Early and late rehabilitation and physical training in elderly patients after cardiac surgery

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RESEARCH ARTICLE

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ABSTRACT

Macchi C, Fattirolli F, Molino Lova R, Conti AA, Luisi MLE, Intini R, Zipoli R, Burgisser C, Guarducci L, Masotti G, Gensini GF: Early and late rehabilitation and physical training in elderly patients after cardiac surgery. Am J Phys Med Rehabil 2007;86:826–834.

Objective: Few randomized trials have enrolled patients who have undergone cardiac surgery, and even fewer have included patients aged 75 yrs or more. Furthermore, the optimal timing of cardiac rehabilitation for postsurgical patients has not yet been codified. The aim of this study was to verify whether rehabilitation outcomes are also favorable in post-surgical patients aged 75 yrs or more and whether an early rehabilitation program is as effective and safe as a late one.

Design: Three hundred patients who underwent cardiac surgery, 27.7% of whom were at least 75 yrs old, were randomly assigned to a rehabilitation program starting within the second week after operation or within the fourth week. All events occurring during the rehabilitation program or in the following year were recorded.

Results: During the rehabilitation program, new-onset atrial fibrillation was significantly more frequent in the early rehabilitation group, independent of age class, and anemia was significantly more frequent in older patients, independent of rehabilitation timing. At the end of the rehabilitation program, more than 90% of patients showed significant increases in walking distance, and during the follow-up, no significant difference was found with regard to mortality, nonfatal events, functional ability, or control of cardiovascular risk factors, independent of rehabilitation timing and age class.

Conclusions: This study provides evidence that in selected patients who have undergone cardiac surgery, rehabilitation outcomes are also favorable in patients aged 75 yrs or more, and an early rehabilitation program is as effective and safe as a traditionally late one.

Key Words: Cardiac Rehabilitation, Physical Activity, Cardiac Surgery, Secondary Prevention, Elderly

Rehabilitation programs are strongly recommended for patients who have undergone cardiac surgery.[1,2] However, although two thirds of patients admitted to European rehabilitation services come from cardiac surgery wards,[3] only a few randomized trials have selectively investigated the effects of rehabilitation on postsurgical patients.[4–9] Furthermore, very old people, often with age-dependent comorbidities and physical limitations, represent an increasing amount of patients undergoing cardiac surgery. In the BARI trial,[10] 38.6% of patients after coronary surgery were older than 65 yrs (age range 65–80); in other series,[11,12] 31% of 1400 patients were older than 70 yrs and 14% of 8000 patients were older than 75 yrs. A retrospective study[13] performed on a small sample of patients with a mean age of 82 yrs and with different admission diagnoses (chronic angina, myocardial infarction, percutaneous coronary angioplasty, and coronary bypass surgery) has documented the favorable effects of the rehabilitation program. However, information on the efficacy of rehabilitation in elderly patients who have undergone cardiac surgery is still limited, though available evidence[7,14,15] indicates that in patients over 70, the functional impairment assessed on admission is improved by rehabilitation, and that elderly patients gain, by means of physical training, an increase of functional ability proportionally comparable with that of younger ones. In the present study, on the basis of the progressive increase of the age of inpatients attending our rehabilitation centers, the 75-yr cutoff has been considered appropriate.

A further, not yet codified feature is represented by the optimal timing of rehabilitation in patients who have undergone cardiac surgery. In effect, the implementation of fast recovery after surgical management allows the achievement of gait autonomy within the fifth postoperative day in more than 90% patients,[16] thus providing the possibility of an earlier transfer to rehabilitation services. Previous experiences[17] have indicated that, in selected and relatively young patients, rehabilitation may begin a week after the operation without any relevant effect on postoperative complications, mortality, or other late major adverse events. However, to the best of our knowledge, no randomized study has compared results of early and late rehabilitation programs in patients who have undergone cardiac surgery.

The aim of this study was to verify whether long-term rehabilitation outcomes are also favorable in patients aged 75 yrs or more, and whether an early rehabilitation program, begun within the second postoperative week, is as effective and as safe as a traditionally late one, begun within the fourth week.

METHODS

Study Population and Study Design

The study population was represented by 300 patients, 205 males (68.3%) and 95 females (31.7%), mean age 67.5 ± 10.6 yrs, enrolled on the fifth postoperative day among 462 consecutive patients who underwent on-pump cardiac surgery. Perioperative myocardial infarction and left ventricular failure, as well as disability in one or more basic activities of daily living,[18] or cognitive deterioration (corrected Mini Mental State Examination score <21),[19] were considered exclusion criteria for this study. Patients living far away from the rehabilitation centers were also excluded.

The ethical committee of the hospital (Azienda Ospedaliero Universitaria Careggi–Florence) approved the project, and all patients signed an informed consent to be included in the study.

Patients were randomly assigned to two in-hospital rehabilitation programs, one starting within the second week after the operation (early cardiac rehabilitation, e-CR, 150 patients), and the other within the fourth week (traditional or late cardiac rehabilitation, l-CR, 150 patients). The protocol foresaw the enrollment of at least 25% of patients aged 75 yrs or more and the allocation of half of them to each group.

Rehabilitation was performed without distinction in either of the two centers (Don Gnocchi Foundation and Unit of Gerontology and Geriatrics) under the supervision of the same medical staff and using the same physiotherapy protocol. All participants were admitted to one or other of the two centers as inpatients.

Patients assigned to the e-CR program were immediately transferred from the cardiac surgery department to the rehabilitation center as inpatients (henceforth referred to as the *early group*), and patients assigned to the l-CR program were discharged from the cardiac surgery department as soon as clinically stable, and then followed three times a week as outpatients to monitor possible complications occurring before their subsequent admission as inpatients to the rehabilitation centers (henceforth referred to as the *late group*). Patients assigned to this latter group did not receive any specific exercise prescriptions before their admission to the rehabilitation centers. In both cases, patients underwent serial clinical and instrumental evaluations (medical examination, routine lab tests, electrocardiogram, echocardiogram, chest x-ray). Possible early postoperative "sequelae," such as chest wall or diaphragm-mobility impairment, bronchial atelectasias, lower-limb edema from saphenectomy, or posture or walking impairment, were treated in individual physiotherapy sessions.

In accordance with current guidelines,[1,2] both the early and late 3-wk rehabilitation programs were focused on the stabilization of the basic cardiac disease and on the control of modifiable cardiovascular risk factors. In detail, both programs included optimal medication adjustment; functional evaluations (6-min walk corridor test, 6mWCT) at the beginning and at the end; continuous 24 hr/day of ECG monitoring by telemetry; 2 hr/day of physical training; educational, nutritional, and psychological counseling (individual interviews and group meetings); and quality-of-life evaluation through the Italian version of the SF-36 questionnaire,[20] administered at the end of the program. Because of the relatively advanced age of participants, the program was conceived to improve aerobic capacity and to optimize balance and coordination to prevent disability and falls. Specifically, physical training included aerobic exercise at cycle ergometry, based on 65–75% of the maximal heart rate, gentle low-level (around 25 W) and short-lasting (1–2 mins) calisthenic exercises, with resistance sequentially provided by single-body-segment weight, and gentle passive stretching involving all main joints.

Any event that occurred between the discharge from the cardiac surgery department and the discharge from the rehabilitation center was recorded. Because of the relatively frequent findings of mild to moderate anemia and of pericardial and pleural effusion in the postoperative course of patients undergoing cardiac surgery, incident anemia was defined as clinically relevant when the hemoglobin level reached values below 9 g/dl with a drop of at least 1 g/dl, pericardial effusion when the anterior echo-free epipericardial space was more than 10 mm, and pleural effusion when fluids reached at least one third of the radiologic pulmonary field. Furthermore, because of the frequent onset of atrial fibrillation (AF) in the postoperative course of patients after cardiac surgery, AF was considered separately from other arrhythmias.

One year after cardiac rehabilitation, patients were invited to a free follow-up visit, which included a medical interview and examination, blood pressure and body weight measurement, 6mWCT, and the administration of the SF-36 questionnaire. Laboratory tests, such as hemoglobin-A1c, total and HDL cholesterol, and triglycerides, were also performed. LDL cholesterol was calculated according to the Friedewald formula.[21] Expected outcomes for cardiovascular risk factors were considered on target[1] if blood pressure at rest was lower than 140/90 mm Hg, or lower than 130/85 mm Hg in the presence of diabetes, chronic renal failure, or chronic heart failure; if HbA1c was lower than 7.0%; if LDL cholesterol was lower than 100 mg/dl in patients with coronary artery disease, or lower than 130 mg/dl in patients without coronary disease; and if weight loss in overweight patients was at least 5%. With regard to arrhythmias, AF was considered, in this context, together with other arrhythmias.

For patients who were unable or unwilling to reach the rehabilitation center for the follow-up visit, a staff physician telephone-interviewed them; for deceased patients, their relatives were interviewed, to record, in all cases, any possible events that had occurred in the previous year.

Statistical Methods

Statistical analysis was performed using STATA 7.0 software (Stata Corporation, College Station, TX). Inference of rehabilitation timing and advanced age was assessed using multivariate linear or logistic regression–based analyses, as appropriate. Type I error was set at 0.05.

RESULTS

Eighty-three patients (27.7%) aged 75 yrs or more were enrolled in the study; 39 were allocated to the early group, and 44 to the late group.

The mean time interval between surgery and admission to the rehabilitation center was 7.8 ± 2.7 days for the e-CR group and 24.6 ± 2.1 days for the l-CR group. The mean postoperative stay in the cardiac surgery department for patients enrolled in the e-CR group coincided with the above interval (7.8 ± 2.7 days), whereas for patients enrolled in the l-CR group, it was 11.9 ± 2.4 days ($P < 0.001$).

Table 1 shows the clinical characteristics of patients according to rehabilitation timing and age class.

Randomization produced a significantly mismatched distribution of surgical operations in the two groups: coronary artery bypass graft (CABG), isolated or associated with valve surgery (VS), was more frequent in the l-CR group, and "pure" valve surgery was more frequent in the e-CR group ($P = 0.012$), independent of age class.

No significant difference was found with regard to age, according to rehabilitation timing, and with regard to sex distribution, according to rehabilitation timing and age class.

In the entire sample, cardiovascular risk factor prevalence was 23.7% for former smoking, 18.0% for current smoking, 56.7% for hypertension, 19.7% for diabetes, 38.3% for dyslipidemia, 39.0% for overweight, and 10.7% for obesity.

Among cardiovascular risk factors, current smoking and dyslipidemia were significantly more frequent in the l-CR group independently of age class, whereas no significant difference was found with regard to former smoking, hypertension, diabetes, overweight, and obesity.

In the entire sample, previous myocardial infarction prevalence was 28.0%, and mean left ventricular echographic ejection fraction was 52.8 ± 10.0%.

TABLE 1 Patients' clinical characteristics at the beginning of the program according to rehabilitation timing and age group

	Early Rehabilitation $n = 150$		Late Rehabilitation $n = 150$			
	<75 yrs $n = 111$	≥75 yrs $n = 39$	<75 yrs $n = 106$	≥75 yrs $n = 44$	Rehabilitation Timing P	Age Group P
Age, yrs	63.0 ± 9.6	79.0 ± 3.3	63.4 ± 8.7	78.5 ± 4.2	NS	—
Female sex	34 (30.6%)	17 (43.6%)	29 (27.4%)	15 (34.1%)	NS	NS
Operation						
CABG	57 (51.4%)	18 (46.2%)	67 (63.2%)	25 (56.8%)		
VR	48 (43.2%)	15 (38.4%)	26 (24.5%)	14 (31.8%)	0.012	NS
Combined surgery (CABG + VR)	6 (5.4%)	6 (15.4%)	13 (12.3%)	5 (11.4%)		
Cardiovascular risk factors:						
Former smokers	33 (29.7%)	9 (23.1%)	22 (20.8%)	7 (15.9%)	NS	NS
Current smokers	11 (9.9%)	2 (5.1%)	23 (21.7%)	8 (18.2%)	0.004	NS
Hypertension	56 (50.5%)	22 (56.4%)	61 (57.6%)	31 (70.5%)	NS	NS
Diabetes	18 (16.2%)	9 (23.1%)	24 (22.6%)	8 (18.2%)	NS	NS
Dyslipidemia	31 (28.0%)	12 (30.8%)	53 (50.0%)	19 (43.2%)	0.001	NS
25 < BMI ≤30	49 (44.1%)	10 (25.6%)	41 (38.7%)	17 (38.6%)	NS	NS
BMI >30	14 (12.6%)	3 (7.7%)	11 (10.4%)	4 (9.1%)	NS	NS
Previous myocardial infarction	17 (15.3%)	6 (15.4%)	46 (43.4%)	15 (34.1%)	0.001	NS
Left ventricular ejection fraction	54 ± 8.5	53 ± 10.8	51 ± 10.8	51 ± 8.4	0.003	NS

Values are expressed as absolute numbers, with percentages in brackets, or as means ± standard deviation. P values are based on multivariate linear or logistic regressions, as appropriate.

Left ventricular ejection fraction was measured noninvasively by echocardiography.

CABG, coronary artery bypass graft; VR, valve repair/replacement; BMI, body mass index.

Previous myocardial infarction was significantly more frequent in the l-CR group, whereas left ventricular ejection fraction was significantly higher in the e-CR group, independent of age class.

Table 2 shows events occurring between discharge from the cardiac surgery department and the end of the rehabilitation program, and physical performance at the beginning and at the end of the program, according to rehabilitation timing and age class.

In the entire sample, no case of death or myocardial infarction was recorded. Angina occurred in 0.7% of patients, left ventricular failure in 3.0%, AF in 7.0%, arrhythmias other than AF in 4.0%, pericardial effusion in 4.7%, pleural effusion in 5.7%, anemia in 6.3%, and sepsis in 1.7%.

No significant difference was found with regard to angina and left ventricular failure. New-onset AF was significantly more frequent in the e-CR group, independent of age class. New-onset AF was also independent of the operation, both in the entire sample (9/167 CABG, 9/103 VS, and 3/30 CABG+VS; $P = 0.459$) and in the e-CR group (7/75 CABG, 8/63 VS, and 2/12 CABG+VS; $P = 0.686$). Furthermore, AF was independent of hypertension, both in the entire sample (10/170 hypertension and 11/130 no hypertension, $P = 0.386$) and in the e-CR group (7/78 hypertension and 10/72 no hypertension, $P = 0.343$). Even if not significant, arrhythmias other than AF and pericardial effusion were more frequent in the e-CR group, whereas pleural effusion was more frequent in the l-CR group, independent of age class. Incident anemia was significantly more frequent in the elderly, independent of rehabilitation timing, despite no significant difference of hemoglobin levels at discharge from the cardiac surgery department (10.9 ± 1.2 *vs.* 10.7 ± 1.3 for younger and older participants, respectively; $P = 0.392$). No significant difference was found with regard to sepsis.

In the entire sample, mean walked distance at 6mWCT was 321 ± 127 m on admission and 415 ± 122 m on discharge, with an absolute increase of 96 ± 68 m. Walked distance improved in 97.3% of patients, remained unchanged in 1.3%, and worsened in 1.4%. Worsened and unchanged walked distances were not related to the occurrence of complication during the rehabilitation program; rather, they were attributable to a lack of compliance.

Walked distance on admission was significantly longer both in the l-CR group and in the younger age group, and walked distance on discharge was significantly longer in the younger age

TABLE 2 Events occurring between discharge from the cardiac surgery department and the end of the rehabilitation program, and physical performance at the beginning and at the end of the program, according to rehabilitation timing and age group

	Early Rehabilitation $n = 150$		Late Rehabilitation $n = 150$			
	<75 yrs $n = 111$	≥75 yrs $n = 39$	<75 yrs $n = 106$	≥75 yrs $n = 44$	Rehabilitation Timing *P*	Age Group *P*
Events						
Death	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	—	—
Myocardial infarction	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	—	—
Angina	0 (0.0%)	0 (0.0%)	1 (0.9%)	1 (2.3%)	—	NS
Left ventricular failure	2 (1.8%)	1 (2.6%)	4 (3.8%)	2 (4.6%)	NS	NS
New-onset atrial fibrillation	13 (11.7%)	4 (10.3%)	3 (2.8%)	1 (2.3%)	0.007	NS
Arrhythmias other than atrial fibrillation	7 (6.3%)	2 (5.1%)	2 (1.9%)	1 (2.3%)	NS	NS
Pericardial effusion	6 (5.4%)	2 (5.1%)	4 (3.8%)	2 (4.6%)	NS	NS
Pleural effusion	5 (4.5%)	2 (5.1%)	7 (6.6%)	3 (6.8%)	NS	NS
Anemia (hemoglobin <9 g/dl)	4 (3.6%)	7 (17.9%)	2 (1.9%)	6 (13.6%)	NS	0.001
Sepsis	2 (1.8%)	0 (0.0%)	2 (1.9%)	1 (2.3%)	NS	NS
6-min walk corridor test						
Admission, m	335 ± 120	239 ± 89	379 ± 119	258 ± 137	0.042	0.001
Discharge, m	458 ± 101	330 ± 96	444 ± 104	313 ± 150	NS	0.001
Absolute difference, m	120 ± 67.6	91.7 ± 60.8	70.2 ± 62.1	67.2 ± 62.9	0.001	NS
Improved	111 (100%)	37 (94.8%)	103 (97.2%)	41 (93.1%)		
Unchanged (±10 m)	0 (0%)	1 (2.6%)	2 (1.9%)	1 (2.3%)	NS	NS
Worsened	0 (0%)	1 (2.6%)	1 (0.9%)	2 (4.6%)		

Values are expressed as absolute numbers, with percentages in brackets, or as means ± standard deviation. *P* values are based on multivariate linear or logistic regressions, as appropriate.

group, independent of rehabilitation timing. The absolute distance increase was significantly higher in the e-CR group, independent of age class. No significant difference was found with regard to the proportion of patients improved, unchanged, or worsened in each group.

Table 3 shows 1-yr general follow-up, dropout, and clinical follow-up, with physical performance and cardiovascular risk factors.

With regard to new events, 1-yr follow-up was completed in all 300 enrolled patients.

Eight patients (2.7%) died during the follow-up (three from stroke, two from myocardial infarction, one from worsening of left ventricular failure, and two from noncardiovascular causes). Nonfatal events requiring hospitalization occurred in 32 patients (10.7%). No significant difference between e-CR and l-CR or age classes was found with regard to death and nonfatal events occurring during follow-up. Thirty-eight patients (12.7%) dropped out (16 because of refusal, 14 for logistic reasons, and 8 for clinical reasons, such as recent stroke in two patients, myocardial infarction in one patient, and noncardiovascular diseases in five patients). No significant difference was found with regard to dropout reasons between the e-CR and l-CR or age classes.

A clinical 1-yr follow-up was completed in 254 patients (84.6%).

In the entire sample, mean walked distance at follow-up 6mWCT was 480 ± 119 m, and absolute difference *vs.* discharge was 48 ± 83 m. Walked distance improved in 63.4% of patients, remained unchanged in 19.7%, and worsened in 16.9%.

Walked distance at 6mWCT was significantly longer in the younger age class, independent of rehabilitation timing. Neither the absolute difference *vs.* discharge nor the proportion of patients who had improved, unchanged, or worsened showed any significant difference with regard to rehabilitation timing or age class.

In the entire sample, smoking cessation was obtained in 77.5% of current smokers. Hypertension was "controlled" in 64.4% of patients, diabetes in 63.2%, and dyslipidemia in 64.0%. Furthermore, only 33.3% of patients with body mass index (BMI) >25 lost at least 5% of their body weight, and 18.0% of patients with BMI <25 at baseline put on enough weight to reach a BMI >25 at follow-up. No significant difference between the e-CR and l-CR or age classes was found with regard to the control of cardiovascular risk factors.

As expected, the SF-36 questionnaire administered at the end of the rehabilitation program

TABLE 3 One-year general follow-up, dropout, and clinical follow-up according to rehabilitation timing and age group

	Early Rehabilitation $n = 150$		Late Rehabilitation $n = 150$			
General Follow-up, $n = 300$ (100%)	<75 yrs $n = 111$	≥75 yrs $n = 39$	<75 yrs $n = 106$	≥75 yrs $n = 44$	Rehabilitation Timing P	Age Group P
Deaths, $n = 8$ (2.7%)	3 (2.7%)	1 (2.6%)	2 (1.9%)	2 (4.6%)	NS	NS
Nonfatal events						
Myocardial infarction	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	—	—
Angina	2 (1.8%)	1 (2.6%)	4 (3.8%)	0 (0.0%)	NS	NS
Left ventricular failure	2 (1.8%)	0 (0.0%)	1 (0.9%)	1 (2.3%)	NS	NS
Arrhythmias	6 (5.4%)	2 (5.1%)	5 (4.7%)	2 (4.6%)	NS	NS
Stroke or transient ischemic attack	2 (1.8%)	1 (2.6%)	1 (0.9%)	1 (2.3%)	NS	NS
Dropouts, $n = 38$ (12.7%)	17 (15.3%)	7 (17.9%)	9 (8.5%)	5 (11.4%)	NS	NS
Refusal	7 (6.3%)	3 (7.7%)	4 (3.8%)	2 (4.5%)		
Logistic reasons	6 (5.4%)	3 (7.7%)	3 (2.8%)	2 (4.5%)	NS	NS
Clinical reasons	4 (3.6%)	1 (2.6%)	2 (1.9%)	1 (2.3%)		
Clinical Follow-up, $n = 254$ (84.6%)	$n = 91$	$n = 31$	$n = 95$	$n = 37$	P	P
6-min walk corridor test						
Follow-up, m	517 ± 115	416 ± 103	471 ± 118	418 ± 110	NS	0.002
Absolute difference *vs.* discharge, m	44.6 ± 85.4	28.2 ± 69.8	68.0 ± 91.4	41.8 ± 79.1	NS	NS
Improved	63 (69.2%)	19 (61.3%)	61 (64.2%)	18 (48.6%)		
Unchanged (−10 m)	15 (16.5%)	7 (22.6%)	18 (18.9%)	10 (27.0%)	NS	NS
Worsened	13 (14.3%)	5 (16.1%)	16 (16.8%)	9 (24.3%)		
Cardiovascular risk factors						
Smoking cessation	7/9 (77.8%)	2/2 (100%)	16/21 (76.2%)	6/8 (75.0%)	NS	NS
Hypertension on target[a]	29/47 (61.7%)	13/19 (68.4%)	35/53 (66.0%)	17/27 (62.9%)	NS	NS
Diabetes on target[b]	10/15 (66.7%)	5/8 (62.5%)	12/20 (60.0%)	4/6 (66.7%)	NS	NS
Dyslipidemia on target[c]	15/25 (60.0%)	7/11 (63.6%)	33/49 (67.3%)	9/15 (60.0%)	NS	NS
BMI >25 at baseline: weight loss (at least 5%)	17/52 (32.7%)	4/11 (36.4%)	15/46 (32.6%)	6/17 (35.3%)	NS	NS
BMI <25 at baseline: weight gain till BMI >25	7/39 (18.0%)	3/20 (15.0%)	9/49 (18.4%)	4/20 (20.0%)	NS	NS

Values are expressed as absolute numbers, with percentages in brackets, or as means ± standard deviation. P values are based on multivariate linear or logistic regressions, as appropriate.

[a] Blood pressure lower than 140/90 mm Hg, or lower than 130/85 in the presence of diabetes, chronic renal failure, or chronic heart failure; [b] hemoglobin-A1c <7%; [c] LDL cholesterol lower than 100 mg/dl for patients having undergone coronary surgery, or lower than 130 mg/dl for patients having undergone isolated valve surgery. BMI, body mass index.

showed that patients who underwent e-CR were significantly less satisfied about the control of bodily pain (BP) ($P = 0.003$), physical functioning (PF) ($P = 0.004$), and role-physical limitation (RF) ($P = 0.001$), independent of age group. However, at the 1-yr follow up, SF-36 items had improved and were aligned with those reported for the age-matched general population.

DISCUSSION

In synthesis, our data show that:

1. Long-term rehabilitation outcomes are also favorable in postsurgical patients aged 75 yrs or more.
2. An early rehabilitation program is as effective and as safe as a traditionally late one and, with the sole exception of new-onset AF, does not involve a higher incidence of adverse events or complications during its course.

In our series, during the rehabilitation program, new-onset AF was significantly more frequent in the e-CR group, independent of age class, and anemia was significantly more frequent in older patients, independent of rehabilitation timing.

New-onset AF is a quite common complication after cardiac surgery, with an incidence of more than 30% within the first three postoperative days, and less than 5% after the sixth day.[22] In our series, new-onset AF occurred in 11.3% of patients admitted to the e-CR and in 2.7% of those admitted to the l-CR. In a separate analysis (data not shown), we tested the association of new-onset AF with e-CR, using a multivariate logistic regression-based model and entering, as covariates, age, kind of operation, left ventricular function, left-atrium diameter, hypertension, previous episodes of AF, and medication. However, contrary to other studies,[23,24] new-onset AF remained significantly associated only with rehabilitation timing. An intriguing hypothesis to explain this finding is that the closure of the purse string used for right atrium cannulation might induce a sort of electrical instability, either because of the ischemia of the tissues involved in the tie or because of the distortion of right-atrium geometry, which takes a few weeks to settle down. In any case, patients who had AF needed, at most, a 48-hr interruption of the rehabilitation program to obtain pharmacological cardioversion and stabilization of the sinus rhythm.

Anemia after cardiac surgery is rather frequent in the first postoperative days and also in the first 2 wks, and it does not need corrective interventions apart from limitation or, more rarely, postponement of the physical training program. In our series, incident anemia was significantly more frequent in elderly patients (15.7% *vs.* 2.8%), independent of rehabilitation timing, despite no significant difference of hemoglobin levels at discharge from the cardiac surgery department between younger and older participants. As for new-onset AF, we tested, in a separate analysis (data not shown), the association of incident anemia with age class, using a multivariate logistic regression-based model and entering, as covariates, medication and lab tests such as iron, ferritine, inflammation markers, and creatinine. However, incident anemia remained significantly associated only with age class. Possibly, the persistence of anemia observed even in elderly patients assigned to the l-CR might be attributable to the slowed regeneration from ineffective erythropoiesis or from other age-related hypoproliferative conditions.

With regard to physical performance, in our series the shorter distance walked on admission by patients assigned to the e-CR was probably related to the shorter time elapsed since operation. In effect, at the end of the rehabilitation program, patients assigned to the e-CR showed a significantly higher absolute increase of walked distance when compared with patients assigned to the l-CR. The fact that older patients assigned both to the e-CR and l-CR walked a shorter distance when compared with younger patients of the same group is in accordance with data reported in a remarkably large series of postsurgical patients.[25] However, at the end of the rehabilitation program, more than 90% of patients showed significant increases in walked distance when compared with admission, independent of rehabilitation timing and age class. These observations, gathered in a sample including patients older than those usually enrolled in other studies,[26] confirm that functional capacity may be increased through appropriate physical training programs, even in very elderly postsurgical noncomplicated patients, as already reported in post-myocardial infarction patients.[27]

Contrary to other trials,[7,28] in which data were collected through questionnaires, we completed a clinical follow-up in 84.6% of enrolled patients. In the entire sample, 1-yr mortality was lower than 3%, and nonfatal events occurred in fewer than 11% of patients, without any significant difference between rehabilitation programs or age classes. These data are in accordance with the PERISCOP multicentric trial,[28] which reports data observed in a large cohort of patients (mean age of 63 ± 10 yrs) who underwent coronary surgery and were admitted to cardiac rehabilitation 20 days after the operation, in which no correlation was found between follow-up events and age.

At 1-yr follow-up evaluation, one third of patients showed worsened or unchanged functional ability and risk factors exceeding target levels, independent of rehabilitation timing and age class. Furthermore, two thirds of overweight patients did not lose weight, one fifth of normal-weight patients became overweight, and one fifth of smokers continued smoking. Though consistent with previously reported data,[6] these results confirm the difficulty in implementing durable healthy lifestyle changes in all patients, despite inclusion in a rehabilitation program of educational, nutritional, and psychological counseling. Possibly, an intensive reinforcement program and a coordinated intervention involving general practitioners and territory facilities might consolidate and complete the multifactorial intervention begun in the in-hospital phase of rehabilitation programs.

Differences in the perceived quality of life evaluated through the SF-36 questionnaire, such as less satisfaction with regard to the control of bodily pain, physical functioning, and role-physical limitation at the end of the rehabilitation program in patients who have undergone the e-CR, were probably related to the shorter time elapsed since operation and were independent of age class. In fact, most SF-36 items were aligned with those reported for the age-matched general population at the 1-yr follow-up.

Finally, though this study was not designed for a cost–benefit analysis, the early rehabilitation program allowed a significantly shorter stay in the cardiac surgery department (7.8 ± 2.7 *vs.* 11.9 ± 2.4 days).

This study inherently has various limitations. First, some of the effects of mismatched distribution of the patients according to the type of operation may have been missed by our analysis. Second, the sample is not representative of the entire population of patients who have undergone cardiac surgery. In fact, the study included selected patients fit enough to start the early rehabilitation program, apart from the actual program they had been allocated to. Consequently, patients needing longer recovery times, and for whom cardiac rehabilitation is even more strongly recommended,[29–30] were excluded from the study. Third, and strictly related to the above observation, incidence of complications and adverse events both during rehabilitation programs and during follow-up was relatively low, and this may have restrained statistical power. Fourth, randomization produced a significantly mismatched distribution of surgical operations in the two groups, so that the prevalence of cardiovascular risk factors was significantly unbalanced. And, finally, our rehabilitation programs were performed on participants who had been admitted as inpatients, so conclusions cannot be directly extended to outpatient rehabilitation settings.

In conclusion, our data clearly show that in selected patients who have undergone cardiac surgery, long-term rehabilitation outcomes are favorable even in patients aged 75 yrs or more, and an early rehabilitation program is as effective and safe as a traditionally late one. Future studies should investigate differences in the two rehabilitation programs in bigger series and, possibly, by enrolling less selected patients. Furthermore, in the view of an optimization of the cost–benefit balance, future studies should also evaluate the feasibility and safety of early rehabilitation programs for outpatients.

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CME Self-Assessment Exam

Answers to September 2007 CME Questions

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CME Article Number 2:
L. El Mhandi et al.

1. D
2. B
3. A
4. C
5. A

CME Article Number 3:
M.M. Glymour et al.

1. B
2. C
3. A
4. C
5. C

CME Article Number 4:
M. Ersoz et al.

1. C
2. B
3. C
4. B
5. A