Natural History of Left Ventricular Function in Patients With Uncomplicated Acute Myocardial Infarction*

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To investigate the serial changes of the infarcted and the noninfarcted areas, first-pass radionuclide angiocardiography was performed in 16 patients with uncomplicated anterior myocardial infarction (MI) at four weeks, one year, and two years after the onset of MI. Global ejection fraction (EF) and regional EF of the infarcted area improved significantly from four weeks to one year after MI (from 39±16 to 44±16 percent, 23±3 to 29±5 percent, both p<0.01), but did not change from one year to two years after MI. Regional EF of the noninfarcted area and left ventricular end-diastolic and end-systolic volume did not change during the study period. There was a significant relation in the direction of the changes of global EF and regional EF of the infarcted area during the first year after MI, whereas no relation was observed between the changes of global EF and regional EF of the noninfarcted area. A greater improvement in regional EF of the infarcted area was observed in seven patients who had spontaneous recanalization compared with nine patients with totally occluded coronary arteries. Thus, a significant improvement in cardiac function, mainly due to the increase in regional EF of the infarcted area, was observed during the first year after MI, which was related to patency of coronary artery. (Chest 1993; 103:1320-24)

Left ventricular function has been shown to be the major determinant of morbidity and mortality after acute myocardial infarction (MI). Radionuclide angiocardiography is a useful method to evaluate left ventricular function, and determines not only global but also regional left ventricular ejection fraction (EF). Global EF is influenced by abnormalities in both infarcted and noninfarcted regions of the left ventricle. Although several investigators have reported the serial change in left ventricular function after acute MI, little is known about the long-term evolution of ventricular function that may be dependent on the patency of infarct related coronary artery. Moreover, the wall motion abnormality of the infarcted area seems to have a different course from the noninfarcted area after MI. The purpose of this study was to investigate the serial change of left ventricular global and regional EF for two years after acute MI in patients with uncomplicated anterior MI.

Methods

Patients

Among 79 consecutive patients admitted to the hospital with acute Q wave anterior MI, 16 men (mean age of 55 years ranging from 27 to 75 years) fulfilled the following criteria: (1) no prior MI; (2) in Killip I at the time of hospital admission; (3) no major complications such as congestive heart failure; post-MI angina, or uncontrolled arrhythmias in the observation period; and (4) completed exercise test (≥85 percent of age-predicted maximal heart rate) without ischemic ST change or chest pain. None of the patients had thrombolytic or revascularization therapy in their hospitalization due to delayed arrival (more than 6 h from onset) and/or absence of symptoms and ST changes suggesting ongoing ischemia and follow-up period.

The diagnosis of acute MI was made when the following criteria were present: (1) prolonged chest pain consistent with myocardial ischemia: (2) characteristic evolutionary electrocardiographic changes of MI; and (3) elevation of total serum creatinine kinase value with detection of the MB isoenzyme.

Radionuclide Angiocardiography

First-pass radionuclide angiocardiography was performed at four weeks, one year, and two years after the onset of MI. In preparation for the procedure, each patient had a short 18-gauge Teflon catheter placed percutaneously into an external vein. For each radionuclide acquisition, 15 mCi of 99mTc pertechnetate was injected as a bolus, and counts were recorded at 25-ms intervals with a multicyrystal gamma camera (Baird Atomic System 77). After correction for background activity and electric dead time, data from three to six individual beats were combined to produce an average of representative cardiac cycle. Left ventricular EF was determined from the background-corrected representative cardiac cycle as follows: (end-diastolic counts minus end-systolic counts)/end-diastolic counts × 100. Left ventricular end-diastolic and end-systolic volume were calculated by the area-length method of Dodge and associates, with the ellipse of revolution modified for the single anterior plane projection as 0.85 × A/L, where A is the area obtained by planimetry, and L is the longest diameter measured from the aortic...
valve to the apex of the left ventricle. There was a good correlation between left ventricular end-diastolic volume measured with radionuclide angiography compared with contrast angiography in our laboratory \( r = 0.9, p < 0.01, \) \( r = 0.9 \times +0.01 \). Regional wall motion was assessed with static images of the end-diastolic and end-systolic perimeters that were outlined by computer program at the 23 percent isocount contour of the end-diastolic image. In additional, regional function was evaluated with a regional EF image that was generated by subtracting end-systolic counts from end-diastolic counts for each of the 21 \( \times \) 14 crystals in the left ventricular image.

Differences in regional function were displayed with a 16-color coded image, each color representing a 6.25 percent difference in the EF. From this left ventricular regional EF image, wall motion was subjectively categorized as normal, hypokinetic, akinetic, or dyskinetic by three experienced observers. Akinetic and dyskinetic zones were defined as infarcted areas, and the remaining categories were defined as noninfarcted areas at four weeks after MI. The same areas that were defined as infarcted and noninfarcted at four weeks were used to calculate the mean regional EF at one and two years after onset of MI (Fig 1). We have measured the precision of the method by assessment of the same data by three observers blinded with respect to prior values. The standard deviation for a single measurement of left ventricular regional EF of infarcted and noninfarcted area was found to be 0.03, and for differences in three observers of measurements 0.03. Therefore, the difference in three estimates required to achieve 95 percent probability is 0.07.

Treatment with all medication was discontinued for 24 h before the radionuclide angiographic study. None of the patients received \( \beta \)-blockers and angiotensin-converting enzyme inhibitors during this study period.

**Coronary Arteriography and Left Ventriculography**

Diagnostic coronary arteriography was performed within three days of first radionuclide angiographic study, and \( \pm 75 \) percent reduction of luminal diameter was considered to be significantly obstructed. After measuring left ventricular end-diastolic pressure, contrast ventriculography was performed in the 30º right anterior oblique projection and recorded at 50 or 60 frames per second. The end-diastolic and end-systolic endocardial contours were projected and traced from the frames with maximal and minimal volumes, from a normal, nonpostpremature sin. Wall motion was measured by the centerline method among 100 chords constructed perpendicular to a centerline drawn midway between the end-diastolic and end-systolic contours and normalized by the end-diastolic perimeter. The circumferential extent of akinetic and dyskinesis was calculated as the number of chords with absolute motion of 0 or less.

**Statistical Analysis**

Results are reported as the mean \( \pm \) SD. Two-way layout analysis of variance was used for quantitative data. A \( p \) value below 0.05 was considered significant.

**RESULTS**

**Serial Changes in Global EF and Left Ventricular End-Diastolic and End-Systolic Volume**

Changes in global EF, left ventricular end-diastolic, and end-systolic volume are shown in Table 1. Global EF improved significantly from four weeks to one year after MI, but global EF did not change significantly from one year to two years after MI. Left ventricular end-diastolic and end-systolic volume did not change during the study period (four weeks, one year, and two years).

**Serial Changes in Regional EF of the Infarcted and the Noninfarcted Area**

Regional EF of the infarcted area increased significantly from four weeks to one year \( (p < 0.001) \), but there was no significant difference between one year and two years (Table 2). Regional EF of the nonin-

![Figure 1. Upper: Left ventricular regional ejection fraction (REF) image. Lower: Digital display of left ventricular regional ejection fraction image. Crystal size within the lined-off area constitute the infarcted area defined at four weeks and the remainder of the noninfarcted area. Left ventricular ejection fraction and REF of infarcted and noninfarcted area were calculated as 37 percent, 29 percent and 53 percent, respectively.](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21671/)
The ejection fraction of the infarcted area did not change during the study period (four weeks, one year, and two years).

Relationship Between Changes in Global EF and Regional EF

There was a significant relation in the direction of the changes of global EF and regional EF of the infarcted area during the first year after MI, whereas there was no significant relation between changes of global EF and regional EF of the noninfarcted area in the same period (Figs 2 and 3).

Coronary Arteriography and Left Ventriculography

All patients had single-vessel coronary disease in the left anterior descending coronary artery (Table 3). Nine patients had totally occluded left anterior descending coronary arteries, but seven patients had less than 75% reduction of luminal diameter. There were no significant differences in the circumferential extent of akinesia and dyskinesia (15 ± 15 vs 11 ± 14 chords), left ventricular end-diastolic pressure (18 ± 4 vs 17 ± 2 mm Hg), and global EF (36 ± 17 vs 41 ± 17 percent) between patients with totally occluded and with partially patent arteries. When the changes in global and regional EF were compared between patients with totally occluded and partially patent coronary arteries, patients with partially patent coronary arteries had greater improvement in global and regional EF of infarcted area from four weeks to one year compared with those patients with totally occluded arteries. On the other hand, there was no significant difference in the change of regional EF of the noninfarcted area between the two groups. There were no significant differences in the changes of regional and global EF between the two groups from one to two years.

Discussion

Previous studies demonstrated radionuclide angio-

Table 2—Changes in Regional Ejection Fraction of the Infarcted and the Noninfarcted Area*

<table>
<thead>
<tr>
<th></th>
<th>4w</th>
<th>1Y</th>
<th>2Y</th>
<th>4w vs 1Y</th>
<th>1Y vs 2Y</th>
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</thead>
<tbody>
<tr>
<td>IREF</td>
<td>23±3</td>
<td>29±5</td>
<td>29±6</td>
<td>&lt;0.001</td>
<td>NS</td>
</tr>
<tr>
<td>NREF</td>
<td>57±10</td>
<td>58±10</td>
<td>59±10</td>
<td>NS</td>
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</table>

*IREF = regional ejection fraction of the infarcted area (percent); NREF = regional ejection fraction of the noninfarcted area (percent); other abbreviations as in Table 1.

![Figure 2](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21671/)

**Figure 2.** Relationship between changes in global and regional ejection fraction (EF) of the infarcted area from four weeks to one year after myocardial infarction. There was a significant relation in the direction of the changes of global and regional EF of the infarcted area during the first year after myocardial infarction.

![Figure 3](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21671/)

**Figure 3.** Relationship between changes in global and regional ejection fraction (EF) of the noninfarcted area from four weeks to one year after myocardial infarction. There was no relation in the direction of the changes of global and regional EF of the noninfarcted area during the first year after myocardial infarction.

Table 3—Differences in Global and Regional Ejection Fraction Between Patients With Partially Patent and Totally Occluded Coronary Arteries*

<table>
<thead>
<tr>
<th></th>
<th>Patent (n = 7)</th>
<th>Occluded (n = 9)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔEF</td>
<td>8.9±3.7</td>
<td>1.4±6.4</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>ΔIREF</td>
<td>6.2±1.7</td>
<td>3.7±1.6</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>ΔNREF</td>
<td>0.5±1.2</td>
<td>0.4±1.4</td>
<td>NS</td>
</tr>
<tr>
<td>ΔEF</td>
<td>-2.8±2.0</td>
<td>1.1±5.0</td>
<td>NS</td>
</tr>
<tr>
<td>ΔIREF</td>
<td>-3.1±2.2</td>
<td>2.1±2.5</td>
<td>NS</td>
</tr>
<tr>
<td>ΔNREF</td>
<td>0.2±2.3</td>
<td>1.3±1.6</td>
<td>NS</td>
</tr>
</tbody>
</table>

*ΔEF = change in left ventricular ejection fraction; ΔIREF = change in regional ejection fraction of the infarcted area; ΔNREF = change in regional ejection fraction of the noninfarcted area. Other abbreviations as in Tables 1 and 2.
Serial changes of ventricular function after acute MI have been reported by many investigators to provide the important prognostic information. The changes in left ventricular function during the follow-up period depend on several factors such as the effect of thrombolytic therapy, EF soon after the onset of MI, and the severity of complications in the late hospital phase. Schelbert and associates reported the improvement in left ventricular EF in 55 percent of patients from 2 to 39 months after the onset of acute MI and indicated that left ventricular performance in patients without persistent cardiomegaly can improve during long-term follow-up. Borer and colleagues reported that the normal exercise response in the radionuclide study at the time of hospital predicted the capacity for improvement of global EF during the year after acute MI. Although global EF is influenced by the motion of the infarcted and the noninfarcted regions of the left ventricle, the functional changes of the noninfarcted and infarcted regions were not investigated in these studies. In our selected patients, there was a significant improvement in global left ventricular EF from four weeks to one year after MI that was mainly due to the recovery of the regional EF in the infarcted area, but both global and regional EF did not improve from one to two years during the follow-up period.

In a canine study, Preuss et al showed that left ventricular function in the border zone could require up to several weeks to return to normal after a 2-h period of occlusion. In a clinical study, Stack and colleagues reported a significant improvement in the regional wall motion abnormalities 16 days after reperfusion in patients with acute MI. From these studies, the delayed functional recovery after reperfusion is attributed to the ischemia-induced disruption of metabolic process, and this phenomenon depends on the duration of ischemia. Although there were no differences in the extent of akinesis and dyskinesis, left ventricular end-diastolic pressure, and global EF at four weeks, a greater improvement in regional EF of the infarcted area was observed in 7 of 16 patients who had spontaneous recanalization compared with those with totally occluded coronary arteries. This indicates that patency of a coronary artery plays an important role for the improvement of EF in the infarcted area. Recent evidence suggests that the tensile strength of unperfused and reperfused infarct scars is different, and that reperfusion prevents the process of myocyte slippage and infarct thinning during the healing stage. These histologic differences could cause the differences in the healing process of the infarcted area.

On the other hand, there was no significant change in the regional EF of the noninfarcted area for four weeks to two years. The dilatation of the left ventricle after MI, "left ventricular remodeling," causes changes in both the infarcted (infarct expansion) and the noninfarcted region (volume-overload hypertrophy). The remodeling process is a compensatory mechanism aiming to restore a reduced stroke volume, and the magnitude of these remodeling changes is inversely related to increased wall stress due to decreased left ventricular pump function. Although Pfeffer et al have shown remodeling in a population of patients with lower left ventricular EF of 30 percent by radionuclide angiocardiography, considering our sample of patients (no clinical heart failure, negative exercise test), it is not surprising to find no increase in left ventricular end-diastolic and end-systolic volumes, because MI in our patients was not large enough to cause significant ventricular remodeling and hence, regional EF of the noninfarcted area was maintained during the second year after MI.

Limitation

Two limitations of our study should be addressed. First, serial left ventriculography was not performed because our patients did not have thrombolytic interventions and were free of complications during the follow-up period. Nevertheless, our results provide the information about natural history of left ventricular function by a noninvasive tool. Second, as the patient population in this study was a highly selected group with a small sample size who had good EF, negative stress test, and single-vessel disease, another population with larger infarct size is necessary to evaluate that our conclusion about the time course of global and regional left ventricular function can be generalized to these patients.

Conclusion

The recovery of left ventricular function could occur in the infarcted area within one year after the onset of MI, which was related to patency of the coronary artery.


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