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Single lead ST resolution as a simple prognostic indicator in thrombolysed patients with acute myocardial infarction

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RESEARCH

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Abstract

Background

Both sum STR and single lead STR methods has been proved early and easy prognostic indicator after thrombolysis in acute myocardial infarction (AMI). The present study was planned to compare both methods.

Method

ST deviation was calculated from baseline ECG recorded immediately on arrival and resolution calculated from ECG recorded 90 minutes after start of thrombolysis. For Single lead STR, ST resolution was calculated from one lead showing the most prominent ST segment deviation either at baseline or at 90 minutes after start of thrombolysis. For sum STR, ST resolution from multiple leads was taken. Patients were divided into 3 subgroups (Complete, partial and no resolution) for both methods. Results obtained by both methods were compared along with 7days and 30 days outcome.

Results

The proportions of patients in three risk subgroups by both methods were similar [highly significant ($p<0.001$) agreement]. Mortality rate, pump failure (LVF/CCF) and arrhythmic events showed a significant relationship to the ST resolution achieved. All clinical outcomes except post MI angina at 7 days were similar in both methods. Single lead STR method was more useful in risk stratification on the base of chances of developing cardiac complications.

Conclusion

Calculation of ST segment resolution from a single lead is reliable and correlates well with ST segment resolution by sum STR method. Compared with sum STR, risk stratification by single lead STR is simpler, easy to calculate, more reliable and helpful in guiding decisions on adjunctive interventions after thrombolysis in AMI.

Key Words

Acute myocardial infarction, Single lead STR, ST segment resolution, Sum STR

Background

Myocardial salvage in acute myocardial infarction (AMI), which depends upon coronary patency, can be attempted by emergency coronary angioplasty or thrombolysis. However, the former being an invasive procedure and not possible at all times, thrombolysis has become the mainstay of treatment in AMI.[1] Aim of thrombolysis is early and complete myocardial reperfusion; failure of which is associated with increased risk of death and left ventricular dysfunction.[2] Hence an early prognostic indicator is required to take timely decision in the management of evolving AMI which must be rapid, simple and inexpensive. [3, 4]

It has been demonstrated that ST resolution is a reliable, early and easily available predictor of reperfusion and can act as an early predictor of outcome in thrombolysed patients of AMI.[5-8] Sum of ST segment resolution in all leads (sum STR / ΣSTR) can represent a reliable and independent predictor of immediate and long term outcome in patients with AMI treated with fibrinolytic agent.[9] Dissmann et al in 1994 concluded that difference in degree of ST elevation resolution at 3 hours may help timely screening of patients for appropriate therapeutic intervention, meaning there by, patients with complete ST resolution (>70%) indicate reperfusion and development of small infarcts and hence may be considered for early discharge. While patients with no ST resolution (<30%) are associated with persistent vessel occlusion and a poor outcome. These patients might benefit from early interventions such as rescue percutaneous transluminal coronary angioplasty or high dose intracoronary thrombolysis to established vessel patency.[10] Ninety minutes post t-PA treatment; Angeja et al calculated the sum of ST segment elevation 20 ms after the J point and compared with the baseline ECG. The percent resolution was categorized as complete (≥70%), partial (30 to 70%) and no resolution (<30%).[11] Anderson et al

concluded that the presence of ST segment resolution 90 minutes after thrombolysis is useful independent predictors of mortality at 30 days and 1 year. [12] To improve the ease of ST segment resolution in 12 lead electrocardiograph (ECG), Zeymer et al concluded that ST segment resolution obtained in a single lead is an easy and accurate prognosticator of cardiac 30 day mortality in patients with ST elevation MI (STEMI). It is therefore useful for early identification of low and high risk subgroups after fibrinolysis.[13] French JK et al concluded that ST resolution measured in the single lead with maximum ST elevation was a predictor of late survival but ΣSTR was not. This simple electrocardiographic parameter can identify patients with a reduced chance of survival who might benefit from additional therapies.[14] Schroder et al compared the power to predict mortality by ΣSTR and resolution of ST segment in the single ECG lead with maximum deviation 90 minutes after start of thrombolysis and concluded that single lead STR predicts early and medium term mortality more accurately than ΣSTR.[13, 15]

Hence the present study was planned to evaluate comparison between single lead STR and sum STR as a prognostic parameter in patients of AMI after 90 min of thrombolysis which can also help us to avoid cumbersome calculations of measuring ST resolution from multiple leads.[16,17]

Method

The study material consisted of 121 patients of acute ST elevation myocardial infarction (STEMI) admitted to intensive coronary care unit over a period of 1 year (from May 2005 to May 2006). Out of these, 9 patients could not be followed up and thus dropped out. Inclusion and exclusion criteria are given in table-1.[13, 15]

Method: Ethical clearance was taken from institutional ethical committee. All patients of AMI coming to ICCU fulfilling the inclusion criteria were thrombolysed with 1.5 million units of streptokinase.[18] Informed consent were taken from all patients. Patients were followed after 7 days and 30 days especially for cardiac complications like mortality, heart failure (Killip Class II-IV), post MI angina and arrhythmias. [13, 15]

ST analysis: ST deviation was calculated from the baseline ECG recorded immediately on arrival and resolution calculated from ECG recorded 90 minutes after the start of thrombolysis.

- ΣSTR: ST segment was measured manually 20 ms after the QRS complex. The sum of ST elevation (ΣST) for anterior wall myocardial infarction (AWMI) was calculated as: ST↑ [I + aVL+V1+V2+V3+V4] mm. In case of lateral wall extension, ST elevation observed in V5 & V6 was also added. For inferior wall myocardial infarction (IWMI), sum ST (ΣST) was calculated as ST ↑ [II+III+aVF]. To determine the area at risk as an index of myocardial injury reflecting potential infarct size, in addition to ST segment elevation, the sum of reciprocal ST segment depression was also added. For AWMI, ST depression in leads II+III+aVF were added and for IWMI, ST depression in leads V1+V2+V3+V4 was added.

$$\% \Sigma ST \text{ resolution} = \frac{\Sigma ST \text{ deviation}_{0min} - \Sigma ST \text{ deviation}_{90min}}{\Sigma ST \text{ deviation}_{0\ min}}$$

Patients were divided into 3 subgroups for ΣSTR: Complete resolution ≥70%, Partial resolution 70-30% and No resolution ≤30%.[11,13,15]

- Single lead STR: ST resolution was calculated from one lead showing the most prominent ST segment deviation either at baseline or at 90 minutes, irrespective of ECG lead in which ST deviation was measured at baseline.

$$\% \text{ single lead ST resolution} = \frac{ST \text{ deviation}_{0min} - ST \text{ deviation}_{90min}}{ST \text{ deviation}_{0\ min}}$$

As in sum STR, for single lead resolution also patients were divided in 3 categories:

For AWMI: Complete resolution ≥70%, partial resolution 70-50% and no resolution <50%.

For IWMI: Complete resolution ≥70%, partial resolution <70-20% and no resolution <20%.[11,13,15]

Results obtained by single lead STR and sum STR were compared along with 7days and 30 days outcome.

Data Analysis: All the data was analyzed by Chi-square test using SPSS 10 and Microsoft Excel 2007.

Results

The Majority of the patients were male (107) and there were only 5 female patients. Among these 57 (50.89%) patients had AWMI, 53 (47.32%) had IWMI and 2 (1.78%) had lateral wall MI. Their age ranged between 20-70 years with mean of 51.5±11.7 years.

Table 2 shows the classification of patients into three subgroups according to ST resolution by both single lead STR and ∑STR methods and shows the two-way frequencies of the agreement between various subgroups. Agreement was 62.5% and 83.33% for complete resolution subgroups, 65.90% and 60.42% for partial resolution subgroups and 82.14% and 67.64% for no resolution subgroups of single lead STR and ∑STR respectively. There was significant difference between the observed and the expected frequencies in the resolution subgroups by ∑STR and single lead STR methods using $\chi 2$ tests (assuming samples to be randomly distributed). There was a significant agreement ($p<0.001$) between resolution subgroups by the two methods ($\chi 2$ value =78.2, degree of freedom =4).

Table 3 shows the proportions of patients developing the cardiac events (in 7 days and 30 days follow up) in three resolution subgroups by sum STR and single lead STR methods.

Mortality: No mortality (0%) was observed in the complete resolution subgroups by either method. Mortality rate was more in partial resolution than complete resolution subgroup, showing a significant association between mortality and ST resolution, [χ^2 value = 6.99 and $p<0.05$ by ∑STR and χ^2 = 9.0, $p<0.02$ by single lead STR method]

indicating that the association was stronger with single lead STR as compared to ∑STR method (table 3).

Heart failure (LVF/CCF):- By ∑STR (table 3), heart failure was commonest complication during 7days and 30 days follow up. Heart failure occurred in 10% patients of complete resolution subgroup and in 30.5% patients of no resolution subgroup that means lesser the STR , more were the complications (χ^2 value = 15.36, p<0.001 at 7 days and χ^2 value = 11.79, p<0.01 at 30 days). However the difference between partial and no resolution subgroups was insignificant both in 7days (p>0.05) and 30 days follow up (p>0.05). Also by single lead STR method (table 3), it was evident that significantly lesser number of patients developed LVF/CCF in complete resolution subgroup during 7days (χ^2 value = 25.27, p<0.01) as well as at 30 days (χ^2 value = 22.17, p<0.001).

Post MI angina: By ∑STR method (table 3) , partial resolution subgroup showed more frequency of post MI angina as compared to both complete and no resolution subgroups , hence indicating no association between resolution and post MI angina during 30 days follow up (p>0.05) but a significant association was reported during 7days follow up. By single lead STR method (table 3), it is evident from the data that significantly lesser number of patients in complete resolution subgroup had post MI angina during 7days follow up (p<0.02) but in 30 days follow up it showed no significant difference (p>0.05, NS).

Arrhythmias: By ∑STR method (table 3), significantly lesser number of patients having complex arrhythmias were seen in complete resolution subgroup during 7days [χ^2=6.75, p<0.05] and 30 days follow up [χ^2=6.75, p<0.05]. Single lead STR method (table 3) also showed significantly lesser arrhythmic events in complete resolution subgroup, both in 7days [χ^2=6.21, p<0.05) and 30 days follow up [χ^2=6.21, p<0.05).

In nutshell mortality rate, pump failure (LVF/CCF) and arrhythmic events showed a significant relationship to the ST resolution achieved. Complete resolution subgroup had least complication rate. Post MI angina had no relation to the ST resolution achieved by either method at 30 days complications (table 3).

Association between proportions of patients in single lead STR subgroups and sum STR subgroups in relation to outcome variables: - The χ^2 tests were applied with a null hypothesis that there was no difference between the clinical outcomes among resolution subgroups by both the resolution methods.

At 7 days, all the clinical outcomes other than post MI angina showed no significant difference between the proportions of patients in three resolution subgroups by both methods of resolution. At 30 days, the proportions of occurrence of all clinical outcomes were similar in both the methods under three resolution subgroups (table 4, 5).

Discussion

Both sum STR and single lead STR methods had been proved as early and easy way to predict clinical outcome after thrombolysis in AMI. [12, 13, 14] To investigate which is better, we planned to compare these two methods.

Our observations shows that there was a significant agreement between resolution subgroups by the two methods (table 3). That means the proportions of patients in three risk subgroups by sum STR were similar to those by single lead STR. Our results correspond to the study reported by Schroder et al.[15]

Mortality rate by ∑STR was observed in complete resolution < partial resolution < no resolution subgroup. These findings were almost consistent with those of Dissmann et al[10] and Schroder et al.[18] They also reported ∑STR as the most powerful predictor of early mortality (P=0.0001). Our study also indicate ∑STR as a good predictor of mortality (P<0.05). No mortality was observed after 7 days. Anderson RD et al also reported very little increase in mortality after discharge from hospital up to 30 days exactly similar to our results.[12] The lesser mortality rates in our study is possible because of smaller number of patients. The mortality rate by Single lead STR observed at 7 days and 30 days was least in complete resolution, maximum in no resolution subgroups and no mortality recorded after hospital discharge up to 30 days with P<0.02 being more significant than by sum STR (P<0.05). More deaths was reported in the no resolution and less deaths in partial resolution subgroups in single lead STR method when compared to similar subgroups in ∑STR method during 7days or in 30 days follow up. This means that compared with sum STR method, patients with a higher mortality risk have been shifted by single lead STR method from partial resolution to no resolution subgroup. This leads to the inference that single lead STR method is better in finding out mortality risk and hence helps better in finding out patients in whom we can offer surgical processes to reduce mortality. Schroder et al observed similar findings.[15]

The proportions of patients developing heart failure calculated by ∑STR was least in complete resolution and highest in partial resolution subgroup during 7days follow up, which was significantly (P<0.001) associated with resolution subgroups that means lesser the STR , more the complication. Similar trend was reported during 30 days follow-up (P<0.01). These results are in tune with studies done by Mauri et al[9], Anderson et al[12], Jeffrey et al[19], James et al[20] and Schroder et al[21]. When measured by Single lead STR, the proportion of patients having LVF/CCF was significantly associated with their resolution subgroup (p<0.001) and higher the resolution, lesser the complication were observed. Our study observed results in concordance with Schroder et al depicting that there were lower complication rate in partial resolution and higher in no resolution subgroup by single lead STR method when compared to similar subgroups of ∑STR, ultimately indicating that single lead STR method is better in finding out higher risk patients more prone to cardiac failure. [15]

Post MI angina had no significant association with their resolution subgroups by both methods in 30 days. By ∑STR method, incidence was highest in partial resolution subgroup. Schroder et al in 1995 also observed similar results.[21] Schroder et al in 1999 reported the incidence of post MI angina in 10% in patients with evidence of failed thrombolysis and 11% in patients who had successful thrombolysis, showing not much difference.[22] These results

corresponds to present study indicating no association of post MI angina with ST resolution.

Arrhythmias are much common after AMI. But most of them are benign arrhythmias – ventricular premature complexes (VPC's), ill sustained ventricular tachycardia, idioventricular rhythm etc. We took into account only complex arrhythmias which required therapy (17 patients). Almost all arrhythmogenic events occurred during early phase of AMI and these were not observed after 7 days. Both methods showed significantly higher proportions in partial and no resolution subgroups indicating that if there is complete resolution, then chances of arrhythmias are less. Our study results here are in correspondence to studies done by Schroder et al[21] and Ito et al[23].

So in overall, mortality rate, pump failure (LVF/CCF) and arrhythmic events except post MI angina showed a significant relationship to the ST resolution achieved by both methods. Single lead STR method is more useful in risk stratification or classifying patients on the base of chances of acquiring any complication.

The significances of difference for cardiac outcomes were calculated between the proportions of patients in three resolution subgroups by two methods of resolution. Proportions of occurrence of all complications except post MI angina at 7days follow up and all clinical outcomes at 30 days follow up were likely to be equal in both the methods under three resolution subgroups (table 3). It is very cumbersome to calculate ∑STR because of addition of ST resolution from many leads in comparison to single lead STR calculation and also single lead STR method is better for risk stratification, so single lead STR method can be used alone.

Study Limitations

In our study we have not added max STE which gives comparable results with accuracy like single lead STR, [24] so max STE can also be compared with single lead STR and sum STR. It was a time bound study in which we got only 5 females. So we were unable to compare the results between males and females.

Conclusion

Calculation of ST segment resolution from a single lead is reliable and correlates well with ST segment resolution calculated from multiple ECG leads by ∑STR method. Compared with sum STR, risk stratification by single lead STR is simpler, easy to calculate, more reliable and seems to be more helpful in guiding decisions on adjunctive interventions after thrombolysis in AMI. In patients identified as being at low risk (complete resolution), are most likely to have a patent infarct related artery and could be targeted for early discharge. On the other hand, patient in the high risk (no resolution) subgroup have persistent vessel occlusion, or no myocardial reflow, or both features. In these subsets, easily identified by single lead ST segment resolution from an ECG recorded 90 minutes after start of fibrinolytic therapy, more aggressive treatment including rescue angioplasty/CABG to improve reperfusion might be considered.

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PEER REVIEW

Not commissioned. Externally peer reviewed.

CONFLICTS OF INTEREST

None

Tables

Table 1: Inclusion and Exclusion Criteria

INCLUSION CRITERIA	EXCLUSION CRITERIA
• All patients of AMI diagnosed by typical history of prolonged chest pain (more than 30 minutes) reaching within 6 hours of onset of symptoms • More than 18years of age • ECG showing ST elevation of ≥0.1mV in the two limb leads or ≥0.2mV in two contiguous precordial electrocardiographic leads • No clear contraindication to thrombolytic therapy	• Patients with age >70 years, • Persistent ECG changes of old infarction • Having contraindication to thrombolysis • ECG showing bundle branch blocks, • Thrombolysed outside • Resuscitated following cardio respiratory arrest • Who died before the end of 90 minutes following thrombolytic therapy • Having associated diseases like cardiomyopathy / valvular heart disease

Table 2: Two-Way Frequency Table on Agreement between Sum STR and Single Lead STR Subgroups

Sum STR	Single lead ST resolution			Total
	No resolution	Partial resolution	Complete resolution	
No. of patients in No resolution Sum STR Single lead	23 (82.14%) (67.64%)	4 (14.28%) (8.33%)	1 (3.57%) (3.33%)	28
No. of patients in Partial resolution Sum STR Single lead	11 (25%) (32.35%)	29 (65.9%) (60.42%)	4 (9.09%) (13.33%)	44
No. of patients in Complete resolution Sum STR Single lead	0 (0%) (0%)	15 (37.5%) (31.25%)	25 (62.5%) (83.33%)	40
Total	34	48	30	112

Table 3: Correlation of Complications According to ∑STR and Single Lead STR

	∑STR					Single lead STR				
	Complete resolution	Partial resolution	No resolution	χ^2	P	Complete resolution	Partial resolution	No resolution	χ^2	P
No. of patients	40 (35.71%)	44 (39.28%)	28 (25%)			30 (26.78%)	48 (42.85%)	34 (30.35%)		
Complications during hospital stay										
Deaths	0 (0%)	3 (6.82%)	2 (7.14%)	6.99	<0.05*	0 (0%)	2 (4.17%)	3 (8.82%)	9.0	<0.02*
LVF/CCF (Killip class ii-iv)	1 (2.5%)	9 (20.45%)	6 (21.43%)	15.36	<0.001*	1 (3.33%)	5 (10.42%)	10 (29.4%)	25.27	<0.01*
Post MI angina	0 (0%)	6 (13.64%)	0 (0%)	27.26	<0.001*	0 (0%)	3 (6.25%)	3 (8.82%)	8.2	<0.02*
Arrhythmia	3 (7.5%)	8 (18.18%)	6 (21.42%)	6.75	<0.05*	2 (6.67%)	9 (18.75%)	6 (17.64%)	6.21	<0.05*
30 days cardiac outcome										
Deaths	0 (0%)	3 (6.82%)	2 (7.14%)	6.99	<0.05*	0 (0%)	2 (4.17%)	3 (8.82%)	9.0	<0.02*
LVF/CCF (Killip class ii-iv)	4 (10%)	14 (31.82%)	8 (28.5%)	11.79	<0.01*	3 (10%)	9 (18.75%)	14 (41.17%)	22.17	<0.001*
Post MI angina	4 (10%)	9 (20.45%)	3 (10.71%)	4.97	>0.05	3 (10%)	6 (12.5%)	7 (20.59%)	4.26	>0.05
Arrhythmia	3 (7.5%)	8 (18.18%)	6 (21.42%)	6.75	<0.05*	2 (6.67%)	9 (18.75%)	6 (17.64%)	6.21	<0.05*

*significant

Table 4: Significance of Difference between Proportions of Single Lead STR Subgroups and Sum STR Subgroups for 7 Days Cardiac Outcomes

Outcome (clinical event)	χ 2	P
Death	0.78	Non-significant
LVF/CCF (Killip class II-IV)	4.60	Non-significant
Post MI angina	11.52	0.01(significant)
Arrhythmias	0.23	Non-significant

Table 5: Significance of Difference between Proportions of Single Lead STR Subgroups and Sum STR Subgroups for 30 Days Cardiac Outcomes

Outcome (clinical event)	χ 2	P
Death	0.78	Non-significant
LVF/CCF (Killip class II-IV)	5.55	Non-significant
Post MI angina	4.74	Non-significant
Arrhythmias	0.22	Non-significant