

Effects of an Early Cardiac Rehabilitation
Following Heart Surgery in Patients
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Abstract

Objective: The aim of the study was to evaluate the effects of an early comprehensive, individualized cardiac rehabilitation program shortly after cardiac surgery and to assess its impact on exercise capacity and quality of life.

Methods: This is a prospective study looking into 2 types of cardiac rehab in 100 patients (men and women), who underwent open heart surgery (for coronary artery bypass graft, heart valve replacement, or a combination of both). The participants were allocated in two groups. Specially designed, individualized step program adapted for rehabilitation after cardiac surgery in the elderly was analyzed vs. our routine program. Individualized rehabilitation subjects (ICR-group), (n=50 mean age 72±3) received exercise plan, tailored to optimally meet the needs of every patient, while control group (RCR-group), (n=50 mean age 73±4) took part in regular program.

Results: ICR-group did better than RCR-group in 6-minute walk test. After cardiac rehabilitation significant improvement in the distance walked in 6 minute walk test ($P < 0.01$) was observed in both groups, with marked increase in the ICR-group. Furthermore, significant difference in walked distance between CABG and valve surgery patients (283.5 ± 64 vs. 242.25 ± 83.25), and in men compared to women (267.75 ± 76.5 vs. 220.5 ± 68.25) was found. In multivariate analysis gender, age, comorbidities and type of surgery were independently associated with the level of functional capacity improvement at discharge.

Conclusion: A personalized physiotherapy plan, devised to increase independent mobility soon after open heart surgery is safe, feasible and more effective than routine cardiac rehabilitation program.

Introduction

The number of over-65 year patients referred for cardiac surgery is rapidly growing mainly due to improved surgical techniques and increased mean population age. Not surprisingly, given the aging population, the Risk Profile (RP) of patients has worsened, so the Cardiac Rehabilitation (CR) program should be tailored according to the individual RP, physical, psychological and social status, assessed as part of the perioperative examination and medical history [1].

The complexity of a rehabilitation program is characterized by World Health Organization (WHO) definition as: "sum of activity required to ensure cardiac patients the best possible physical, mental, and social conditions so that they may, by their own efforts, regain as normal as possible a place in the community and lead an active life" [2].

Optimal results are obtained with integrated, multicomponent CR programs, which include exercise training together with counseling and psychosocial measures that may help patients maintain sustained changes toward a healthier lifestyle. Evidence from Randomized Controlled Trials (RCTs) and meta-analyses supports the efficacy of cardiac rehabilitation on clinically relevant outcomes such as reduced long-term morbidity and mortality, enhanced functional profile and improved control of cardiovascular risk factors. However, the vast majority of this evidence derives from trials with only small numbers of patients >70 years of age. In elderly patients the goal of CR differs from those of the younger and includes the preservation of mobility, self-sufficiency and mental function. After heart surgery elders require multidisciplinary approach with the leading role of cardiac rehabilitation team [3].

Phase 1 applies to inpatients, being the first step toward an active life, in which should predominate the combination of low-intensity exercises, techniques for stress management and educational programs in relation to risk factors along with medications. The goal at discharge is that the patient is with the best possible physical and psychological condition, with all the needed information regarding healthy lifestyle [4].

The length of stay in rehabilitation units is practically limited by organizational and economic hindrances, and by the elderly patient's desire for returning home as early as possible. It therefore seems that achieving a training effect in this phase is unrealistic, so the in-hospital rehabilitation phase should be aimed, instead, at accelerating the recovery to the highest possible level of functional autonomy.

The relevance of implementing individually tailored CR program was the high frailty level at department admission, differing from patient to patient, owing to comorbidity, type of surgery and the post-operative course.

The current study focuses on assessing the effect of the personalized CR program, and to compare this effect with that of our regular program. As achieving this we want to validate our clinical approach by demonstrating the impact of the tailored CR complex on patient's hemodynamic indices and exercise test results.

Methods

The study comprised 100 individuals, aged over 70 years (mean age 74 ± 2.5 years, 62 (62%) male and 38 (38%) female), who had undergone Coronary Artery Bypass Graft Surgery (CABG), valvular surgery, or both. They were admitted at the 7 ± 2 post-operative day. The length of stay in CR Department was 8 ± 1 days.

Patients

100 participants, among the patients, consecutively admitted to the Cardiac Rehabilitation Department of National Heart Hospital, Sofia, Bulgaria, who did not meet the exclusion criteria, were enrolled. Exclusion criteria were: age < 70 years, perioperative myocardial infarction, uncontrolled arrhythmia, large pleural and/or pericardial effusion, prosthetic valve dysfunction, sternal wound dehiscence, Systolic Blood Pressure (SBP) > 150 mmHg, or SBP < 100 mmHg, pyrexia ($t > 37.5$ °C; > 99.5 °F), severe osteoarthritis/other musculoskeletal disease limiting physical activity, previous stroke, marked cognitive dysfunction, lack of compliance.

The selected individuals were assigned in two groups - one with specially designed, individualized CR program (ICR-group), while the second participated in routine program, and was used as a control (RCR-group). Based on the type of surgery patients were stratified in three: CABG group, Valve Replacement (VR) group and one with the combined procedure. A written informed consent of all participants was taken. It is important to note, that all enrolled patients did not have any major surgical complication at the time of admission.

Program

Our RCR-program generally consists of early mobilization, breathing exercises, pulmonary clearing techniques, range of motion exercises, psychological counseling and risk factors management along with optimal pharmacological treatment.

The protocol comprises three stages. Stage 1 (1-5 post-operative days) was performed in the post-surgery Intensive Care Department. It begins with early mobilization, followed by sedation, active assisted or free standing position and exercises with incentive spirometry.

Stage 2 starts with admission in CR Department. It consists of steps, divided in two daily sessions, with constant duration and unified set of exercises for all patients. The RCR-program is briefly represented in Table 1.

Stage 3 includes the above mentioned followed by treadmill tests with increasing training parameters. Hemodynamics monitoring was obtained during tests.

Table 1: RCR-program protocol during stage 2 (CW-Corridor Walk).

Day 1	50m CW + 5 stairs
Day 2	100m CW+ 13 stairs
Day 3	200m CW + 20 stairs
Day 4	300m CW + 28 stairs
Day 5	500m CW + 35 stairs
Day 6	750m CW + 42 stairs
Day 7	1000m CW + 50 stairs

A personalized CR program based upon medical history, comorbidities, present physical and mental status was created by our team. The progression was made individually, following the program steps, which were modified to sets of exercises with gradually increasing training parameters (intensity, frequency and duration). Moderate level of perceived exertion was encouraged. The exact intensity and duration of each session differed for each patient according to the individual's present functional status. The sets included walking in the room and corridor. After achieving 200m + 20 stairs, training continued on treadmill. In ICR-program sessions, additional strength or flexibility exercises were included, according to patient's needs. Participants were given all instructions and explanations needed. Special attention was paid to measures aimed at enhancing motivation. Sternal precautions recommended for the healing period were constantly reminded.

The 6MWT for both groups (ICR and RCR) was performed on the fourth day and at discharge (8 ± 1 day) which are the 11th and 15th post-operative days respectively.

Measurements

At admission a set of anthropometric measurements (including height, weight, Body-Mass Index (BMI), waist, hip, and chest circumference) was obtained. At each daily visit baseline vital signs were recorded for all patients. Systolic (SBP) and Diastolic (DBP) Blood Pressures and Resting Heart Rate (RHR) were measured by the attending physician and classified according to the current guidelines [5]. Maximal SBP, DBP and HR were recorded in the specific sessions by physiotherapist.

During stay the following were analyzed: basic laboratory results (full blood count, serum lipids level, cholesterol ratio LDL/HDL, creatinine and glucose levels), results of routine ECGs, Holter-ECGs, pre and post-operative radiographs and other necessary data.

Self-perceived health status was assessed with Euro QoL questionnaire at admission and at discharge [6]. Patients were asked to indicate their health state by rating the level of mobility, self-care, usual activities, pain/discomfort, anxiety/depression and then on a visual analogue scale where the endpoints are labelled "Best imaginable health state" and "Worst imaginable health state".

The 6-minute walk test (6-MWT) was performed according to the guidelines of the American Thoracic Society (ATS) [7]. The Borg scale was used to rate baseline dyspnea and overall fatigue. Standard instructions were given. The test was symptom-limited, so patients who became symptomatic (e.g. angina, severe dyspnoea, dizziness and musculoskeletal pain) were told to stop walking and re-start when possible from the exact same point of the route. The total distance walked was measured to the nearest meter and recorded.

Immediately after the test an electrocardiogram was performed. To assess the effect of the comprehensive CR, the 6-MWT was done on the fourth day of stay and at discharge (8±1 day).

Echocardiograms were performed by certified physicians, according to the recommendations of the American Society of Echocardiography/European Association of Cardiovascular Imaging (ASE/EACVI) [8]. Two-dimensional apical 2-and4-chamber views were used for volume measurements; Left Ventricular Ejection Fraction (LVEF) was calculated with a modified Simpson’s method using biplane apical (2- and 4-chamber) views. Left ventricular systolic dysfunction was defined as an LVEF < 50%.

Statistical analysis

Mean and standard deviations for all continuous variables were calculated. The ratios are presented as percentage. Paired sample t-test was used to compare the difference of continuous variables before and after CR program. A two-tailed p value less than 0.05 were considered statistically significant. The non-normally distributed data were analyzed using the Mann-Whitney and the Wilcoxon tests. The association between clinical variables and 6MWT results were assessed by Pearson coefficient of correlation when the variables were continuous. Variables found to be significant at univariate analysis were further analyzed by a multivariate linear regression model in order to identify a set of variables independently associated with 6MWT performance.

Results

Clinical and demographic characteristics of the study population are represented in Table 2. Most patients were male (N=64), as the women were slightly older than the men (76±6 years vs 72±4, p < 0.01). The predominant type of surgery is CABG (N=52), followed by valve replacement operations (N=40), which can be subdivided into: aortic valve replacement (N=23); mitral valve replacement (N=11); aortic + mitral (N=4); mitral + tricuspid (N=2). The individuals who underwent a combined CABG + aortic VR procedure were 8.

Table 2: Baseline characteristics of patients: 'Anamnesis and laboratory data for pre-operative RFs: AH- Arterial Hypertension; CKD- Chronic Kidney Disease; CAD- Coronary Artery Disease, CABG- Coronary Artery Bypass Graft, VR- Valve Replacement.

	Total	ICR-group	RCR-group
Subjects (N)	100	50	50
Age (years)	74±2,5	73±2	75±3
Male gender (N)	64	34	30
LVEF admission (%;± SD)	38±10	40±8	36±12
LVEF discharge (%;± SD)	42±12	46±8	38±16
Risk Factors ¹			
• Diabetes mellitus (N)	47	24	23
• AH (N)	62	29	33
• Dyslipidemia (N)	48	26	22
• Smoking (N)	30	17	13
• Obesity (N)	32	14	18
• CKD (N)	49	24	25
• Family history of CAD (N)	56	27	29
EQ VAS (pts;SD) -admission	40±12	42±10	38±14
EQ VAS (pts;SD) -discharge	55±5	60±4	50±6
Type of surgery			
• CABG (N)	52	29	23
• VR (N)	40	18	22
• Both procedures (N)	8	3	5

The presence of cardiovascular risk factors and comorbidities has a high prevalence of cardiac patients, especially in the elderly. In the studied group, the following RFs were observed: family history of Cardiovascular Disease (CAD), Arterial Hypertension (AH), Diabetes Mellitus (DM), dyslipidemia, Chronic Kidney Disease (CKD), smoking (active or history of), obesity (BMI>30). 42 individuals had combination of 2 RFs, 26 had 3 RFs and 21 had >3 RFs. 32 patients had permanent Atrial Fibrillation (AF).

During the rehabilitation course 34 patients had at least one clinical complication, such as: post-operative atrial fibrillation (n=24) 18 of them after VR, small pleural effusion (n=15), anemia (n=14), transient asthenia (n=18), sternal wound secretion (n=9). No serious complications occurred during the exercise sessions. Paroxysmal rhythm disorders were properly pharmacologically treated. Optimal rate control was achieved for all the patients with permanent AF.

In the RCR-group hemodynamic parameters at admission were: resting SBP 124±12 mmHg, maximum SBP 136±13 mmHg, HR at rest 76±14 bpm, peak HR 125±16 bpm. At the end of the program resting SBP was 123±10 mmHg, SBP-max was 134±11 mmHg, resting HR was 74±10bpm and HR-max was 122±14 bpm. In the ICR-group the respective parameters were: resting SBP 125±14 mmHg, SBP-max 135±10 mmHg, resting HR 78±12 bpm, HR-max 123±11 bpm. At discharge values were: SBP-rest 121±7 mmHg, SBP-max 129±8 mmHg, HR at rest 72±8 bpm, HR-max 113±9 bpm.

The results from 6MWT (in meters) are given in Table 3. The absolute value of distance walked during the test (6MWD) was inversely related to age (p < 0.001) and was significantly greater in men than in women (p < 0.001) in both groups. 6MWD was lower in patients with diabetes compared with non-diabetics.

Table 3: 6MWD stratified by gender and type of surgery.

	ICR-group			RCR-group		
	first test	discharge	P	first test	discharge	P
Men	252±81	293±76	0.012	248±73	278±76	0.016
Women	210±62	238±71	0.013	205±68	229±72	0.015
CABG	273±62	311±59	0.012	259±67	291±68	0.014
VR	243±90	269±88	0.014	213±74	244±81	0.016
CABG+VR	257±71	291±72	0.014	236±69	262±71	0.014

At multivariate analysis, the 6MWT was positively associated with gender (p < 0.001) and type of surgery (p < 0.01), and negatively associated with age (p < 0.001) and diabetes mellitus (p < 0.01).

Furthermore, most patients (93%) showed >10% increase in distance walked between the two tests; according to previous studies, this increase should be considered a true improvement in functional capacity as a consequence of therapeutic intervention and not inter-test variability [7].

The self-rated health status, assessed with the EQ-5D-5L descriptive system and the EQ Visual Analogue scale (EQ VAS) was lower at admission and increased significantly at the time of discharge. Patients demonstrated improvement of the levels of mobility, self-care, usual activities, pain and anxiety/depression. EQ VAS number at admission was 38±14 for RCR-group and increased to 50±6. In the ICR-group improvement was higher: from 42±10 at admission to 60±4 at discharge.

Discussion

The primary objective of cardiovascular surgery is to extend a patient's life. The long-term goal of this intervention is to improve the quality of life. Successful heart surgery only initiates the process. Improving the post-operative quality of life is based on the phase 1 rehabilitation outcome. Identifying high risk individuals at an early stage of CR provides the opportunity to take special measures, thus optimizing the outcome of rehabilitation as much as possible. It is worth to note that the phase 1 is a foundation of the forthcoming treatment measures, which lasts until the end of one's life. Thus, the success of the early stage of CR is crucial to the fate of post-surgery patients.

The main rationale of CR early after cardiac surgery in elderly is to improve functional status and also to treat and prevent postoperative complications. Although there are findings that a comprehensive approach to cardiac rehabilitation would produce greater improvements in health and functional status, compared with uniform exercise plan, sufficient evidence are still lacking in the literature.

The novelty of this study lies in the assessment of the effects of moderate-exertion CR program, individually tailored to elderly patient's functional capacity and psychosocial status early after heart surgery.

As our data shows, there is significant development in functional capacity and all hemodynamic responses in the ICR-group compared with the RCR-group. The improvement is observed independently of sex, age, comorbidities and baseline functional status, with men and CABG patients have advantage at multivariate analysis.

RCR-program comprises daily sessions, with constant duration and unified set of exercises for all patients. Major drawback of this approach is the fact, that even though the patient is capable of achieving higher exercise levels, sessions are discontinued. Despite that some elders require focus on strength or flexibility exercises, they are treated uniformly. Another shortcoming of regular programs is that insufficient time is spent on psychosocial counselling.

In ICR-program was created an optimized protocol, according to one's individual status and special requirements, thus allowing to achieve best possible level of functional autonomy at discharge.

Some elderly patients, however, are not likely to participate in a physical training program, particularly soon after a major surgical procedure, as they fear of increasing physical pain with exercise and possible damage of the recent sternal wound. They also complain of an early and subjectively overestimated exhaustion, suffer from anxiety, somatization, and even show hostility. Important part of CR program is to manage the distress and to provide psychological support [9]. Despite that this approach is more time consuming, it leads to better patient compliance.

In a recent study, mean scores of anxiety and depression decreased significantly after comprehensive CR program [10]. It is shown that overall efficacy of rehabilitation was lower in patients with anxiety and depression.

The personalized CR program was safe and well accepted by all the patients in our study. Self-perceived health status was good owing

to decreased level of emotional discomfort. Significant reduction in hostility and depressive symptoms was observed following rehabilitation in both groups, with marked decrease in ICR-group.

Although uncontrolled Atrial Fibrillation (AF) is a contraindication to exercise rehabilitation, asymptomatic patients with controlled AF can participate safely in exercise. Patients with post-operative AF are usually receiving anticoagulation therapy at a recent time and CR team has the important role of providing patient education about achieving and maintaining optimal anticoagulation regime.

A very important aspect of comprehensive CR early after surgery is the safety of exercise training. These patients are a high-risk group due to a possibility of life-threatening ventricular arrhythmias, post-surgical complications and usually significant reduced left ventricular systolic function. For these reasons, clinicians were previously reluctant to refer these patients for moderate level of cardiac rehabilitation. Individualized approach suited to one's functional status made possible reaching optimal level of mobility within CR Department stay, which led to faster recovery.

Moreover, in ICR-group the rehabilitative length of stay paralleled the functional autonomy, hence, on one hand, time far from home was reduced in the self-sufficient patients and on the other, physiotherapy resources could be optimized and offered to these who need it most.

Physiological effects of comprehensive CR program include the benefits of increased shear stress on the endothelium, optimized myocardial perfusion and reduced progression of the underlying disease. Changes in peripheral vasculature with reduction in the after load as a result of training also play a significant role [11,12].

In our study, a correlation between improvement in LVEF and changes in exercise capacity parameters could not be made, because of the short length of stay and residual adrenergic drug effect. This is consistent with the current understanding that the left ventricular systolic function assessed by resting echocardiography does not correlate with exercise capacity [13].

Study limitations

This study was performed in a small selected group of individuals, followed for a short period of time and admitted to a single center rehabilitation program.

In addition, we did not analyze the effect of rehabilitation on patient survival and the risk of cardiovascular events. We cannot exclude the effect of drug therapy on final results.

Conclusion

Cardiac rehabilitation significantly improves functional capacity and hemodynamic responses after heart surgery. The same benefits observed in younger patients are also seen in the septuagenarians. The results indicate that the functional capacity, as expressed by distance walked during the 6MWT, is significantly reduced shortly after cardiac surgery and quickly improves after proper physical training. The improvement is observed independently of age, sex, comorbid conditions and baseline functional capacity. In the current study ICR-group did significantly better than RCR-group in 6MWT. Therefore CR programs with moderate level of exertion are safe and beneficial for selected elderly patients.

In septuagenarians CR requires a multidisciplinary approach, including comprehensive assessment, management of risk factors and comorbidities, along with psychosocial counseling. After major heart surgery physicians must be encouraged to prescribe CR programs specially optimized for elderly.

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