Introduction and objectives. Very little information is available on the effect of cardiac rehabilitation programs on long-term survival. The primary aim of this study was to assess the effect of a structured cardiac rehabilitation program on mortality in patients who had suffered acute myocardial infarction. The secondary endpoint was the effect on morbidity.

Patients and method. The study included 180 low-risk male patients aged under 65 years. Patients were randomly assigned to one of 2 groups: 90 entered into a comprehensive cardiac rehabilitation program, and 90 served as a control group. The mean follow-up period was 10 years.

Results. All-cause mortality was significantly lower in the intervention group: the 10-year survival rate was 91.8% in the intervention group compared with 81.7% in the control group (P=.04). There was also a decrease in cardiovascular mortality, though it was not statistically significant: the 10-year survival rate was 91.8% in the intervention group compared with 83.8% in the control group (P=.10). The incidence of non-fatal complications was lower in the intervention group (35.2% vs 63.2%, P=.03), as was the incidence of unstable angina (15.7% vs 33.9%, P=.02) and cardiac heart failure (3.0% vs 14.4%, P=.02), and the need for coronary intervention (8.4% vs 22.9%, P=.02).

Conclusions. The application of a comprehensive cardiac rehabilitation program significantly decreased long-term mortality and morbidity in low-risk patients after acute myocardial infarction.

Key words: Myocardial infarction. Survival. Secondary prevention. Cardiac rehabilitation. Mortality.
ABBREVIATIONS
CV: cardiovascular.
CG: control group.
RG: rehabilitation group.
AMI: acute myocardial infarction.
CRP: cardiac rehabilitation program.

has demonstrated their efficacy in increasing functional capacity,1,3 controlling coronary risk factors,2,4-6 reducing symptoms,7 andcountering psychological deterioration.8,9 They have also been shown to improve cost-efficiency.10,11

Given that ischemic heart disease is a progressive, chronic illness and that low-risk patients are included in CRP, possible beneficial effects of these therapeutic programs on morbidity and mortality require long-term evaluation.

The present study was designed to compare the clinical evolution of 2 groups of patients with AMI: one following our multidisciplinary CRP and the other receiving conventional treatment.

Our principal objective was to analyze and compare incidence of death in both groups at 10-year follow-up; the secondary objective was to analyze complications occurring in the same period.

PATIENTS AND METHOD
Selection of Patients

We enrolled 180 consecutive male patients diagnosed with AMI and admitted to the coronary care unit of our hospital. Enrolments were based on the American Association of Cardiovascular and Pulmonary Rehabilitation inclusion criteria12: age <65 years, low-risk (hospital course without complications, absence of signs of myocardial ischemia, functional capacity >7 metabolic equivalent time [MET], ejection fraction >50%, and absence of severe ventricular arrhythmias).

Patients were excluded on grounds of age and gender because of evidence that very few women are found with infarction and in an age range lower than that described. We set the age limit at 65 years, retirement age, because a high percentage of older patients abandon CRP for a variety of reasons.

All patients gave signed informed consent according to unit procedure and the study was approved by our hospital ethics committee.

The 180 patients were randomized into 2 groups: one followed our cardiac rehabilitation program (RG) and the other, the control group (CG), received conventional treatment and served as a point of reference.

The Hospital Ramón y Cajal CRP13 begins at 2 weeks post-discharge and consists of:

1. Three months supervised, individualized physical training.
2. Psychological program including behavior modification techniques, group therapy, and relaxation sessions.
3. Educational program on modifying lifestyle and controlling coronary risk factors.
4. Return to work counseling.

Physical training consisted of 3 1-hour sessions per week in the hospital gym. At each session, patients followed a table of physiotherapy and aerobic training on mats or an exercise bicycle.

During training, heart rate was calculated individually following stress exercise treadmill tests (Bruce protocol) at the start and end of the program. The initial test served to filter enrolments and patients with ischemia and low exercise levels were excluded and indicated for coronary angiography.

Patients with exercise tests without signs of ischemia had their target heart rate set at 75% of the maximum achieved for the first 6 weeks of training and 85% for the last 6 weeks.

Supervised training was complemented by progressively increasing daily walks of ≤1 hour in duration, when patients tried to maintain the heart rate achieved during training. Walks were undertaken by patients individually and were unsupervised.

The psychological program consisted of individualized evaluation of psychological profile using tests to evaluate anxiety (Hamilton),14 depression (Zung),15 and personality (Bortner),16 and Schultz method relaxation techniques17 practiced 2 days per week. Once a week patients underwent group therapy. Patients with greater deterioration received individualized treatment from psychologists and, if needed, from the unit psychiatrist.

The educational program involved a weekly seminar for patients and immediate family to inform and advise about the illness and the need to modify coronary risk factors and lifestyle.

Return to work counseling included social and vocational evaluation and recommendations on post-discharge return to work.

Phase II CRP interventions were performed full- or part-time by staff of a multidisciplinary unit depending on the cardiology service and consisting of 4 cardiologists, 1 rehabilitation specialist, 2 psychologists, 1 psychiatrist, 2 nurses, 2 physiotherapists, and 1 social worker.

Phase III of the program covered the rest of the patient’s life. According to the discharge report, patients continued to take physical exercise 4-5 days a week, followed relaxation guidelines 2-3 times per day, and controlled risk factors. For 4 years, patients attended...
the hospital rehabilitation unit once a month for physical training and relaxation sessions to support them in fulfilling CRP recommendations.

Following current unit norms, patients were later advised to continue taking exercise individually or in a gym following specific training norms in the discharge report.

After post-AMI discharge, CG patients were advised to take standard secondary prevention measures: stop smoking, follow a low cholesterol diet, and take physical exercise, without following a structured CRP.

Patients in both groups underwent periodic cardiology outpatient clinic check-ups at 1, 3, 6, and 12 months during the first year, and once a year or according to need thereafter, up to the time of writing.

To avoid differences in clinical management during follow-up, all patients were reviewed and treated by the 4 rehabilitation unit cardiologists. Medical treatment during follow-up was that considered adequate by the cardiologists responsible for clinical control of the patients.

**Statistical Analysis**

Chi-squared was used to compare percentages. In both groups, we calculated Kaplan-Meier survival curves and compared these using log-rank tests. Values of \( P < 0.05 \) were considered statistically significant.

**RESULTS**

During the 2-year enrolment period, 520 patients with AMI were admitted to the hospital coronary unit. We excluded those who did not fulfill the previously described criteria \((n=330)\). After initial exercise tests, 10 patients were excluded with indication for coronary angiography due to signs of ischemia at low load levels.

The remaining 180 were randomized into 2 groups of 90: 1 group (RG) followed the CRP and the other (CG) served as a reference.

At 10-year check-up, 11 patients had been lost (7 RG and 4 CG), leaving 83 and 86 patients, respectively (Figure 1).

Baseline patient characteristics were similar in both groups (Table 1). Medical treatment at discharge did not show differences.

At 10-year follow-up, all-cause mortality was 7 RG patients (7.7%) and 16 CG patients (17.7%) with survival curves showing statistically significant differences \((\text{P}=0.04)\) of 91.8% and 81.7%, respectively (Figure 2).
All RG patient deaths were due to cardiovascular (CV) causes, making CV mortality the same as all-cause mortality (7.7%). Two CG patients died of non-CV causes (1 cirrhosis and 1 neoplasia) with 15.5% CV mortality. At 10 years, CG survival was 83.8% and RG survival was 91.8% (P=.10).

Specific causes of mortality in each group appear in Tables 2 and 3. Mortality due to sudden death was 2.2% (RG) and 4.4% (CG) (P=.68). Secondary mortality due to reinfarction was 4.4% (RG) and 4.4% (CG) and that due to heart failure was 1.1% (RG) and 4.4% (CG) (P=.37).

During the mean 10-year follow-up, the proportion of patients with non-fatal complications was higher in the CG (63.2%) than in the RG (35.2%) (P=.03).

Data on the etiology of complications are in Table 4. Percentages refer to the number of patients for whom we had information on each variable. We found a significant fall in unstable angina (P=.02), heart failure (P=.02), and need for revascularization surgery (P=.02). Non-fatal reinfarction and need for coronary angioplasty were also less frequent but not statistically significant (P=.40 and P=.50, respectively).

**DISCUSSION**

Results of this long-term follow-up, randomized study of patients at low-risk of infarction show that cardiac rehabilitation programs significantly reduce mortality and percentage of complications, especially revascularization, unstable angina, and heart failure.

Modification of lifestyle behaviors such as smoking, eating abundant quantities of fats, sedentary habits, and methods of dealing with stress, can significantly reduce risk of coronary heart disease. Similarly, better fulfillment of therapeutic guidelines to treat hypertension, diabetes and dyslipidemia can prevent the ap-

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**Table 1. Baseline Characteristics of Patients**

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Rehabilitation Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, mean±SD</strong></td>
<td>52.6±9</td>
<td>50.3±6</td>
</tr>
<tr>
<td><strong>Previous AMI</strong></td>
<td>1.1%</td>
<td>4.8%</td>
</tr>
<tr>
<td><strong>Diabetes</strong></td>
<td>8.9%</td>
<td>6.0%</td>
</tr>
<tr>
<td><strong>AHT</strong></td>
<td>22.7%</td>
<td>24.4%</td>
</tr>
<tr>
<td><strong>Dyslipidemia</strong></td>
<td>22.1%</td>
<td>28.1%</td>
</tr>
<tr>
<td><strong>Smoking</strong></td>
<td>86.2%</td>
<td>95.2%</td>
</tr>
<tr>
<td><strong>Site of AMI</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Anterior</strong></td>
<td>48.3%</td>
<td>40.0%</td>
</tr>
<tr>
<td><strong>Inferior/posterior</strong></td>
<td>46.3%</td>
<td>48.3%</td>
</tr>
<tr>
<td><strong>Non-Q wave</strong></td>
<td>5.3%</td>
<td>11.6%</td>
</tr>
</tbody>
</table>

*SD indicates standard deviation; AHT, arterial hypertension; AMI, acute myocardial infarction.

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**Table 2. Characteristics of Rehabilitation Group Patients Who Died**

<table>
<thead>
<tr>
<th>No.</th>
<th>Initial Age, Years</th>
<th>AMI Site</th>
<th>Cause of Death</th>
<th>Years Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>63</td>
<td>INF-POS</td>
<td>Sudden death</td>
<td>10</td>
</tr>
<tr>
<td>18</td>
<td>39</td>
<td>INF</td>
<td>Re-AMI</td>
<td>8</td>
</tr>
<tr>
<td>24</td>
<td>64</td>
<td>INF</td>
<td>Re-AMI</td>
<td>2</td>
</tr>
<tr>
<td>33</td>
<td>57</td>
<td>INF</td>
<td>Re-AMI</td>
<td>2</td>
</tr>
<tr>
<td>38</td>
<td>65</td>
<td>ANT</td>
<td>APE</td>
<td>10</td>
</tr>
<tr>
<td>47</td>
<td>58</td>
<td>ANT</td>
<td>Re-AMI</td>
<td>3</td>
</tr>
<tr>
<td>56</td>
<td>59</td>
<td>ANT</td>
<td>Sudden death</td>
<td>10</td>
</tr>
</tbody>
</table>

*ANT indicates anterior; APE, acute pulmonary edema; AMI, acute myocardial infarction; INF, inferior; POS, posterior.

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**Table 3. Control Group Patients Who Died**

<table>
<thead>
<tr>
<th>No.</th>
<th>Initial Age, Years</th>
<th>AMI Site</th>
<th>Cause of Death</th>
<th>Years Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>57</td>
<td>ANT</td>
<td>Sudden death</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>51</td>
<td>ANT</td>
<td>Re-AMI</td>
<td>5</td>
</tr>
<tr>
<td>21</td>
<td>56</td>
<td>ANT</td>
<td>Sudden death</td>
<td>8</td>
</tr>
<tr>
<td>28</td>
<td>56</td>
<td>INF</td>
<td>Cancer</td>
<td>8</td>
</tr>
<tr>
<td>32</td>
<td>61</td>
<td>ANT-LAT</td>
<td>Sudden death</td>
<td>9</td>
</tr>
<tr>
<td>37</td>
<td>49</td>
<td>INF</td>
<td>ACVA</td>
<td>10</td>
</tr>
<tr>
<td>42</td>
<td>48</td>
<td>ANT-LAT</td>
<td>Re-AMI</td>
<td>2</td>
</tr>
<tr>
<td>51</td>
<td>62</td>
<td>INF</td>
<td>HF</td>
<td>5</td>
</tr>
<tr>
<td>59</td>
<td>62</td>
<td>INF</td>
<td>APE</td>
<td>10</td>
</tr>
<tr>
<td>60</td>
<td>65</td>
<td>INF</td>
<td>ACVA</td>
<td>3</td>
</tr>
<tr>
<td>62</td>
<td>53</td>
<td>Septal</td>
<td>Sudden death</td>
<td>10</td>
</tr>
<tr>
<td>64</td>
<td>62</td>
<td>ANT</td>
<td>Cirrhosis</td>
<td>2</td>
</tr>
<tr>
<td>69</td>
<td>50</td>
<td>ANT</td>
<td>APE</td>
<td>2</td>
</tr>
<tr>
<td>73</td>
<td>58</td>
<td>Non-Q wave</td>
<td>Re-AMI</td>
<td>1</td>
</tr>
<tr>
<td>78</td>
<td>55</td>
<td>ANT</td>
<td>HF</td>
<td>9</td>
</tr>
<tr>
<td>89</td>
<td>59</td>
<td>INF</td>
<td>Re-AMI</td>
<td>1</td>
</tr>
</tbody>
</table>

*ACVA indicates acute cerebrovascular accident; ANT, anterior; APE, acute pulmonary edema; AMI, acute myocardial infarction; HF, heart failure; INF, inferior; LAT, lateral; POS, posterior.
In our study, 10-year all-cause mortality in the RG was reduced by 56.5%. Note that mortality was low in both groups (7.7%, RG; 17.7%, CG) by comparison with the earlier studies. Hämäläinen et al.23 reported 10-year all-cause mortality of 43.6% in the RG and 51.9% in the CG; Hedbäck et al.26 reported 42.2% in the RG and 57.6% in the CG.

These differences could be explained in several ways: a) the natural history of ischemic heart disease in Spain differs from that of other countries, with a lower rate of post-IAM mortality27; b) our sample, selected on inclusion criteria, consisted of low-risk patients; c) the mean age of our patients (51 years) was lower than that of the other studies (Hämäläinen et al.23 54 years; Hedbäck et al.26 57 years), perhaps meaning a better prognosis27; and d) our patients were enrolled 10 years after the other 2 studies and clinical management and treatment would have improved.

Since year 1 of follow-up, we found more deaths in the CG than in the RG and this pattern has been maintained throughout the study. At 4 and 6 years differences were not statistically significant, perhaps due to low mortality rates.28,29 However, at 10 years, the greater number of deaths led to statistically significant differences.

Belardinelli et al.30 confirmed that low-risk conditions produce significant short-term results. They enrolled 94 patients (mean age 59±14 years) with controlled heart failure randomized into 2 groups. They found that patients following a CRP (n=48) had a significant reduction in mortality (P=.01) versus control group patients (n=46) after a mean 14-month follow-up.

Most deaths in our study patients were due to CV causes. Although the difference between groups was 50.4%, this was not statistically significant, probably due to the limited number of deaths and patients.

As with all-cause mortality, we found markedly lower percentages of CV mortality than those reported by Hämäläinen et al.31 (35.1%, RG; 47.1%, CG) and Hedbäck et al.26 (38.7%, RG; 53.1%, CG), probably for the same reasons.

Our 10-year follow-up results for morbidity showed a 63.15% incidence of CG patients with non-fatal complications, which was much higher than that of the RG (35.15%) and statistically significant (P=.03).

As in other follow-up studies and the meta-analysis,19-22 we found no significant differences in the number of non-fatal reinfarctions. However, there was greater incidence of unstable angina (P=.02) leading to admission and explaining the greater need for surgery among CG patients. The low incidence of angioplasty was related to the period when patients were enrolled, when the technique was less well-developed in Spain.

A reduced number of patients presented heart failure in both groups although the incidence of this complication was greater and statistically significant in the...
CG (P=.02). This was probably due to the positive effect of risk factor control and taking exercise (improved ventricular function, endothelial dysfunction, collateral circulation, etc) widely described in CRP manuals.21

We should explain why we did not correlate morbidity and mortality results with the parameters of prognostic interest that the CRP aims to control (sedentary habits, psychological deterioration and control of risk factors).

There can be no doubt as to the positive effect of cardiac rehabilitation in these contexts in short-term studies, as Taylor et al’s meta-analysis corroborates. However, it is very difficult to show that continuous adherence to advice is maintained in the long-term. The patients in the groups compared may have been crossed and treatment and complete control of risk factors may have varied during their evolution.

Table I shows a lower mean age in the rehabilitation group (better prognosis) but the proportion of RG patients with risk factors is clearly greater than that of CG patients. We believe that these data are a consequence of the randomization and number of patients and they do not influence the final results.

However, we think the benefit of CRP is due to the healthy lifestyle habits that patients “learn” while following the program (giving up smoking, changes in diet, taking regular exercise) and that, if this is maintained during the first year post-AMI, they are likely to be maintained in the long-term. It would be interesting to continue with “refresher” sessions on a continuous basis, taking advantage of the excellent health service infrastructure available in Spain. However, experience has shown that, for a variety of reasons, this “excellent infrastructure” is totally inefficient at managing this type of intervention.32

Finally, we consider our data are of interest because they show results in Spain where incidence of ischemic heart disease is clearly lower than in northern Europe, and because the percentage of patients included in Spanish CRPs is remarkably low, some 3% according to current reports.33,34

CONCLUSION

The results of our study support the hypothesis that a multifactor CRP with secondary prevention measures maintained in the long-term favorably influences prognosis in post-AMI patients.

ACKNOWLEDGEMENTS

Our colleagues in the cardiac rehabilitation unit: Maximino Lozano (psychiatrist), Adela Alonso (psychologist), Carmen Carcedo (psychologist), Rafael Torres (rehabilitation specialist), Fernando Cabrero (physiotherapist), Julián Délgado (physiotherapist), María Teresa Portuondo (nurse), Paloma Marugán (nurse), Margarita Palacios (social worker), and José Antonio Benito (administrative officer).

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