# Accuracy of Resolution of ST-Segment Elevation in Electrocardiogram to Determine the Patency of Infarct-Related Artery

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## Abstract

**Objective**: To determine the accuracy of ST-Segment resolution on ECG for the success of thrombolysis of infarct-related artery in acute myocardial infarction, in comparison to angiography.

**Methodology:** Five hundred patients (311male and 189 females) with acute STEMI receiving streptokinase, within 12 hours of symptomswere included in the study via consecutive convenient non-probability sampling. ECG was recorded immediately after the patient arrived in the emergency unit of cardiology. ST-Segment elevation was recorded as in 1mm, 2mm, or >2 mm, and infarct related artery (IRA) was identified on ECG. Serial ECGs were analyzed for ST-Segment deviation in terms of ST-Segment elevation and resolution. The subsequent ECGs were recorded at 90 minutes after the administration of Streptokinase. ST-Segment resolution, which was recorded as percentage (>50%) resolution of ST-Segment elevation in the same lead.

**Results:** Out of 500 participants, 239(47.8%) were Diabetic, 267(53.4%) hypertensive, 274(54.8%) smokers, 261(52.2%) had hyperlipidemia. Anterior wall myocardial infarction (MI) was the most common site 253(50.6%)and the commonest artery involved was the left anterior descending artery 241(48.2%) followed by right coronary artery in 146(29.2%)patients. ST-resolution of more than 50% on ECG was found in 320 (64.0%) participants. Thrombolysis in MI (TIMI) grade III flow in angiography was found in 211(61.8%) participants. The sensitivity of ST-Segment resolution on ECG after SK was 84%, specificity of 62%, positive predictive value was 75% and negative predictive value was 75%.

**Conclusion:**ST resolution on ECG after Streptokinase can predict infarct-related artery patency on coronary angiography. ST-Segment resolution on ECG has moderate sensitivity (84%) and specificity (62%) in the detection of TIMI III flow in infarct-related artery.

**Keywords:** angiography, ECG, patency, infarct-related artery, streptokinase

**Introduction:**

Coronary artery disease (CAD) has been identified as the primary cause of morbidity and mortality globally [1]. In developing countries also, acute myocardial infarction is also a rising epidemic [2].Generally, CAD is characterized by the plaqueformation in the coronary arteries lumen that obstruct the blood flow causing apoorblood and oxygen supply to the myocardium. Presentation of acute coronary syndrome (ACS) varies depending on the level of underlying pathology and may result in unstable angina, non-ST segment elevation myocardial infarction (NSTEMI) or ST-segment elevationmyocardial infarction (STEMI) [3].In Pakistan, it is predicted the highest prevalence rates of coronary artery disease [4]. In a study conducted in Pakistan in 2015, 56% of all myocardial infarction (MI) were caused by STEMI[5].

High rates of complication and mortality are seen in both ST-segment elevation myocardial infarction (STEMI) and non-ST segment elevation myocardial infarction (NSTEMI) [6]. Administration of intravenous Streptokinase (SK) in patients with acute STEMI has shown a substantial reduction in mortality statistically[7]. According to TIMI flow grade classification, grade 0 to II flow in the infarct-related artery (IRA) is related to poor functional recovery of the left ventricle, whereas grade III of TIMI indicates good functional recovery [8]. However, grade III flow according to Thrombolysis in Myocardial Infarction (TIMI) classification system was achieved in only 60-70 percent of patients of acute STEMI receiving thrombolytic therapy[9]. Resolution of ST-segment elevation on ECG is a non- invasive marker of reperfusion after thrombolytic therapy[10]. Fifty percent resolution of ST-segment elevation is aeffective prognosticator of a better outcome [11]. The specificity of ECG is limited, however by large individual variations in coronary anatomy as well as pre-existing coronary artery disease[12]. The sensitivity and specificity of ECG for recognition of inadequate antegrade flow in IRA are 81% and 88% respectively [13]. For the assessment of patency of the IRA, coronary angiography is a gold standard investigation with a sensitivity of 94% and specificity of 100%[14]. Patients

who show no resolution of ST-Segment can usefully be scheduled for early angiography and coronary intervention so that serious complications may be avoided.

In Pakistan, there is scarce data available in comparing the accurateness of ECG to angiography in envisaging reperfusion status. Therefore, this study was planned to evaluate the accuracy of ST-Segment resolution on ECG in comparison to angiography for the success of thrombolysis of infarct-related artery in patients with acute myocardial infarction.

**Methodology:**

This longitudinal study was performed in the Cardiology Department of Shalamar Hospital, Lahore. The duration of the study was about 6 months from August 2020 to January 2021. The Ethical approval was approved from the ethical board of concerned Hospital. The calculated sample size was 500 cases, with a 10% margin of error, 95% confidence level, taking sensitivity, specificity of ST-segment resolution for the detection of thrombolysis 81 % and 88% of cases with myocardial infarction undergoing coronary angiography during their admission for acute ST-segment elevation myocardial infarction and percentage of cases with myocardial infarction eligible for thrombolysis i.e 60%.

Patients with the first episode of ST-Elevation myocardial infarction diagnosed on the basis of typical chest pain, ECG changes (>1mm) and raised cardiac enzymes (indication for thrombolysis)Patients receiving streptokinase as a thrombolytic agent (within 12 hours after initiation of typical chest pain) for STEMI were included in the study. Whereas, patients who were not given consent for coronary angiography and patients with re-infarction during the same admission or previous history of myocardial infarction were excluded from the study.

All patients with acute STEMI fulfilling the inclusion criteria receiving streptokinase, within 12 hours of symptoms were included after taking informed consent either from the patient or their attendant. All patients or their legally authorized representatives were explained about the study and obtained written informed consent. ECG was performed soon after the arrival of the patient in the cardiac emergency unit. A complete historywas obtained from the patient and/or attendant followed by relevant physical examination. All patients were treated according to standard management protocol of the hospital.

ECG was recorded immediately after the patient arrived in the emergency. ST-Segment elevation was recorded as in 1mm, 2mm, or >2 mm, and infarct related artery (IRA) was identified on ECG. Serial ECGs were analyzed for ST-Segment deviation in terms of ST-Segment elevation and resolution. Standard treatment for STEMI was initiated immediately, which consists of analgesics, oxygen therapy and antiplatelet therapy. Streptokinase (SK) injection was administered in the standard dose of 1.5 million units over 60 minutes within half an hour in emergency unit. The subsequent ECGs were recorded at 90 minutes after the administration of Streptokinase. ST-Segment resolution, which was recorded as percentage (>50%) resolution of ST-Segment elevation in the same lead.

Coronary angiography was executed in 24 hours of hospitalization and flow in the IRA was assessed in terms of TIMI grade flow. TIMI grade III was considered as success of thrombolysis. All this information was recorded in a special proforma.

Data was analyzed using SPSS version 22. Variables of the study were age, and sex. Frequency distribution of categorical data like sex, ST-resolution (>50%, <50%), and TIMI grade flow were generated. The numeric variable such as age was presented as mean ± standard deviation. The sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV) of the ECG for the assessment of ST-segment resolution after thrombolysis was calculated using an online calculator (medCalc) taking angiography as the gold standard.

**Results**

A total of 500 patients diagnosed with myocardial infarction were enrolled for the study wherein the mean age of the patients was 45.7±11.79 years. Out of 500 patients, 311(62.2%) were males and 189 (37.8%) were females. Regarding coronary artery risk factors, 239(47.8%) had Diabetes, 267(53.4%) were hypertensive, 274(54.8%) were smokers, 261(52.2%) had dyslipidemia, 271(54.2%) had a family history of ischemic heart disease and 267(53.4%) had the previous history of ischemic heart disease, as shown in Table I.

Findings of Electrocardiogram showed that patients who suffered from anterior wall myocardial infarction were 253(50.6%), 147 (29.4%) patients had inferior wall myocardial infarction, and 100 (20%) had lateral wall myocardial infarction. As far as the infarct artery is concerned, Left Anterior Descending was involved in 241(48.2%) patients, Right Coronary Artery was involved

in 100(20%) patients, Left Circumflex Artery was involved in 146 (29.2%) patients and Left Main Stem was involved in 13(2.6%) patients. ST-segment resolution >50% after 90 minutes of Streptokinase administration was observed in 320(64.0%) patients while <50% was found in 180(36.0%) patients. Overall TIMI Grade III flow was found in 285(57.0%) cases whereas not observed in 215(43.0%) cases, as shown in Table II.

Measures of diagnostic test accuracy showed sensitivity of ST-Segment resolution on ECG after Streptokinase administration was 84%, specificity was 62%, positive predictive value was 75% and negative predictive value was also 75%, as shown in Table III.

**Table I: Baseline Demographics and clinical characteristics of the study Patients.**

| Variable | | Mean±SD n(%) |
|---|---|---|
| **Age (years)** | | 45.75±11.79 |
| **Gender** | **Male** | 311(62.2%) |
| | **Female** | 189(37.8%) |
| **Diabetes** | **Yes** | 239(47.8%) |
| | **No** | 261(52.2%) |
| **Hypertension (HTN)** | **Yes** | 267(53.4%) |
| | **No** | 233(46.6%) |
| **Smoker** | **Yes** | 274(54.8%) |
| | **No** | 226(45.2%) |
| **Dyslipidemia** | **Yes** | 261(52.2%) |
| | **No** | 239(47.8%) |
| **Family history of heart disease** | **Positive** | 271(54.2%) |
| | **Negative** | 229(45.8%) |
| **Past history of heart disease** | **Yes** | 267(53.4%) |
| | **No** | 233(46.6%) |

**Table II: Site and infarct related artery in Myocardial infarction.**

| Variable | | n(%) |
|---|---|---|
| **Myocardial infarction site (wall involved)** | **Anterior Wall** | 253(50.6%) |
| | **Inferior Wall** | 147(29.4%) |
| | **Left Wall** | 100(20.0%) |
| **Myocardial infarction site (Artery Involved)** | **Left Anterior Descending** | 241(48.2%) |
| | **Right Coronary Artery** | 100(20.0%) |
| | **Left Circumflex Artery** | 146(29.2%) |
| | **Left Main Stem** | 13(2.6%) |
| **ST Resolution** | **>50%** | 320(64.0%) |
| | **<50%** | 180(36.0%) |
| **Thrombolysis in Myocardial Infarction (TIMI) Grade III flow** | **Yes** | 285(57.0%) |
| | **No** | 215(43.0%) |

**Table III: Predictive values of the study population**

| Predictive values | % (CI) |
|---|---|
| **Sensitivity** | 84.21% (79.45% to 88.24%) |
| **Specificity** | 62.79% (55.96% to 69.27%) |
| **Positive predictive value** | 75.0% (71.46% to 78.23%) |
| **Negative predictive value** | 75.0% (69.24% to 79.99%) |
| **Accuracy** | 75.0% (70.96% to 78.74%) |

## Discussion

Timely thrombolysis decreases morbidity and mortality associated with acute myocardial infarction. Given the invasive nature of the coronary angiography ST-segment resolution has been one of the indicators used to assess successful thrombolysis and hence patency of IRA in STEMI. In international studies, ST resolution on ECG has good predictive value and sensitivity to detect IRA patency.

We studied 500 patients with acute MI presented in the cardiology department of Shalamar Hospital, Lahore. Patients were thrombolysis with Streptokinase in the duration of 12 hours after beginning of typical chest pain and 90-minute post-SK. ECG was analyzed for 50% ST resolution. Coronary angiography was performed within 24 hours.

Mean age of the participants was 45.7±11.79 years and most common risk factor was dyslipidemia that was reported by the 271(54.2%) participants with acute STEMI followed by hypertension in 267(53.4%) while history of type II diabetes mellitus was present in 239(47.8%) patients.These findings were corroborated with further Pakistani studies. [15, 16]

The majority of the patients 320(64%) showed significant ST-segment resolution >50% in 90-minute ECG. However, TIMI Grade III was found in a significant number of patients 285(57%). These results are also similar to other reported studies maybe because of the same ethnic population. [16]

In the GUSTO-I trial, ST-segment resolution 50% was found in 50-60% after thrombolysis with Streptokinase after 90 min[17]. Bhatia et al studied 85 patients of acute MI, they observed 45 (53%) patients showed ST resolution in their 90 minutes post-SK ECG. Similarly, Anderson et al. evaluated the effectiveness of thrombolytic therapy on ST resolution subsequent to ECG. ST resolution was reported in 44.2% and 56.5% of the patients following one and a half hour and three hours, respectively [18]. Purcell studied 187 cases with acute MI treated with thrombolysis by Streptokinase, there were 60% of patients achieved an ST-segment resolution of 50% in post-SK ECG at 90 minutes[19]. Lee et al studied192 subjects with acute MI treated with thrombolysis by Streptokinase[20]. A total of 83 (43%) patients had ST-segment resolution.Hence, ST resolution varies between 43-79% in various studies. This variation is most probably multifactorial due to Door to needle time of SK administration, Continues ECG

monitoring versus ECG at fixed intervals plus Quality of SK preparation and its method of administration.

TIMI III flow is the ideal flow to be achieved after thrombolysis or PCI of IRA in acute MI because it was associated with decreased in-hospital and long-term mortality, preserved LV systolic function, and improved survival [21,22]. However, in larger studies, only a minority of patients achieved TIMI III flow, e.g. GUSTO-I trial, ST-segment resolution 50% was found in 50-60% after thrombolysis with Streptokinase after 90 min[96]. However, TIMI Grade III flow was attainedonly in 285(57%) of the patients.

ST-segment resolution and IRA patency on coronary angiography resulted in moderate sensitivity (84%) and specificity (62%) of the test, Zeymer et al achieved 76% sensitivity and 68% specificity were almost comparable to our study[23].

ST-segment resolution has also been correlated with the hospital course of the patients. The study done by Shaikh M et al. observed that the sensitivity and specificity of ST-resolution to detect TIMI gradeIII flow was 94.79% and 67.69%, respectively, while accuracy was observed in 84.46% cases [16]. These results were in accordance to our study findings.

**Limitations**

The present study assessed the ability of simple ECG criteria (ST-segment resolution 50%) to predict patency (TIMI III flow) of the infarct-related artery. We found that this method is moderately sensitive and specific. For a good screening, test sensitivity should be above 90% to detect almost all of the perfused cases. This low sensitivity could be due to common correctable factors, like an improved door to needle time, strict adherence to SK infusion protocol, and quality control of SK preparation.

Similarly, continuous ECG monitoring should be utilized to detect significant ST-segment resolution, capturing a higher frequency of ST-segment resolution.

Another caveat is the timing of coronary angiography post-SK, in the majority of international studies; angiography was done at 90-180 minutes post-infusion, this gives a true indication of immediate post-SK-related patency of IRA. Because as the effect of SK weans off in the next 24 hours some vessels re-occlude while other vessels may reopen due to ongoing fibrinolysis. This

late reopening of IRA would not be as beneficial as early patency of IRA, as more IRA tend to be occluded than to reopen post-SK, late coronary angiography could give us a wrong percentage of patency of IRA post-SK.

Another limiting factor of our study was the non-randomized study design along with small sample size of patients. It was also a single-center study.

All the factors described above need to be reconsidered when applying low sensitivity of ST resolution in clinical situations i.e. whether good IRA patency has been achieved or not.

**Conclusion**

ST resolution on ECG following treated with Streptokinase can predict infarct-related artery patency on coronary angiography. ST-Segment resolution on ECG has moderate sensitivity and specificity in the detection of TIMI III flow in infarct-related artery.

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