Effect of Cardiac Rehabilitation on Prevention of Implantable 
Cardioverter Defibrillator therapy in Patients with 
Reduced Left Ventricular Ejection Fraction

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Running Title: USEFULNESS OF CARDIAC REHABILITATION FOR ICD

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Abstract

**Purpose:** Appropriate and inappropriate shocks lead to high mortality risk for patients with implantable cardioverter-defibrillators (ICD) or cardiac resynchronization therapy defibrillator (CRT-D). Cardiac rehabilitation (CR) is an established therapy for patients with ischemic heart disease and/or congestive heart failure. However, it is unclear whether CR could reduce device therapies. The purpose of this study was to investigate whether CR reduce device therapies and mortality in patients with severe cardiac dysfunction using ICD/CRT-D.

**Methods:** Among 390 patients who were implanted with ICD or CRT-D from 1998 to 2015, we investigated 222 patients (178 men and 44 female) with a low ejection fraction (EF) less than 45%. We divided the study cohort into two groups, CR group (N=70) and non-CR group (N=152). We compared the baseline clinical characteristics between two groups. Furthermore, we compared the numbers of all device therapy, appropriate therapy, inappropriate therapy, and mortality for one year after ICD/CRT-D implantation.

**Findings and conclusions:** There was no significant difference between CR group and non-CR group in the baseline clinical characteristics. (Age; 68.5 years versus 66.2 years, P=0.16, EF; 27.9 % versus 29.7 %, P=0.14). With Kaplan-Meier method, CR group was less all device therapy events and inappropriate therapy events as compared with non-CR group. (all device therapy events; P=0.01, inappropriate therapy events; P=0.03). Appropriate therapy events and
mortality were not significantly different between the two groups. (appropriate therapy events; 5.7% versus 13.1%, P=0.09, mortality; 11.4% versus 17.0%, P=0.28).

CR may have beneficial effects on the prevention of therapy events, especially inappropriate therapy events in patients with ICD/CRT-D.

257 words

**Key words:** Cardiac rehabilitation, ICD, therapy event, inappropriate therapy event.
Background

Implantable cardioverter-defibrillators (ICDs) have been shown to be efficacious against sudden cardiac death (SCD) in patients with ventricular fibrillation (VF) or ventricular tachycardia (VT). The MADIT II trial showed the efficacy of ICD therapy in patients with ischemic heart failure, while the SCD-HeFT trial showed that patients with a low left ventricular ejection fraction (LVEF) benefitted from ICD therapy. Recently, the indications for ICD implantation have expanded. On the other hand, one study showed that appropriate or inappropriate shocks are one of the risk factors for prognosis. Furthermore, sub-analysis of the data from MADIT-II and SCD-HeFT showed a two-fold increased risk of death in patients who experienced inappropriate ICD shocks. New strategies changing the detection time and zone for ventricular arrhythmia have been proposed to reduce inappropriate shocks. However, these new strategies could not completely reduce ICD shocks and we have to try avoiding any shock.

Cardiac rehabilitation (CR) is an established therapy for patients with ischemic heart disease and/or congestive heart failure, with various benefits such as exercise ability, psychological functioning and prognosis. However, it is unclear whether CR could reduce device therapies in patients with ICD/CRT-D. Therefore, we investigated the effect of CR in patients with ICD/CRT-D who had a low EF.

Methods
Patients and study protocol

This study was a retrospective analysis. Among 390 patients with ICD or CRT-D between 1998 and 2015 at our hospital, 222 patients (57%) had a low LVEF of less than 45% by echocardiography which was performed before implantation. We divided these patients into 2 groups: the CR group (n = 70) and the non-CR group (n = 152). The CR group was defined as the patients who started CR immediately before or after ICD/CRT-D implantation, and the non-CR group was defined as the patients who did not undergo CR during the follow-up period. If patients received upgrade from pacemakers to ICDs or CRT-Ds, we defined the upgrade day as the starting date of the follow-up period. The follow-up period was 1 year after implantation of device. We defined that primary endpoint was device therapy. We excluded patients who have the following criteria: (1) CR was not started immediately before and/or after device implantation, (2) patients who did not visit after hospital discharge, and (3) history of cardiac surgery within 1 month after implantation. This study was approved by the institutional committee at our institution.

Measurements

We evaluated the ICD therapies after implantation using the device reports. The assessment of shock therapy and antitachycardia pacing (ATP) therapy was also determined using the device reports. Appropriate therapy events were defined that ATP and shock therapies delivered for
VT and VF. Inappropriate therapy events were defined that ATP and shock therapies delivered for tachycardia including atrial fibrillation (AF), supraventricular tachycardias (SVTs), sinus tachycardia and device error such as oversensing and lead dislodgement. All device therapy events were defined as therapies including appropriate therapy event and inappropriate therapy event. If one patient experience both appropriate therapy and inappropriate therapy during the follow-up period, we count the two therapies separately. If one patient experience many time of appropriate therapy or inappropriate therapy during the follow-up period, we count the events one. We examined mortality with summary and telephone contact for patient’s family. Mortality was divided into cardiac mortality and non-cardiac mortality. And we examined the numbers of all-cause mortality and cardiac mortality. LVEF was assessed by biplane Simpson’s equation using the apical 4-chamber and 2-chamber views. Blood samples were analyzed before device implantation.

**Cardiac Rehabilitation**

The CR program was started in the early phase after device implantation. Patients underwent CR a few times a week for 2-6 months. CR was consisted with gymnastic and a 30 min supervised aerobic exercise using a bicycle ergometer. The prescribed intensity was determined individually at 40% - 60% of HR reserve (Karvonen’s equation, k=0.4–0.6), at an anaerobic threshold level obtained by cardiopulmonary exercise (CPX) or at level 12–13 of
Borg Scale for Ratings of Perceived Exertion (RPE) according to the Japanese Circulation Society guidelines.19

Exercise capacity was measured by CPX. If patients were physically exhausted or developed severe dyspnea or dizziness during CPX, we discontinued exercise. Peak oxygen consumption (peak VO$_2$) was decided to consider the results at the time of maximum exercise load. We measured the rest heart rate (HR) and maximal HR using continuous electrocardiographic the follow-up period, CPX was performed at the beginning of CR (Pre-CR) and at the end of CR (post-CR). Exercise capacity was evaluated using these two CPX data. The programmed rate zone during exercise was determined for each patient by the physicians. We decided the exercise intensity to the individual patient level of CR. If patients could not try CPX for low level of exercise capacity, the exercise intensity was decided for each individual patient by the cardiologists.

ICD/CRT-D Implantation and Definitions

We decided to implant ICD or CRT-D with reference to the ACC/AHA/HRS guidelines for device-based therapy of cardiac rhythm abnormalities and the guidelines for non-pharmacotherapy of cardiac arrhythmias published by the Japanese circulation society.20-21

When we implanted CRT-D, LV lead was implanted transvenously via the coronary sinus tributaries and placed preferably to stimulate the lateral or postero-lateral LV wall.
We decided the device programming as following. If we confirmed ventricular arrhythmia, we set the rate zone after considering the cycle length of tachycardia. If we could not confirm cycle length of ventricular arrhythmia in patients with implantation for primary prevention, rate zone and the therapies were programmed according to the attending physician’s discretion.

The standard programming was following, VT zone was defined as the ventricular rate up to 150 beats / min and a fast VT was defined as the ventricular rate up to 188 beats / min. And VF zone was defined as the ventricular rate up to 250 beats / min. The ICDs were programmed as follows: VT monitor zone was programmed in all patients (150 to 188 beats / min). Any VT faster than 188 beats / min was attempted to be terminated with ATP or device shocks. Any VF faster than 250 beats / min was directly attempted to be terminated by device shocks. The number of intervals to detect programming rate zone was defined as 18 of 24 intervals. ATP was attempted with 8 pulses at 88 % of the measured cycle length with a 10-ms decrement between bursts. The initial device shock was attempted at the defibrillation threshold plus at least 10 J. The remaining device shock should be maximal energy shocks.

**Statistical Analysis**

The data were presented as the mean ± standard deviation. Categorical data were summarized as frequencies and percentages. Differences in baseline characteristics between CR group and non-CR group were analyzed using unpaired Student’s t tests. The Kaplan–Meier method was
used to analyze the time to the recurrence of the therapy event and mortality during the
follow-up period, and compared using the log-rank test. P values < 0.05 were considered
statistically significant. The authors had full access to and take full responsibility for the
integrity of the data. All authors have read and agree to the manuscript as written.

Results

Patient characteristics

We investigated and analyzed a total of 222 patients who received ICD or CRT-D implantations.
There were 178 men and 44 women, and their mean age was 67 ± 11 years. The baseline
characteristics of the patients are summarized in Table 1. Among these patients, 70 patients
(31%) performed CR and 152 patients (69%) did not perform CR. Patients in CR group
performed CR for mean 115.6 ± 15.3 days. There was no statistically significant difference in
baseline age, sex, body mass index, LVEF and primary prevention. There was no statistically
significant difference with single/dual chamber between 2 groups, however, patients in CR
group presented more frequently with CRT-D than those in non-CR group (59% versus 43%,
P=0.03). There was no statistically significant difference in baseline underlying disease
between 2 groups. Furthermore, there was no significant difference with history of AF
between CR group and non-CR group (32% versus 34%). There was no statistically
significant difference in the baseline medications except for diuretics between 2 groups (90 %
versus 78 %, P = 0.03).

Comparison of mortality and therapy events between 2 groups

Table 2 showed the comparison of mortality and therapy events between 2 groups. During the 12 months follow-up, 8 (11.4%) in CR group and 26 (17.0%) in non-CR group had all-cause mortality (P = 0.28), and 5 (7.1%) in CR group and 15 (9.8%) in non-CR group had cardiac mortality (P = 0.49).

There was a significant difference with all device therapy events between CR group and non-CR group (7.1% versus 20.2%, P=0.01). During the 12 months follow-up, 4 (5.7%) in CR group and 20 (13.1%) in non-CR group experienced first appropriate ICD therapy (P = 0.09). And inappropriate therapy event was significantly fewer with CR group as compared to those with non-CR group (1.4% versus 9.2%, P=0.03).

Figure 1 (A) showed the Kaplan-Meier estimates of the percentage of patients remaining free from all device therapy (n = 222) during 12 months follow-up period. The event free rate was 93% in CR group and was 80% in non-CR group during the follow-up period. The risk reduction of CR group was 13% (log rank P=0.01).

Figure 1 (B) showed the Kaplan–Meier estimates of the percentage of patients remaining free from appropriate therapy (n = 222) during 12 months follow-up period. In CR group, event free rate was 94 % during the follow-up period. In non-CR group, event free rate was 87 %
during the follow-up period. Risk reduction of CR group was 7% (log rank P=0.09).

Figure 1 (C) showed the Kaplan–Meier estimates of the percentage of patients remaining free from inappropriate therapy (n = 222) during 12 months follow-up period. In CR group, event free rate was 99% during the follow-up period. In non-CR group, event free rate was 91% during the follow-up period. Risk reduction of CR group was 8% (log rank P=0.03).

Figure 2 (A) showed the Kaplan–Meier estimates of the percentage of patients remaining free from all-cause mortality (n = 222) during 12 months follow-up period. The event free rate was 89% in CR group and 83% in non-CR group during the follow-up period (log rank P=0.28).

Figure 2 (B) showed the Kaplan-Meier estimates of the percentage of patients remaining free from cardiac mortality (n = 222) during 12 months follow-up period. The event free rate was 93% in CR group and 90% in non-CR group during the follow-up period (log rank P=0.49).

Table 3 showed the contents of inappropriate therapy events. Supraventricular tachycardia (SVT) was defined AF, atrial flutter and atrial tachycardia. In CR group, 1 patient experienced inappropriate therapy by sinus tachycardia. In non-CR group, 4 patients experienced inappropriate therapy by sinus tachycardia, 8 by SVT, and 2 by oversensing. Furthermore, we investigated the cause of inappropriate therapy in non-CR group. About content of SVT, 7 patients were AF (CRT-D 4 patients, ICD 1 patient) and 1 patient was suspected atrial tachycardia (CRT-D 1 patient, ICD 0 patient). Four patients had inappropriate therapy due to
sinus tachycardia (CRT-D 0 patient, ICD 4 patients) and 2 patients had inappropriate therapy due to oversensing (CRT-D 1 patient, ICD 1 patient).

**Change in baseline characteristics and CPX data pre- and post-CR**

Table 4 showed the changes in baseline characteristics pre- and post-CR in CR group. Twenty two patients performed CPX pre- and post- CR. There was no significant difference with rest HR, peak HR and RPE between 2 groups. The peak VO₂ with post-CR was significantly higher as compare to those with pre-CR (14.0 versus 12.9, P=0.005).

**Discussion**

**Main findings**

The main finding of this study is that number of inappropriate therapy events in CR group was fewer than those in non-CR group for 1 year follow-up period. However, the number of appropriate therapy events, cardiac mortality, and all-cause mortality in CR group were as many as those in non-CR group. Furthermore, patients in CR group improved peak VO₂ after CPX.

The baseline characteristics including the proportion of CRT implantation, and diuretic use with CR group were more frequently as compared to those in non-CR group.

**Association between CR and ICD/CRT-D**

Some studies had reported that patients with chronic heart disease or ischemic heart disease improved prognosis by undergoing CR. 14-18
Recently, some papers reported that CR did not increase the risk of inappropriate shocks.\textsuperscript{22-25}

Our study indicated that CR in patient with ICD/CRT-D did not induce the inappropriate therapy events. Furthermore, CR reduced the number of shock for patients. We believe that the improvement of exercise capacity by CR may have led to these results.

In our study, all inappropriate therapy events were almost related to sinus tachycardia and arrhythmia (Table 3). Inappropriate therapy events such as device errors including oversensing, were confirmed only two patients in this study. Therefore, rate control strategy might lead to reduce the incidence of inappropriate therapy. In general, we attempted the rate control strategy using beta-blockers and antiarrhythmic drugs such as amiodarone and sotalol. Both medication and CR could suppress HR of patients. If patients improved their exercise capacity, the increase of HR on exercise would be relatively smaller as compared to those with patients without improvement of exercise capacity.\textsuperscript{26} Improvement of exercise capacity may suppress an elevation of HR, and may protect patients from inappropriate therapy events.

**Association between inappropriate therapy and mortality**

Our study indicated that CR reduced number of therapy events, however CR could not reduce number of all cause death. Sub analysis of MADIT II supported to our result. Inappropriate shock associated with the risk of all causes mortality, however inappropriate therapy including shock and ATP didn’t make significant difference about mortality. And the study suggested
that inappropriate ATP might not influence mortality.\textsuperscript{8} According to the theory, our result was consistent that CR reduced inappropriate therapy events but didn’t reduce mortality, because we counted the number of inappropriate therapy including shock and ATP.

ADVANCE\textsuperscript{III} trial also supported to our result. The trial indicated that programming long detection intervals reduced the number of inappropriate shocks, but didn’t reduce mortality.\textsuperscript{10-11} We speculated that follow-up period was important to clear the association between inappropriate therapy and mortality. In MADIT\textsuperscript{II} trial, patients were followed for median 20 months, and for median 45 months in SCD-HeFT trial.\textsuperscript{8-9} It was only 12 months in our study. If follow-up period was longer in our study, a significant association might have been found between inappropriate therapy and mortality.

\textbf{Limitation}

This study has some limitations. First, we instructed CPX to the patients in the CR group only. We did not investigate exercise capacity and maximum oxygen intake in patients with non-CR group. Furthermore, we used CPX only to investigate the effect of CR. CPX needed some exercise capacity, and if patients could not undergo CPX because of their low exercise capacity, we did not investigate the effect of CR. Second, this study had a small number of patients. These results had to be interpreted with caution. However we believe that the statistical methodology was rigorous, and CR and inappropriate therapy were well validated, which
substantiates the main conclusions. Third, some patients were decided cycle length of VT/VF
zone and exercise intensity by discretion of each physician. Therefore, it is possible that this
could have led to the setting of inappropriate rate zones, and overwork might have led to
excessive elevation of HR. Study will be better to make the definition of rate zone clear.
Further prospective studies will be required to evaluate the relationship between CR and device
therapies.

**Conclusion**

This study suggested that improvement of exercise capacity by CR might lead to reduce number
of therapy event, especially inappropriate therapy in patients with ICD/CRT-D. Improvement
of exercise capacity might be a main reason for reduction of the number of therapy events.
References


6) Bardy GH, Lee KL, Mark DB, et al for the Sudden Cardiac Death in Heart Failure Trial


**Figure legends**

**Figure 1**

(A) Kaplan–Meier estimates of the percentage of patients remaining free from all device therapy during the follow-up period.

Figure 1 (A) shows the Kaplan-Meier estimates of the percentage of patients remaining free from all device therapy (n = 222). The x-axis shows the duration of follow-up (days) after ICD implantation. The event free rate was 93% in CR group and was 80% in non-CR group during follow-up period. The risk reduction of CR group was 13%.

(B) Kaplan–Meier estimates of the percentage of patients remaining free from appropriate therapy during the follow-up period.

Figure 1 (B) shows the Kaplan–Meier estimates of the percentage of patients remaining free from appropriate therapy (n = 222) during 12 months follow-up period. The x-axis shows the duration of follow-up (days) after ICD implantation. The event free rate was 94% in CR group and was 87% in non-CR group during the follow-up period. Risk reduction of CR group was 7%.

(C) Kaplan–Meier estimates of the percentage of patients remaining free from inappropriate therapy during the follow-up period.

Figure 1 (C) shows the Kaplan–Meier estimates of the percentage of patients remaining free
from inappropriate therapy (n = 222). The x-axis shows the duration of follow-up (days) after ICD implantation. The event free rate was 99% in CR group and was 91% in non-CR group during the follow-up period. Risk reduction of CR group was 8%.

Figure 2

(A) Kaplan–Meier estimates of the percentage of patients remaining free from all-cause mortality during the follow-up period.

Figure 2 (A) shows the Kaplan–Meier estimates of the percentage of patients remaining free from all-cause mortality (n = 222). The x-axis shows the duration of follow-up (days) after ICD implantation. The event free rate was 89% in CR group and 83% in non-CR group during the follow-up period. Risk reduction of CR group was 6%.

(B) Kaplan–Meier estimates of the percentage of patients remaining free from cardiac mortality during the follow-up period.

Figure 2 (B) shows the Kaplan-Meier estimates of the percentage of patients remaining free from cardiac mortality (n = 222). The event free rate was 93% in CR group and 90% in non-CR group during the follow-up period. Risk reduction of CR group was 3%. 

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## Table 1: Comparison of baseline characteristics among 2 groups

<table>
<thead>
<tr>
<th></th>
<th>Total population (n=222)</th>
<th>CR group (n=70)</th>
<th>Non-CR group (n=152)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years: mean ± SD)</td>
<td>67±11</td>
<td>69±11</td>
<td>66±11</td>
<td>0.16</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>178 (80 %)</td>
<td>60 (85 %)</td>
<td>119 (78 %)</td>
<td>0.21</td>
</tr>
<tr>
<td>BMI (kg/m²: mean ± SD)</td>
<td>23±4</td>
<td>22±6</td>
<td>23±5</td>
<td>0.52</td>
</tr>
<tr>
<td>Heart rate at rest (bpm)</td>
<td>74.1</td>
<td>74.1</td>
<td>74.1</td>
<td>0.98</td>
</tr>
<tr>
<td>Systolic/Diastolic BP (mmHg)</td>
<td>111.5/64.5</td>
<td>109.0/63.5</td>
<td>112.6/64.9</td>
<td>0.08/0.36</td>
</tr>
<tr>
<td>LVEF (%: mean ± SD)</td>
<td>29±8</td>
<td>28±7</td>
<td>30±8</td>
<td>0.14</td>
</tr>
<tr>
<td>NYHA III/IV</td>
<td>94 (42 %)</td>
<td>36 (51 %)</td>
<td>58 (38 %)</td>
<td>0.08</td>
</tr>
<tr>
<td>Primary prevention</td>
<td>118 (53 %)</td>
<td>40 (57 %)</td>
<td>78 (51 %)</td>
<td>0.38</td>
</tr>
<tr>
<td><strong>Device</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single chamber</td>
<td>40 (18 %)</td>
<td>10 (14 %)</td>
<td>30 (20 %)</td>
<td>0.33</td>
</tr>
<tr>
<td>Dual chamber</td>
<td>75 (34 %)</td>
<td>19 (27 %)</td>
<td>56 (37 %)</td>
<td>0.13</td>
</tr>
<tr>
<td>CRT</td>
<td>107 (48 %)</td>
<td>41 (59 %)</td>
<td>66 (43 %)</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Underling disease</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>95 (44 %)</td>
<td>30 (44 %)</td>
<td>65 (43 %)</td>
<td>0.98</td>
</tr>
<tr>
<td>Hypertension</td>
<td>123 (55 %)</td>
<td>40 (56 %)</td>
<td>83 (53 %)</td>
<td>0.77</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>82 (37 %)</td>
<td>28 (40 %)</td>
<td>54 (36 %)</td>
<td>0.55</td>
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<tr>
<td>Hyperlipidemia</td>
<td>128 (58 %)</td>
<td>41 (59 %)</td>
<td>87 (57 %)</td>
<td>0.88</td>
</tr>
<tr>
<td>CKD</td>
<td>93 (42 %)</td>
<td>30 (44 %)</td>
<td>63 (41 %)</td>
<td>0.88</td>
</tr>
<tr>
<td>Atrial fibrillation*</td>
<td>72 (32 %)</td>
<td>21 (32 %)</td>
<td>51 (34 %)</td>
<td>0.86</td>
</tr>
<tr>
<td><strong>Medication</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACE-I/ARB</td>
<td>134 (62 %)</td>
<td>44 (64 %)</td>
<td>91 (61 %)</td>
<td>0.76</td>
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<tr>
<td>Beta-blockers</td>
<td>173 (78 %)</td>
<td>58 (83 %)</td>
<td>115 (76 %)</td>
<td>0.28</td>
</tr>
<tr>
<td>Amiodarone/Sotalol</td>
<td>67 (30 %)</td>
<td>18 (26 %)</td>
<td>49 (32 %)</td>
<td>0.35</td>
</tr>
<tr>
<td>Digoxin</td>
<td>14 (6 %)</td>
<td>4 (6 %)</td>
<td>10 (7 %)</td>
<td>0.99</td>
</tr>
<tr>
<td>Diuretics</td>
<td>181 (82 %)</td>
<td>63 (90 %)</td>
<td>118 (78 %)</td>
<td>0.03</td>
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<tr>
<td><strong>Laboratory data (mean ± SD)</strong></td>
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<td></td>
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<tr>
<td>K (mEq/l)</td>
<td>4.2±0.55</td>
<td>4.4±0.54</td>
<td>4.3±0.57</td>
<td>0.22</td>
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<tr>
<td>Creatinine (mg/dl)</td>
<td>1.5±1.7</td>
<td>1.2±1.0</td>
<td>1.6±1.4</td>
<td>0.19</td>
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<tr>
<td>BNP (pg/ml)</td>
<td>713±1080</td>
<td>570±520</td>
<td>794±1292</td>
<td>0.20</td>
</tr>
</tbody>
</table>

CKD; chronic kidney disease, CRT; cardiac resynchronization therapy, LVEF; left ventricular ejection fraction, ACE-I; angiotensin converting-enzyme inhibitors, ARBs; angiotensin receptor blockers, NYHA; New York Heart Association

*Atrial fibrillation: we defined af included paroxysmal, persistent, and chronic.
Table 2

<table>
<thead>
<tr>
<th>Mortality and therapies during follow up period</th>
<th>CR group (70)</th>
<th>non-CR group (152)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause mortality</td>
<td>8 (11.4 %)</td>
<td>26 (17.0 %)</td>
<td>0.28</td>
</tr>
<tr>
<td>Cardiac mortality</td>
<td>5 (7.1 %)</td>
<td>15 (9.8 %)</td>
<td>0.49</td>
</tr>
<tr>
<td>All device therapy events</td>
<td>5 (7.1 %)</td>
<td>31 (20.2 %)</td>
<td>0.01</td>
</tr>
<tr>
<td>Appropriate therapy events</td>
<td>4 (5.7 %)</td>
<td>20 (13.1 %)</td>
<td>0.09</td>
</tr>
<tr>
<td>Inappropriate therapy events</td>
<td>1 (1.4 %)</td>
<td>14 (9.2 %)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 3

<table>
<thead>
<tr>
<th>Contents of inappropriate therapy events</th>
<th>CR group (70)</th>
<th>non-CR group (152)</th>
<th>total population (222)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sinus tachycardia</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>SVT</td>
<td>0</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>oversensing</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>total</td>
<td>1</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

SVT; supraventricular tachycardia

SVT includes atrial fibrillation, atrial flutter and atrial tachycardia.

Table 4

<table>
<thead>
<tr>
<th>Change in characteristics pre- and post- cardiac rehabilitation.</th>
<th>pre-CR (n=22)</th>
<th>post-CR (n=22)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPX data (mean ± SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rest HR (bpm)</td>
<td>75.7 ± 14.1</td>
<td>73.7 ± 7.6</td>
<td>0.45</td>
</tr>
<tr>
<td>Peak HR (bpm)</td>
<td>118.5 ± 16.4</td>
<td>121.2 ± 17.4</td>
<td>0.35</td>
</tr>
<tr>
<td>Peak VO₂ (ml/kg/min)</td>
<td>12.9 ± 3.0</td>
<td>14.0 ± 3.0</td>
<td>0.005</td>
</tr>
<tr>
<td>RPE (leg)</td>
<td>15.0 ± 2.0</td>
<td>15.5 ± 2.3</td>
<td>0.49</td>
</tr>
<tr>
<td>RPE (dyspnea)</td>
<td>16.1 ± 2.4</td>
<td>16.1 ± 3.2</td>
<td>1.00</td>
</tr>
</tbody>
</table>

CPX; cardiopulmonary exercise test, HR; heart rate, Peak VO₂; Peak oxygen consumption, RPE; Borg Scale for Ratings of Perceived Exertion
Figure 1 (A): All device therapy event

Figure 1 (B): Appropriate therapy event
Figure 1 (C): Inappropriate therapy event

Log rank
p=0.03

Figure 2 (A): All-cause mortality

Log rank
p=0.28
Figure 2 (B): Cardiac mortality