

# Electrocardiographic Differentiation of Occlusion of the Left Circumflex Versus the Right Coronary Artery as a Cause of Inferior Acute Myocardial Infarction

C. NOEL BAIREY, MD, PREDIMAN K. SHAH, MD, ALLAN S. LEW, MD,  
and SHARON HULSE

To determine whether the admission electrocardiogram can identify left circumflex or right coronary artery occlusion as the cause of an inferior acute myocardial infarction (AMI), findings from electrocardiography and coronary angiography performed within 12 hours of each other were retrospectively assessed in 41 consecutive patients with inferior AMI. All patients had ST-segment elevation in 1 or more inferior leads (II, III or aVF). Of the 12 patients with circumflex coronary artery occlusion, 10 (83%) had ST-segment elevation in 1 or more lateral leads (aVL, V<sub>5</sub> or V<sub>6</sub>) without ST-segment depression in lead I. Similar electrocardiographic findings were noted in only 1 of 29 patients (4%) with right coronary occlusion ( $p < 0.001$ ). ST-segment depression in precordial leads V<sub>1</sub>-V<sub>3</sub> was equally prevalent in both groups. Thus, the presence of both ST-segment elevation in 2 or more inferior leads

and ST-segment elevation in 1 or more lateral leads with an isoelectric or elevated ST segment in lead I identified circumflex coronary occlusion with a sensitivity of 83%, specificity of 96%, positive predictive accuracy of 91% and negative predictive accuracy of 93%. When these criteria were prospectively applied to an additional cohort of 19 consecutive patients with inferior AMI (5 with left circumflex and 14 with right coronary artery occlusion), presence of left circumflex coronary artery occlusion was predicted with a sensitivity of 80%, specificity of 93%, positive predictive accuracy of 100% and negative predictive accuracy of 93%. Thus, the admission 12-lead electrocardiogram can assist in differentiating left circumflex from right coronary artery occlusion in patients with inferior AMI.

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**A**lthough identification of occlusion of left anterior descending coronary artery is accurately predicted by the pattern of anterior acute myocardial infarction (AMI) on a 12-lead electrocardiogram, differentiation of left circumflex from right coronary artery occlusion is difficult because either may be associated with an electrocardiographic pattern of inferior AMI.<sup>1-3</sup> Previous correlative studies yielded conflicting results and were limited by variable delays between recording of

the electrocardiogram and acquisition of anatomic information, inclusion of patients with ischemia without AMI and reliance on insensitive and nonspecific criteria such as presence and location of Q waves.<sup>1-4</sup> To better determine the value of the admission electrocardiogram in discriminating left circumflex from right coronary occlusion as a cause of inferior AMI, 41 consecutive patients with inferior AMI were studied in whom coronary angiographic data were obtained in close temporal proximity to the admission electrocardiogram. The criteria thus derived were tested prospectively in an additional cohort of 19 consecutive patients with inferior AMI.

## Methods

The study population was derived from a consecutive series of 84 patients admitted with evidence of an AMI, within 4 hours of onset of symptoms, who were

From the Division of Cardiology and Department of Medicine, Cedars-Sinai Medical Center, Los Angeles, California. Manuscript received May 4, 1987; revised manuscript received May 18, 1987; accepted May 24, 1987.

Address for reprints: Prediman K. Shah, MD, Division of Cardiology, Room 5314, Cedars-Sinai Medical Center, 8700 Beverly Boulevard, Los Angeles, California 90048.

enrolled in our trial of intracoronary thrombolytic therapy and underwent coronary angiography within 12 hours of admission. Inclusion criteria were a history of chest pain lasting 30 minutes or longer associated with at least 1 mm of ST-segment elevation in 2 or more electrocardiographic leads, without resolution within 5 minutes of administration of gr 1/150 sublingual nitroglycerin. Diagnosis of AMI was confirmed by subsequent diagnostic elevations of plasma total and MB-creatine kinase levels. Forty-four patients had electrocardiographic signs of inferior AMI with ST-segment elevation in 2 or more inferior leads (II, III or aVF). Three patients with total or subtotal occlusion of both circumflex and right coronary arteries were excluded from analysis. The remaining 41 patients (37 men, 4 women), mean age 57 years, form the study population from which the electrocardiographic criteria were derived. The criteria were then prospectively applied to an additional cohort of 19 consecutive patients with inferior AMI with identical inclusion criteria. These 19 patients were derived from a cohort of 44 consecutive patients undergoing intravenous thrombolytic therapy followed by coronary angiography within 24 hours.

**Electrocardiograms:** Admission 12-lead electrocardiograms were recorded in all patients within 4 hours of onset of symptoms of AMI. Admission electrocardiograms of the first 41 patients (group I) were interpreted by 1 of the investigators with prior knowledge of the coronary anatomy. ST-segment deflection was measured 0.08 second after the J point to the nearest 0.5 mm. One millimeter or more of ST elevation or depression was considered significant except in the case of lateral lead elevation (I, aVL, V<sub>5</sub> or V<sub>6</sub>), where 0.5 mm or more was accepted. Initial ST-segment determination was independently confirmed by a different investigator.

The admission electrocardiograms of the subsequent 19 patients (group II) were interpreted by another investigator without prior knowledge of coronary

anatomy, and patients were predicted to have either circumflex or right coronary artery occlusion as the cause of infarction based on the electrocardiographic criteria derived from group I patients.

**Coronary angiography:** Coronary angiography was performed using the Judkins technique. In the group I patients, a preintervention coronary angiogram was recorded and the infarct-related artery was identified by presence of total or subtotal occlusion followed by improvement after intracoronary administration of streptokinase. In group II patients the infarct-related artery was identified as the artery with evidence of residual stenosis and residual intracoronary thrombus (with staining by contrast and presence of an ulcerated plaque) after administration of intravenous thrombolytic therapy.

## Results

**Group I:** The left circumflex coronary artery was the infarct-related vessel in 12 patients and the right coronary artery in 29. The 2 groups of patients did not differ with respect to mean age, gender, history of infarction or coronary artery bypass surgery or the number of major epicardial vessels with a coronary stenosis of at least 70% of the diameter.

**Electrocardiographic findings (Table I)—limb leads:** All 41 patients had at least 1 mm of ST-segment elevation in 1 or more inferior leads. Additional lateral ST-segment elevation (at least 0.05 mm) was present in leads I or aVL in 2 patients with circumflex coronary occlusion and in no patient with right coronary occlusion. ST-segment depression (at least 1 mm) in leads I or aVL was present in 4 patients with circumflex coronary occlusion and 24 with right coronary occlusion ( $p < 0.01$ ). An isoelectric or elevated ST segment in lead I was present in all 12 patients (100%) with left circumflex occlusion, vs 8 of 29 (28%) with right coronary occlusion ( $p < 0.001$ ).

**Precordial leads (V<sub>1</sub>–V<sub>4</sub>):** ST-segment depression in 1 or more anterior precordial leads was equally

TABLE I Electrocardiographic Correlations

ECG Findings	Circumflex Coronary Occlusion (n = 12)	Right Coronary Occlusion (n = 29)	p Value
Inferior leads (II, III, aVF)			
ST $\uparrow$ ( $\geq 1$ mm)	12 (100%)	29 (100%)	NS
ST $\downarrow$ ( $\geq 1$ mm)	0 (0%)	0 (0%)	NS
Lateral limb leads (I and/or aVL)			
ST $\uparrow$ ( $\geq 0.05$ mm)	2 (17%)	0 (0%)	NS
ST $\downarrow$ ( $\geq 1$ mm)	4 (33%)	24 (81%)	<0.01
ST $\uparrow$ or Isoelectric in lead I alone	12 (100%)	8 (28%)	<0.001
Lateral precordial leads (V <sub>5</sub> , V <sub>6</sub> )			
ST $\uparrow$ ( $\geq 0.05$ mm)	10 (83%)	7 (24%)	0.001
ST $\downarrow$ ( $\geq 1$ mm)	4 (33%)	14 (48%)	NS
Precordial leads (V <sub>1</sub> –V <sub>4</sub> )			
ST $\uparrow$ ( $\geq 1$ mm)	0 (0%)	5 (17%)	NS
ST $\downarrow$ ( $\geq 1$ mm)	9 (75%)	24 (81%)	NS
Combined			
Isoelectric or ST $\uparrow$ in I plus $\geq 0.05$ mm ST $\uparrow$ in V <sub>5</sub> and/or V <sub>6</sub> and/or aVL	10 (83%)	1 (4%)	<0.0001

ECG = electrocardiographic; NS = not significant.

TABLE II Angiographic Correlations

Catheterization Findings	Circumflex Coronary Occlusion (n = 12)	Right Coronary Occlusion (n = 29)	p Value
1-vessel disease	5 (42%)	15 (52%)	NS
2-vessel disease	4 (33%)	6 (20%)	NS
3-vessel disease	3 (25%)	8 (28%)	NS
LAD disease	5 (41%)	13 (44%)	NS
Concomitant right/LC disease	4 (33%)	7 (24%)	NS
Proximal vessel occlusion	9 (75%)	11 (38%)	NS
Native left dominant circulation	2 (17%)	0 (0%)	NS
Functional left dominant circulation	4 (33%)	2 (7%)	NS

Native vessel dominance determined by which vessel, LC or right, forms the posterior descending artery. Functional vessel dominance determined by which vessel, LC or right, supplies the posterior descending artery, through native vessel or collateralization.

LAD = left anterior descending; LC = left circumflex; NS = not significant.

prevalent in the 2 groups. Only 5 patients, all with right coronary occlusion, had ST-segment elevation in 1 or more precordial leads  $V_1$ - $V_4$ .

**Precordial leads ( $V_5$ - $V_6$ ):** ST segments were elevated (at least 0.5 mm) in  $V_5$  and/or  $V_6$  in 10 patients with circumflex coronary occlusion and 7 with right coronary occlusion ( $p = 0.001$ ). ST-segment depression in lead  $V_5$  or  $V_6$  (at least 1 mm) was equally prevalent in the 2 groups.

**Composite electrocardiographic findings:** The best means of distinguishing patients with circumflex coronary occlusion from those with right coronary occlusion was provided by considering ST-segment deviation in a lateral limb (I or aVL) and precordial ( $V_5$  or  $V_6$ ) leads. An isoelectric or elevated ST segment in lead I with any ST-segment elevation (0.5 mm or more) in 1 or more leads ( $V_5$ ,  $V_6$  or aVL) was present in 10 patients with circumflex coronary occlusion and only 1 patient with right coronary occlusion ( $p < 0.0001$ ). This composite criterion identified circumflex coronary occlusion with a sensitivity of 83%, specificity of 96%, positive predictive accuracy of 91% and negative predictive accuracy of 93%.

**Angiographic findings (Table II):** The groups had similar frequencies of concomitant left anterior descending coronary artery involvement (as defined by a stenosis of at least 70%). Similarly, they had comparable frequencies of involvement of the alternate vessel, i.e., those with right coronary occlusion had a left circumflex stenosis rate of 33% and those with left circumflex stenosis had a right coronary artery stenosis rate of 24%. The groups differed in rates of proximal occlusion of the involved artery: among patients with left circumflex occlusion 9 of the 12 occlusions (75%) occurred before or involved the first obtuse marginal, and among those with right coronary occlusion, 11 of 29 occlusions (38%) occurred in the first third of the vessel (difference not significant). Most patients in both groups had native right dominant systems, as defined by the vessel supplying the posterior descending artery. However, a greater proportion of patients with left circumflex occlusion had additional left to right collateralization of the posterior descending artery than those with right coronary occlusion. This resulted

in a functionally left dominant system being present among patients with circumflex occlusion, 33% vs 7% in the right coronary group (difference not significant).

**Group II:** In 5 patients the circumflex coronary artery and in 14 the right coronary artery was the artery of infarction. Four of 5 patients with the left circumflex coronary artery as the infarct vessel were correctly identified by composite electrocardiographic criteria derived from group I patients. None of the 14 patients with right coronary artery as the infarct vessel had electrocardiographic criteria of circumflex coronary occlusion. Thus, electrocardiographic criteria of circumflex coronary occlusion derived from group I had a sensitivity of 80%, specificity of 93%, positive predictive accuracy of 100% and negative predictive accuracy of 93%.

## Discussion

We correlated acute electrocardiographic changes with those of coronary angiography performed in close temporal proximity to onset of symptoms of AMI. The patients were well defined, relatively homogeneous and derived from a consecutive cohort in which all presented with electrocardiographic signs of an inferior AMI. Thus, our study differs from that of Blanke et al.,<sup>5</sup> who included a more heterogeneous patient population in which almost a third of the patients did not have classic electrocardiographic presentation of AMI.

Among patients presenting with electrocardiographic signs of inferior AMI with ST-segment elevation in 2 or more limb leads (II, III or aVF), presence of circumflex coronary artery occlusion as the cause of AMI is suggested by electrocardiographic evidence of an isoelectric or elevated ST segment in limb lead I and any ST-segment elevation (0.5 mm or more) in 1 or more lateral leads ( $V_5$ ,  $V_6$  or aVL). The overall accuracy of this criterion ranges from 91 to 93% and appears to be independent of other concomitant coronary artery stenosis. Presence or absence of ST-segment depression in leads  $V_1$ - $V_4$  was not of discriminating value between circumflex and right coronary occlusions. Because ischemic involvement of the right ventricle is almost exclusively seen with right coronary occlusion,

presence of electrocardiographic evidence of right ventricular infarction may assist in differentiating right coronary from circumflex occlusion. This is supported by the presence of ST-segment elevation in leads  $V_1$ - $V_4$ , a previously documented sign of concomitant right ventricular involvement,<sup>6</sup> in 5 of 29 patients with right coronary occlusion and none with circumflex coronary occlusion. However, although it is specific, low sensitivity of this finding limits its value. The electrocardiographic criteria derived from retrospective analysis of group I patients retained their predictive accuracy when prospectively applied to the group II patients.

**Limitations:** Although the data were retrospectively analyzed and prospectively validated, the findings are relevant only to the group of patients presenting with AMI and ST elevation in electrocardiographic leads II, III and aVF. Some patients with right coronary as well as circumflex coronary occlusion may present without ST elevations in leads II, III or aVF, in

which case the criteria defined in this study may or may not be applicable.

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