

# New Electrocardiographic Criteria for Predicting the Site of Coronary Artery Occlusion in Inferior Wall Acute Myocardial Infarction

Masami Kosuge, MD, Kazuo Kimura, MD, Toshiyuki Ishikawa, MD, Yoichiro Hongo, MD, Yasuyuki Mochida, MD, Mitsugi Sugiyama, MD, and Osamu Tochikubo, MD

In patients with inferior wall acute myocardial infarction (AMI), the site of the culprit lesion is an important determinant of outcome. Patients with right ventricular infarction have a poor prognosis, whereas those with occlusion of the left circumflex coronary artery (LCx) have a good prognosis. Therefore, we assessed whether standard 12-lead electrocardiograms obtained on admission could identify the site of coronary artery occlusion, (i.e., a site proximal to the origin of the right ventricular branch of the right coronary artery [RCA], a site distal to the origin of the right ventricular branch of the RCA, or a site in the LCx). The ratio of ST depression in lead V<sub>3</sub> to ST elevation in lead III (V<sub>3</sub>/III ratio) was evaluated immediately before coronary angiography in 152 patients

with a first inferior wall AMI confirmed by coronary angiography within 12 hours after the onset of symptoms. For occlusion of the proximal RCA, distal RCA, and LCx, V<sub>3</sub>/III ratio was  $0.2 \pm 0.3$ ,  $0.8 \pm 0.5$ , and  $2.5 \pm 2.5$  ( $p = 0.0001$ ), respectively. The V<sub>3</sub>/III ratio  $<0.5$  identified proximal RCA occlusion,  $0.5 < V_3/III$  ratio  $\leq 1.2$  identified distal RCA occlusion, and  $1.2 < V_3/III$  ratio identified LCx occlusion with sensitivities of 91%, 84%, and 84%, and specificities of 91%, 93%, and 95%, respectively. We conclude that the V<sub>3</sub>/III ratio is useful in predicting the site of coronary artery occlusion in patients with inferior wall AMI. ©1998 by Excerpta Medica, Inc.

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In patients with inferior wall acute myocardial infarction (AMI), the infarct-related artery can be either the right coronary artery (RCA) or the left circumflex coronary artery (LCx).<sup>1</sup> Patients with right ventricular infarction have a poor prognosis,<sup>2-5</sup> whereas those with occlusion of the LCx have a good prognosis.<sup>6</sup> The site of coronary artery occlusion is thus an important determinant of outcome. We therefore studied whether 12-lead electrocardiograms (ECG) obtained on admission could identify the site of coronary artery occlusion with respect to the RCA and the LCx in patients with inferior wall AMI.

## METHODS

**Patients:** Between December 1990 and December 1997, 304 patients were consecutively admitted to our coronary care unit with a first inferior wall AMI. They were retrospectively included if they had the following criteria: (1) typical chest pain of  $>30$  minutes duration; (2) ST elevation of  $\geq 1$  mm in  $\geq 2$  inferior leads (II, III, or aVF); (3)  $>2$ -fold increase in serum creatine kinase levels; (4) complete occlusion (Thrombolysis In Myocardial Infarction [TIMI]<sup>7</sup> grade 0) of the RCA or the LCx confirmed by coronary angiography within 12 hours after the onset of symptoms; (5)

no right or left bundle branch block at coronary angiography. Subsequently, 152 patients (117 men and 35 women, aged 31 to 88 years [mean  $\pm$  SD,  $62 \pm 11$ ]) met the inclusion criteria.

**Coronary angiography:** Coronary angiography was performed within 12 hours after the onset of symptoms in all patients. The grade of collateral filling was evaluated according to the criteria of Rentrop et al<sup>8</sup> (0 = no visible filling of any collateral channel; 1 = filling only of side branches without visualization of the epicardial segment; 2 = partial filling of the epicardial segment; and 3 = complete filling of the epicardial segment). A good collateral channel was defined as grades 2 or 3, and a poor collateral channel as grades 0 or 1.

**Electrocardiographic analysis:** Immediately before coronary angiography, 12-lead ECGs were recorded at a paper speed of 25 mm/s and an amplification of 10 mm/mV. The isoelectric line was defined as the level of the preceding TP segment. ST-segment deflection was measured at the J point by an experienced observer blinded to patient data. The degree of ST-segment elevation was measured in leads II, III, and aVF, and ST-segment depression was measured in leads V<sub>1</sub> to V<sub>6</sub>.

**Statistical analysis:** Mean values  $\pm$  SD were calculated for continuous variables, and absolute and relative frequencies were measured for discrete variables. For continuous variables, the statistical significance of differences between groups was analyzed by unpaired Student's *t* test. The chi-square test was used to compare differences between discrete variables. The cut-

From the Critical Care and Emergency Medical Center, and the Second Department of Internal Medicine, Yokohama City University School of Medicine, Yokohama, Japan. Manuscript received May 11, 1998; revised manuscript received and accepted June 26, 1998.

Address for reprints: Kazuo Kimura, MD, Critical Care and Emergency Medical Center, Yokohama City University School of Medicine, Urafunecho 3-46, Minami-ku, Yokohama 232-0024, Japan.

**TABLE I** Clinical and Angiographic Characteristics of Study Patients

	Group Proximal RCA (n = 64)	Group Distal RCA (n = 69)	Group LCx (n = 19)
Age (yrs)	64 ± 11	63 ± 11	61 ± 12
Men (%)	50 (78%)	53 (77%)	14 (74%)
Time to recording ECG (h)	4.0 ± 2.8	4.1 ± 2.1	3.9 ± 1.6
Previous angina (%)	34 (53%)	45 (65%)	12 (63%)
Collateral grade ≥ 2* (%)	15 (23%)	18 (26%)	3 (16%)
Concomitant LAD disease (%)	9 (14%)	12 (17%)	2 (11%)
Culprit lesion			
RCA			
Segment 1	58 (91%)	25 (36%)	—
Segment 2	6 (9%)	23 (33%)	—
Segment 3	—	21 (31%)	—
LCx			
Segment 11	—	—	7 (37%)
Segment 13	—	—	10 (53%)
Segment 14	—	—	1 (5%)
Segment 15	—	—	1 (5%)

\*Rentrop classification.  
Patients are subgrouped according to the site of coronary artery occlusion. Data presented are mean value ± SD.  
LAD = the left anterior descending artery; †p < 0.05 versus group proximal RCA and group distal RCA.

**TABLE II** Relation of the Culprit Lesion to Electrocardiographic Findings

ECG findings	Group Proximal RCA (n = 64)	Group Distal RCA (n = 69)	Group LCx (n = 19)
ST elevation in inferior leads (mm)			
II	2.7 ± 2.0	2.4 ± 1.4	1.7 ± 1.0
III	3.8 ± 2.5	3.2 ± 1.7	1.8 ± 0.7*†
aVF	3.1 ± 2.2	2.7 ± 1.5	1.7 ± 0.9*†§
ST depression in precordial leads (mm)			
V <sub>1</sub>	0.3 ± 0.8	1.0 ± 1.0*	1.2 ± 1.0*
V <sub>2</sub>	1.1 ± 2.1	2.2 ± 2.0*	2.4 ± 1.3*
V <sub>3</sub>	1.1 ± 2.3	2.5 ± 2.0*	3.3 ± 1.7*§
V <sub>4</sub>	1.3 ± 1.9	2.1 ± 1.5*	2.5 ± 1.8*
V <sub>5</sub>	1.2 ± 1.4	1.4 ± 1.3	1.0 ± 1.3
V <sub>6</sub>	0.7 ± 1.0	0.6 ± 0.9	0.4 ± 0.8
V <sub>3</sub> /III ratio	0.2 ± 0.3	0.8 ± 0.5*	2.5 ± 2.5*†

\*p < 0.001; †p < 0.05 versus group proximal RCA; ‡p < 0.001; §p < 0.05 versus group distal RCA.  
Data presented are mean value ± SD.  
V<sub>3</sub>/III ratio = the ratio of the degree of ST-segment depression in lead V<sub>3</sub> to the degree of ST-segment elevation in lead III.

off point of electrocardiographic criteria for predicting the site of coronary artery occlusion was obtained by discriminant analysis using a statistics program package, SPSS for Windows (release 6.1J, SPSS Inc., Chicago, Illinois). A p value < 0.05 was considered statistically significant.

## RESULTS

**Patient characteristics:** Patients were classified into the 3 groups according to the site of coronary artery occlusion as documented by coronary angiography: group proximal RCA, a site proximal to the origin of the first major right ventricular branch of the RCA (n = 64); group distal RCA, a site distal to the origin of the first major right ventricular branch of the RCA (n = 69); and group LCx (n = 19). The clinical and

angiographic characteristics of the 3 groups are summarized in Table I. There were no significant differences among the 3 groups in age, gender, time interval from symptom onset to electrocardiographic recording, prevalence of previous angina, collateral development, or clinically relevant concomitant stenosis of the left anterior descending artery.

**Electrocardiographic findings (Table II):** ST-SEGMENT ELEVATION IN INFERIOR LEADS: There were no significant differences among the 3 groups in the degree of ST elevation in lead II. In contrast, in leads III and aVF, the degree of ST elevation was significantly greater in groups proximal RCA and distal RCA than in group LCx. The difference was particularly prominent in lead III.

ST-SEGMENT DEPRESSION IN PRECORDIAL LEADS: In leads V<sub>1</sub>, V<sub>2</sub>, and V<sub>4</sub>, there was a significant difference in the degree of ST depression between groups proximal RCA and distal RCA and between groups proximal RCA and LCx, but not between groups distal RCA and LCx. In lead V<sub>3</sub>, however, all 3 groups could be distinguished on the basis of the degree of ST depression (i.e., group proximal RCA < group distal RCA < group LCx). Criteria for predicting the site of coronary artery occlusion on the basis of the degree of ST depression in lead V<sub>3</sub> were calculated; the sensitivity, specificity, and positive and negative predictive values obtained with these criteria are shown in Table III. Predictive accuracy of the degree of ST depression in lead V<sub>3</sub> for the site of coronary artery occlusion was 63%. In leads V<sub>5</sub> and V<sub>6</sub>, there were no significant differences in the degree of ST depression among the 3 groups.

RATIO OF ST-SEGMENT DEPRESSION IN PRECORDIAL LEADS TO ST-SEGMENT ELEVATION IN INFERIOR LEADS: The ratio of the degree of ST-segment depression in lead V<sub>3</sub> to the degree of ST-segment elevation in lead III (V<sub>3</sub>/III ratio) was highest in group LCx and lowest in group proximal RCA among the 3 groups (Table II). The criteria defining the V<sub>3</sub>/III ratios used to predict the site of coronary artery occlusion had the sensitivities, specificities, and positive and negative predictive values shown in Table V. The overall diagnostic accuracy of the V<sub>3</sub>/III ratio ranged from 73% to 98%; all values were slightly higher than those obtained on the basis of the degree of ST depression in lead V<sub>3</sub>. The predictive accuracy of the V<sub>3</sub>/III ratio for the site of coronary artery occlusion was 87%, which was sig-

<b>TABLE III</b> Sensitivity, Specificity, and Accuracy of the Degree of ST-Segment Depression in Lead V <sub>3</sub> for Predicting the Site of Coronary Artery Occlusion				
	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Degree of ST-depression in lead V <sub>3</sub> <1.5 mm predicts RCA occlusion proximal to the RV branch	78	76	70	83
1.5 mm ≤ degree of ST depression in lead V <sub>3</sub> ≤ 3.0 mm predicts RCA occlusion distal to the RV branch	49	80	67	65
3.0 mm degree of ST depression in lead V <sub>3</sub> predicts LCx occlusion	58	86	37	93
RV = right ventricular.				

<b>TABLE IV</b> Relation of V <sub>3</sub> /III Ratio to the Site of Coronary Artery Occlusion			
	Group Proximal RCA	Group Distal RCA	Group LCx
V <sub>3</sub> /III ratio <0.5	58*	6	2
0.5 ≤ V <sub>3</sub> /III ratio ≤ 1.2	5	58*	1
1.2 < V <sub>3</sub> /III ratio	1	5	16*
*p < 0.05.			

<b>TABLE V</b> Sensitivity, Specificity, and Accuracy of V <sub>3</sub> /III Ratio for Predicting the Site of Coronary Artery Occlusion					
	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	
V <sub>3</sub> /III ratio <0.5 predicts RCA occlusion proximal to the RV branch	91	91	88	93	
0.5 ≤ V <sub>3</sub> /III ratio ≤ 1.2 predicts RCA occlusion distal to the RV branch	84	93	91	88	
1.2 < V <sub>3</sub> /III ratio predicts LCx occlusion	84	95	73	98	
V <sub>3</sub> /III ratio as defined in Table II.					

nificantly higher than that based on the degree of ST depression in lead V<sub>3</sub> (p < 0.0001).

## DISCUSSION

Several previous studies have correlated electrocardiographic changes with the site of coronary artery occlusion as determined by coronary angiography.<sup>9,10</sup> However, patients in those angiographic studies were heterogeneous with respect to several demographic factors influencing ST-segment deflection, such as time interval from symptom onset to electrocardiographic recording, collateral circulation, and the presence or absence of reperfusion. Therefore, to study the relations between electrocardiographic and coronary arteriographic findings during inferior wall AMI, we enrolled only patients with a first inferior wall AMI and total occlusion of the infarct-related artery as confirmed by coronary angiography within 12 hours after the onset of symptoms.

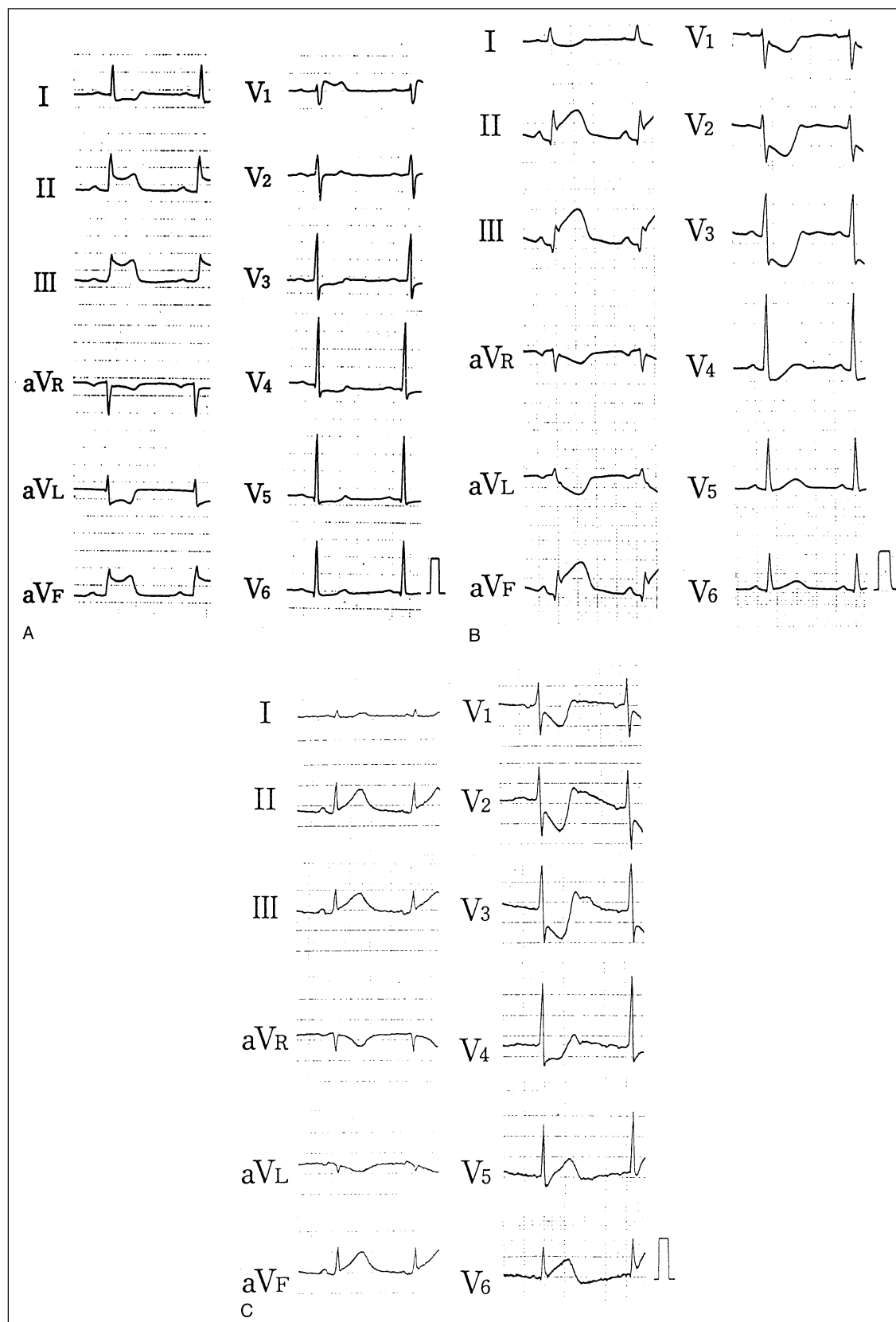
Our data indicate that among patients with inferior wall AMI the degree of ST-segment elevation in in-

ferior leads III and aVF, particularly lead III, was significantly greater in RCA occlusion than in the LCx. These findings are consistent with the results of previous studies.<sup>10-12</sup> The RCA supplies blood mainly to the inferior myocardium, whereas the LCx supplies blood to the posterior, posterolateral, or posteroinferior myocardium. Therefore, differences in the territories perfused by the RCA and LCx may influence the direction and degree of inferior ST-segment elevation, as reported by Herz et al.<sup>11</sup>

In precordial leads V<sub>1</sub> to V<sub>4</sub>, we found that the degree of ST-segment depression was significantly greater in distal RCA occlusion and LCx occlusion than in proximal RCA occlusion; furthermore, in lead V<sub>3</sub>, ST-segment depression was greater in LCx occlusion than even in distal RCA occlusion. Although the pathophysiology of precordial ST-segment depression during inferior wall AMI remains controversial, one mechanism may involve reciprocal alteration of inferior ST-segment elevation.<sup>13</sup> Because Geft et al<sup>14</sup> reported that acute right ventricular ischemia could cause ST-segment elevation in leads V<sub>1</sub> to V<sub>5</sub>, we can assume that

precordial ST-segment deviation during inferior wall AMI is caused by summing of ST-segment depression due to reciprocal changes in inferior ST-segment elevation and ST-segment elevation due to concomitant right ventricular ischemia. Greater precordial ST-segment depression in LCx occlusion might be explained by the reciprocal changes in inferior and posterior ST-segment elevation. The relation of the vector direction between the posterior and anterior wall is more strongly opposed than that between the inferior and anterior wall. Therefore, reciprocal changes in posterior ST-segment elevation might cause more prominent precordial ST-segment depression than that caused by changes in inferior ST-segment elevation.

On the basis of these observations, we selected lead III as a representative inferior lead and lead V<sub>3</sub> as a representative precordial lead. Furthermore, we were more precisely able to differentiate the site of coronary artery occlusion by using the ratio of precordial ST-segment depression to inferior ST-segment elevation than by using only the degree of precordial ST-



**FIGURE 1.** Representative electrocardiograms of the 3 groups. (A) Group proximal RCA, culprit lesion, segment 1. The degree of ST-segment elevation in lead III is 6.0 mm. The degree of ST-segment depression in lead V<sub>3</sub> is 1.5 mm. The V<sub>3</sub>/III ratio is 0.25. (B) Group distal RCA, culprit lesion, segment 2. The degree of ST-segment elevation in lead III is 5.0 mm. The degree of ST-segment depression in lead V<sub>3</sub> is 6.0 mm. The V<sub>3</sub>/III ratio is 1.2. (C) Group LCx, culprit lesion, segment 13. The degree of ST-segment elevation in lead III is 1.5 mm. The degree of ST-segment depression in lead V<sub>3</sub> is 4.5 mm. The V<sub>3</sub>/III ratio is 3.0.

segment depression. In this study, the overall diagnostic accuracy of this ratio ranged from 71% to 98%, which is similar to the results of previous studies.<sup>15,16</sup> However, prior investigations could not discriminate among the 3 groups defined in our study.

To precisely evaluate the relations between electrocardiographic changes and the site of coronary artery occlusion, we studied only patients with total occlusion as confirmed by coronary angiography within 12 hours after the onset of symptoms. Consequently, we conclude that we can fairly accurately predict the site of coronary artery occlusion by using standard 12-lead ECGs in patients with ST elevation in the inferior leads. The electrocardiographic patterns were not necessarily similar in patients with total occlusion of the infarct-related artery and those with subtotal occlusion, as described by Blanke et al.<sup>10</sup> Because the criteria used in this study may not be applicable in patients with subtotal occlusion, further studies are needed to assess the clinical usefulness of these criteria in patients with inferior wall AMI.

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