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Original article

Reduction of cardiovascular event rate: different effects of cardiac rehabilitation in CABG and PCI patients

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Running title: Rehabilitation in PCI and CABG patients

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Abstract

Objective

In coronary artery disease, the implementation of a cardiac rehabilitation (CR) programme favourably affects cardiovascular prognosis. However, it remains uncertain whether patients benefit to a similar extent from CR after coronary artery bypass graft surgery (CABG) or percutaneous coronary intervention (PCI). In this study, we have assessed whether CR is equally effective for suppressing the two-year cardiovascular event incidence after CABG or PCI.

Methods and results

194 PCI and 149 CABG patients participated in a three-month CR programme, while 245 PCI and 89 CABG patients received standard care. After the completion of CR during a two-year follow-up, data on cardiovascular risk factors, medication and cardiovascular events (repeat coronary revascularisation, acute myocardial infarction, and death) were collected from hospital files. Both CABG and PCI patients included into CR showed a significantly lower mortality, as compared to control patients (0.6% vs. 4.2%, $P < 0.05$). However, total cardiovascular disease incidence was significantly lower as a result of CR in CABG patients (4.7% vs. 14.0%, $P < 0.05$), but not in PCI patients (19.1% vs. 22.4%, $P > 0.05$).

Conclusion

When following a similar 3-month cardiac rehabilitation programme, the reduction of cardiovascular disease incidence during 2-years of follow-up is different between PCI and CABG patients.

Keywords: PCI – CABG – rehabilitation – mortality – cardiovascular disease.

Introduction

Cardiac rehabilitation lowers cardiovascular mortality and morbidity in patients who underwent coronary artery bypass graft surgery (CABG) or percutaneous coronary intervention (PCI)[1]. Data indicate that especially aerobic exercise, a component of cardiac rehabilitation, is an important treatment modality for reducing cardiovascular mortality in these patients. Previous research reported an inverse relationship between peak whole-body oxygen uptake capacity (VO_{2peak}), a surrogate for aerobic exercise capacity, and mortality[2]. In addition, improved VO_{2peak} as a result of exercise training is significantly related to reduced mortality during follow-up[3,4]. Besides increasing VO_{2peak}, exercise training also improves traditional cardiovascular disease risk factors, blood rheology and endothelial function. It lowers low-degree inflammation, reduces coronary atherosclerosis, and facilitates coronary collateralisation[5-9].

However, there seem to be significant differences in cardiovascular disease incidence between CABG and PCI patients, unrelated to exercise interventions. Due to the high need for repeat coronary revascularisations in PCI patients, CABG patients show a lower total cardiovascular event incidence[10-13]. In addition to these findings, important differences between CABG and PCI are apparent at entry of rehabilitation. As a result of median sternotomy and a longer hospitalisation period[14,15] , CABG patients often present with a reduced pulmonary function, skeletal muscle mass loss, and a lower VO_{2peak}.

Therefore, as a result of cardiac rehabilitation, the cardiovascular disease incidence reduction might differ between CABG and PCI patients. Even though CABG and PCI patients have been investigated separately in a limited number of studies[16-21], for an identical rehabilitation programme, no single study has compared the cardiovascular disease incidence reduction between those two groups.

In this study, we have investigated during two years the effects of a three-month cardiac rehabilitation programme on the cardiovascular event incidence in CABG and PCI patients.

Methods

Six hundred and seventy-seven coronary artery disease patients presented at our coronary revascularisation unit with a critical stenosis and/or acute myocardial infarction. From this group, 439 patients were revascularised with a percutaneous coronary intervention (PCI) and 238 patients with coronary artery bypass graft surgery (CABG). CABG was preferred in the case of three-vessel disease and/or reduced left ventricular contractility, diabetes mellitus, and/or the inability to achieve revascularisation by PCI. After hospital discharge, 194 PCI patients and 149 CABG patients were referred to a cardiac rehabilitation programme in the same hospital. 245 PCI and 89 CABG patients were referred from another hospital and offered standard care as there were no cardiac rehabilitation facilities. As a result, we have compared patients with and without the opportunity to rehabilitate in a multidisciplinary centre. The control and rehabilitation groups were closely matched for baseline demographic characteristics and cardiovascular disease risk factors. Follow-up included at least two clinical examinations in the first six months after revascularisation and a yearly follow-up visit afterwards. For each patient, a follow-up period of two years was analysed. In case of recurrent myocardial ischaemia, the cardiologist decided if a change of therapy or a new intervention was indicated.

No patient had a CABG or PCI before this study. Patients were excluded if CABG or PCI were not successful, or after significant complications (life-threatening haemorrhage, need for re-intervention during hospitalisation, acute renal failure). Patients with a cardiovascular event within two weeks post-PCI or four weeks post-CABG were excluded from the study. Patients with symptomatic or important co-morbidity were excluded.

This study was approved by the hospital's ethical committee.

Outcome measures

All first-count cardiovascular events (acute myocardial infarction, need for repeat coronary revascularisation, death) were collected from hospital files and from general practitioners. Follow-up started after completion of the rehabilitation programme. Also the relationship between baseline cardiovascular risk factors and cardiovascular incidents was analysed.

Rehabilitation programme

The multidisciplinary ambulatory rehabilitation programme was started one or two weeks after hospital discharge, for a total duration of three months. It included at least 24 hospital-based exercise sessions: each week three one-hour aerobic exercise training sessions (treadmill, cycling and arm cranking). The patients trained at their ventilatory threshold level, tested by maximal ergospirometry (V-slope method).

All patients received psychological and dietary counselling. If necessary, they were advised to participate in a smoking cessation programme.

Both control and rehabilitation programme patients were advised to perform endurance exercise at home for at least 30 minutes each session, at least three days per week (from hospital discharge in the control patients, and after completion of the rehabilitation programme in the intervention patients).

Data analysis

Statistical analysis of patient characteristics, cardiovascular disease risk factors, and medication use in the 4 subgroups was performed with the SPSS-programme (version 14.0, Microsoft Windows): (i) a chi-square test for nominal data; (ii) analysis of variance (ANOVA) for ordinal data. A chi-square test compared the cardiovascular event rate between rehabilitation and control groups. In addition, odds ratios (OR) were calculated for the rehabilitation and control groups. Logistic regression tested the relationship between the total cardiovascular event rate and all baseline risk factors in the total population. A Kaplan-Meier curve compared the total cardiovascular event rate for all four subgroups.

Results

In table 1, the baseline patient characteristics are shown. When significant differences between groups were found, the relation with the total cardiovascular event rate during follow-up is displayed. Differences between groups were found for the number of revascularised coronary arteries and plasma high-density lipoprotein levels ($P < 0.05$). However, there was no correlation with the total cardiovascular event rate ($P > 0.05$). In addition, the number of supervised exercise training sessions was significantly different between groups ($P < 0.05$) and related to the total cardiovascular event rate ($P<0.05$). No other differences between groups were found.

Within the PCI patient subpopulations, the use of antiplatelets, ACE-inhibitors, digitalis, nitrates and statins was not different between the rehabilitation and control group. The use of anticoagulants (13% vs. 3%), beta-blockers (72% vs. 80%), and calcium antagonists (20% vs. 33%) was significantly different between the subgroups ($P < 0.05$). No significant correlation was found between the use of different medications and the total cardiovascular event rate. In the CABG patient subpopulations, between the rehabilitation and control group, the use of anticoagulants, beta-blockers, calcium antagonists, digitalis, and statins was not different. The use of antiplatelets (80% vs. 92%), ACE-inhibitors (20% vs. 7%), and nitrates (30% vs. 18%) was significantly different between groups ($P < 0.05$). No significant correlations were found between the use of medication and the total cardiovascular event rate.

In the total population, the incidence of total cardiovascular events (20.4% vs. 12.8%), acute myocardial infarction (3.9% vs. 0.9%) and death (4.2% vs. 0.6%) was significantly higher in the control group as compared to the rehabilitation group ($P < 0.05$) (see table 2). In the CABG patients, the incidence of total cardiovascular events (14.0% vs. 4.7%), acute myocardial infarction (3.2% vs. 0.0%) and death (5.4% vs. 0.7%) was significantly higher in the control group, as compared to the rehabilitation group ($P < 0.05$). In the PCI patients, death and the need for repeat revascularisation of target coronary arteries were significantly higher in the control group (12.6% and 3.7%, respectively), as compared to the rehabilitation group (6.2% and 0.5%, respectively) ($P < 0.05$). No other differences were found between groups.

In figure 1, a Kaplan-Meier curve presents the total cardiovascular event rate in all subgroups during the follow-up period.

Discussion

In this study, the effects of a three-month cardiac rehabilitation programme in CABG and PCI patients were analysed during two years of follow-up. There are two major findings.

First, analysis of the total cardiovascular event rate showed that CABG patients benefit more from cardiac rehabilitation as compared to PCI patients, i.e. total cardiovascular event rate was not significantly lower as a result of the intervention in PCI patients.

Second, CABG and PCI patients who followed the rehabilitation programme show a significantly lower mortality as compared to the control patients. In accordance, other investigators have reported a mortality reduction as a result of exercise training in CABG and PCI patients[16-19]. Therefore, in agreement with previous studies, our findings suggest that cardiac rehabilitation has a profound impact on mortality in CABG and PCI patients. The reduction in mortality risk in these patients can be related, at least in part, to the increase in peak whole-body oxygen uptake capacity (VO_{2peak}). Previous studies have reported a correlation between changes of VO_{2peak} and mortality. Therefore, by selecting effective training modalities, the increase inVO_{2peak} might even be greater[22], and contribute to larger survival benefits.

However, compared to CABG patients, total cardiovascular event rate is less reduced in PCI patients because of the high need for repeat coronary revascularisation. Because training modalities were equal in PCI and CABG patients, the difference in long-term outcome might be related to differences in post-rehabilitation lifestyle changes. After completion of the rehabilitation programme, previous studies have reported a lower physical activity level in PCI patients, as compared to CABG patients[23]. This might be related to a worse illness perception in PCI patients. An increasing amount of evidence indicates that most PCI patients are not concerned about their medical condition[24]. In recent studies, one out of three PCI patients considers their cardiac problem as nonexistent. At least 42% of PCI patients are convinced they are completely cured[25,26]. On the other hand, in CABG patients illness perception resulted in a higher treatment adherence[27]. Therefore, a greater physical activity and lifestyle change promotion should be implemented in the care of PCI patients.

Besides changes in VO_{2peak}, rehabilitation may have favourable effects on blood circulation, endothelial function, collateral circulation, low-degree inflammation and coronary atherosclerosis [-9]. In addition, a multidisciplinary rehabilitation might also increase the awareness of health profile and lifestyle, resulting in a lower fat intake and/or increased physical activity[28].

From this study, an important implication emerges. Cardiac rehabilitation significantly reduces cardiovascular mortality in both CABG and PCI patients, and should therefore be a preferred intervention in both groups. However, for PCI patients, post-rehabilitation lifestyle changes should be addressed with emphasis on physical activity.

This study has some limitations. (i) We have compared groups of two different hospitals, with only one hospital having rehabilitation facilities. Our study tried to reduce bias by comparing populations undergoing CABG or PCI in one centre, by the same operators. In addition, baseline demographic and cardiovascular disease risk factors were closely matched between groups. (ii) Differences in medication have been found between groups. This should not bias the outcome results, as these differences were not in favour of one or another group. There was no correlation between the different medical regimens and cardiovascular event rate. (iii) We did not collect data on changes in daily physical activity and diet during the two-year follow-up. Changes between CABG and PCI patients might have contributed to and/or explain the different cardiovascular event reduction between subgroups. (iv) The number of training sessions –being different between CABG and PCI patients- was significantly related to the total cardiovascular event rate. However, it seems unlikely that a difference of five training sessions would entirely contribute to the different cardiovascular event rate between CABG and PCI patients.

Conclusion

After two years of follow-up, cardiac rehabilitation significantly reduces mortality in CABG and PCI patients. However, with respect to the total cardiovascular event rate, the benefit seems to be greater in CABG patients.

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Conflict of interest: none declared.

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Tables

Table 1. Presentation of the baseline patient characteristics in the four subgroups

	Rehabilitation		Control		
	PCI	CABG	PCI	CABG	Relation with MACE
Number	194	149	245	89	
Age (years)	63.4 ± 7.6	65.0 ± 9.0	64.2 ± 10.4	66.2 ± 8.3	
Men (%)	76.3	69.8	76.4	67.7	
Cardiovascular disease risk factors					
Body mass index (kg/m^2)	26.8 ± 3.3	26.9 ± 3.7	27.3 ± 4.2	26.8 ± 3.5	
Total cholesterol (mg/dl)	223 ± 41	225 ± 42	214 ± 40	217 ± 51	
HDL cholesterol (mg/dl)	51 ± 17*	50 ± 22	45 ± 12	46 ± 14	NS
LDL cholesterol (mg/dl)	144 ± 36	144 ± 41	136 ± 37	139 ± 44	
Systolic blood pressure (mm/Hg)	136 ± 19	141 ± 21	136 ± 22	138 ± 20	
Diastolic blood pressure (mm/Hg)	78 ± 11	78 ± 11	79 ± 11	80 ± 10	
Hyperglycaemia (>110 mg/dl) (%)	14.8	17.7	14.6	22.1	
Smoking (%)	28.3	29.6	34.6	24.7	
Family history of CVD (%)	54.6	64.2	56.0	58.1	
Revascularised artery					
Left descending artery (%)	50.0*	78.1	39.0	94.6	NS
Right ascending artery (%)	46.4*	59.2	37.8	36.6	NS
Circumflex artery (%)	30.4*	55.6	35.8	43.0	NS
Stenting (%)	79.9	x	78.8	x	
Supervised training sessions (n)	43 ± 19*	48 ± 25	0	0	<0.05

Abbreviations: CABG, coronary artery bypass graft surgery; NS, not significant; PCI, percutaneous coronary intervention.
*significantly different between four subgroups (*P* < 0.05)

Table 2. Effects of the rehabilitation programme on the cardiovascular event rate.

	Total population		PCI		CABG	
	Rehabilitation	Control (OR)	Rehabilitation	Control (OR)	Rehabilitation	Control (OR)
Number	343	334	194	245	149	89
Total cardiovascular event rate (%)	12.8*	20.4 (1.6)	19.1	22.4 (1.2)	4.7¶	14.0 (3.0)
Acute myocardial infarction (%)	0.9*	3.9 (4.3)	1.5	4.2 (2.8)	0.0¶	3.2
Repeat revascularisation with PCI (%)	10.2	12.0 (1.2)	14.9	13.8 (0.9)	4.0	6.5 (1.6)
*on target coronary artery (%)	x	x	6.2§	12.6 (2.0)	x	x
Repeat revascularisation with CABG (%)	2.6	2.7 (1.0)	4.1	3.7 (0.9)	0.7	0.0
Death (%)	0.6*	4.2 (7.0)	0.5§	3.7 (7.4)	0.7¶	5.4 (7.7)

Abbreviations: CABG, coronary artery bypass graft surgery; OR, odds ratio; PCI, percutaneous coronary intervention
Odds ratios between rehabilitation and control groups.
*significant difference between total rehabilitation and control groups ($P < 0.05$)
§significant difference between PCI rehabilitation and control groups ($P < 0.05$)
¶significant difference between CABG rehabilitation and control groups ($P < 0.05$)

Figure legends

Figure 1. Kaplan-Meier curve presenting the total cardiovascular event rate in the four subgroups during a two-year follow-up.

*significantly different between control and rehabilitation group ($P < 0.05$)
MACE, major adverse cardiac event.