Extension of Myocardial Infarction: Incidence and Prognosis

Theodore D. Fraker, Jr., M.D., Galen S. Wagner, M.D., and Robert A. Rosati, M.D.

SUMMARY The incidence and prognosis of myocardial infarct extension were studied prospectively among patients presenting without symptomatic heart failure (Killip class I or II). Infarct extension was defined as a new clinical event (recurrent pain, arrhythmias or worsening hemodynamic status) that occurred at least 24 hours after a documented myocardial infarction and accompanied by at least two of the following: 1) new QRS changes on the scalar ECG, 2) reappearance of the MB band of creatine kinase (MB CK), or 3) a new peak of total CK. Suspected infarct extension was defined as a new clinical event accompanied by only one of the above. Survival rates were calculated by the life-table method and compared at 1 year by chi-square analysis. Follow-up information was 99.4% complete. Between January 1971 and April 1977 there were 458 admissions for myocardial infarction and 58 episodes of definite or suspected extension (13%). Hospital mortality in patients with extensions was 36% (21 of 58) vs 9% (36 of 400) in those without extensions (p < 0.001). Of patients in both groups who survived hospitalization, 1-year survival was 76% in patients with definite or suspected extension and 91% in those without extension. The incidence of infarct extension in this group of patients was lower than that in other reports. The poor hospital and 1-year survival rates mandate early therapeutic intervention in these patients.

The incidence of extension of an acute myocardial infarction (MI) varies widely, depending upon the population of patients studied, the method of detection and the criteria for diagnosis. In 1974, Reid et al.1 reported an 86% incidence of infarct extension in 19 patients with anterior infarction using reevaluation of the electrocardiographic ST segment during daily ST-segment mapping as their criterion. Madias et al.2 used clinical criteria, including chest pain, ventricular arrhythmias and elevation of creatine kinase (CK), as well as precordial ST-segment mapping to identify infarct extensions in 48% of 25 patients with anterior infarcts and 50% of 10 patients with inferior infarcts. Kronenberg et al.3 reported infarct extension associated with ST elevation in 33% of 27 patients, six of whom died. Mathey et al.4 found that abnormal CK release curves suggesting infarct extension were present in 62% of 40 patients. In a postmortem study, Hutchins and Bulkley5 found histologic evidence of recent foci of necrosis around an infarct in 17% of 76 hearts.

We studied the incidence and prognosis of clinically diagnosed MI extensions in a large series of patients. Several authors have suggested that measures designed to reduce myocardial ischemia should favorably alter the incidence of infarct extension and subsequent morbidity. Because efforts to limit infarct size are most appropriate in patients without preceding pump failure, we considered only patients who presented without symptomatic heart failure.

Methods

From January 1, 1971 to April 1, 1977, there were 458 admissions from the emergency room or outpatient facilities for acute MI in patients without symptomatic heart failure (Killip class I or II). Patients admitted by inter-ward or inter-hospital transfer were eliminated from analysis because they frequently had other complicating illnesses. Patients presenting with symptomatic pulmonary edema or cardiogenic shock were excluded so that the study population would reflect a relatively low-risk group.

Fifty-two items of information were collected on each patient upon admission and again daily until the patient left the coronary care unit. The data collected included ECG changes, clinical status and presence or absence of complications and were over 92% complete. Arrhythmias were noted on hourly summary sheets from continuous ECG monitoring while patients were in the coronary care unit. Resident house officers or cardiology fellows recorded the data on daily flow sheets and the information was verified by at least one senior cardiologist. Survival information was obtained at 6 months and 1 year either by office appointment with a staff cardiologist or by telephone conversation with a research associate. The follow-up data were 99.4% complete.

Criteria for the diagnosis of MI included at least two of the following: 1) a clinical history of chest pain suggesting acute MI, 2) new Q-waves or typical evolutional ST changes on the scalar ECG, and 3) characteristic changes in serum enzymes. All patients in this study had determinations of total CK and the heart isoenzyme (MB band) of CK as well as standard measures of SGOT and LDH at 12-hour intervals for at least 72 hours. To be included in this study, the infarction had to be acute as documented by persistent elevation of MB CK upon admission or thereafter.
Extension of MI was defined as a new clinical event (such as recurrent chest pain, arrhythmias or worsening clinical status) occurring at least 24 hours after admission to the hospital for a documented MI and accompanied by two of the following: 1) new QRS changes (new Q waves or loss of R waves), 2) reappearance of MB CK, or 3) a new peak of total CK. Suspected extensions of MI were noted when patients had a new clinical event characterized by only one of the above. For example, a patient with recurrent chest pain, ST-segment changes only, and a rise in total CK while the MB fraction was present would be considered to have a suspected extension. If QRS changes had occurred in this patient, extension of MI would be considered definite. In general, patients with suspected extension failed to meet criteria for definite extension of MI because of conduction defects affecting the ECG (e.g., left bundle branch block) or because serum for enzyme determinations was not obtained before death. Serial enzymes were routinely drawn and analyzed every 12 hours for 72 hours after MI. Repeat sets of enzymes were drawn for another 72 hours when any new event suggested further infarction.

Survival rates after hospitalization were calculated by the life-table method and compared at 1 year by chi-square analysis. Because some patients were admitted more than once, posthospital survival rates were calculated from the first admission for a documented MI.

**Results**

Definite extensions occurred in 9.4% (43 of 458) of patients admitted from an outpatient facility for acute MI without preceding pump failure. Suspected extensions occurred in an additional 3.3% (15 of 458). In-hospital mortality was 33% (14 of 43) for patients with definite extension and 47% (seven of 15) for patients with suspected extension of MI. The combined hospital mortality was 36% (21 of 58). In contrast, the hospital mortality for patients without infarct extension was significantly lower ($p < 0.001$) at 9% (36 of 400). The median time from onset of symptoms to hospitalization was 5 hours for the entire population. Seventy-eight percent of patients had the onset of symptoms within 24 hours of hospitalization and 93% were hospitalized within 48 hours.

All in-hospital deaths in patients with infarct extensions, definite or suspected, were due to cardiac causes, i.e., pump failure or cardiac arrest. Of those surviving to leave the hospital, 19% (seven of 37) had moderate pump failure (Killip class III) after the infarct extension.

In patients without infarct extension, 50% of the in-hospital deaths (18 of 36) occurred as a result of a cardiac arrest. The remaining deaths were due to cardiogenic shock in 19% (seven of 36) and noncardiac causes in 31% (11 of 36).

Of the hospital survivors, six of 29 patients with definite infarct extension and three of eight with suspected extension died within 1 year, yielding survival rates of 79% and 62%, respectively (combined survival 76%). The 1-year survival for patients without evidence of infarct extension was 91% ($p < 0.05$). The 1-year survival for patients with and without infarct extension who survived hospitalization is shown in figure 1.

Extension of MI occurred an average of 3.4 days after admission to the hospital (range 30 hours to 11 days) (fig. 2). Consistent with a previous report from this institution, all patients with an extension occurring after the fifth day had some other serious complication during the first 4 days of care. Congestive heart failure, hypertension and diabetes mellitus were more common in patients with subsequent infarct extension (table 1). There were no differences in the incidence of early hospital complications among patients with or without infarct extension that would predict the occurrence of an infarct extension (table 2).

**Discussion**

The incidence of definite or suspected extension of acute MI in this large series of patients without complications was only 13%. Another 12 patients developed cardiogenic shock late in their hospital course without meeting criteria for infarct extension. It could be argued that these patients also had extensions that were not clinically evident. If included, they would raise the incidence of infarct extension to 15%.
Table 1. Baseline Characteristics of Patients with Myocardial Infarction (Killip Class I or II)

<table>
<thead>
<tr>
<th>Infarct extension (%)</th>
<th>No extension (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 55 years</td>
<td></td>
</tr>
<tr>
<td>74</td>
<td>65</td>
</tr>
<tr>
<td>Male</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>67</td>
</tr>
<tr>
<td>History of previous MI</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>25</td>
</tr>
<tr>
<td>History of CHF</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>13</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>23</td>
</tr>
<tr>
<td>Hypertension</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>45</td>
</tr>
<tr>
<td>Smoking history</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>58</td>
</tr>
</tbody>
</table>

Abbreviations: MI = myocardial infarction; CHF = congestive heart failure (defined as shortness of breath responsive to digitalis or diuretics).

(70 of 458). The true incidence of infarct extension may have been underestimated in this study, because serum enzyme determinations were not routinely performed more often than every 12 hours unless a new clinical event ensued. It seems unreasonable, however, to assume that the underestimation was large.

Because patients presenting with symptomatic pulmonary edema or cardiogenic shock were excluded from the series, the in-hospital mortality rate of 36% among patients with infarct extension suggests that a poor prognosis accompanies this complication. Even among hospital survivors, infarct extension significantly worsened the prognosis for 1-year survival compared with patients without clinically diagnosed extensions. Infarct extensions occurred at least 24 hours (by definition) after admission to the hospital and most often on the third hospital day; over half of the extensions occurred within the first 4 days. These figures suggest that measures to prevent infarct extension must be initiated upon admission and continued during the early hospital phase.

In an autopsy study, Hutchins and Bulkey6 examined the hearts from patients with clinically diagnosed and histologically proved MIs. Of the 76 hearts examined, only 13 (17%) had recent foci of necrosis around an infarct. Though this study probably included seriously ill patients, infarct extensions were clinically diagnosed in only 14 patients (18%), and 11 were later confirmed histologically. These figures compare favorably with the incidence of infarct extension reported here.

Other authors have reported significantly higher incidences of infarct extension in small series of selected patients. While these studies sometimes included more seriously ill patients, the higher incidences may have been due to the use of less specific criteria for extension, i.e., ST-segment mapping or CK release curve characteristics with or without a coincident clinical event.

The 86% incidence of infarct extension reported by Reid et al.1 was in patients with uncomplicated anterior infarcts (all patients but one were Killip class I or II). The diagnosis of extension was based upon changes in precordial ST-segment mapping, but only about half of their patients had recurrent pain and enzyme changes to suggest a new clinical event. No correlation between this definition of infarct extension and subsequent prognosis was mentioned. Madras et al.2 reported infarct extensions diagnosed by clinical criteria, including chest pain, arrhythmias and elevation of CK in 49% (18 of 37) of patients with anterior, inferior or lateral transmural MIs. At least eight of these patients presented with pump failure. Electrocardiographic ST-segment changes were noted by precordial mapping techniques, but there was no correlation between maximum ST change or peak enzyme values and mortality. Kronenberg et al.3 also noted that major precordial ST-segment elevations occurred in 48% of 27 patients with acute MI (14 presenting with various degrees of heart failure). Six patients with major ST elevations by mapping died

Table 2. Complications During Early Hospitalization* in Patients with Myocardial Infarction (Killip Class I or II)

<table>
<thead>
<tr>
<th>Infarct extension (%)</th>
<th>No extension (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventricular tachycardia</td>
<td>12</td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>3</td>
</tr>
<tr>
<td>Recurrent angina</td>
<td>33</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>9</td>
</tr>
<tr>
<td>Sinus tachycardia</td>
<td>52</td>
</tr>
<tr>
<td>Complete atrioventricular block</td>
<td>4</td>
</tr>
<tr>
<td>Mobitz II atrioventricular block</td>
<td>0</td>
</tr>
</tbody>
</table>

*Early hospitalization is defined as day 1 or day 2 after admission. Recurrent angina is compared only on day 2, because most patients had pain accompanying the initial infarct.
during hospitalization, and another three had clinical events suggesting infarct extension. Not all episodes of ST-segment fluctuation, however, were associated with clinical events. Reese et al. found no correlation between ST-segment maps and infarct extensions detected by secondary rises of CK enzymes in 20 patients. Experimental studies in dogs by Irvin and Cobb and by Heng et al. have shown very poor correlation between epicardial ST-segment elevation and regional myocardial blood flow reduction or histologic infarction. Several recent articles have appeared in which the known limitations of precordial mapping techniques for evaluating ischemia have been reviewed. In general, precordial ST-segment mapping techniques cannot be used to identify new ischemic events such as infarct extension in the absence of other clinical parameters. Infarct extension defined solely by ST-segment mapping techniques is probably not useful without a well-defined relationship to increased cardic mortality.

Methods other than precordial ST-segment mapping have been used to define infarct extension. In 1975, Mathey et al. reported infarct extensions in 62% of 40 patients with acute MI. Infarct extension was determined by variations from normal in the duration of CK release after clinical infarction. Despite early enthusiasm for infarct sizing by CK release curves, recent studies in dogs have shown poor correlation between infarct sizing by CK release and histologic inspection. Yasmineh et al. have shown that delayed CK release occurs from infarcted tissue without necessitating new ischemia. In view of the variable course of CK release from infarcted tissue, it seems unreasonable to base the diagnosis of infarct extension only on serial enzyme changes, especially in the absence of a proved relationship to subsequent prognosis.

The present study shows that clinically defined infarct extensions are associated with a poor hospital and 1-year survival. An incidence of infarct extension of less than 15% is an important factor in designing clinical trials aimed at limiting infarct size where extension is the end point. Large numbers of patients will be needed to show therapeutic benefit and decreased morbidity. Since most infarct extensions occur within the first few days of hospitalization, therapeutic interventions must be initiated in all patients soon after admission.

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