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Role of Angiographic Perfusion Score in Prediction of Perfusion Success and Risk Stratification in Patient with STEMI Treated with Primary PCI

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Abstract:

Background: Coronary artery disease (CAD) and acute myocardial infarction are major causes of death and morbidity worldwide. The study aimed to assess short term clinical outcome in a patient of STEMI after primary PCI by using angiographic perfusion score (APS). **Methods:** This prospective observational study included 100 patients with ST elevation myocardial infarction (STEMI) and underwent primary PCI within 12 h from symptom onset or between 12 and 24 h with evidence of continuing ischemia. **Results:** Death occurred in 7 (24.14%) patients in Failed Perfusion group, in 1 (1.49%) patient in Partial perfusion group and in 0 (0%) patients in Full perfusion. Re MI occurred in 5 (16.67%) patients in Failed Perfusion group, in 2 (2.94%) patients in Partial perfusion group and in 0 (0%) patients in Full perfusion. TVR occurred in 6 (20%) patients in Failed Perfusion group, in 2 (2.94%) patients in Partial perfusion group and in 1 (25%) patient in Full perfusion. The composite occurred in 9 (31.03%) patients in Failed Perfusion group, in 1 (1.49%) patient in Partial perfusion group and in 1 (25%) patient in Full perfusion. MACE (death, Re MI, TVR and composite) were significantly different among the three APS groups. mechanical complications were present in 4 (4%) patients. MACE was present in 35 (35%) patients. Regarding MACE, Death occurred in 8 (8%) patients, Re MI in 7 (7%) patients, TVR in 9 (9%) patients and Composite in 11 (11%) patients. **Conclusion:** The assessment of angiographic perfusion using the APS revealed significant associations with short-term clinical outcomes.

Keywords: Angiographic Perfusion Score; Perfusion Success; Risk Stratification; STEMI; PCI.

Introduction

Coronary artery disease (CAD) and acute myocardial infarction are major causes of death and morbidity worldwide [1].

Rapid restoration of coronary blood flow to the jeopardized myocardium is the crux of therapy after AMI. Primary percutaneous coronary intervention (PCI) is an effective treatment for STEMI when it can be performed rapidly. However Many patients with STEMI present to hospitals that do not have on site PCI capabilities and therefore cannot undergo PCI within the timelines recommended in the guidelines; instead, they receive fibrinolytics as the initial reperfusion therapy Despite the effectiveness and worldwide availability of intravenous thrombolysis, the usefulness of this therapy is greatly threatened by a high proportion of failed reperfusion and a substantial rate of re-occlusion [2].

The success of a Reperfusion procedure is best defined by 3 interrelated components: angiographic findings, procedural events, and clinical outcome [3].

Angiographic Success was defined in ACCF/AHA/SCAI 2011 Asa minimum diameter stenosis of < 10% (with an optimal goal of as close to 0% as possible) With final TIMI (thrombolysis in myocardial infarction)flow grade 3, without occlusion of a significant side branch, flow-limiting dissection, distal embolization, or angiographic thrombus . Reperfusion therapy is considered to be angiographically successful when a good TIMI flow is achieved in the infarct-related coronary artery. Improved epicardial flow assessed by TIMI flow grades (TFG) has been related to reduced mortality after coronary revascularization. However, even when a good TIMI flow is achieved, some patients have less than optimal reperfusion at the tissue level, and myocardial reperfusion is not always achieved in patients with a good TIMI flow of epicardial coronary artery. Several mechanisms have been suggested to be involved such as no reflow and distal embolization [4].

TIMI myocardial perfusion grade (TMPG) is an angiographic measure of myocardial perfusion at capillary level. TMPG has been found to be useful in both pharmacological and catheter-based reperfusion after AMI and is suggested as a useful indicator of successful myocardial reperfusion. Patients with both normal epicardial flow and myocardial perfusion have been shown to have a very low mortality rate of 0.73%. Thus, the TMPG adds additional prognostic information to the conventional epicardial TFG. Incorporation of these two variables envisaging a combined index of epicardial and myocardial microvascular blood flow has been suggested as the Angiographic Perfusion Score (APS) [5].

APS is a simple, angiographic metric that takes into account indices of epicardial and myocardial perfusion, both before and after PCI, to arrive at a single perfusion grade. The APS is the sum of the TFG (0-3) added to the TMPG (0-3) before and after PCI, therefore, a total grade of 0 to 12 is possible. Failed perfusion was defined as an APS of 0-3, partial perfusion as an APS of 4-9, and full perfusion as an APS of 10-12. Among STEMI patients with larger infarct sizes, the association of APS with the incidence of death or MI has been found to be statistically significant with an APS score of (0-9) [6].

The procedural success of Reperfusion was defined as achievement angiographic success without associated in- hospital major clinical complications (e.g. death, MI, stroke, emergency CABG) , while The clinically successful PCI requires both anatomic and procedural success along with relief of signs and/or symptoms of myocardial ischemia [7].

The purpose of this study was to assess short term clinical outcome in a patient of STEMI after primary PCI by using of APS.

Patients and methods

This prospective observational study included 100 patients presented to ER of Benha University Hospital and El Mahalla Cardiac Center during the period between 30 th of December 2022and 1st of January2024 diagnosed as STEMI within the first 24 hours of symptoms onset.

An informed written consent was obtained from the patients. The study was done after being approved by the Research Ethics Committee, Faculty of Medicine, Benha University.

Inclusion criteria were patients with ST elevation myocardial infarction (STEMI) and underwent primary PCI within 12 h from symptom onset or between 12 and 24 h with evidence of continuing ischemia.

Exclusion criteria were NSTEMI" patients, unstable angina patients, "STEMI" patients presented after 24 hours from symptoms onset, who received fibrinolytic therapy in form of streptokinase in non-PCI capable center then transferred to PCI capable center for PCI after more than 24 h, failed PCI in STEMI patients, refused to be enrolled in the study,and with Poor echocardiographic windows.

All studied cases were subjected to the following: Detailed history taking, including age, gender, current diabetes mellitus (DM), hypertension, smoking, history of ischemic heart disease (IHD), family history of premature coronary artery disease and history of chronic kidney disease.]. **Full clinical examination: [**vital signs, cardiac examination to assess the Killip classification]. Electrocardiography, Cardiac risk scores and PCI.

Electrocardiography: STEMI is defined as an increase in troponin I above 1 ng/mL, a new ST-segment elevation as measured at the J point, should be found in two contiguous leads and be ≥0.25 mV in men below the age of 40 years,≥0.2 mV in men over the age of 40 years, or ≥0.15 mV in women in leads V2–V3 and/or ≥0.1 mV in other leads (in the absence of left ventricular (LV) hypertrophy or left bundle branch block (LBBB) pattern[8].

Cardiac risk scores: Cardiac risk scores were be calculated for all patients, Thrombolysis in myocardial infarction (TIMI) risk score (TRS) according to age, diabetes mellitus (DM), hypertension (HTN) or angina, heart rate of less than 100 bpm, systolic blood pressure (SBP) of less than 100 mmHg, Killip class II-IV, weight of less than 67 kg, anterior MI or LBBB presentation, and latency of more than 4hour were recorded [9]. Calculation of the TRS was performed using a computer program. Global registry of acute coronary events (GRACE) risk score (GRS) also was determined for all patients including age, creatinine, heart rate, SBP, Killip class, cardiac arrest on admission, elevated cardiac markers, and ST-segment deviation were recorded [10].

PCI procedure: Trans femoral standard technique was used in all patients using 6 Fr sheath. As soon as the arterial sheath is in place, a dose of 10.000 units of heparin was injected. If the procedure continues for more than 1 hour, another 5000 units of heparin was given after 1 hour.

Coronary angiography was performed assessing: Culprit lesion as regards site of the occlusion, severity of the occlusion, and TIMI flow grade.

Guiding catheter & guide wire selection: Utilization of 6 Fr. guiding catheters in most of cases and several types of guide wires used including floppy, intermediate and hydrophilic wires. Although the guiding catheter and guide wire selection is influenced by criteria related to the vessel anatomy, the lesion morphology, and the devices to be used. After guide wire successfully crossed the culprit lesion, subsequent balloon angioplasty if needed and stent implantation were performed with appropriately sized devices. DES or BMS were selected as indicated for the case.

Coronary flow assessment: Angiographic films was reviewed and interpreted by two experienced interventional cardiologists as

regard to Angiographic perfusion score (APS) which is the sum of the Thrombolysis in Myocardial Infarction (TIMI) flow grade (TFG; 0-3) added to the TIMI myocardial perfusion grade (TMPG; 0-3) before and after PCI, Therefore, a total grade of 0 to 12 is possible. Failed perfusion was defined as an APS of 0-3, partial perfusion as an APS of 4-9, and full perfusion as an APS of 10-12. Coronary blood flow patterns after PCI were subject to a thorough evaluation based on TIMI flow grade, using grades 0, 1, 2, and 3. TIMI blood flow grades are used to evaluate the quality of coronary flow during coronary angiography (The Thrombolysis in Myocardial Infarction [11]. TIMI perfusion grade "myocardial blush" has been proposed as a measure of the filling and clearance of contrast in the myocardium. The final TIMI flow grade and myocardial blush grade (MBG) were assessed using standard methods, two cardiologists were blinded to the patient's clinical situations assessed the post procedural TIMI flow grade of infarcted related artery (IRA). Angiographic no reflow (NRF) phenomenon is defined as a coronary TIMI flow grade of ≤ 2 after the vessel was recanalized or TIMI flow grade 3 together with a final MBG of <2 [12].

Post-PCI management: Access site care, monitoring for myocardialischemia: A 12 lead ECG is obtained 60-90 minutes after PCI. The patient is monitored in a coronary care unit that has continuous ECG monitoring with routine post-PCI care.

Medications: Lifelong Aspirin (75-100 mg/d) for all patients without allergy, Clopidogrel 150 mg/d for 7 days, then 75 mg/d for all patients for at least 6 months, Beta-blockers in all patients who tolerate these medications and without contraindications, ACEIs or ARBs and spironolactone when indicated & no contraindications, Statins in all patients without contraindications irrespective of cholesterol levels to achieve LDL c < 70 mg/dl, G IIb/IIIa inhibitors:

Patients were put under observation to detect the occurrence of any in-hospital MACEs or other hemodynamic complications.

Transthoracic echocardiography (TTE):

Transthoracic echocardiography (TTE) was performed at time of hospitalization at the coronary care unit (CCU) and within 4 to 6 weeks after discharge to determine: Ejection Fraction (EF) and Fractional shortening (FS):

In hospital follow up: During the in-hospital follow-up period patients were monitored for major adverse cardiac events (MACEs). Cardiogenic shock, new advanced heart failure, pulmonary edema, complete atrio-ventricular block (AVB) requiring a temporary pacemaker, severe ventricular arrhythmia, and in-hospital mortality during the post-PCI follow-up period were regarded as MACEs. An in-hospital mortality was only considered a MACEs if the death was caused by myocardial infarction, cardiac arrest, or other cardiac related causes. Cardiogenic shock was defined as: marked and persistent hypotension lasting more than 30 min with a SBP less than 80 mmHg and signs of hypoperfusion due to left ventricular dysfunction, right ventricular infarction, or cardiac mechanical complications. New-onset advanced heart failure and severe ventricular arrhythmias (ventricular tachycardia, ventricular fibrillation, or a systole) were MACEs if they occurred within 48 hours of onset.

Approval code: MS 28-11-2022

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Shapiro-Wilks test and histograms were used to evaluate the normality of the data distribution. Quantitative parametric data were presented as mean and standard deviation (SD) and were compared by paired T-test. Qualitative variables were presented as frequency and percentage (%) and were compared by Chi-square test. A two-tailed P value < 0.05 was considered statistically significant.

Results

Table 1 shows demographic data and risk factors of the studied patients.

Table 2 shows vital signs and Laboratory data of the studied patients.

EF was significantly higher in immediately after PCI than pre operation (P value<0.001). SWMI was significantly lower in immediately after PCI than pre operation (P value <0.001). TIMI and TMPG significantly different between before PCI and after PCI (P value <0.001). Table 3

Table 4 shows GRACE score, APS, complications and MACE of the studied patients.

Baseline parameters (Age, sex, HTN, DM, Dyslipidemia, Smoking, Family history, SBP, DBP and Pulse) were insignificantly different among the three APS groups. GRACE score was significantly lower in partial perfusion and full perfusion than failed perfusion and in Full perfusion than partial perfusion.

MACE (death, Re MI, TVR and composite) were significantly different among the three APS groups Table 5

In Multivariate regression, GRACE score and APS was independent predictors of Perfusion Success score (P value <0.05) while death, TVR, RE MI and Composite were not. Table 6

Table 1: Demographic data and risk factors of the studied patients.

		(n=100)
Age (years)		59.5 ± 4.86
Gender	**Male**	66 (66%)
	Female	34 (34%)
BMI (Kg/m^2)		27 ± 3.31
Risk factors		
HTN		36 (36%)
DM		27 (27%)
Dyslipidemia		19 (19%)
Smoking		30 (30%)
Family history		15 (15%)

Data presented as Mean ± SD or frequency (%), BMI: Body mass index, HTN: hypertension, DM: diabetes mellitus.

Table 2: Pre- operation vital signs and laboratory data of the studied patients.

	(n=100)
SBP (mmHg)	128.6 ± 10.79
DBP (mmHg)	74.1 ± 9.56
Pulse (beats/ min)	84.9 ± 8.67
Laboratory data	
Hb (g/dl)	12.9 ± 1.22
Serum creatinine (mg/dL)	1 ± 0.17
AST (U/L)	18.8 ± 4.04
TC (mg/dL)	191.8 ± 24.93
TGS (mg/dL)	137.5 ± 20.36
LDL (mg/dL)	117.2 ± 9.06
HDL (mg/dL)	49.9 ± 6.17
Troponin (ng/mL)	0.7 ± 0.47

Data presented as Mean ± SD, SBP: Systolic blood pressure, DBP: Diastolic blood pressure. Hb: Hemoglobin. AST: Aspartate aminotransferase. TC: Total cholesterol. TGS: Triglycerides. LDL: Low-density lipoprotein. HDL: High- density lipoprotein.

Table 3: Ejection fraction, SWMI, TIMI and TMPG of the studied patients.

		Pre	**Immediately after PCI**	P value
EF%		46 ± 11.44	49.1 ± 11.42	<0.001*
SWMI		1.7 ± 0.33	1.5 ± 0.3	<0.001*
		Before PCI	**After PCI**	P value
TIMI flow grade	**0**	75 (75%)	5 (5%)	<0.001*
	1	19 (19%)	7 (7%)	
	2	6 (6%)	9 (9%)	
	3	0 (0%)	79 (79%)	
TMPG	**0**	90 (90%)	16 (16%)	<0.001*
	1	1 (1%)	15 (15%)	
	2	9 (9%)	15 (15%)	
	3	0 (0%)	54 (54%)	

*: significant P value ≤0.05. EF: Ejection fraction, TIMI: Thrombolysis in Myocardial Infarction, TMPG: Myocardial Perfusion Grade.

Table 4: GRACE score**,** APS, complications and MACE of the studied patients.

		(n=100)
GRACE score		128.6 ± 14.65
APS	**Failed perfusion (0-3)**	29 (29%)
	Partial perfusion (4-9)	67 (67%)
	Full perfusion (10-12)	4 (4%)
Mechanical complications		4 (4%)
MACE	**Yes**	35 (35%)
	N=35	
	Death	8 (8%)
	Re MI	7 (7%)
	TVR	9 (9%)
	Composite	11 (11%)

MACE: Major adverse cardiovascular events, MI: myocardial infarction, TVR: Target vessel revascularization. APS: Angiographic Perfusion Score.

Table 5: Baseline parameters and MACE in the three APS groups.

		Failed perfusion (n=29)	Partial perfusion (n=67)	Full perfusion (n=4)	P value
Age(years)		59.7 ± 3.45	59.4 ± 5.33	58.5 ± 6.45	0.651
Sex	**Male**	24 (82.76%)	40 (59.7%)	2 (50%)	0.072
	Female	5 (17.24%)	27 (40.3%)	2 (50%)	
HTN		12 (41.38%)	21 (31.34%)	3 (75%)	0.162
DM		12 (41.38%)	14 (20.9%)	1 (25%)	0.115
Dyslipidemia		6 (20.69%)	11 (16.42%)	2 (50%)	0.241
Smoking		8 (27.59%)	20 (29.85%)	2 (50%)	0.656
Family history		7 (24.14%)	7 (10.45%)	1 (25%)	0.192
SBP (mmHg)		129.7 ± 9.95	127.9 ± 11.36	131.5 ± 6.76	0.360
DBP (mmHg)		74.7 ± 9.86	73.7 ± 9.4	76.8 ± 12.09	0.534
Pulse (beats/ min)		83.5 ± 8.62	85.2 ± 8.5	89.5 ± 12.15	0.063
GRACE score		143.4 ± 19.82	127 ± 11.26	106.8 ± 7.85	<0.001 P1<0.001 P2=0.002 P3<0.001
MACE					
Death		7 (24.14%)	1 (1.49%)	0 (0%)	0.001*
Re MI		5 (16.67%)	2 (2.94%)	0 (0%)	0.041*
TVR		6 (20%)	2 (2.94%)	1 (25%)	0.013*
Composite		9 (31.03%)	1 (1.49%)	1 (25%)	< 0.001*

*Significant as P value ≤0.05, MI: myocardial infarction, TVR: Target vessel revascularization.

Table 6: Multivariate regression of predictors versus Perfusion Success.

	Multivariate Odds ratio	95% CI	P
GRACE score	1.36	0.234-0.897	<0.001
Death	1.010	0.180 – 5.66	0.990
TVR	0.808	0.183 – 3.568	0.779
RE MI	1.212	0.224- 6.55	0.822
Composite	0.943	0.220 – 4.036	0.937
APS	4.319	1.635-11.41	**0.003***

*Significant as P value≤0.05, CI: Confidence interval.

Discussion

In our study, the age ranged from 47 to 71 years with a mean value ± SD of 59.5 ± 4.86 years. There were 66 (66%) males and 34 (34%) females. BMI ranged from 22.4 to 32.7 kg/m^2 with a mean value ± SD of 27 ±3.31 kg/m^2.

In their study of the long- term clinical outcomes after Rescue PCI in Patients with Acute Myocardial Infarction, [13]. indicated that, the mean age of individuals was 59.7 ± 11.4 years and there were male predominance [13].

In our study, EF was significantly higher in post operation than pre operation (P value <0.001). SWMI was significantly lower in post operation than pre operation (P value <0.001). In agreement, Amal Hafez ELHadidy et al. [14] who studied the relationship between TMP grade (at the end of the PCI procedure) and left ventricular ejection fraction (LVEF) and infarct size within 1 month in such patients. They reported that there was a significant correlation between the myocardial perfusion grade and the final infarct size. The higher the MP grade the lesser the infarct size with (p = 0.001). They found that EF was strongly and significantly related to the MPG, the higher the grade the higher the EF (p = 0.002).

In the study by Wong et al. [15], TMPG was correlated with NSTEMI. TMPG 0/1 flow both before and after intervention was associated with increased risk of death or myocardial infarction at 6 months.

In our study, APS assessed failed perfusion in 29 (29%) patients, Partial perfusion in 67 (67%) patients and full perfusion in 4 (4%) patients. This slightly agrees with Iqbal et al. [16] who aimed to evaluate the association of APS for determining the short term clinical outcomes after PCI in ST-segment elevation myocardial infarction without thrombolytic therapy. They reported that, majority (62.9%) of the patients had partial reperfusion, 32.7% had full reperfusion and rest of the 4.4% had failed reperfusion. The observational study by Karn et al. [3] who aimed to compare the predictive accuracy of APS with post-procedure TMPG in evaluating reperfusion success and short-term clinical outcomes, specifically MACE, following PCI in Acute Coronary Syndrome (ACS) patients. They reported that, reperfusion success was identified significantly more in APS group versus TMPG alone (STEMI: 69.5% vs. 21.7% (p<0.05); Non-STEMI/UA, late perfusion: 81.8% vs. 30.3% (p<0.05) respectively.

In our study, baseline parameters (Age, sex, HTN, DM, Dyslipidemia, Smoking, Family history, SBP, DBP and Pulse) were insignificantly different among the three APS groups.

In our study, death occurred in 7 (24.14%) patients in Failed Perfusion group, in 1 (1.49%) patient in Partial perfusion group and in 0 (0%) patients in Full perfusion. Re MI occurred in 5 (16.67%) patients in Failed Perfusion group, in 2 (2.94%) patients in Partial perfusion group and in 0 (0%) patients in Full perfusion. TVR occurred in 6 (20%) patients in Failed Perfusion group, in 2 (2.94%) patients in Partial perfusion group and in 1 (25%) patient in Full perfusion. Composite

occurred in 9 (31.03%) patients in Failed Perfusion group, in 1 (1.49%) patient in Partial perfusion group and in 1 (25%) patient in Full perfusion. MACE (death, Re MI, TVR and composite) were significantly different among the three APS groups.

In accordance, Narain et al. [17] found a statistically significant correlation between APS and all the three MACE parameters and the composite of all endpoints. As compared to TMPG grading done post PCI, APS identified more individuals with risk for future events. The incidence of MACE was significantly higher as predicted by failed APS (22.4%) in contrast to that reported in TMPG 0 (9.8%; $0 \leq 0.01$).

Conclusion

The assessment of angiographic perfusion using the APS revealed significant associations with short-term clinical outcomes. Higher post-operative left ventricular EF and lower SWMI were observed, emphasizing the positive impact of primary PCI on cardiac function. Importantly, APS categorized patients into Failed Perfusion, Partial Perfusion, and Full Perfusion groups, demonstrating its utility in predicting adverse events.

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