Acute Anterior Wall Myocardial Infarction Presenting with Positive T Waves and Without ST Segment Shift* 

Electrocardiographic Features and Angiographic Correlation

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Eighteen patients with a first AMI, who during the acute ischemic phase did not develop ST segment elevation, but only positive or peaked T waves, are described. Patients who do not develop ST segment elevation during evolving anterior AMI represent a subgroup with a high probability of total obstruction of the LAD artery with retrograde filling via collateral vessels and a small degree of left ventricular dysfunction. We assume that during the period of total obstruction there was preexisting adequate collateral circulation in order to prevent transmural ischemia, which explains the absence of ST segment elevation.

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AML = acute myocardial infarction; LAD = left anterior descending artery

In the electrocardiogram, ST segment displacement is one of the most useful signs of acute myocardial ischemia; ST segment elevation has been considered to reflect transmural ischemia and ST segment depression to reflect subendocardial or nontransmural ischemia. Prolonged ST segment elevation in the precordial leads during ischemic chest pain usually is accompanied by acute total occlusion of the LAD and occurs in patients with the clinical syndrome of evolving anterior AMI. The clinical and electrocardiographic course and angiographic findings in patients with evolving anterior AMI, in whom there was no ST segment elevation but only positive or peaked T waves, have not been fully elucidated. The purpose of this study was (1) to describe the electrocardiographic and clinical course in this group of patients with uncommon electrocardiographic presentation of anterior AMI, and (2) to determine whether there is a correlation between this electrocardiographic pattern and the angiographic findings.

METHODS

We studied 18 patients (35 to 70 years of age) with the diagnosis of anterior AMI who during the acute ischemic episode did not develop ST segment elevation but only positive or peaked T waves in the precordial leads. All patients studied underwent coronary angiography, 13 during hospitalization and the other five within two months. The indications for coronary angiography were as follows:

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Electrocardiographic Protocol

According to our routine protocol, continuous electrocardiographic recording of the leads with the most prominent electrocardiographic changes was done during the acute stage for the first hour of anterior AMI and every 15 to 30 min for the next 4 h. Afterwards an ECG was taken every 12 h in the following 48 h, and relatively young population and/or small (incomplete) infarction. Patients with the following characteristics were excluded: (1) past history or ECG documentation of old anterior myocardial infarction, (2) more than 70 years of age, (3) ST segment elevation above 1 mm during the acute ischemic phase, (4) presence of bundle branch block, (5) cardiomyopathy of any origin, (6) patients treated with thrombolytic therapy. These patients were not considered for thrombolytic therapy on the basis of the fact that the ECG was not considered diagnostic during the first hours of pain in some of the patients, and due to the fact that no significant infarct limitation is seen in patients with low ST elevation in the absence of Q waves.

The diagnosis of anterior AMI was based on the triad of chest pain, typical enzymatic curve and ECG changes in the precordial leads. Important clinical characteristics in this group are presented in Table 1.

Table 1—Patient Characteristics (18 Patients)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>54</td>
</tr>
<tr>
<td>Mean</td>
<td>35-70</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15 (83%)</td>
</tr>
<tr>
<td>Female</td>
<td>3 (17%)</td>
</tr>
<tr>
<td>Arterial hypertension</td>
<td>5 (26%)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>2 (11%)</td>
</tr>
<tr>
<td>Previous infarction</td>
<td></td>
</tr>
<tr>
<td>inferior wall</td>
<td>4 (22%)</td>
</tr>
<tr>
<td>Previous angina</td>
<td></td>
</tr>
<tr>
<td>Duration (years)</td>
<td>14 (78%)</td>
</tr>
<tr>
<td>Mean</td>
<td>3.5</td>
</tr>
</tbody>
</table>

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once daily during the remainder of the hospitalization period. Electrode placement and ECG standardizations in the serial tracing were identical. The ECG recording was done while patients still had severe prolonged chest pain. Patients who presented after the pain subsided were not included in this study. The height of the ST segment was measured 0.06 s after the end of the QRS complex.

Coronary Angiographic Analysis

Films were reviewed independently by two observers without knowledge of the clinical or electrocardiographic findings. Coronary stenosis of greater than 70 percent of the luminal diameter in any view was considered significant. Collateral vessels were looked for in all patients and were graded as good, poor or absent, based on a modification of the criteria of Levin. Good collateral vessels caused complete opacification of the portion of the recipient artery distal to the obstructive lesion. Poor collateral vessels caused faint or incomplete visualization of the recipient artery distal to its obstructive lesion. In cases with multiple collateral vessels, only the vessel causing the highest grade of opacification was used in the analysis.

Left ventricular ejection fraction was calculated from 30° right anterior oblique view left ventriculography. The time from the onset of acute infarction to cardiac catheterization during hospitalization averaged ten days (range, 1 to 19 days). Statistical analysis was done by using Student's t test.

RESULTS

Clinical Characteristics

The age, gender, risk factors and the rate of previous infarctions are presented in Table 1. Anginal history was present in 14 patients (78 percent) and averaged 3.5 years (range, 0.5 to 8 years).

Electrocardiographic Data

By study design, all 18 patients studied had isoelectric or minimally elevated (three patients) ST segment during prolonged episodes of chest pain (Fig 1, Table 2). In seven patients, the T waves were tall and peaked, and in the remaining 11 patients the T waves were positive with normal configuration. The appearance of new pathologic Q waves or significant augmentation of previous minimal Q waves occurred in 17 patients after an average time of 32 h (range, 10 to 96 h) following the onset of acute infarction, and occurred typically in a gradual fashion (Fig 1). The location of the pathologic Q waves was in leads V1 to V3 in 11 patients, in leads V1 to V4 in four patients and in leads V2 to V4 in two patients. The T wave inversion occurred in 16 patients after an average time of 4.8 days (range, 1 to 12 days).

![Figure 1. Case 9. Representative electrocardiographic tracing of evolving anterior wall myocardial infarction. A. During prolonged chest pain showing positive peaked T waves without ST segment elevation. B-F. Show gradual shortening of R waves and late appearance of Q waves.](image-url)
Angiographic Findings

In all 18 patients studied, there was significant obstruction of the LAD (Fig 2, Tables 2 and 3). In 14 patients (78 percent), there was total obstruction, and in four there was near total obstruction. Five patients (28 percent) from the study group had single-vessel disease, seven had double-vessel disease, and six had triple-vessel disease; thus, the incidence of multivessel disease was high (72 percent).

Retrograde filling of the LAD via collateral vessels from the right coronary artery or the circumflex artery was observed in 17 patients (94 percent). Collateral vessels were graded as good in ten patients and poor in the remaining seven patients. The supplying artery was severely obstructed in all seven patients with poor collateral circulation.

The mean left ventricular ejection fraction was 50 ± 12 percent. The ten patients with good collateral vessels showed higher ejection fraction than those with poor collateral vessels (55 ± 43 percent, p < 0.05).

Table 3—Angiographic Findings (18 Patients)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Left main stenosis &gt;50%</td>
<td>0</td>
</tr>
<tr>
<td>LAD stenosis</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>14</td>
</tr>
<tr>
<td>&gt;95%</td>
<td>4</td>
</tr>
<tr>
<td>Circumflex artery stenosis</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>3</td>
</tr>
<tr>
<td>&gt;70%</td>
<td>7</td>
</tr>
<tr>
<td>Right coronary artery stenosis</td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>3</td>
</tr>
<tr>
<td>&gt;70%</td>
<td>6</td>
</tr>
<tr>
<td>Extent of disease</td>
<td></td>
</tr>
<tr>
<td>Single vessel</td>
<td>5</td>
</tr>
<tr>
<td>Double vessel</td>
<td>7</td>
</tr>
<tr>
<td>Triple vessel</td>
<td>6</td>
</tr>
<tr>
<td>Collateral circulation to LAD</td>
<td>17</td>
</tr>
<tr>
<td>Ejection fraction (mean)</td>
<td>50% ± 12</td>
</tr>
</tbody>
</table>

Clinical Course and in-Hospital Prognosis

The incidence of cardiac complications, such as congestive heart failure (two patients), malignant ventricular arrhythmias (two patients) and cardiogenic shock (0 patients) was very low. No patient died during hospitalization.

Discussion

In the present study we describe a subgroup of patients with anterior AMI who during the acute ischemic phase did not develop ST segment elevation but only positive or peaked T waves in the precordial leads. To explain this uncommon electrocardiographic presentation of anterior AMI we searched for an angiographic correlation. Two major angiographic findings were evident: (1) there was high incidence of total or near total (>95 percent) obstruction of the LAD. (2) retrograde filling of the LAD via collateral vessels was observed in nearly all patients (94 percent). De Wood et al. found total obstruction of the coronary artery in 85 percent of patients who were evaluated within 4 hs of the onset of acute infarction, and this proportion decreased significantly to 65 percent when patients were studied within 12 to 24 hs after the onset of symptoms. Other authors reported an incidence of around 45 percent of total LAD obstruction in patients with anterior AMI within three weeks of the onset of acute infarction.10-13 In our data, 78 percent had complete obstruction and 95 percent had total or near-total obstruction of the LAD, which is considerably higher than reported figures in the previously mentioned studies. The reported incidence of coronary collateral vessels observed during angiography performed around two weeks of the onset of anterior AMI is about 40 percent.10-12,13 In our study group, angiography performed an average ten days from the onset of infarction revealed a higher incidence of collateral circulation in comparison to the above-mentioned studies. The differences in the angiographic findings in our group are probably related to the different electrocardiographic presentations of anterior AMI. In the formerly reported series, the criteria for diagnosis of anterior AMI were based on a classic electrocardiographic pattern of ST segment elevation during the acute phase of infarction. In our group, we observed no ST segment elevation during prolonged chest pain. We assume that during the period of total LAD obstruction there was adequate collateral circulation in order to prevent transmural ischemia, which explains the absence of ST segment elevation during the acute phase of infarction. It is possible that patients in whom there are no collateral vessels during the acute phase of infarction have less severe atherosclerotic narrowing before complete occlusion by a thrombus than did our patients, in whom we believe there was preexisting severe atherosclerotic
narrowing before complete obstruction. The seven patients with poor collateral circulation had the same ECG presentation as the patients with good collateral circulation but significantly lower left ventricular ejection fraction. Thus, it seems that poor collateral flow was enough to prevent ST elevation in the acute phase; however, it was not enough for preserving left ventricular function.

The fact that the majority (78 percent) of our patients had anginal history of long duration further supports our assumption that in our patients coronary obstruction may have occurred more gradually, allowing enough time for the development of collateral circulation. Our findings are in agreement with previous clinical studies\textsuperscript{14-16} on the difference in duration of angina pectoris before infarction between patients with and without collateral circulation. Patients with collateral circulation had a longer history of angina pectoris than patients without collateral filling.

Patients with coronary artery disease undergoing elective percutaneous transluminal coronary angioplasty provide a model for prospective evaluation of the functional significance of collateral circulation in the setting of sudden coronary artery occlusion. Rentrop et al\textsuperscript{17} and Cohen and Rentrop\textsuperscript{18} have previously shown that in a high percentage of patients with severe coronary stenosis, collateral channel filling improves within 30 to 60 s after balloon occlusion. Patients with poor collateral circulation or none at all had marked ST segment elevation during infarction. In contrast, patients with good collateral circulation had no electrocardiographic changes or wall motion abnormalities. These studies and others\textsuperscript{10,20} support our assumption that in patients with preexisting adequate collateral circulation sudden complete obstruction of the coronary artery does not produce ST segment elevation, but only ST segment depression or no deviation at all during acute LAD occlusion induced by percutaneous transluminal coronary angioplasty or spasm.

\textit{Preservation of Left Ventricular Function}

Although considerable controversy surrounds the functional significance of coronary collateral circulation, there is general agreement that collateral blood flow protects the heart from transmurral infarction. This conclusion is underscored by the frequent findings of preserved wall motion\textsuperscript{21} and absence of morphologic myocardial infarction supplied by a totally occluded artery.\textsuperscript{22} In our study group, the mean left ventricular ejection fraction was 50 percent and it was significantly better in those with good vs poor collateral vessels (55 vs 43 percent, \textit{p}<0.05). The uneventful clinical course in the majority of the patients without mortality also indicates a small degree of left ventricular dysfunction.

\textit{Electrocardiographic Importance}

From an electrocardiographic point of view, the importance of the present study is in the ability of the ECG to predict with high probability the presence of total obstruction of the LAD with retrograde filling via collateral vessels. We recently reported\textsuperscript{23} transient right axis deviation during anterior AMI as another useful electrocardiographic sign enabling us to predict the presence of total obstruction of the right coronary artery with retrograde filling via collateral vessels.

It previously has been reported\textsuperscript{24,25} that when there is ST segment elevation in anterior AMI it takes between 12 and 24 h for the ST segment to return to the isoelectric line, if it returns at all. In the present study, we made a continuous electrocardiographic recording from the time of admission during the first hours of chest pain. It is unlikely that we missed the period of ST segment elevation because if there had previously been any changes in the ST segment, they would have persisted for at least 12 h and we would have recorded it.

\textit{Q and T Wave Course}

Another characteristic of this group of patients was the interval between the onset of symptoms and electrocardiographic appearance of pathologic Q waves and inverted T waves. Review of the literature\textsuperscript{26} shows evidence that Q waves may appear either late or early during the process of acute infarction. Late appearance of Q waves during AMI (usually from 2 to 12 h) indicates myocardial necrosis,\textsuperscript{27} constituting an irreversible change in the infarcted myocardium. According to Blumenthal et al.,\textsuperscript{28} early appearance of Q waves (within 1 h) may indicate blood reperfusion in the infarcted area. In the majority of our subjects, we encountered a very late appearance of Q waves (average, 32 h) as well as inverted T waves (average, 4.8 days). Since we know that there was no spontaneous recanalization with anterograde filling of the LAD in our patients, one possible explanation is that delay of the Q wave genesis may result from prolonged compromised reperfusion via collateral vessels of the infarcted area.

\textit{Limitation}

The major limitation in the present study is the delay between the onset of infarction to cardiac catheterization. In only one patient (case 9) do we have angiographic proof that before and during the period of total obstruction there was adequate collateral filling of the LAD. In the remainder of the cases, we can only speculate about the presence of collateral circulation during the acute phase; thus, we cannot provide a definitive proof of some of the conclusions. Another limitation is that we could not analyze a comparable control population presenting with ST segment elevation and we were forced to rely on
historical controls from the literature. The reason for this was that patients who presented with ST elevation during the acute phase were treated with thrombolytic therapy and thus could not serve as a control group.

**CONCLUSION AND CLINICAL IMPLICATION**

We have identified a subgroup of patients with anterior AMI and nondiagnostic ECG. It is important to recognize this uncommon electrocardiographic presentation of anterior AMI which can easily be misdiagnosed. A critical feature in determining the functional role of collateral vessels is knowledge of their presence before or during the early stages of infarction. In the present study, we identified subgroups of patients who do not develop ST segment elevation during the early phase of anterior AMI, in whom we could predict with high probability the presence of total LAD obstruction with retrograde filling via collateral vessels. The prediction was based only on the electrocardiographic presentation in the acute phase. Since, in some of these patients the collateral supply to the ischemic area is also in jeopardy due to obstruction of the collateral vessel supplying the coronary artery, we feel that early coronary angiography is indicated in order to better evaluate the need for possible intervention, such as angioplasty or surgery.

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