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## 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

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**R**ight ventricular (RV) myocardial infarction (MI) occurs in 30% to 50% of patients with acute left ventricular inferior MI.<sup>1,2</sup> RV MI typically happens when there is occlusion of the right coronary artery proximal to the acute marginal branch, resulting in greater posterior RV wall infarct size compared with occlusion distal to the acute marginal branch.<sup>3–6</sup> Although inferior MI generally has a favorable prognosis, the presence of RV involvement is associated with increased mortality. Furthermore, there is higher incidence of complications such as atrioventricular conduction block and hemodynamic instability.<sup>4,7</sup> Successful reperfusion reduces the frequency of RV dysfunction during inferior MI,<sup>8,9</sup> and thus, prompt recognition of RV involvement is important to allow early interventions such as thrombolytic therapy or angioplasty.<sup>10</sup> In this retrospective review of 175 patients with inferior MI, we evaluated the diagnostic and prognostic value of ST elevation in lead III > II compared with lead V<sub>4</sub>R, in predicting in-hospital mortality and diagnosing RVMI.

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Patients admitted to the Vancouver General Hospital from January 1995 to March 1998 with an inferior MI were included in our study if they met the following criteria: (1) standard 12-lead electrocardiogram obtained within 12 hours from onset of infarct symptoms, (2) ST elevation  $\geq 1$  mm in  $\geq 2$  of leads II, III, and aVF, and (3) elevations in serum creatine kinase-MB and index indicative of MI (with analysis performed on a Chiron ACS 180 system; creatine kinase-MB  $> 7$   $\mu$ L and index  $\geq 4\%$ ).

The electrocardiograms were reviewed blindly without knowledge of the patient's clinical course. ST elevation was measured 0.08 second after the J point in leads II, III, aVF, and V<sub>4</sub>R, to an accuracy of 0.5 mm. At least 2 consecutive QRS complexes were measured with the PQ segment used as the isoelectric line, and the mean value recorded for each lead. Each patient was analyzed for the presence of ST elevation  $\geq 1$  mm in lead V<sub>4</sub>R, the ratio of ST elevation in leads III/II  $> 1$ , and the presence of ST depression in leads V<sub>1</sub> to V<sub>4</sub>  $\geq 1$  mm. The hospital records were then reviewed independently for age, gender, physical examination findings (jugular venous pressure, presence of Kussmaul's sign, chest auscultatory findings), cardiac investigations performed (echocardiogram, cardiac catheterization, hemodynamic measurements, radionuclide ventriculogram, and autopsy), thrombolytic use, and mortality.

RVMI was diagnosed by any 1 of the following: (1) autopsy showing RVMI,<sup>3</sup> (2) cardiac catheterization (occlusion or severe stenosis of the right coronary artery proximal to the acute marginal branch),<sup>11,12</sup> (3) invasive hemodynamic measurements (right atrial pressure  $> 10$  mm Hg, and ratio of right atrial pressure to pulmonary wedge pressure  $> 0.8$ ),<sup>1,13,14</sup> (4) echocardiography (RV dilatation, RV wall asynergy),<sup>15,16</sup> (5) radionuclide ventriculography (low RV ejection fraction and wall motion abnormalities),<sup>13,17</sup> or (6) physical examination findings (elevated jugular venous pressure  $\geq 3$  cm above sternal angle, and either clear lung fields or Kussmaul's sign).<sup>7,14,18,19</sup>

Discrete variables were compared between groups with Pearson's chi-square or McNemar test, as appropriate. A p value  $< 0.05$  was considered to indicate statistical significance. Positive and negative predictive values, and negative likelihood ratios [(1 – sensitivity)/specificity] were calculated. Negative likelihood ratio  $< 0.1$  often generates large and significant change from pretest to post-test probability. Logistic

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TABLE 1 Patient Characteristics						
Variable	III > II (n = 117)	III ≤ II (n = 58)	p Value	V <sub>4</sub> R+ (n = 59)	V <sub>4</sub> R- (n = 77)	p Value
Average age	64.4 years	61.8 years	0.19	65 years	64.5 years	0.47
Male gender	90 (76.9%)	44 (75.9%)	0.88	42 (71.2%)	63 (81.8%)	0.15
Thrombolysis	86 (73.5%)	36 (62.1%)	0.12	48 (81.4%)	53 (68.8%)	0.10
Precordial ST depression	41 (35.0%)	16 (27.6%)	0.32	12 (20.3%)	37 (48.1%)	0.0007
III > II = ST elevation in lead III > II; III ≤ II = ST elevation in lead III ≤ II; V <sub>4</sub> R+ = ST elevation in V <sub>4</sub> R ≥ 1 mm; V <sub>4</sub> R- = ST elevation in V <sub>4</sub> R < 1 mm.						

regression analysis was used to assess the independent effect of selected clinical variables (ST elevation in lead III>II, ST elevation in lead V<sub>4</sub>R, age, sex, thrombolytic use, and precordial ST depression) on in-hospital mortality. Statistical significance was evaluated by the likelihood ratio test, and reported as the odds ratio with corresponding profile likelihood-based 95% confidence interval.

There were 175 consecutive patients with inferior MI reviewed, of which RVMI was found to be complicated in 82 patients (47%). Thrombolytic drugs were given to 122 patients (70%). Right-sided leads (V<sub>4</sub>R) were recorded in only 136 patients (78%). Table 1 summarizes the characteristics of patients with or without ST elevation in III>II (III>II or III ≤ II respectively), and those with or without ST elevation in V<sub>4</sub>R (V<sub>4</sub>R+ or V<sub>4</sub>R-, respectively). RVMI was identified by autopsy in 4 patients, radionuclide ventriculography in 2, invasive hemodynamic measurements in 8, echocardiography in 9, cardiac catheterization in 25, and by physical examination only in 34 patients.

There were 14 in-hospital deaths (8%) in the 175 patients, ST elevation in III>II was able to identify 13 (93%), with a negative predictive value of 98%, and an odds ratio for mortality of 7.1 (95% confidence interval 1.4 to 131.0). Lead III>II was associated with a higher mortality of 11.1% compared with 1.7% in patients with III ≤ II (p = 0.031). Multivariate analysis was performed to assess the independent prognostic effect of III>II on in-hospital mortality. Odds ratios were calculated, and adjusted for the effect of age, sex, thrombolytic use, and precordial ST depression. III>II remained an independent predictor for in-hospital mortality with an adjusted mortality odds ratio of 6.7 (95% confidence interval 1.2 to 124.8).

Of the 136 patients with right-sided leads recorded, there were 12 in-hospital deaths. Lead III>II identified 11 of 12 patients (92%) with a negative predictive value of 98% and mortality odds ratio of 5.0 (95% confidence interval 0.9 to 93.8, p = 0.09). ST elevation in V<sub>4</sub>R was able to identify only 7 of 12 patients (58%) with a negative predictive value of 94% and mortality odds ratio of 1.9 (95% confidence interval 0.6 to 6.9, p = 0.27).

In the 136 patients with right-sided leads, III>II identified RVMI with a sensitivity of 97% (66 of 68) compared with 65% (44 of 68) for V<sub>4</sub>R+ (chi-square 20.2, p <0.001). However, V<sub>4</sub>R+ has higher specificity than III>II (78% [53 of 68] vs 56% [38 of 68])

TABLE 2 Comparison of III > II Versus V<sub>4</sub>R in Diagnosing RV MI

	III > II	V <sub>4</sub> R
Sensitivity	97% (93%–100%)	65% (53%–76%)*
Specificity	56% (44%–68%)	78% (68%–88%)*
Negative likelihood ratio	0.05 (0.01–0.21)	0.45 (0.32–0.64)
Positive predictive value	69% (59%–78%)	75% (63%–86%)
Negative predictive value	95% (88%–100%)	69% (58%–79%)
*p <0.001. The 95% confidence intervals are expressed in parentheses.		

for diagnosing RVMI (chi-square 13.2, p <0.001) (Table 2). The incremental value of including V<sub>4</sub>R criteria to those of III>II only increases the yield by 1 patient (67 of 68). V<sub>4</sub>R+ did not detect 24 of 68 patients (35%) with RVMI, but the addition of III>II led to the diagnosis of RVMI in 23 of these 24 patients.

Because the physical examination criteria may be considered the weakest criteria for diagnosing RVMI, the data were reanalyzed by eliminating it as a criterion. Therefore, of the 136 patients who had either autopsy, cardiac catheterization, invasive hemodynamic measurements, echocardiography, or radionuclide ventriculography, 48 had RVMI based on their criteria. Sensitivity and negative predictive values remained high for III>II (96% for both) for diagnosing RVMI.

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Our study revealed that in the 175 patients presenting with inferior MI, lead III>II was associated with a higher in-hospital mortality than without this electrocardiographic finding. However, in a subgroup of patients with right-sided leads recorded, neither III>II nor V<sub>4</sub>R+ was a significant predictor of mortality. This lack of significance of III>II was possibly due to a reduction in power after eliminating 39 patients. Zehender et al<sup>20</sup> in a study of patients with inferior MI showed that V<sub>4</sub>R was an independent predictor of major complications and in-hospital mortality. However, their study was a prospective trial that used different gold standards in diagnosing RVMI, and only 36% of their patients underwent thrombolytic therapy (compared with 70% in this study).

The presence of III>II is highly sensitive for diagnosing RVMI, with a high negative predictive value and low negative likelihood ratio. Thus this criteria, universally available on all electrocardiograms, is a

good screening tool for RVMI. However, it is relatively nonspecific, being often present in patients without RVMI. In this study, the added value of including V<sub>4</sub>R+ criteria to III>II only increases the yield of RVMI by 1 patient. Therefore, in the absence of III>II, the likelihood of RVMI with inferior MI is extremely low.

**In conclusion, ST elevation in III>II is more sensitive than V<sub>4</sub>R in diagnosing RVMI. It is an excellent screening tool for RVMI, given its universal availability on all electrocardiograms. Moreover, III>II is a significant predictor of in-hospital mortality, but further studies are needed to evaluate whether it is superior to V<sub>4</sub>R for predicting in-hospital mortality.**

**Acknowledgment:** We would like to acknowledge Min Gao, MD, at the British Columbia Cardiac Registry, Center for Health Evaluation and Outcome Sciences, for her contribution of statistical analyses.

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## Can We Replace the 90-Minute Thrombolysis In Myocardial Infarction (TIMI) Flow Grades With Those at 60 Minutes as a Primary End Point in Thrombolytic Trials?

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**T**he goal of this study was to validate 60-minute Thrombolysis In Myocardial Infarction (TIMI) flow grades as a surrogate end point in thrombolytic

trials. We hypothesized that the TIMI flow grade at 60 minutes after thrombolytic administration would be related to in-hospital and 30-day survival. Furthermore, we hypothesized that the prognostic information provided by the 60-minute TIMI flow grades would be similar to that provided at 90 minutes.<sup>1–8</sup>

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TIMI flow grade data at 60 and 90 minutes after initiation of thrombolytic therapy was pooled from the TIMI 4, 10A, 10B, and 14 trials, which have been previously described.<sup>9–12</sup> The TIMI flow grade was assessed as previously defined at the TIMI Angiographic Core Laboratory.<sup>1</sup> All flow data were assessed

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