Home-Based Versus In-Hospital Cardiac Rehabilitation After Cardiac Surgery: A Nonrandomized Controlled Study

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Background. Exercise rehabilitation after cardiac surgery has beneficial effects, especially on a long-term basis. Rehabilitative programs with telemedicine plus appropriate technology might satisfy the needs of performing rehabilitation at home.

Objective. The purpose of this study was to compare exercise capacity after home-based cardiac rehabilitation (HBCR) or in-hospital rehabilitation in patients at low to medium risk for early mortality (EuroSCORE 0–5) following cardiac surgery.

Design. A quasi-experimental study was conducted.

Methods. At hospital discharge, patients were given the option to decide whether to enroll in the HBCR program. Clinical examinations (electrocardiography, cardiac echo color Doppler, chest radiography, blood samples) of patients in the HBCR group were collected during 4 weeks of rehabilitation, and exercise capacity (assessed using the Six-Minute Walk Test [6MWT]) was assessed before and after rehabilitation. A group of patients admitted to the in-hospital rehabilitation program was used as a comparison group. Patients in the HBCR group were supervised at home by a medical doctor and telemonitored daily by a nurse and physical therapist by video conference. Periodic home visits by health staff also were performed.

Results. One hundred patients were recruited into the HBCR group. An equal number of patients was selected for the comparison group. At the end of the 4-week study, the 2 groups showed improvement from their respective baseline values only in the 6MWT. No difference was found in time × group interaction.

Limitations. Because patients self-selected to enroll in the HBCR program and because they were enrolled from a single clinical center, the results of the study cannot be generalized.

Conclusions. In patients who self-selected HBCR, the program was found to be effective and comparable to the standard in-hospital rehabilitative approach, indicating that rehabilitation following cardiac surgery can be implemented effectively at home when coadministered with an integrated telemedicine service.

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[Scalvini S, Zanelli E, Comini L, et al. Home-based versus in-hospital cardiac rehabilitation after cardiac surgery: a nonrandomized controlled study. *Phys Ther.* 2013; 93:1073–1083.]

Published Ahead of Print: April 18, 2013
Accepted: April 15, 2013
Submitted: May 28, 2012

Rehabilitation after cardiac surgery often improves self-assessment and clinical parameters,[1] reduces risk factors, and can increase physical capacity. A 20% reduction in all-cause mortality and a 27% reduction in cardiac mortality have been reported in systematic reviews.[2,3] However, despite international guidelines that recommend cardiac rehabilitation,[1] the proportion of patients admitted to a rehabilitative program remains small.[4–7] Mostly, patients are discharged to the home without any rehabilitation.[8]

For this reason, home-based cardiac rehabilitation (HBCR) programs have been introduced in the United States and some European countries in attempts to increase patient participation, in particular for older or socially deprived people, ethnic minorities, and those from rural areas who encounter difficulties in attending center-based facilities. Home-based cardiac rehabilitation programs could yield clinical outcomes similar to those of rehabilitation programs, with a possible positive impact on some areas of health care utilization.[9,10]

In Italy, formal cardiac rehabilitation is offered within a rehabilitative hospital.[11] However, the inclusion of patients in rehabilitation programs following surgery differs among Italian regions. The ISYDE study,[11] designed to provide a detailed snapshot of cardiac rehabilitation in Italy for patients after a surgical procedure, shows that in-hospital rehabilitation service was provided by 62.4% of the centers, whereas outpatient care is provided on a day-hospital basis by 10.9% of facilities, with 20% of the centers referring patients to ambulatory structures.[11] Indeed, differences from region to region are present. In the Lombardy region, all patients who have undergone cardiac surgery are admitted for in-hospital rehabilitation. Moreover, patients who have undergone cardiac surgery without complications are allowed to participate in pilot programs at home using telemedicine as an alternative to an in-hospital rehabilitation program. In particular, all patients discharged 5 to 10 days after cardiac surgery stayed at a rehabilitative center for a mean period of 18 days.[12]

Up to 2006, in the Lombardy region, all patients after cardiac surgery followed an in-hospital rehabilitation program. From 2006 onward, a regional project (CRITERIA) proposed, at an experimental level, an HBCR program with telemedicine to follow up patients at low to medium risk for early mortality after cardiac surgery at home.

Telemedicine and application of information and communication technology in the health system have been shown to support and manage home care programs quite efficiently.[13] However, few studies have examined the application of HBCR with telemedicine in patients after cardiac surgery, myocardial infarction, and percutaneous transluminal coronary angioplasty[14,15]; to our knowledge, we have performed the only investigation in Italy to test the feasibility of this approach in patients following cardiac surgery.[16]

The current study was aimed at reproducing at home the in-hospital cardiac rehabilitation protocol procedures in patients at low to medium risk after cardiac surgery. The primary objectives of the study were:

The Bottom Line

What do we already know about this topic?

Rehabilitation after cardiac surgery often improves quality of life, reduces cardiovascular disease risk factors, and can increase physical capacity. A 20% reduction in all-cause mortality and a 27% reduction in cardiac mortality following cardiac rehabilitation also have been reported in systematic reviews.

What new information does this study offer?

This study compared exercise capacity after a home-based cardiac rehabilitation (HBCR) program or an in-hospital program in patients with a low to medium risk for early mortality after cardiac surgery. The study found that the HBCR program was feasible, safe, and comparable to the conventional in-hospital rehabilitation approach, indicating that rehabilitation following cardiac surgery in patients at low risk for early mortality can be implemented effectively at home when programmed with an integrated telemedicine service.

If you're a patient, what might these findings mean for you?

If you are at low risk for early mortality after cardiac surgery, you may achieve a better quality of life with a complete, supervised rehabilitation program at home via telemedicine.

Table 1.
Rehabilitative Intervention in the 2 Different Settings[a]

Measure	What	When and How	Home-Based Rehabilitation (n=100)	In-Hospital Rehabilitation (n=100)
Patient selection	Age, sex, LFEV, EuroSCORE, type of intervention		Yes	Yes
Time for rehabilitation			4 wk	4 wk
Education intervention		At discharge At home	Yes Yes	Yes No
Exercise monitoring			Video conference	Face to face
Exercise intervention (how)			DVD	Face to face
Exercise intervention (what and when)	Calisthenic (upper and lower limbs, trunk, neck, shoulders, education, and bronchial clearing)	50 min/session Once a day	Morning	Morning
	Stretching/relaxation (5 min × 2)	10 min/session Once a day	Morning	Morning
	Interval training on cycle ergometer	40 min/session Twice a day		
		Start at 25 W for 5 min	Morning and afternoon	Morning and afternoon
		Increase to 50 W for 35 min		
Bicycle graded symptom-limited exercise test		At the end of the program (25 W increased every 3 min)	Yes	Coming on-site
Internal staff		Nurse tutor	Every 2 wk	Usual care
		Physical therapist	First day after discharge and every week	Usual care
		Specialists	On demand	Usual care

[a] LFEV=left ventricular ejection fraction.

(1) to evaluate the feasibility of implementing an in-hospital rehabilitation protocol in a home setting with an up-to-date telemedicine platform and (2) to compare key efficacy indicators such as exercise capacity (assessed using the Six-Minute Walk Test [6MWT]). Length of the rehabilitative period, number of days from the surgical intervention to rehabilitation, and mean total duration of the rehabilitative sessions were secondary outcome measures.

Method

Design

The study was designed as quasi-experimental.

Participants

The study participants were divided into 2 groups: (1) an HBCR group and (2) an in-hospital group, which served as a comparison group.

HBCR group. The HBCR group (n=100) included all patients allocated in our institute (Fondazione Salvatore Maugeri) who underwent cardiac surgery procedures between January 2006 and June 2010 at a single cardiac surgery center (Fondazione Poliambulanza Istituto Ospedaliero, Brescia, Italy). All participants gave their written informed consent.

Inclusion criteria were: over 18 years of age, EuroSCORE between 0 and 5 (European System for Cardiac Operative Risk Evaluation: 0–2=low-risk group, 3–5=medium-risk group, ≥6=high-risk group),[17] no major complications after surgery, and hemoglobin value >8.5 g/dL. All enrolled patients were required to have the availability of a caregiver at home and to live within 30 km from the hospital. The main exclusion criteria were insulin-dependent diabetes and overt chronic respiratory insufficiency. Allocation to the HBCR group was made based on the patients' preference. Among 387 patients who were admitted to the

Table 2.
Core Elements of Home-Based Cardiac Rehabilitation and Ways of Delivering Through the Care Platform[a]

Elements	Tools
1. Assessment review and follow-up	1. Face-to-face assessment appointment with a nurse 2. Participants receive training on using the service, mobile telephone and its applications 3. Personnel health record 4. Scheduled telephone support by nurse 5. Video conference
2. Physical activity and exercise training	6. Videoconference 7. Education by a physical therapist (DVD) 8. Telemonitoring: 1-lead ECG and BP measurement 9. Home intervention by a physical therapist
3. Behavioral modification strategies and risk-factor management	10. Scheduled telephone support by a nurse 11. Wellness diary to record weight, food intake, sleep, alcohol, smoking, exercise, BP 12. Educational sessions by a nurse
4. Nutritional counseling	13. Dietitian interview at discharge
5. Psychological and psychosocial management	14. Video conference applications 15. Weekly teleconference

[a] BP=blood pressure, ECG=electrocardiogram.

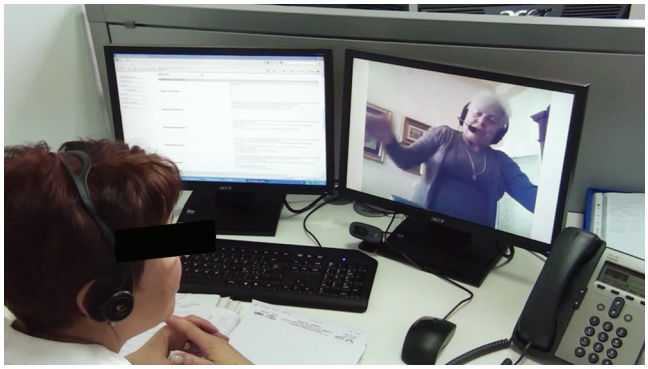

Figure 1.
The platform of video conference used during the home cardiac telerehabilitation.

hospital after cardiac surgery, 100 were enrolled as the HBCR group.

In-hospital group. The in-hospital group (n=100) was retrospectively identified from the database of the Cardiovascular Rehabilitation Department (Fondazione Salvatore Maugeri) of patients consecutively admitted between January 2006 and June 2010. All patients who had been hospitalized in our hospitals a priori gave signed informed consent for the use of their data for research, and none had to be contacted for this reason.

A matching program[18] was used to select participants based on age, sex, left ventricular ejection fraction (LVEF), EuroSCORE, and type of intervention. Among 600 patients who were admitted to the hospital after cardiac surgery during the period of the current study, 100 were identified as the comparison group.

Procedure

The HBCR program[16] was set up in an identical fashion to the in-hospital rehabilitation program.[11] Physical activity performed during the rehabilitative program in both settings is summarized in Table 1.

During the in-hospital rehabilitation, a standardized training program for cardiovascular rehabilitation following Italian recommended guidelines[11] was applied (Tab. 1). Clinical examinations included electrocardiographic (ECG) testing, cardiac echo color Doppler, chest radiography, and routine blood tests. Exercise capacity was assessed with the 6MWT before and after the rehabilitation period. The training program included callisthenic exercises, cycle training, and education on healthy lifestyles. The program was individualized, with exercises provided ad hoc for particular problems of each patient and adapted daily as needed by the physical therapist.

Details on the HBCR program are described in Table 2. At time of discharge from the Cardiac Surgery Department, a nurse and cardiologists provided an educational session to introduce the program to each patient.

During the HBCR program, participants underwent testing similar to that of the in-hospital setting (eg, cardiology visits and blood tests, cardiac echo color Doppler, chest radiography, and 6MWT) before and after rehabilitation. Electrocardiographic testing was performed either in the hospital during visits (12-lead ECG recording), or measurements were collected at home during bicycle training through transtelephonic 1-lead ECG recording (Card-Guard 2206, Card Guard Scientific Survival Ltd, Rehovot, Israel) or during home visits the by nurse through 12-lead ECG recording (Card-Guard 7100, Scientific Survival Ltd).

All participants in the HBCR group were supervised by a medical doctor and teleassisted at home daily by a nurse and a physical thera-

pist by video conference. The participants were given instructions on their medications and directions to the respective emergency department in case of an emergency. All drugs for routine therapy and an emergency kit (antibiotics, anti-inflammatory drugs, sedatives, diuretics, beta-blockers, and general medicaments) were supplied to each participant. A DVD illustrating the correct way to perform callisthenic exercises also was provided. Furthermore, a 1-lead ECG recorder and a computer notebook with mobile broadband capabilities (which allowed point-multipoint video and audio transmissions simultaneously) were provided to each participant. An electronic health record was prepared for each patient, and the patient's general practitioner was informed.

Table 3.
Clinical and Functional Characteristics of the Participants at Baseline[a]

Characteristic	In-Hospital Rehabilitation (n=100)	Home-Based Rehabilitation (n=100)	*P*
Age (y), $\bar{X}$ (SD)	63 (11)	63 (12)	ns
Male (n)	89	86	ns
CABG (n)	61	57	ns
Valve (n)	26	36	ns
CABG+valve (n)	6	5	ns
Plastic surgery on valve (n)	7	2	ns
EuroSCORE, $\bar{X}$ (SD)	3.78 (1.7)	3.95 (2.5)	ns
COPD (n)	4	2	ns
Renal insufficiency (n)	2	2	ns
Diabetes (n)	10	16	ns
Body weight (kg), $\bar{X}$ (SD)	62 (5)	64 (8)	ns
LVEF (%), $\bar{X}$ (SD)	56.2 (7.3)	55.7 (7.7)	ns
6MWT score (m), $\bar{X}$ (SD)	354 (102)	334 (90)	ns
Hemoglobin (mg/dL), $\bar{X}$ (SD)	11 (1.7)	10.2 (1.3)	.001
Cholesterol (mg/dL), $\bar{X}$ (SD)	145.9 (37)	155.7 (33)	ns
Triglycerides (mg/dL), $\bar{X}$ (SD)	123.3 (43.3)	116.6 (39)	ns

[a] CABG=coronary artery bypass graft, COPD=chronic obstructive pulmonary disease, LVEF=left ventricular ejection fraction, 6MWT=Six-Minute Walk Test, ns=not significant. EuroSCORE value represents a score for the prediction of early mortality in patients after cardiac surgery in Europe on the basis of 17 objective risk factors: 9 patient-related factors, 4 derived from the patient's preoperative cardiac status, and 4 dependent on the timing and nature of the operation performed. The system is additive and identifies 3 different categories of patients: low risk=0–2, medium risk=3–5, and high risk≥6. Baseline differences between the 2 groups were analyzed by chi-square test for discrete variables, by the Student *t* test for normally distributed continuous variable, and by the Mann-Whitney test for non–normally distributed continuous variables.

Video conference rehabilitation sessions directed by a nurse or a therapist were provided every morning and afternoon (Fig. 1). We are currently using a multiple platform video conference that can follow multiple patients simultaneously, mimicking the in-hospital program. We can follow up to 8 patients at each rehabilitation session. The operator of telemedicine rehabilitation views on the monitor a mosaic composed of a video of each patient participating in the session, but the interaction is one to one. Conversely, the patient views only the operator. It is possible to allow direct communication with the individual patient during the rehabilitation session and shift from one to another. The platform allows the management of video signal in full screen mode (ie, turning off the microphone and displaying a full screen video).

All training exercise sessions (Tab. 1) were supervised at the participant's home by the physical therapist the day after discharge and once a week. The nurse tutor provided services every 2 weeks at home. During this visit, the nurse performed a 12-lead ECG recording. Rehabilitation sessions (Monday–Friday) lasted approximately 100 minutes at the morning session and 40 minutes at the afternoon session. Saturday sessions consisted of the morning session only. The maximum period of the rehabilitation program was 24 working days (4 weeks). The training included 60 minutes of arm and leg isotonic calisthenic exercises as well as exercises for posture and respiration and techniques for muscle relaxation. These exercises had to be performed once a day in the morning with the help of the DVD. The cycle ergometer exercise was performed twice a day (40 minutes/session) with the help of cardiac telemonitoring through 1-lead ECG recordings. Daily, the nurse tutor contacted the participant by telephone for the collection of his clinical data, confirmation or variation of the therapy, and resolution of possible needs (ie, to dress the surgical wound and adaptation of the daily physical performance). In case of mild complications, the participant was supported by teleassistance or unscheduled home visits performed by either a nurse or physical therapist. In cases of severe complications, the participant had access to a cardiologist or to the emergency department.

During the HBCR program, participants visited the hospital to undergo routine blood tests and clinical examinations (ie, cardiac

Table 4.
Clinical Outcomes and Process Measures Evaluated at the End of the Program[a]

Measure	In-Hospital Rehabilitation (n=100)	Home-Based Rehabilitation (n=100)	*P*
LVEF (%), $\bar{X}$ (95% CI)	56.3 (46.8–65.8)	56.9 (47.2–63.6)	ns
6MWT score (m), $\bar{X}$ (95% CI)	442 (345–539)	449 (346–552)	ns
Hemoglobin (mg/dL), $\bar{X}$ (95% CI)	11.4 (1.2)	12.4 (1.2)	.001
Time from surgical intervention to rehabilitation (d), $\bar{X}$ (95% CI)	9.8 (7.8–11.8)	7.9 (5.8–9.0)	.01
Rehabilitative period (d), $\bar{X}$ (95% CI)	23 (22–24)	22 (21–23)	ns
Total duration of rehabilitative sessions (min), $\bar{X}$ (95% CI)	891 (800–982)	984 (914–1,054)	ns
Patients with antiplatelet/anticoagulant at discharge (%)	98	100	ns
Patients with statins at discharge (%)	70	98	.01
12-lead ECG/patient (n), $\bar{X}$ (95% CI)	5.2 (4.7–5.7)	4.1 (3.8–4.5)	.02
Echocardiograms/patient (n), $\bar{X}$ (95% CI)	1.6 (1.4–1.8)	3.2 (3.0–3.4)	.001
Chest radiographs/patient (n), $\bar{X}$ (95% CI)	1.3 (1.2–1.4)	1.2 (1.1–1.3)	.05
Blood withdrawings/patient (n), $\bar{X}$ (95% CI)	7.1 (6.6–7.7)	5.6 (5.2–6.1)	.001

[a] CABG=coronary artery bypass graft, COPD=chronic obstructive pulmonary disease, LVEF=left ventricular ejection fraction, 6MWT=Six-Minute Walk Test, 95% CI=95% confidence interval, ECG=electrocardiogram, ns=not significant. Data are reported as mean (95% CI) or percentage.

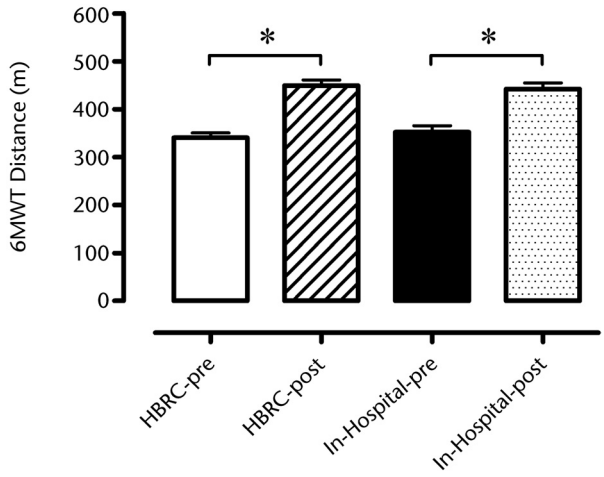

Figure 2.
Participants in the home-based cardiac rehabilitation (HBCR) and in-hospital rehabilitation groups each made significant gains in Six-Minute Walk Test (6MWT) distance following their respective rehabilitation intervention; pre=before intervention, post=after intervention. No evidence of time × group interaction was found. Asterisk indicates $P<.001$.

echo-color Doppler and 6MWT). The final visit to the hospital also included the evaluation of maximal exercise capacity by a bicycle graded symptom-limited exercise test (25 W increased every 3 minutes). At the end of the HBCR program, participants filled in a general questionnaire (Appendix) indicating their satisfaction with the program.[16]

Data Analysis

Data are expressed as number, percentage or mean (standard deviation), and mean (95% confidence interval [95% CI]) where indicated. The differences between the 2 groups were analyzed by the chi-square test for discrete variables, by the Student *t* test for normally distributed continuous variable, and by the Mann-Whitney test for non-normally distributed continuous variables using Prism GraphPad version 4 software (GraphPad Software Inc, La Jolla, California).

The SAS/STAT Logistic program (SAS Institute Inc, Cary, North Carolina) was used to evaluate the analysis of variance (ANOVA) for repeated measures. The ANOVA model was constructed to analyze the effect of time, group, and time × group interaction for the 6MWT, LVEF, and hemoglobin measurements obtained at entry and at the end of the rehabilitation program. Post hoc tests were used to compare means when a significant F ratio of the main effects was found in ANOVA model. The *P* value was considered significant if $<.05$.

Results

Data from all participants in the HBCR and in-hospital groups were

subjected to statistical analysis. Table 3 shows the clinical and functional participants' characteristics at time of enrollment in the 2 groups. No significant baseline differences in the participants' characteristics were found except for hemoglobin level, which was higher in the in-hospital group ($P<.001$).

During the program, a total of 3,042 calls were made. Ninety-nine percent of the calls were scheduled by the nurse tutor. Only 1% of calls were requested by the participant. The mean (standard deviation) numbers of home care visits made by nurse, physical therapist, and cardiologists were 1.6±1.0, 2.5±1.0, and 0.2±0.4 visits/patient, respectively.

The outcomes and clinical measures of the 2 groups are described in Table 4. Length of rehabilitative period was similar in the 2 groups (Tab. 4). However, the number of days from the surgical intervention to rehabilitation were significantly higher in the in-hospital rehabilitative setting ($P<.01$, Tab. 4).

Comparing data at entry and discharge from the program in the 2 groups, we found that both groups increased LVEF without significant differences within groups ($F=3.73$, P=nonsignificant). On the contrary, a significant increase in hemoglobin concentration, which was more evident in the HBCR group, was found at the end of the program ($F=59.36$, $P<.001$). Participants in the HBCR group performed the exercise programs for a mean (SD) total time of 983.9 (358.1) minutes compared with 891.0 (464.4) minutes for the in-hospital group (P=nonsignificant) (Tab. 4). In particular, participants at home spent more time on a cycloergometer (645.6 [278.1] minutes, 16.9 [6.9] sessions/participant) with respect to rehabilitative sessions (338.6 [137.6] minutes, 21.5 [9.3] sessions/participant).

Both groups increased their 6MWT scores ($F=159.34$, $P<.001$, Tab. 4, Fig. 2). The HBCR group improved by +109.3 m (95% CI=85.6–133.0), and the in-hospital group improved by +89.1 m (95% CI=69.1–109.1). These increases were statistically nonsignificant, and no within-group differences were found ($F=0.024$, P=nonsignificant). At the end of the program, the graded symptom-limited exercise test accounting for maximal exercise capacity in the HBCR group was similar to that of the in-hospital group (107.4 [3.7] W versus 100.8 [4] W, respectively).

The mean numbers of 12-lead ECGs per participant, chest radiographs per participant, and blood withdrawings per participant were significantly fewer in the HBCR group ($P<.02$, $P<.001$, and $P<.05$, respectively) than in the in-hospital group (Tab. 4). On the contrary, a higher mean number of echocardiographs per participant was performed in the HBCR group ($P<.001$).

The percentage of participants with coronary artery disease under antiplatelet or anticoagulant therapy at discharge was 100% in the HBCR group and 98% in the in-hospital group (Tab. 3); participants using statins at discharge, an obligatory therapy for patients with coronary artery disease, was 94% in the HBCR group and 70% in the in-hospital group ($P<.01$) (Tab. 4).

Clinical Events

No statistically significant differences in clinical events, evaluated by chi-square test for discrete variables, were observed between the 2 groups. During the HBCR period, complications were documented in 19 participants due to the following issues: pericardial effusion (n=4); atrial tachyarrhythmia (n=9), stroke (n=1), thrombosis (n=1), wound infection (n=1), congestive heart failure decompensation (n=1), atrial fibrillation (n=1), and psychiatric cause (n=1). Four participants were sent to the emergency department. No deaths occurred. Only 1 participant dropped out of the study for personal reasons. The global satisfaction of the HBCR group was reported as "very much high" by 80% of the participants, "high" by 12% of the participants, "medium" by 4% of the participants, and "low" by 4% of the participants.

In the in-hospital group, clinical events were reported in 18 participants who required hospitalization due to atrial tachyarrhythmia (n=11), infection complications (n=3), pericardial effusion (n=2), or dehiscence of the wound (n=2). Seven participants prematurely interrupted the program, and 3 participants dropped out for personal reasons. No deaths occurred in this group as well.

Discussion

At the international level, guidelines state that all patients who undergo cardiac surgery should participate in a cardiac rehabilitation program. However, because of organization and cost problems, in-hospital rehabilitation is reserved for patients who are very ill. Although many patients at low to medium risk could be rehabilitated at home, HBCR remains a very small service compared with the number of patients who can take advantage of it. This study represents the first experience of a home-based rehabilitation program monitored by telemedicine in a homogeneous group of patients at low to medium (noncomplicated) risk who underwent cardiac surgery and comparing exercise capacity with a conventional in-hospital rehabilitation program. In our previous study,[16] a feasibility study of 47 patients, we gave a detailed description of the service and of the first release of the telemedicine platform in these patients, and the results of

the program were not validated. The present study was a quasi-experimental study performed on 100 patients at home with respect to a comparative in-hospital group; a different technology (video conference during rehabilitation sessions) was provided to help physical therapists to follow up on patients at home in real time or later (store and forward system), and results on validation of the program are presented.

In contrast to the present study, Dalleck et al[6] included in their rehabilitation program patients with different types of cardiac conditions (postcardiac surgery, acute myocardial infarction, and percutaneous transluminal coronary angioplasty) and with a different incidence of events in the first period after surgery. They compared changes in risk factors for cardiovascular disease in a conventional rehabilitation outpatient program toward rehabilitation performed in a telemedicine center, located 240 km far from the conventional cardiac rehabilitation center. The 2 studies are similar in the technology used but completely different regarding the modality used to deliver the service: in the telemedicine rural center,[6] there was a junior exercise physiologist, whereas in the current study, a physical therapist and a nurse were present in hospital as pivotal people for telesupport and telemonitoring of the program and for assisting patients at their home.

In the study by Ades et al,[9] patients were recruited not only after coronary artery bypass graft but also after acute myocardial infarction and percutaneous transluminal coronary angioplasty. That study compared home rehabilitation and outpatient service of cardiac rehabilitation, whereas our study compared home rehabilitation and in-hospital rehabilitation. An important difference in technology support also was found between the 2 studies in that Ades and colleagues used direct voice contact but did not use a video conference.

Our study showed that HBCR is feasible and yields similar outcomes for the majority of patients. The application of information and communication technology facilitated implementation of the HBCR program, and the use of telemedicine allowed a safer approach to the program. There was a selection bias because patients could decide whether to enter the study (ie, to undergo HBCR or usual in-hospital rehabilitation) and intervention could not be randomized to individual patients. Although the percentage of patients who had chosen the home-based model is relatively low, the data are in agreement with the findings of a previous study.[19] This low rate of enrollment was mainly related to patients' fear of clinical complications to be managed at home by relatives during convalescence. This observation highlights the role that structured assessments and sharing of patient information in the in-hospital setting have in promoting favorable patient outcomes after discharge.[20]

Because the patients came only from one cardiac surgery center, it is difficult to transfer our results to the general population. The participation of a greater number of patients, facilitated by telemedicine, obviously could lead to events reduction (eg, secondary prevention).

We have found that the number of days from the surgical intervention to rehabilitation was significantly higher in the in-hospital rehabilitative setting. The most plausible explanation for the different times to rehabilitation between the 2 groups could be that hospital admission requires hospital patient turnover, such as bed availability. However, it also could reflect a different medical or functional recovery of the patients. The home-based program was effective and comparable to the conventional inpatient rehabilitative approach, providing similar improvement in exercise capacity and quality of life as that found in the study by Ades and colleagues.[9]

Supervision and education of HBCR by the physical therapist provided an important validation of the HBCR concept. Indeed, the physical therapist has unique skills compared with a nurse or exercise physiologist in this setting and, with the cardiologists' supervision, is fundamental in providing valuable guidance both in the inpatient setting and in a home care setting (as shown by HBCR). The physical therapist can promote favorable patient outcomes after discharge by structured assessments and sharing of patient information during the in-hospital or home setting. The physical therapist, embracing the role of advocate for the cardiac rehabilitation, can educate patients on the value of participating in this important lifestyle intervention and ensuring that the patients' adherence to recommendations may lower the risk of readmission. Moreover, supervision by health staff using telemedicine allows the performance of HBCR patients at low to medium risk without compromising the high medical safety that exists in the in-hospital environment. Similar results were reported by other authors.[21,22] In particular, the use of supervised ECG and video conference capabilities allowed objective parameters to be monitored during the HBCR. This approach also provided accurate data on exercise time and bypassed reliance on self-reported exercise time, which may lead to an overestimation or underestimation of exercise.[23]

A therapeutic approach was followed in this study in agreement with the coronary prevention guidelines.[24] In particular, the use of antiplatelet or anticoagulant therapy for reducing cardiovascular events has been shown to be equally dispensed in both settings.

The number of clinical events was not significantly different between the 2 programs: acute intervention was necessary only in a few cases at home, whereas events arising during in-hospital rehabilitation were directly managed in the hospital. The study was not designed for cost evaluation, but we can consider that the HBCR program, with equivalent efficacy, might result in a cost-benefit to the health care system (Lombardy region) because the mean (standard deviation) fee per patient in the program is €2,972± €1,000.8 (US $3,945±$1,328) in HBCR compared with €7,079.6± €2,228.7 (US $9,396±$2,958) in in-hospital rehabilitation.

A well-designed and surveyed program, both for medical treatment and exercise training, could become an attractive method to restore functional capacity in selected patients after cardiac surgery. The good results of this study are corroborated by the good results of a satisfaction questionnaire.

Limitations

Although patients self-selected into the groups are representative of a particular subgroup of patients who underwent cardiac surgery (with EuroSCORE less than 5, without any complication after surgery, and meeting all of the inclusion criteria), the results could be applied to a broader population with the same inclusion criteria. This study did not specifically take into consideration (eg, asking the patients via a questionnaire) whether there were intrinsic factors to the patients who chose HBCR that contributed to their outcomes, but we believe that many patients, with those inclusion criteria, could benefit from a HBCR program, particularly if other possibilities for cardiac rehabilitation do not exist in their location. Further studies should analyze whether it is possible to reach similar outcomes. Because of its observational and retrospective nature, this quasi-experimental study could not apply an intention-to-treat analysis. During the exercise sessions, a greater proportion on the cycle performed by the HBCR group could have influenced the results. The inpatient satisfaction was not measured by the same questionnaire used for HBCR.

Conclusions

The HBCR program was feasible, safe, and comparable to the conventional in-hospital rehabilitation approach, indicating that rehabilitation following cardiac surgery can be implemented effectively at home when programmed with an integrated telemedicine service. In the Lombardy region, a great number of patients who have undergone cardiac surgery without complications could participate in HBCR programs using telemedicine as an alternative to in-hospital rehabilitation.

The choice of participating in HBCR is expected to provide more options for patients at low to medium risk. In an era of cost-containment in health care, the challenge to cardiac rehabilitation specialists will be to encourage home cardiac rehabilitation using a new integrated care model with the help of information communication technologies, appropriately identifying who could be safely allocated. Indeed, although patients with severe conditions require a more conventional in-hospital cardiac rehabilitation setting, patients at low to medium risk appear to be more likely triaged to supervised home programs.

The possibility to adopt the same program in different settings justifies future randomized controlled studies to explore the real effectiveness of telemedicine-based cardiac rehabilitation programs. Mixed models could take into consideration the management of patients with post-surgery complications, with half of the conventional period of rehabilitation (ie, first 10 days) in the hospital and continuing at home for a similar period of time.

Dr Scalvini and Dr Giordano provided concept/idea/research design. Dr Scalvini and Dr Comini provided writing. Dr Zanelli, Dr Troise, and Dr Febo provided data collection. Dr Comini and Dr Dalla Tomba provided data analysis. Dr Scalvini provided project management and fund procurement. Dr Scalvini, Dr Zanelli, Dr Dalla Tomba, Dr Troise, Dr Febo, and Dr Giordano provided study participants. Dr Comini provided institutional liaisons. Dr Scalvini, Dr Zanelli, Dr Comini, Dr Dalla Tomba, Dr Troise, and Dr Giordano provided consultation (including review of manuscript before submission). The authors thank Mrs Doriana Baratti and Mr Giuliano Assoni for their excellent professional assistance and Dr Margherita Penna for providing pharmacy assistance. The authors are indebted to Dr Alessandro Bettini, medical writer, for the English revision of the manuscript.

The study was approved by deliberation VIII/002471 (May 11, 2006) and by the Scientific and Technical Committee (CTS June 15, 2006) of Fondazione Salvatore Maugeri and followed the principles stated in the Declaration of Helsinki.

The current program is the result of the authors' participation in the CRITERIA Project, a joint project of 2 structures: Fondazione Salvatore Maugeri IRCCS and Centro Cardiologico della Fondazione Monzino IRCCS. This project, under the scientific responsibility of Dr Maurizio Marzegalli (Cardiological Department, San Carlo Hospital, Milan, Italy), was financed by the Italian Health Ministry (Programma Di Ricerca ex art.12, lett.b, D.Lgs. #502/92) and by the Lombardy Region Decree of the General Director (Health General Directorate #15882, September 29, 2003) and coordinated by the Lombardy Region Health and Family General Directorates.

DOI: 10.2522/ptj.20120212

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Appendix.

Questionnaire of Satisfaction for the Home-Based Cardiac Rehabilitation Program

Question 1: How do you judge the system overall?

Very Satisfying Quite Satisfying Fairly Satisfying Poorly Satisfying Not Satisfying At All

Question 2: Was it easy to use the telecardiography/pulse oximeter system?

Very Complicated Quite Complicated Complicated Quite Easy Very Easy

Question 3: Did you experience difficulties in contacting the service?

Very Frequently Frequently Sometimes Rarely Never

Question 4: How was the relationship with your nurse tutor?

Optimal Good Satisfying Discontinuous No Relationship

Question 5: Were the indications of the nurse tutor clear?

Very Clear Quite Clear Fairly Clear Poorly Clear Not At All

Question 6: Are you satisfied with the support of the system in dealing with acute crises?

Completely Satisfied Quite Satisfied Neither Satisfied nor Unsatisfied Quite Unsatisfied Totally Unsatisfied

Question 7: Do you feel more secure since having access to the service?

Very Secure Much Secure Quite Secure Poorly Secure Not At All

Question 8: How frequently do you contact your family doctor since you have had access to the service?

Much More Frequently More Frequently As Before Less Frequently Much Less Frequently

Question 9: Do you believe the access to the system improved your life?

Very Much Much Fairly Poorly Not At All

Question 10: Did the access to the service help your family or the people you live with?

Very Much Much Fairly Poorly Not At All