Assessment of the Relationship between Reperfusion Success and T-peak to T-end Interval in Patients with ST Elevation Myocardial Infarction Treated with Percutaneous Coronary Intervention or Pharmacoinvasive Therapy

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Background: Acute coronary syndrome encompasses unstable angina, non-ST-segment elevation myocardial infarction (NSTEMI) and ST-segment elevation myocardial infarction (STEMI). STEMI is mostly caused by coronary artery occlusion which treated either by fibrinolytic therapy or primary percutaneous coronary intervention (pPCI). The aim of this work was to investigate the relationship between therapeutic plasma exchange (TPE) interval and successful perfusion in patients with STEMI treated with pPCI or pharmaco-invasive therapy.

Methods: This cohort prospective study was carried out on 60 patients admitted to cardiology department in Tanta University Hospitals with STEMI. All patients were subjected to full medical history taking, clinical examination, laboratory investigations, electrocardiography, transthoracic echo Doppler study, coronary angiography, follow up for early outcome during hospital stay and late outcome after 3 months and assessment of thrombolysis in myocardial infarction (TIMI) flow.

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Results: There was a statistically non-significant difference regarding age, gender, hypertension and diabetes between both groups. Regarding vessel affected, in group I, there were 20% with RCA lesion, 46.7% with LAD lesion and 33.3% with LCX lesion while in group II there were 30% with RCA lesion, 43.3% with LAD lesion, 20% with LCX lesion and 6.7% was LM with statistically non-significant difference between the groups. In comparison TPE preprocedural and TPE post-procedural in successful PCI group, there was statistically highly significant difference with P value 0.001. While comparing TPE preprocedural and TPE Postprocedural in failed PCI group, there was statistically non-significant difference with P value =0.09. ROC curve analysis was done to pick up the best cut off value of TPE at admission for prediction of Pharmaco-invasive group which revealed TPE at admission more than 104.5 with sensitivity 73.3% and specificity 63.3%. Area under the curve 0.725 with 95% CI ranged from 0.596 to 0.854.

Conclusions: The present study demonstrated that prolonged TPE interval is associated with ischemia and thus shortened TPE could be used as a marker for reperfusion success. TPE prolongation also associated with poor prognosis in patients with STEMI

1. INTRODUCTION

Acute coronary syndrome is one of the leading causes of death worldwide. Acute coronary syndrome encompasses unstable angina, non-ST-segment elevation myocardial infarction (NSTEMI) and ST-segment elevation myocardial infarction (STEMI) [1].

STEMI is mostly caused by coronary artery occlusion which in most cases is caused by intracoronary thrombus [2].

STEMI is treated either by fibrinolytic therapy or primary percutaneous coronary intervention (pPCI) [3].

Primary PCI is the preferred reperfusion strategy in patients with STEMI within 12h of symptom onset, provided it can perform expeditiously (120 min from STEMI diagnosis) by an experienced team [4].

Pharmaco-invasive strategy is the use of Fibrinolysis combined with rescue PCI (in case of failed fibrinolysis) as well as routine early PCI strategy (in case of successful fibrinolysis) [5].

T-peak to T-end (TPE) interval, which is defined as the interval between the peak and end of the T-wave, represents the dispersion of repolarization. Abnormal repolarization and prolonged TPE interval are associated with increased malignant ventricular arrhythmia and sudden cardiac death (SCD) in many acquired and congenital cardiac diseases [6].

Recently, the relationship between prolonged TPE interval and worse short- and long-term outcomes in patients with STEMI will be established. even in patients with (STEMI) who are treated with successful primary percutaneous coronary intervention (pPCI) [7].

The aim of this study was to investigate the relationship between TPE interval and successful perfusion in patients with STEMI treated with pPCI or pharmaco-invasive therapy.

2. PATIENTS AND METHODS

This prospective cohort study was carried out on 60 patients admitted with STEMI to cardiology department in Tanta University Hospitals at Tanta University Hospital from December 2019 to August 2020. Informed written consent was obtained from all cases before participating in the study. Also, the study was done after approval by the local ethical committee of Faculty of Medicine, Tanta University Patients with a Previous history of STEMI and structural heart disease, Inappropriate electrocardiogram (ECG) due to poor quality, bundle branch block, second and third-degree AV block and QRS duration > 120 Ms, end stage renal failure (creatinine clearance <15 mL/ min), hematological disorders, active hepato-biliary disease, active infections, neoplastic diseases, thyroid dysfunction, recent major surgical procedure or trauma , connective tissue disorders and who refused to give written consent were excluded.

Patients were divided equally into two groups as follows: group I primary PCI group and group II pharmaco-invasive group.

All Patients were Subjected to the Following: Full medical History taking Corticosteroids,

cytotoxic drugs, thrombolytic therapy, glycoprotein IIb/IIIa inhibitors, clinical examination, laboratory investigations, electrocardiography, transthoracic echo Doppler study, coronary angiography, follow up for early outcome during hospital stay and late outcome after 3 months.

Assessment of Thrombolysis in Myocardial Infarction (TIMI) Flow: The TIMI flow grade has become the standard for semi-quantitative evaluation of myocardial perfusion before and after coronary reperfusion therapies, determination of TIMI flow grade after coronary reperfusion yields important prognostic information in patients with acute myocardial infarction. In early analyses, both TIMI flow grades 2 and 3 were considered indicative of successful reperfusion.

TIMI Grade Flow is a scoring system from 0-3 referring to levels of coronary blood flow assessed during percutaneous coronary angioplasty: TIMI 0 flow (no perfusion) refers to the absence of any antegrade flow beyond a coronary occlusion, TIMI 1 flow (penetration without perfusion) is faint antegrade coronary flow beyond the occlusion, with incomplete filling of the distal coronary bed. TIMI 2 flow (partial reperfusion) is delayed or sluggish antegrade flow with complete filling of the distal territory.

2.1 Statistical Analysis

Data were analyzed using the Statistical Package of Social Science (SPSS) program for Windows (Standard version 21). The normality of data was first tested with one-sample Kolmogorov-Smirnov test. Qualitative data were described using number and percent. Association between categorical variables was tested using Chi-square test while Fischer exact test and Monte carlo test were used when expected cell count less than 5. Continuous variables were presented as mean ± SD (standard deviation) for parametric data and median (min-max) for non-parametric data. The two groups were compared by student t- test (parametric) and Mann Whitney test (non-parametric) while paired groups were compared with paired t test for parametric data. P value < 0.05 was considered significant.

3. RESULTS

Our study showed that there was a statistically non-significant difference regarding age, gender, hypertension and diabetes between both groups in (Table 1).

Comparing HR preprocedural and HR Postprocedural in group I, statistically significant difference with P value ≤0.001. While comparing HR preprocedural and HR postprocedural in group II, there was statistically non-significant difference with P value =0.825.

Comparing TPE preprocedural and TPE Postprocedural in group I, there was statistically highly significant difference with P value ≤0. 001.While comparing TPE preprocedural and TPE Postprocedural in group II, there was statistically significant difference with P value ≤0. 001.Comparing corrected QT preprocedural and corrected QT postprocedural in group I, there was statistically non-significant difference with P value =0.176. While comparing Corrected QT preprocedural and Corrected QT postprocedural in group II, there was statistically non-significant difference with P value =0.861 in (Table 2).

Table 1. Comparison between primary PCI and pharmaco-invasive groups regarding demographic data and risk factors

Variables	Total (n=60)	Primary PCI (n=30)	Pharmaco-invasive (n=30)	Test of significance	P value
Age (years) Mean ± SD	55.58±9.87	54.23±10.6	56.93±9.06	t=1.06	0.293
Sex				χ^2=0.278	0.598
Male	36 (60.0%)	17 (56.7%)	19 (63.3%)		
Female	24 (40.0%)	13 (43.3%)	11 (36.7%)		
Smoking	32 (53.3%)	14 (46.7%)	18 (60.0%)	χ^2=1.07	0.301
HTN	36 (60%)	17 (56.7%)	19 (63.3%)	χ^2=0.278	0.598
Dyslipidemia	35 (58.3%)	18 (60.0%)	17 (56.7%)	χ^2=0.069	0.793
DM	35 (58.3%)	16 (53.3%)	19 (63.3%)	χ^2=0.617	0.432

Table 2. Comparison between Primary PCI and Pharmaco-invasive groups regarding ECG

ECG	Total (n=60)	Primary PCI (n=30)	Pharmaco-invasive (n=30)	Test of significance	P value
HR preprocedural	92.05±9.81	93.23±9.49	90.87±10.15	t=0.933	0.355
HR Postprocedural	88.13±11.45	85.93±8.85	90.33±13.36	t=1.50	0.138
P pre-post	P =0.012*	P ≤0.001*	P=0.825	-	-
TPE preprocedural	105.33±8.11	102.17±7.36	108.5±7.68	t=3.26	0.002*
TPE Postprocedural	99.30±7.95	96.00±6.75	102.60±7.78	t=3.51	0.001*
P pre-post	P ≤0.001*	P ≤0.001*	P ≤0.001*	-	-
Corrected QT Pretprocedural	418.90±19.89	416.40±31.88	416.90±20.32	t=0.072	0.943
Corrected QT Postprocedural	417.95±20.25	421.33±19.35	416.47±20.46	t=0.946	0.348
P pre-post	P=0.303	P=0.176	P=0.861	-	-
Arrhythmias preprocedural	20 (33.3%)	10 (33.3%)	10 (33.3%)	χ^2=0	1
Arrhythmias Postprocedural	19 (31.7%)	7 (23.3%)	12 (40%)	χ^2=1.92	0.165
P pre-post	P=1.0	P=0.625	P=1	-	-
ST segment resolution	39 (65%)	22 (73.3%)	17 (56.7%)	χ^2=1.83	0.176

ECG: Electrocardiogram, HR: Heart rate, TPE: therapeutic plasma exchange

In comparison cTpn preprocedural and cTpn postprocedural in group I, there was statistically significant difference with P value ≤0.001. In comparison cTpn preprocedural and cTpn postprocedural in group II, there was statistically significant difference with P value =0. 001.Comparing CKMB preprocedural and CKMB Postprocedural in group I, there was statistically significant difference with P value ≤0.001 comparing CKMB preprocedural and CKMB Postprocedural in group I, there was statistically significant difference with P value ≤0. 001.Comparing CKMB preprocedural and CKMB Postprocedural in group II, there was statistically non-significant difference with P value =0.086 (Table 3).

Regarding the vessel affected, there was statistically non-significant difference between the groups, P value 0.312. Regarding the degree of lesion, there was statistically significant difference between the groups with high total occlusion in group I, P value ≤0.001.

Regarding TIMI flow There was statistically significant difference between the groups with high successful PCI in group I, P value 0.045 in (Table 4).

Table 3. Laboratory investigations between primary PCI and pharmaco-invasive groups

Laboratory investigations	Total (n=60)	Primary PCI (n=30)	Pharmaco-invasive (n=30)	Student t test	P value
cTpn pre	1.08±0.33	1.09±0.36	1.06±0.31	t=0.348	0.729
cTpn post	1.27±0.29	1.35±0.34	1.19±0.21	t=2.07	0.043*
P pre-post	P≤ 0.001*	P≤ 0.001*	P=0.001*	-	-
CKMB pre	200.62±56.7	206.67±50.14	194.57±62.86	t=0.824	0.413
CKMB post	226.08±46.7	242.93±47.71	209.23±39.75	t=2.97	0.004*
P pre-post	P ≤0.001*	P≤0.001*	P=0.086	-	-

CKMB: Creatine kinase-MB, PCI: percutaneous coronary intervention

Table 4. Coronary angiography among primary PCI and pharmaco-invasive groups

Coronary angiography	Total (n=60)	Primary PCI (n=30)	Pharmaco-invasive (n=30)	Test of significance	P value
Vessel affected				MC	0.312
RCA	15 (25%)	6 (20%)	9 (30%)		
LAD	27 (45%)	14 (46.7%)	13 (43.3%)		
LCX	16 (26.7%)	10 (33.3%)	6 (20%)		
LM	2 (3.3%)	0 (0%)	2 (6.7%)		
Degree of lesion				χ^2=11.28	**0.001***
Total occlusion	31 (51.7%)	22 (73.3%)	9 (30%)		
Subtotal	29 (48.3%)	8 (26.7%)	21 (70%)		
TIMI flow:				χ^2=3.47	0.177
Preprocedure:					
TIMI 0	37 (61.7%)	22 (73.3%)	15 (50%)		
TIMI 1	9 (15%)	3 (10%)	6 (20%)		
TIMI 2	14 (23.3%)	5 (16.7%)	9 (30%)	χ^2=4.02	**0.045***
Postprocedure:					
Failed PCI	**n=17 (28.3%)**	**n=5 (16.7%)**	**n=12 (40%)**		
TIMI 0	10 (16.7%)	3 (10%)	7 (23.3%)		
TIMI 1	1 (1.7%)	0 (0%)	1 (3.3%)		
TIMI 2	6 (10%)	2 (6.7%)	4 (13.3%)		
Successful PCI					
TIMI 3	**43 (71.7%)**	**25 (83.3%)**	**18 (60%)**		

PCI: Percutaneous coronary intervention, RCA: right coronary artery, LAD: left anterior descending LCX: left circumflex coronary LM: lymphatic malformation

Comparing TPE preprocedural and TPE post-procedural in successful PCI group, there was statistically significant difference with P value 0.015. While comparing TPE preprocedural and TPE Postprocedural in failed PCI group, there was statistically non-significant difference with P value =0.088 (Fig. 1).

The difference of EF between the groups was statistically significant lower in group II with P value =0.002 (Fig. 2. EF among primary PCI and pharmaco-invasive groups. Regarding RWMA, the main difference between the groups were statistically non-significant with P value =0.189 (Fig. 3).
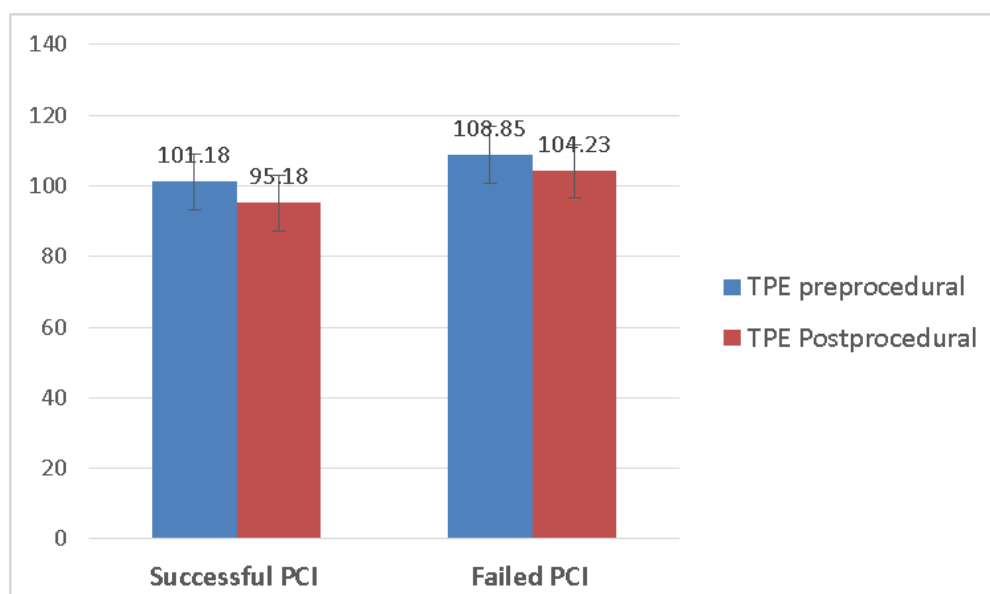

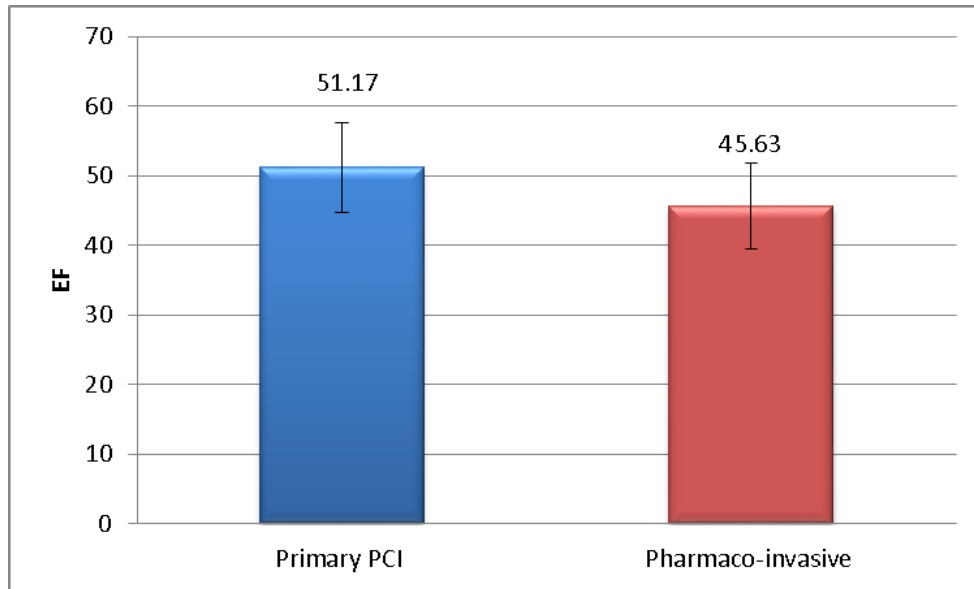**Fig. 1 .TPE pre and post PCI between successful and failed PCI groups**

Fig. 2. EF among primary PCI and pharmaco-invasive groups
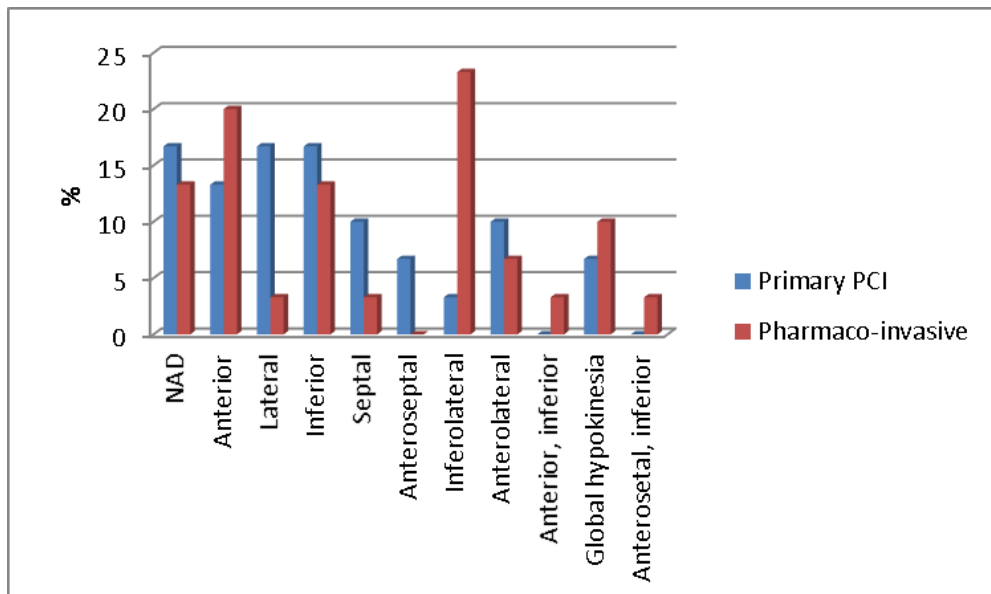

Fig. 3. RSWMA among primary PCI and pharmaco-invasive groups

Regarding early outcome of HF, there was statistically significant higher HF cases in group II, P value 0.01, While late Outcome (after 3 months) HF, there was statistically non-significant difference between the groups, P value 0.214. Regarding Early Outcome (during hospital stay) SCD, there was statistically non-significant difference between the groups, P value = 0.472, While late Outcome SCD, there was statistically non-significant difference between the groups, P value = 0.066. Regarding late outcome reinfarction, in group I, there were

7.4% patients suffering from reinfarction, while in group II there were 12.5% patients with no statistically significant difference, P value 0.656 (Table 5).

ROC curve analysis was done to pick up the best cut off value of TPE at admission for prediction of pharmaco-invasive group which revealed TPE at admission more than 104.5 with sensitivity 73.3% and specificity 63.3%. Area under the curve 0.725 with 95% CI ranged from 0.596 to 0.854).

Table 5. Early and late outcome among primary PCI and pharmaco-invasive groups

Outcome	Total (n=60)	Primary PCI (n=30)	Pharmaco-invasive (n=30)	P value
Early Outcome				
HF	17 (28.3%)	4 (13.3%)	13 (43.3%)	χ^2=6.65 0.010*
SCD	9 (15%)	3 (10%)	6 (20%)	FET 0.472
Late Outcome (N=51)				
HF	11 (21.6%)	4 (14.8%)	7 (29.2%)	χ^2=1.54 P=0.214
Reinfarction	5 (9.8%)	2 (7.4%)	3 (12.5%)	FET 0.656
SCD	9 (17.6%)	2 (7.4%)	7 (29.2%)	FET 0.066

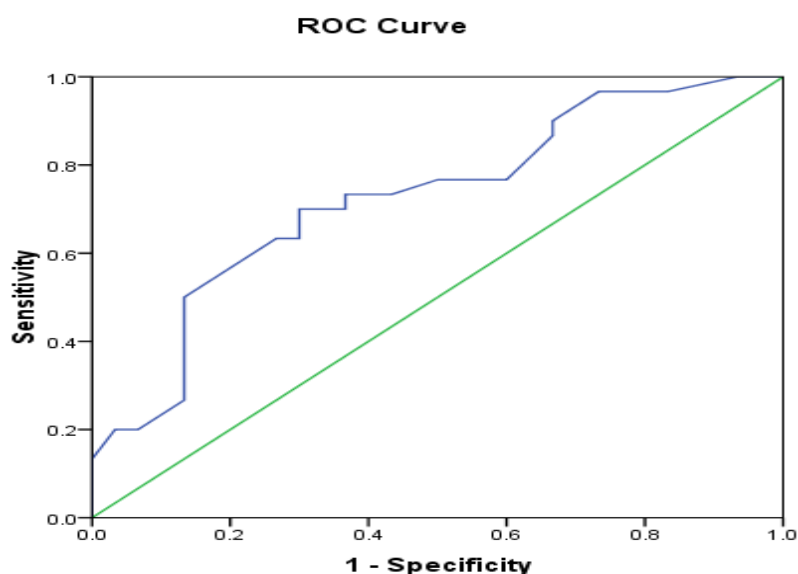*HF: Heart rate, SCD: Sudden cardiac death*

Fig. 4. ROC for prediction of pharmaco-invasive group

4. DISCUSSION

Acute coronary syndrome is one of the leading causes of death worldwide[8].

Acute coronary syndrome encompasses unstable angina, non-ST-segment elevation myocardial infarction (NSTEMI) and ST-segment elevation myocardial infarction (STEMI) [1].

STEMI is mostly caused by coronary artery occlusion which in most cases is caused by intracoronary thrombus.

Our study showed that the main difference between the groups was statistically significant regarding TPE preprocedural and TPE Postprocedural with P value =0.002 and =0.001 respectively. This was in agreement with (Çoner et al., [9] in which A total of 177 STEMI patients (mean age: 60.5±11.1 years; 138 men and 39 women) were enrolled in this retrospective study to evaluate Admission Tpe interval predicts reperfusion success in STEMI patients and divided the patients into two groups and found Admission Tpe interval (ms) and Follow-up Tpe interval (ms) was statistically significant with p value <0.001 for both. Also in our study, we found in comparison TPE preprocedural and TPE Postprocedural in group I and II, there was statistically highly significant difference with P value ≤0.001 for both groups. This also in agreement with (Çoner et al., [9] (Çağdaş et al., [10] (Dwijanarko et al., [11] who found that the

main difference between the groups was statistically significant regarding TPE preprocedural and TPE Postprocedural with P value <0.001 for both.

Our study showed that the main difference between the groups was statistically non-significant regarding Corrected QT preprocedural and Corrected QT Postprocedural with P value =0.943 and 0.348 respectively This agreed with (Özbek and Sökmen et al., [12] who found the main difference between the groups was statistically non-significant regarding Corrected QT preprocedural and Corrected QT Postprocedural with P value > 0.05. In contrast of our results (Çoner et al., [9] who found that the main difference between the groups was statistically significant regarding Corrected QT preprocedural with P value <0.001 while non-significant difference regarding Corrected QT postprocedural with P value =0.220. In our study the main difference between the groups was statistically non-significant regarding Serum creatinine and HG with P value =0.532 and 0.134 respectively. This was in agreement with (Elitok et al., [13] in which Forty-four patients (34) male and mean age of 54.9 ± 10.9 years) with acute STEMI studied for the relationship between T-wave peak-to end interval and ST segment recovery and found statistically non-significant difference regarding serum creatinine and HG with P value = 0.83 and 0.64 respectively.

In our study, the main difference between the groups was statistically non-significant with P value >0.05 in cTpn preprocedural while there was statistically significant difference regarding cTpn postprocedural p value 0.043. While in comparison cTpn preprocedural and cTpn Postprocedural in group I and in group II there was statistically significant difference with P value < 0.001. This was in line with [9] who study the interval between the peak of the T wave and the end of the T wave (Tpe) and predicts reperfusion success in STEMI patients and found admission hs-troponin (pg/mL) and maximum hs-troponin (pg/mL) was statistically non-significant with P value >0.05. While In-group interaction p value for ∆ hs-troponin was statistically significant with P value < 0.05 in group I and in group II.

In our study the main difference between the groups was statistically significant in CKMB postprocedural with P value =0. 004.This was in agreement with (Çağdaş et al., [10] who study the relationship between reperfusion success and T-peak to T-end interval in patients with ST elevation myocardial infarction and found Peak CK-MB, mg/dL was statistically significant with P value <0.001.
In our study the main difference between the groups was statistically significant in EF with P value =0.002. This was in agreement with (Szydło et al., [14] who study Repolarization parameters in patients with acute ST segment elevation myocardial infarction and divided study population into two groups with statistically significant difference between the groups regarding LVEF.

In our study TIMI flow, in group I, there were 16.7% failed PCI and 83.3% successful PCI while in group II there were 40% failed PCI and 60% successful PCI. There was statistically significant difference between the groups, P value 0.045. (Çağdaş et al., [10] stated that preprocedural TIMI grade 0, TIMI thrombus grade ≥2, and angiographic no-reflow were seen more frequently in patients with failed PCI.

Our study showed that ROC curve analysis was done to pick up the best cut off value of TPE at admission for prediction of pharmaco-invasive group which revealed TPE at admission more than 104.5 with sensitivity 73.3 % and specificity 63.3%. Area under the curve 0.725 with 95% CI ranged from 0.596 to 0.854. This was in line with (Özbek and Sökmen et al., [12] who study Usefulness of Tp-Te interval and Tp-Te/QT ratio in the prediction of reperfusion success and mortality in acute STEMI patients and found Tp-Te, Tp-Te/QT, QTd, QTc and left ventricular ejection fraction (LVEF) predicted reperfusion success and outcome arrythmia with cut-off for Tp-Te/QT to predict reperfusion success was >0.305 with 87.5% sensitivity and 60.1% specificity (AUC: 0.90; 95% CI: 0.85–0.95; p < 0.001). In contrast with [15] who study Progressive increase of the T Peak-Tend interval is associated with ischemia-induced ventricular fibrillation and reperfusion success in patients with STEMI and found T peak-Tend ≥123 MS (10th min) predicted reperfusion success and delayed VF episodes with HR = 4.5 95% CI 1.1–17.8, P = 0.031.

Also, in agreement with our results, (Çoner et al., [9] who found Successful reperfusion was achieved in 119 patients (67.2%). The average Tpe interval on the admission ECG was shorter (91.7 vs. 100.9 milliseconds [ms]) (p<0.001) and shortened more in the successful reperfusion group (9.3 vs. 4.5 ms) (p<0.001). A cut-off value

of 89.0 ms for the Tpe interval on the admission ECG was found to be related to reperfusion success with a sensitivity of 90.9%.

The limitations of our study were that relatively small sample size of this study and the results were obtained from only one center.

5. CONCLUSION

The present study demonstrated that prolonged TPE interval is associated with ischemia and thus shortened TPE could be used as a marker for reperfusion success. TPE prolongation also associated with poor prognosis in patients with STEMI.

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

The study was done after approval by the local ethical committee of Faculty of Medicine, Tanta University.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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