ST elevation after myocardial infarction: what does it mean?

L A Piérard

See article on page 1376

Heart 2007;93:1329–1330. doi: 10.1136/hrt.2007.119131

Acute coronary syndromes are currently classified according to the presence or absence of ST elevation at hospital admission. ST elevation usually reflects acute thrombotic coronary occlusion. The most effective treatment consists in recanalisation of the occluded artery as soon as possible, preferably by primary percutaneous coronary intervention (PCI) or by thrombolytic treatment. However, myocardial salvage relies on rapid, and sustained myocardial tissue perfusion. Epicardial patency does not necessarily imply adequate perfusion at the myocyte level. Alteration of endothelial integrity, tissue oedema, platelet aggregation, neutrophil infiltration, distal embolisation of thrombus can compromise the restoration of myocardial perfusion. This low-reflow or no-reflow phenomenon related to microvascular damage can be demonstrated by several imaging modalities. It was first observed 15 years ago by intracoronary contrast echocardiography.¹ Myocardial contrast echocardiography, positron emission tomography or cardiac magnetic resonance can distinguish between adequate tissue perfusion and microvascular obstruction. This distinction is clinically important. Indeed, absence or impairment of myocardial reperfusion leads to more extensive necrosis and more frequent complications, such as left ventricular (LV) dysfunction and enlargement, in-hospital cardiac decompensation and mortality, rehospitalisation for heart failure and increased risk of cardiac death, including sudden death.

Numerous studies have tested the usefulness of ST-segment recovery as an easily obtainable marker of myocyte reperfusion and of clinical outcome. Most studies have concentrated on early occurrence of ST resolution versus persistent elevation, by comparing 12-lead ECGs at baseline and soon after the start of treatment. On the whole, most investigations have demonstrated that early resolution of ST elevation is associated with myocardial reperfusion, myocardial salvage, smaller infarct area, recovery of LV function and a lower incidence of early and late cardiac complications and mortality. These studies differ in their criteria for defining ST resolution: the timing after reperfusion treatment, the use of snapshot ECG versus continuous monitoring of ST deviation, the inclusion or not of reciprocal ST depression, the presence versus absence of resolution or distinction between complete, partial and no resolution, the method used for calculating ST deviation and the cut-off values for defining resolution.

Methods of ECG analysis differ in their accuracy of predicting the presence or absence of tissue reperfusion and myocardial salvage. Patients with greater ST elevation at baseline usually have a more extensive area at risk. Early and medium-term mortality are accurately estimated by simply measuring, 90 minutes after thrombolysis, ST elevation in a single ECG lead, the lead showing maximum deviation. The prediction is lower with the sum of ST elevation resolution.² Absolute ST resolution—the ST score at baseline minus the ST score after reperfusion—better predicts final infarct size than relative ST resolution—absolute ST resolution divided by ST score at baseline.³ Although the single lead approach is more simple, many studies used the sum of ST elevation or when reciprocal ST depression is considered, the sum of ST deviation. When the population is divided into two groups (presence or absence of resolution), the cut-off value is frequently $\geq 50\%$ versus $< 50\%$ ST recovery.⁴ When partial resolution is analysed, two cut-off points are applied: $\geq 70\%$ for complete and $< 70\%$ to 30% for partial resolution.² When continuous ECG monitoring is used, the end points may be the time to achieve ST recovery and the stability of the resolution.⁵

Absence of ST resolution usually indicates failed reperfusion treatment and has been found to be associated with high early mortality, whereas complete resolution predicts a small infarct area and low mortality.⁶ Partial ST resolution predicts a larger infarct area, low early mortality but increased long-term mortality risk.⁷

Early assessment is most logical when thrombolytic treatment is used. Absence of ST resolution may indicate either no myocardial reflow or persistent epicardial coronary artery occlusion, which may warrant rescue angioplasty and pharmacological approaches.

After angiographically successful primary PCI, the absence of ST resolution identifies patients who are more likely to develop microvascular damage. This information has prognostic significance and may be even more important if adjunctive therapeutic options are shown to be effective.

The pre-discharge ECG remains a useful tool. Several characteristics can be observed: Q-wave regression, normalisation versus persistence of negative T waves, persistence of ST elevation, QT dispersion. These measures are usually analysed at rest but may also be assessed during an exercise or a pharmacological stress test. In this issue of the journal, Galiuto *et al* describe the functional and

Correspondence to:
Professor L Piérard,
Department of Cardiology,
University Hospital Sart
Tilman, B-4000 Liege,
Belgium; lpierard@
chu.ulg.ac.be

Abbreviations: LV, left ventricular; PCI, percutaneous coronary intervention

structural correlates of persistent ST elevation in consecutive patients who underwent successful primary or rescue PCI for first ST-segment elevation acute coronary syndrome (*see article on page 1376*).⁸ The population was divided according to the persistence or resolution of ST elevation at hospital discharge. The cut-off value for defining persistent ST elevation was ≥ 0.4 mV. Myocardial contrast echocardiography was performed at discharge and conventional echocardiography at discharge and at 6 months. An association was found between persistent ST elevation and anterior infarction, larger microvascular damage, higher wall motion score index and a greater incidence of LV aneurysm formation. However, LV volumes were not significantly different in the two groups, with the exception of a larger end-diastolic volume in patients with persistent ST elevation only at hospital discharge, but not at the 6-month follow-up.

Microvascular dysfunction has been found to be the most important predictor of LV remodelling by Bolognese *et al*,⁹ but in their study, the earliest measurement of LV volume was already made at day 1 and LV dilatation was defined as an increase in volume based on repeated measurements in individual patients. The absence of a relation between persistent ST elevation and LV remodelling may be surprising. Manes *et al* found that residual ST elevation at hospital discharge after anterior myocardial infarction was an independent predictor of persistent LV dysfunction and of progressive LV enlargement.¹⁰ However, Bodi *et al* showed that patients with persistent ST elevation had a greater end-systolic volume 1 week after myocardial infarction, but not after 6 months.¹¹

Persistent ST elevation in the acute phase of a myocardial infarction has been considered as a marker of continuing ischaemia. Later, it can be observed in patients with pericarditis or LV aneurysm. Aneurysm was indeed more frequently seen by Galiuto *et al*⁸ in patients with persistent than in patients with resolved ST elevation. This contrasts with other observations showing that ST elevation relates to akinesis and dyskinesis in anterior and septal regions but does not indicate impaired LV function or predict the presence of an LV aneurysm.¹² All the patients of Galiuto *et al* with persistent ST elevation had an anterior infarction.⁸ Anterior myocardial infarcts have less frequently adequate collateral flow and more frequently a high amount of ischaemic tissue and higher wall stress; this may explain the higher incidence of the no-reflow phenomenon among patients with anterior as compared with those with inferior myocardial infarcts.¹³

Persistent ST elevation is most frequently accompanied by persistent negative T waves. Persistent negative T waves—even in the absence of coexisting ST elevation—a few months after a first acute myocardial infarction are independently associated with a worse outcome.¹⁴ Persistent T-wave inversions are related to extensive necrosis or jeopardised myocardium not submitted to coronary revascularisation. In contrast, T-wave normalisation before discharge is associated with stunned myocardium and improvement of LV function. Later T-wave normalisation seems to be associated with viable, ischaemic and revascularised myocardium.¹⁵ In reperfusion treatment, ST elevation developing during dobutamine or exercise stress

testing has a different clinical significance from persistence at rest. It is often associated with a biphasic response during stress, a sign of viable myocardium in jeopardy and is an independent predictor of functional recovery.^{16, 17}

In summary, although imaging modalities such as echocardiography, cardiac magnetic resonance and radionuclide techniques provide much precise, but costly, information, the ECG should not be used only for classifying an acute coronary syndrome. It remains an essential tool for risk stratification and identification of patients who require more aggressive treatment strategies and careful follow-up.

Conflict of interest: None declared.

REFERENCES

- 1 Ito H, Tomooka T, Sakai N, *et al*. Lack of myocardial perfusion immediately after successful thrombolysis: a poor predictor of poor recovery of left ventricular function in anterior myocardial infarction. *Circulation* 1992;**85**:1699–705.
- 2 Schröder K, Wegscheider K, Zeymer U, *et al*. Extent of ST-segment deviation in a single electrocardiogram lead 90 min after thrombolysis as a predictor of medium-term mortality in acute myocardial infarction. *Lancet* 2001;**358**:1479–86.
- 3 Desmet WJ, Mesotten LV, Maes AF, *et al*. Relation between different methods for analysing ST segment deviation and infarct size as assessed by positron emission tomography. *Heart* 2004;**90**:887–92.
- 4 Claeys MJ, Bosmans J, Veenstra L, *et al*. Determinants and prognostic implications of persistent ST-segment elevation after primary angioplasty for acute myocardial infarction. *Circulation* 1999;**99**:1972–7.
- 5 Andrews J, Straznicki IT, French JK, *et al*. ST-segment recovery adds to the assessment of TIMI2 and 3 flow in predicting infarct wall motion after thrombolytic therapy. *Circulation* 2000;**101**:2138–43.
- 6 Schröder R, Wegscheider K, Schröder K, *et al*. Extent of early ST segment elevation resolution: a strong predictor of outcome in patients with acute myocardial infarction and a sensitive measure to compare thrombolytic regimens. *J Am Coll Cardiol* 1995;**26**:1657–64.
- 7 Schröder R, Dissman R, Brüggeman T, *et al*. Extent of early ST segment elevation resolution: a simple but strong predictor of outcome in patients with acute myocardial infarction. *J Am Coll Cardiol* 1994;**24**:384–91.
- 8 Galiuto L, Barchetta S, Paladini S, *et al*. Functional and structural correlates of persistent ST elevation after acute myocardial infarction successfully treated by percutaneous coronary intervention. *Heart* 2007;**93**:1376–80.
- 9 Bolognese L, Carrabba N, Parodi G, *et al*. Impact of microvascular dysfunction on left ventricular remodeling and long-term clinical outcome after primary coronary angioplasty for acute myocardial infarction. *Circulation* 2004;**109**:1121–6.
- 10 Manes C, Pfeffer MA, Rutherford JD, *et al*. Value of the electrocardiogram in predicting left ventricular enlargement and dysfunction after myocardial infarction. *Am J Med* 2003;**114**:99–105.
- 11 Bodi V, Sanchis J, Ullac A. ST-segment elevation on Q leads at rest and during exercise: relation with myocardial viability and left ventricular remodeling within the first 6 months after infarction. *Am Heart J* 1999;**137**:1107–15.
- 12 Bhatnagar SK. Observations of the relationship between left ventricular aneurysm and ST segment elevation in patients with a first acute anterior Q wave myocardial infarction. *Eur Heart J* 1994;**15**:1500–4.
- 13 Kenner M, Zajac EJ, Kondos GT, *et al*. Ability of the no-reflow phenomenon during an acute myocardial infarction to predict left ventricular dysfunction at one-month follow-up. *Am J Cardiol* 1995;**76**:861–8.
- 14 Lancellotti P, Gérard PL, Kulbertus HE, *et al*. Persistent negative T waves in the infarct-related leads as an independent predictor of poor long-term prognosis after acute myocardial infarction. *Am J Cardiol* 2002;**90**:833–7.
- 15 Piérard LA, Lancellotti P. Determinants of persistent negative T waves and early versus late T wave normalisation after acute myocardial infarction. *Heart* 2005;**91**:1008–12.
- 16 Piérard LA, Lancellotti P, Kulbertus HE. ST-segment elevation during dobutamine stress testing predicts functional recovery after acute myocardial infarction. *Am Heart J* 1999;**137**:500–11.
- 17 Lancellotti P, Seidel L, Hoffer E, *et al*. Exercise versus dobutamine-induced ST elevation in the infarct-related electrocardiographic leads: clinical significance and correlation with functional recovery. *Am Heart J* 2001;**141**:772–9.