

Diagnostic Value of aVL Derivation for Right Ventricular Involvement in Patients with Acute Inferior Myocardial Infarction

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Background: Right ventricular (RV) involvement is associated with increased morbidity and mortality in patients with acute inferior myocardial infarction (MI). Although electrocardiography is probably the most useful, simple, and objective tool for the diagnosis of acute MI, there are no well-defined criteria in the standard 12-lead electrocardiogram to properly identify RV involvement in patients with acute inferior MI. Our objective was to evaluate the value of ST-segment depression in lead aVL in diagnosing RV involvement in patients with acute inferior MI.

Materials and Methods: Sixty-seven patients, hospitalized with acute inferior myocardial infarction, were included in this study. The diagnosis of acute inferior myocardial infarction was based on the clinical history, characteristic enzyme pattern of CK-MB values, and the appearance of ST-segment elevation ≥ 1 mm in at least two of the leads (leads II, III, aVF). RV infarction was defined by ST-segment elevation ≥ 1 mm in lead V4R. ST-segment depression in lead aVL that is more than 1 mm was accepted as a diagnostic criterion for RV involvement in patients with acute inferior MI.

Results: Thirty-one patients had >1 mm ST-segment depression and 28 of them had right ventricular infarction according to lead V4R. Thirty-six patients showed ≤ 1 mm ST-segment depression indicating no right ventricular involvement but four of them also had right ventricular infarction according to V4R.

Conclusion: More than 1 mm ST-segment depression in lead aVL was found to have high sensitivity (87%), specificity (91%), high positive and negative predictive value (90%, 88%, respectively), and high diagnostic accuracy (89%) in diagnosing RV involvement in patients with acute inferior MI. Therefore, by using a simple 12-lead electrocardiographic sign, ST-segment depression >1 mm in lead aVL, obtained on admission, it is possible to identify RV involvement in patients with acute inferior MI.

A.N.E. 2003;8(3):185-188

inferior myocardial infarction; right ventricular myocardial infarction; aVL derivation

Right ventricular (RV) myocardial infarction (MI) is common in patients with acute inferior MI. The reported incidence in patients with acute inferior MI is 25–53%.^{1,2} Although inferior MI generally has a more favorable prognosis than that of anterior infarction, the presence of RV involvement is associated with increased morbidity and mortality.^{3–5} Therefore, it is critical to determine early whether RV infarction is present and to initiate appropriate therapy as soon as possible. Although electrocar-

diography is probably the most useful, simple, and objective tool for the diagnosis of acute MI, there are no well-defined criteria in the standard 12-lead electrocardiogram to properly identify RV involvement in patients with acute inferior MI.⁶ Erhardt et al.⁷ first described the value of the right precordial leads, which are not included in the standard 12-lead electrocardiogram, particularly lead V4R in diagnosing right ventricular infarction in 1976. The conventional electrocardiogram samples body

surface potentials from the horizontal axis in an orderly fashion from right to left across body surface lacking leads indicating RV involvement. Furthermore, there is no well-defined criterion for the diagnosis of RV involvement on the frontal plane in patients with inferior MI. Lead aVL is one of the unipolar limb leads of the conventional 12-lead electrocardiogram on the frontal plane.

In the present study, we aim to evaluate the value of ST-segment depression in lead aVL in diagnosing RV involvement in patients with acute inferior MI.

PATIENTS AND METHODS

The study population consisted of 67 patients (51 male, 16 female), ages ranging from 37 to 73 (mean age 55 ± 8) years, hospitalized with acute inferior MI. Patients with posterior, lateral, and anterior wall extension, mechanical complications, prior MI, prior bypass surgery or angioplasty, left ventricular hypertrophy, and chronic obstructive pulmonary disease were excluded from the study. Six patients with inferolateral MI, seven patients with inferoposterior MI, seven patients with lateral and posterior extension, four patients with associated complete atrioventricular block, and four patients with left ventricular hypertrophy were excluded from the study. Besides, patients who were admitted with chest pain of more than 6 hours were not included in the study. The diagnosis of acute inferior MI was based on the clinical history, characteristic enzyme pattern of CK-MB values, and the appearance of ST-segment elevation ≥ 1 mm in at least two of the leads (leads II, III, and aVF). RV infarction was defined by ST-segment elevation ≥ 1 mm in lead V4R. All electrocardiographic tracings were analyzed separately by two cardiologists unaware of the clinical status of the patients. ST-segment deviations were assessed 0.04 seconds after J point in all recorded leads. The isoelectric line was defined as the level of the preceding TP segment. More than 1 mm ST-segment depression in lead aVL was considered a cut-off point. ST-segment depression in lead aVL that is higher than 1 mm was accepted as a diagnostic criterion for RV involvement in patients with acute inferior MI.

Statistical Analysis

Categorical variables were expressed as a percentage and continuous variables were expressed as mean \pm SD. Sensitivity, specificity, diagnostic

Table 1. Clinical Characteristics of Patients

Variables	Group I (n = 31)	Group II (n = 36)
Age (mean \pm SD)	56 ± 9	54 ± 8
Gender (M/F)	27/9	24/7
Diabetes	7 (19%)	6 (19%)
Hypertension	13 (36%)	12 (38%)
Hypercholesterolemia	12 (33%)	10 (32%)
CK-MB peak levels (mean \pm SD)	$353 \pm 199^*$	143 ± 50
Thrombolytic therapy	26/31 (84%)	29/36 (81%)

*P < 0.001 vs group II.

accuracy, positive predictive value, and negative predictive value were calculated in the usual fashion. Chi-square tests were performed for a comparison of categorical variables and unpaired *t*-test for a comparison of continuous variables. A P value <0.05 considered as statistically significant.

RESULTS

Characteristics of patients are presented in Table 1. On admission electrocardiogram, 32 of 67 (48%) patients with acute inferior MI were diagnosed as having RV involvement based on ≥ 1 mm ST-segment elevation in lead V4R. Others were diagnosed as having isolated acute inferior MI. There was no disagreement between the two cardiologists regarding the diagnosis of RV infarction based on ≥ 1 mm ST-segment elevation in lead V4R. Patients were divided into two groups; patients having >1 mm ST-segment depression in lead aVL, group I and having ≤ 1 mm ST-segment depression, group II. Thirty-one patients had >1 mm ST-segment depression and twenty-eight of them had RV infarction according to lead V4R. Thirty-six patients showed ≤ 1 mm ST-segment depression indicating no RV involvement but four of them also had RV infarction according to V4R. Diagnosis of RV involvement by using >1 mm ST-segment depression in lead aVL in patients with acute inferior myocardial infarction is summarized in Table 2. When electrocardiographic RV involvement was compared with CK-MB peaks there was a constant and clear tendency (P < 0.001) toward greater myocardial involvement in patients with RV extension than in those without (Table 1). Table 3 shows the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of the test (>1 mm ST-segment depression in lead aVL) in

Table 2. Diagnosis of Right Ventricular Involvement by Using >1 mm ST-Segment Depression in Lead aVL in Patients with Acute Inferior Myocardial Infarction

	True Positive	True Negative	False Positive	False Negative
>1 mm ST-segment depression in lead aVL	28	32	3	4

the diagnosis of RV involvement in a patient with acute inferior MI. Therefore, more than 1 mm ST-segment depression in lead aVL has high sensitivity (87%), specificity (91%), high positive and negative predictive value (90%, 88%, respectively), and high accuracy (89%) in diagnosing RV involvement in patients with acute inferior MI.

DISCUSSION

RV MI associated with acute inferior MI has important therapeutic and prognostic implications.^{3–5} Although inferior MI generally has a favorable prognosis than those with anterior wall MI, the presence of RV involvement is associated with increased morbidity and mortality.^{3–5} Besides, RV involvement in patients with acute inferior MI changes the treatment strategies of the patients.^{8,9} Therefore, it is critical to determine early whether RV involvement is present and to initiate appropriate therapy as soon as possible.

The diagnosis of RV MI can be based on electrocardiographic changes,^{4–7,10} echocardiography,^{11,12} radionuclide angiography,^{13,14} pyrophosphate myocardial scintigraphy,¹³ or right ventricular catheterization.^{15,16} Of these methods, electrocardiography provides the simplest and most objective data in the acute stage of infarction.^{8,10,17} Because of the obvious importance of a simple and rapid noninvasive test for RV MI, we de-

cided to evaluate the diagnostic accuracy of the more widely available standard 12-lead electrocardiographic lead aVL as an early diagnostic criterion for RV involvement in a prospective series of patients admitted with acute inferior MI.

Electrocardiographic diagnosis of RV MI has been correlated with echocardiographic, hemodynamic, and scintigraphic data and autopsies.^{7,8,10} During the acute stage of right ventricular infarction, ST-segment elevation in lead V4R is considered to be superior with respect to the diagnostic accuracy and simplicity when compared with other diagnostic modalities.^{8,10,17} ST-segment elevation in the right precordial leads (V3R–V6R) has been shown to be both sensitive and specific for RV MI.^{4–10} Zehender et al.⁵ have reported that ST-segment elevation of ≥ 1 mm in lead V4R was the best electrocardiographic predictor of RV involvement in the setting of an acute inferior MI with high sensitivity (92%), specificity (80%), and a high diagnostic accuracy (87%). In addition, Lopez-Sendon et al.⁶ have reported that ST-segment elevation of ≥ 1 mm in lead V4R has high sensitivity (100%) and negative predictive value (100%) and an intermediate specificity (68%) and positive predictive value (67%) in diagnosing RV involvement in the setting of an acute inferior MI.

Although attempts to diagnose RV MI by ST-segment changes in the standard 12-lead electrocardiogram have been made,^{18–21} to our knowledge the diagnostic significance of ST-segment depression in lead aVL has not been evaluated. aVL is one of the unipolar limb leads of the conventional electrocardiogram. The right ventricle is located anteriorly on the frontal plane.²² The usual inferior MI produces a ST-segment vector that is directed inferiorly and parallel to the frontal plane or slightly posteriorly.²² RV infarction should be suspected when the mean ST vector is directed more than 100° to the right and anteriorly.²³ The further the mean ST-segment vector is directed to the right and anteriorly, the more likely it is that the right ventricle is infarcted.^{22,23} In the present study, the ST-segment vector was found to be $+140 \pm 15^\circ$. Therefore, display of lead aVL (-30°) in inverted format as lead -aVL ($+150^\circ$) might be used in the diagnosis of right ventricular involvement in patients with acute inferior MI on the frontal plane. ST-segment depression in lead aVL represents ST-segment elevation in lead -aVL. The presence of more than 1 mm ST-segment depression in lead aVL was found to be highly sensitive and specific for diagnosing right

Table 3. Value of aVL Derivation in Diagnosing Right Ventricular Myocardial Infarction

	ST-Segment Depression > 1mm in Lead aVL
Sensitivity	87%
Specificity	91%
Positive predictive value	90%
Negative predictive value	88%
Diagnostic accuracy	89%

ventricular infarction, with high positive and negative predictive value and high diagnostic accuracy. Furthermore, patients with more than 1 mm ST-segment depression in lead aVL have higher levels of CKMB than those without it, indicating a larger area of myocardial involvement.

Study Limitation

The main limitation of this study is that the cases were highly selected to eliminate anyone with other than a normal electrocardiogram with ST-segment elevation in inferior leads. However, most of the patients with acute inferior MI detected during clinical practice have associated changes on the electrocardiogram related to conduction abnormalities, left ventricular hypertrophy, or extension of MI to lateral or posterior wall.

CONCLUSION

By using a simple 12-lead electrocardiographic sign, ST-segment depression >1 mm in lead aVL, obtained on admission, it is possible to identify RV involvement in patients with acute inferior MI. With the support of further large clinical studies criteria of >1 mm ST depression in aVL for identifying RV involvement in patients with acute inferior MI, can be used as an early, simple, and reliable method.

REFERENCES

- Sharpe DN, Botvinick EH, Shames DM, et al. The non-invasive diagnosis of right ventricular infarction. *Circulation* 1978;57:483-490.
- Wackers FJ, Lie KI, Sokale EB, et al. Prevalence of right ventricular involvement in inferior wall myocardial infarction assessed with myocardial imaging with thallium-201 and technetium-99m pyrophosphate. *Am J Cardiol* 1978;42:358-362.
- Berger PB, Ryan TJ. Inferior myocardial infarction: High-risk subgroups. *Circulation* 1990;81:401-411.
- Lew AS, Laramie P, Shah PK, et al. Ratio of ST segment depression in lead V2 to ST segment elevation in lead aVF in evolving inferior acute myocardial infarction: An aid to the early recognition of right ventricular ischemia. *Am J Cardiol* 1986;57:1047-1051.
- Zehender M, Kasper W, Kauder E, et al. Right ventricular infarction as an independent predictor of prognosis after acute inferior myocardial infarction. *N Engl J Med* 1993;328:981-988.
- Lopez-Sendon J, Coma-Canella I, Alcasena S, et al. Electrocardiographic findings in acute right ventricular infarction: Sensitivity and specificity of electrocardiographic alterations in right precordial leads V4R, V3R, V1 and V3. *J Am Coll Cardiol* 1985;6:1273-1279.
- Erhardt LR, Sjogren A, Wahlberg I. Single right-sided precordial lead in the diagnosis of right ventricular involvement in inferior myocardial infarction. *Am Heart J* 1976;91:571-576.
- Klein HO, Tordjman T, Ninio R, et al. The early recognition of right ventricular infarction: Diagnostic accuracy of the electrocardiographic V4R lead. *Circulation* 1983;67:558-565.
- Rodrigues EA, Dewhurst NG, Smart LM, et al. Diagnosis and prognosis of right ventricular infarction. *Br Heart J* 1986;56:19-26.
- Croft CH, Nicod P, Corbett JR, et al. Detection of acute right ventricular infarction by right precordial electrocardiography. *Am J Cardiol* 1982;50:421-427.
- Lopez-Sendon J, Garcia-Fernandez MA, Coma-Canella I, et al. Segmental right ventricular function after acute myocardial infarction: two-dimensional echocardiographic study in 63 patients. *Am J Cardiol* 1983;51:390-396.
- Bellamy GR, Rasmussen HH, Nasser FN, et al. Value of two-dimensional echocardiography, electrocardiography, and clinical signs in detecting right ventricular infarction. *Am Heart J* 1986;112:304-309.
- Dell'Italia LJ, Starling MR, Crawford MH, et al. Right ventricular infarction: identification by hemodynamic measurements before and after volume loading and correlation with noninvasive techniques. *J Am Coll Cardiol* 1984;4:931-939.
- Shah PK, Maddahi J, Berman DS, et al. Scintigraphically detected predominant right ventricular dysfunction in acute myocardial infarction: Clinical and hemodynamic correlates and implications for therapy and prognosis. *J Am Coll Cardiol* 1985;61:264-272.
- Cohn JN, Guiha NH, Broder MI, et al. Right ventricular infarction: Clinical and hemodynamic features. *Am J Cardiol* 1974;33:209-214.
- Lopez-Sendon J, Lopez de Sa E, Roldan I, et al. Determinants of hemodynamic compromise with severe right ventricular infarction. *Circulation* 1990;82:359-368.
- Kinch J, Ryan T. Right ventricular infarction. *N Engl J Med* 1994;330:1211-1217.
- Saw J, Davies C, Fung A, et al. Value of ST elevation in lead III greater than lead II in inferior wall acute myocardial infarction for predicting in-hospital mortality and diagnosing right ventricular infarction. *Am J Cardiol* 2000;87:448-450.
- Gefft IL, Shah PK, Rodrigues L, et al. ST elevations in leads V1 to V5 may be caused by right coronary artery occlusion and acute right ventricular infarction. *Am J Cardiol* 1984;53:991-996.
- Tsuka Y, Sugiura T, Hatada K, et al. Clinical significance of ST-segment elevation in lead V1 in patients with acute inferior wall Q-wave myocardial infarction. *Am Heart J* 2001;141:615-620.
- Edmunds JJ, Gibbons RJ, Bresnahan JF, et al. Significance of anterior ST depression in inferior wall acute myocardial infarction. *Am J Cardiol* 1994;73:143-148.
- Hurst JW. Comments about the electrocardiographic signs of right ventricular infarction. *Clin Cardiol* 1998;21:289-291.
- Hurst JW. Detection of right ventricular myocardial infarction associated with inferior myocardial infarction from the standard 12-lead electrocardiogram. *Heart Dis Stroke* 1993;2:464-467.