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Original Article

Pre-angiography total ST-segment resolution is not a reliable predictor of an open infarct-related artery

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ABSTRACT

Background: While the cutoffs of predictive value for ST-segment elevations resolution (STSR) following thrombolysis and/or primary PCI were well documented, the impact of pre-angiography STSR has not been established yet.
Objectives: The aim of this study is to assess prognostic utility of pre-angiography STSR to predict pre-procedural TIMI flow in the infarct-related artery (IRA) and infarct size in STEMI patients undergoing primary PCI.
Methods: A prospective study was performed, including 310 patients, admitted within 12 h of symptom onset and who underwent primary PCI. ST-segment elevations were measured in: (1) qualifying ECG, (2) ECG before angiography, and (3) ECG post PCI. STSR was defined as: total (≥70%), partial (between 70% and 30%) and none (<30%). Relationships between pre-angiography STSR, initial TIMI flow and troponin T level (TnT) were analyzed.
Results: Pre-angiography STSR correlated with initial TIMI flow in the IRA ($r_S = 0.619$; $p < 0.001$). Pre-angiography total STSR was observed in 23.2% patients. It was noted in 79.2% of patients with pre-procedural TIMI flow ≥2 and in 20.8% with TIMI flow ≤1 ($p < 0.001$). Although the sensitivity of pre-angiography total STSR to detect pre-procedural TIMI flow ≥2 was 93%, its specificity was only 56% and the likelihood ratio was 2.1. Pre-angiography total STSR was associated with lower peak TnT level (2.2 ± 2.5 ng/ml vs. 6.4 ± 5.0 ng/ml, $p < 0.0001$) when compared to the remaining patients.
Conclusions: 1. Pre-angiography STSR correlates with preprocedural TIMI flow. 2. The sensitivity of pre-angiography total STSR in detection of pre-procedural TIMI flow ≥2 is high, but low specificity of only 56% makes it an unreliable predictor of an open IRA.

1. Introduction

Since prompt reperfusion was established as a standard treatment in patients with STEMI, an effort was made to shorten the time delay to treatment and a search for optimal adjunctive pharmacotherapy was conducted [1]. Different electrocardiographic, angiographic, echocardiographic and magnetic resonance parameters were tested to assess both prognostic factors and the efficacy of reperfusion therapy [2–7]. Based on the results of thrombolytic trials, STSR was identified as a simple, noninvasive diagnostic tool capable of quantifying the magnitude of myocardial reperfusion. Several cutoffs and timeframes of prognostic value were proposed and the relationships between STSR and the patients outcome were documented [2,8–10].

Studies on pharmacologically induced pre-hospital reperfusion in STEMI patients undergoing primary PCI have shown a high incidence, between 16.6% and 23.9%, of pre-angiography total STSR [11–13]. Although the resolution of ST-segment elevations is quite a common phenomenon in STEMI patients who, after initial pharmacologic intervention, are transferred to PCI-capable centers, its clinical relevance has not yet been established.

The aim of our study was to assess the relationships between pre-angiography STSR, initial TIMI flow and infarct size in STEMI patients undergoing primary PCI.

2. Methods

The methods of the study have been described previously [14]. In brief, the prospective observational study was performed on STEMI

Abbreviations: STEMI, ST-segment elevation myocardial infarction; STSR, ST-segment elevations resolution; PCI, percutaneous coronary intervention; ECG, electrocardiogram; IRA, infarct-related artery; TIMI, thrombolysis in myocardial infarction; ROC, receiver-operating-characteristics.

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patients who were referred to our department for primary PCI. Inclusion criteria were: (1) chest pain persisting for >30 min, (2) ST-segment elevation in ≥2 contiguous leads with the cut-points: ≥0.2 mV in leads V_{1-3} and ≥0.1 mV in all other leads (I, aVL, V_{4-6}, II, III, aVF) in the qualifying ECG, (3) admission within 12 h of the symptom onset, and (4) informed written consent obtained from each patient. The major exclusion criteria were: (1) a delay between the onset of symptoms and angiography of ≥12 h, and (2) qualifying ECG ineligible for analysis (paced rhythm, left bundle-branch block, artifacts).

The study complied with the Declaration of Helsinki. The protocol of the study was approved by the local ethics committee.

3. Procedures

After confirmation of STEMI in the referring center or in the ambulance, all patients received 600 mg of clopidogrel and 300 mg of aspirin orally and a bolus of 5000 IU of unfractionated heparin, administered intravenously. Thereafter, they were sent to catheterization laboratory for angiography and PCI. The decision concerning treatment methods was at the discretion of the operator. After PCI, all patients were treated with clopidogrel, 75 mg for 12 months and aspirin, 75 mg daily indefinitely. Other medications were given in accordance with current STEMI guidelines.

Time intervals were defined as follows: (1) the time from the onset of symptoms to angiography, (2) the time from the onset of symptoms to first balloon inflation (total ischemic time), and (3) the time from qualifying ECG and initial pharmacological intervention to angiography.

Diabetes mellitus was considered to be present if such a diagnosis and treatment regime, including dietary, oral hypoglycemic drugs or insulin had been given prior to admission.

4. Electrocardiographic evaluation

ST-segment deviations were calculated in ECGs obtained at: (1) referral centers or in the ambulance where STEMI was confirmed and a pharmacological intervention was initiated (qualifying ECG), (2) before angiography (after patient's transfer) and (3) 60 min after PCI. For anterior infarction the sum of ST-segment elevations in leads V_1 to V_6, I and aVL was added to the sum of ST-segment depressions in leads II, III, aVF. For inferior infarction the sum of ST-segment elevations in leads II, III, aVF (I, aVL, V_5 and V_6 if present) was added to the sum of ST-segment depressions in leads V_1 to V_4. STSR was classified as follows: total (resolution of initial ST-segment elevations ≥70%), partial (≥30% and <70%) and none (<30%) [2]. The sum of ST-segment deviations in all 12 leads was assessed at the J point in the ECG laboratory by personnel unaware of patients' clinical status.

Based on the magnitude of pre-angiography STSR patients were divided into 2 groups: group I—STSR ≥70% (patients with total pre-angiography STSR) and group II—STSR <70% (patients with partial STSR and patients with no STSR or an aggravation of ST-segment elevations).

5. Angiographic evaluation

Qualitative and quantitative measurements of angiographic parameters, including the flow in the IRA were performed by two independent reviewers who were blinded to each other and to clinical data. Flow in the IRA prior to and post PCI was graded according to the TIMI flow classification [15]. Interobserver variability in the assessment of TIMI flow when using a random sample of 40 films showed a κ value of 0.94.

6. Infarct size measurement and end-points

The extent of myocardial necrosis was calculated by measurements of serum troponin T level. Blood samples were collected on admission, just after PCI and subsequently at 4, 8, 12 and 24 h after PCI. The left ventricular contractility and the ejection fraction were assessed by 2-dimensional echocardiography prior to patient discharge.

The primary end-point of the study was the incidence of pre-procedural TIMI flow ≥2 in patients with pre-angiography total STSR. The secondary end-point was the infarct size as assessed by the peak troponin T level [16].

7. Statistical analysis

All statistical calculations were performed by an independent laboratory using the data analysis software system STATISTICA version 10 (StatSoft, Inc., Tulsa, Oklahoma). The data were expressed as means ± SDs or medians for continuous variables and as absolute and relative frequencies for categorical variables. The Shapiro–Wilk test for normal distribution was used to check normality. Depending on the distribution continuous variables were compared using nonparametric Mann–Whitney *U* test or parametric Student *t* test. Fisher's exact test and χ^2 test with Yate's correction for continuity were used to compare categorical variables. Using ROC analysis the diagnostic performance of pre-angiography STSR cutoff was evaluated besides the pre-specified criteria. The correlation between variables was evaluated with Spearman's correlation coefficient r_S for non-normal distribution. Values of $p < 0.05$ were considered significant.

8. Results

310 patients out of 596 consecutive STEMI patients who were referred to our department for primary PCI between September 2008 and December 2010 met the inclusion criteria and were enrolled in the study. Based on the magnitude of pre-angiography STSR, patients were divided into 2 groups: group I (STSR ≥70%)—72 patients (23.2%)

Table 1
Patients and infarct characteristics.

	STSR ≥ 70% $n = 72$	STSR < 70% $n = 238$	*p*
Patient characteristics			
Age (years [IQR[a]])	58.0 [36.0–83.0]	59.5 [34.0–90.0]	0.15
Men (%)	81.9	73.9	0.21
Hypertension (%)	52.3	48.9	0.66
Hypercholesterolemia (%)	40.3	35.4	0.54
Diabetes mellitus (%)	9.7	20.7	0.03
Smoking (%)	70.8	58.6	0.08
BMI[b] (kg/m^2 [IQR])	27.0 [16.0–45.5]	27.7 [15.1–41.5]	0.87
Renal insufficiency (%)	4.2	10.1	0.11
Previous infarction (%)	6.9	8.4	0.69
MPV[c] (fL, [SD])	10.07 [1.02]	10.18 [1.1]	0.46
Infarct characteristics			
Infarct localization (%)			
Anterior	45.8	43.0	0.77
Inferior	54.2	57.0	0.77
Killip class >1 (%)	12.5	19.3	0.25
No. of diseased vessels (%)			
1	63.0	68.1	0.42
2	23.6	25.2	0.78
3	8.3	11.8	0.41
Heart rate (bpm [IQR])	75.0 [30.0–124.0]	76.0 [37.0–147.0]	0.87
Initial TIMI flow (%)			
0	13.9	74.4	<0.0001
1	6.9	6.7	0.95
2	27.8	11.8	=0.001
3	51.4	7.1	<0.0001
TnT[d] max (ng/ml [IQR])	1.13 [0.04–11.7]	5.1 [0.1–22.1]	<0.0001
LV EF (%)	54.3 ± 7.5	46.1 ± 8.8	<0.0001

[a] IQR—interquartile ranges (in parentheses).
[b] BMI—body mass index.
[c] MPV—mean platelet volume.
[d] TnT—troponin T.