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Impact of early, late, and no ST-segment resolution measured by continuous ST Holter monitoring on left ventricular ejection fraction and infarct size as determined by cardiovascular magnetic resonance imaging ☆

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Abstract

Background: The goal of this study is to determine the predictive value of ST-segment resolution (STR) early after percutaneous coronary intervention (PCI), late STR, and no STR for left ventricular ejection fraction (LVEF) and infarct size (IS) by cardiovascular magnetic resonance (CMR) at follow-up in patients with ST-segment elevation myocardial infarction.

Methods: The analysis included 199 patients who were enrolled in the PRoximal Embolic Protection in Acute myocardial infarction and Resolution of ST-Elevation trial and in whom both continuous ST Holter and CMR at follow-up were available. Patients were stratified into 3 groups: (1) early complete (≥70%) STR measured immediately after last contrast injection (n = 113); (2) late complete STR (n = 52), defined as complete STR from 30 to 240 minutes after PCI; and (3) no complete STR after 240 minutes (n = 34).

Results: Patients with early STR had more preserved LVEF and smaller IS compared to patients with late STR or no STR (LVEF: early STR, 54% ± 8%; late STR, 46% ± 13%; no STR, 43% ± 11%; and IS: 3.9 ± 3.3 g/m^2; 8.0 ± 6.9 g/m^2; 12.0 ± 6.0 g/m^2; respectively; all $P < .0001$). Early STR was independently predictive for LVEF ($\beta = 8.5$; $P = .0005$) and IS ($\beta = -7.0$; $P < .0001$). Late STR was not predictive for LVEF ($\beta = 1.6$; $P = .51$) but predictive for IS ($\beta = -3.5$; $P = .003$).

Conclusions: Patients with early complete STR after primary PCI have better preserved LVEF and smaller IS. Patients with late complete STR do not have better preserved LVEF but do have smaller IS. ST-segment resolution is a strong, independent predictor of LVEF and IS as assessed by CMR.

Keywords: ST-segment resolution immediately after PCI; Late ST-segment resolution; Primary percutaneous coronary intervention; ST-segment elevation myocardial infarction; Cardiovascular magnetic resonance imaging

Introduction

ST-segment resolution (STR) is a noninvasive, clinically, and scientifically useful method to assess the intensity and duration of myocardial ischemia in patients with ST-segment elevation myocardial infarction (STEMI).[1] In several studies, the relationship between STR and (intermediate) outcomes in acute myocardial infarction populations was assessed.[2-7] In these studies, STR at varying time points appeared to be independently predictive for mortality, infarct size (IS), and left ventricular ejection fraction (LVEF). Infarct size and LVEF after acute myocardial infarction are important determinants of outcome and are accurately visualized with contrast-enhanced cardiovascular magnetic resonance (CMR) imaging.[8] Therefore, we sought to determine the relationship between early STR, late STR, and no STR and LVEF and IS as determined by CMR imaging at 4 to 6 months after index procedure.

☆ Disclosure: none of the authors has declared any conflict of interest.

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Methods

In the PRoximal Embolic Protection in Acute myocardial infarction and Resolution of ST-Elevation (PREPARE), study patients with STEMI were randomized to primary percutaneous coronary intervention (PCI) with combined proximal embolic protection and thrombus aspiration using the Proxis Embolic Protection System (St Jude Medical, St Paul, MN [n = 141]) or primary PCI alone (n = 143). In brief, patients were eligible for inclusion in the PREPARE trial if they experienced onset of symptoms of myocardial infarction less than 6 hours before presentation with electrocardiographic evidence of persistent ST-segment elevation of at least 200 μV in 2 or more contiguous leads and Thrombolysis In Myocardial Infarction (TIMI) flow grade 0 to 1 on diagnostic angiography. Exclusion criteria were age less than 18 years, any contraindications to the use of glycoprotein IIb/IIIa receptor antagonists, coexistent condition associated with a limited life expectancy, prior coronary artery bypass grafting or lytics, and recurrence of myocardial infarction in same myocardial area. With the use of continuous digital 12-lead electrocardiographic/Holter monitoring (Northeast Monitoring 180+, Natick, MA), STR was assessed at the end of the PCI procedure after last contrast injection and 30, 60, 90, 120, 180, and 240 minutes after last contrast. All ST Holter data were analyzed at an independent core laboratory.[9,10] Primary end point of the PREPARE study was STR at 60 minutes after last contrast injection. As part of an ancillary study, patients underwent CMR at 4 to 6 months after index procedure. The CMR imaging was performed with a 1.5T clinical scanner (Sonato/Avanto; Siemens, Erlangen, Germany). Functional assessment was studied with a standard cine steady state free precession sequence, and late gadolinium enhancement images were acquired after administration of gadolinium-based contrast agent (0.2 mmol/kg, Magnevist; Schering AG, Berlin, Germany), with slice position identical to the cine images. Per patient short-axis views were obtained every 10 mm starting from base to apex and covering the entire left ventricle. All data were analyzed on a separate workstation using a dedicated software package (MASS 5.1; MEDIS Medical Imaging Systems, Leiden, the Netherlands) and by one experienced investigator (J.D.E.H.) who was blinded to patient data. Left ventricular volumes were determined by planimetry of all short-axis images in each patient, and the LVEF was calculated. Papillary muscles were excluded from the myocardium. The final IS was calculated by automatic summation of all slice volumes of hyperenhancement (signal intensity >6 SD above the mean signal intensity of remote myocardium). Although patients with STEMI treated with primary PCI with combined proximal embolic protection and thrombus aspiration had significantly better immediate microvascular flow as measured by STR,[11] combined proximal embolic protection and thrombus aspiration did not result in significant differences in IS or LVEF at follow-up CMR.[12]

Statistical methods

The current analysis included all patients with combined CMR data and continuous ST Holter data who were enrolled the PREPARE trial. As shown in Fig. 1, of the 284 patients who were included in the PREPARE trial, a total of 85 patients were excluded from this analysis. Thus, 199 patients formed the study group.

In this analysis, STR was categorized as complete (≥70%) according to Schröder et al.[13,14] Early complete STR was defined as the occurrence of complete STR immediately after PCI (at the end of PCI). Late complete STR was defined as any occurrence of STR between 30 and 240 minutes after last contrast injection. No complete STR was determined as incomplete (<70%) STR after 240 minutes after last contrast injection.

Left ventricular ejection fraction (%) and IS (g/m^2) were analyzed by category of STR using univariable and multivariable analyses. Baseline comparisons between early complete STR, late complete STR, and no complete STR were analyzed by the Cochran-Armitage test (dichotomous) and Kruskal-Wallis rank sum test (continuous). Left ventricular ejection fraction and IS by early complete STR, late complete STR, and no complete STR were compared with the Kruskal-Wallis rank sum test. The association between early complete STR and late complete STR and LVEF and IS was investigated with the use of both univariable and multivariable linear regression models adjusting for univariable predictors of LVEF and IS (history of myocardial infarction, preprocedural TIMI-graded flow <2, anterior myocardial infarction, and maximal ST-segment deviation). Data are expressed as mean ± SD or median (25th-75th percentile) for continuous variables and as frequency with percentage for categorical variables. Patients who were lost to follow-up due to death received imputed values equal to the worst cardiac CMR parameters in our

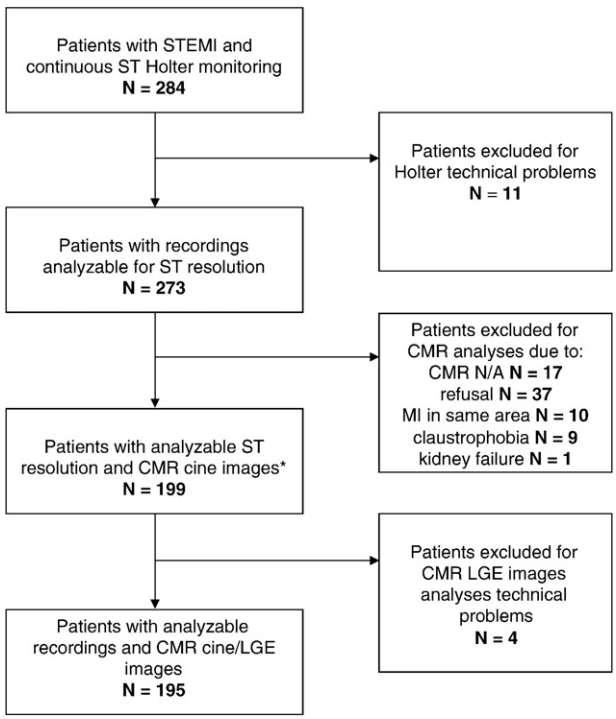

Fig. 1. Flow chart of patients included in the analysis. Asterisk indicates that imputed values for the 6 deaths are included. N/A indicates not available; LGE, late gadolinium enhancement; MI, myocardial infarction.