, in groups of 8-12 patients, usually on ergocycles or treadmills, if possible on an outpatient basis *(Figure 2).* Due to the individually adjusted workload for each patient on each ergocycle, this setting allows to provide an individually tailored ET program while benefiting from the positive psychological effects of a group-based approach. Beyond endurance training, the ET program should also comprise resistance training units for segmental reinforcement *(Figure 3)*, group gymnastics *(Figure 4)*, and active relaxation. In a growing number of CR centers patients can benefit from more original and therefore more motivating physical activities such as Tai Chi or yoga.

Secondary prevention in CR centers

HF patients go through a particularly vulnerable period during the first weeks after a congestive episode, when pharmacotherapy needs to be readjusted and residual congestion must be resolved, physical deconditioning is particularly pronounced due to prolonged bed rest, and anxiety/depression can be predominant. More than half of hospital readmissions occur during the first month after discharge. The complexity and the gravity of this clinical situation require a careful and standardized post-discharge management at the end of the acute care. Referral of these patients to CR centers allows to efficiently addressing all residual and modifiable problems in a secure environment by a specialized multidisciplinary team.
At the end of the acute care following decompensation, most of the HF patients still present a significant sub-clinical residual congestion, which is known to favor early readmissions. The elimination of residual congestion, i.e. titration of the baseline (or “dry”) weight and of the baseline NT-proBNP levels reflecting the lowest possible LV filling pressures for each patient, needs time and careful adjustment of diuretic therapy to avoid symptomatic blood pressure drop and worsening of the renal function. The fast and safe removal of residual congestion not only reduces the risk of repeated decompensations, but also reduces exercise dyspnea and favors exercise tolerance, facilitating rapid reconditioning.
During decompensation, pharmacotherapy with beta blocker and/or inhibitors of the renin-angiotensin-aldosterone system is usually reduced or even stopped in case of hemodynamic instability and/or worsening of renal function. These drugs must be safely up-titrated to provide again, and as soon as possible, efficient pro-

FIGURE 2. Endurance training

FIGURE 3. Resistance training

tection against neurohormonal activation and LV remodeling. CR centers provide the best possible care with regard to optimization of pharmacotherapy after a congestive episode for two main reasons: first, HF patients are closely monitored by specialists allowing for shorter titration intervals whit systematic control of hemodynamic and biological tolerance of each titration step, and second, improved exercise capacity favors the hemodynamic tolerance in particular of betablocker therapy, allowing for a more rapid up-titration.

The most effective approach to avoid future decompensations is probably patient education. The risk of decompensation is markedly reduced if the HF patient has understood the crucial importance of uninterrupted drug treatment and is able to identify possible side effects; if he is aware of the link between salt intake and fluid retention, and is able to estimate the salt content of foods; if he has understood the importance of regular weight control and knows when, how and who to alert in case of significant weight gain; if he is aware of the link between deconditioning and exercise intolerance, and thus of the importance of regular physical exercise; and if he has understood the importance of a well-organized specialized follow-up with regular office consultations. Therefore, CR centers offer structured patient education programs addressing all these issues, starting with an individual evaluation of knowledge and motivation, followed by group-based thematic workshops *(Figure 5).*

The integrated care in CR centers addresses not only HF and deconditioning, but also the control of all risk factors (RF) potentially favoring disease progression. In HF patients with coronary artery disease, the most frequent cause of HF in developed countries, the participation in a complete CR program usually allows to obtain an optimal control of all modifiable CVRF such as hypertension, hypercholesterolemia, and diabetes. Finally, CR centers offer professional psychological support in case of marked depression and/or anxiety, smoking cessation programs, addictology support in case of alcoholism, social assistance in case of professional difficulties or social isolation.

Post-discharge management

The Achilles' heel of CR in HF patients remains the maintain of the benefits at long term (10). The most important and still largely unmet challenge is to motivate HF patients to continue regular endurance ET after discharge from the CR center. This goal is much more challenging than to obtain optimal compliance for drug therapy and CVRF control, since regular ET is time-consuming, and requires a particularly high motivational level and re-organization of the personal time schedule. In younger HF patients, ET training sessions might be difficult to integrate into the daily life due to professional and/or familiar constraints. In elderly patients, transport problems, social isolation, and/or musculoskeletal comorbidities frequently limit the maintain of CR benefits at long term.

Conclusions

CR in HF is beneficial and therefore strongly recommended, however largely underused due to lack of referral and/or limited capacity of CR centers. CR improves cardiac and peripheral muscle function, improves thereby exercise capacity and exercise tolerance resulting in increased quality of life, and significantly reduces morbidity and mortality. The beneficial effects of CR are observed not only in HFrEF, but also in HFpEF patients. The most important unresolved question in CR is how to maintain patient motivation to continue exercise training after discharge.

FIGURE 4. Group gymnastics

FIGURE 5. Group-based therapeutic education

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