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Assessment of Myocardial Salvage Index after Primary Percutaneous Intervention of ST Elevation Myocardial Infarction Patients Using Myocardial Magnetic Resonance Imaging Techniques

Asmaa Ramadan Abd El Naby[1*], Magdy Mohamed Elmasry[1], Mai M. Abd Elmoneim Salama[1], Mohamed El Sayed El Setiha[1] and Raghda Ghonimy Elsheikh[1]

[1]Department of Cardiovascular Medicine, Faculty of Medicine, Tanta University, Egypt.

Authors' contributions

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

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ABSTRACT

Objectives: The aim of this work was assessment of myocardial salvage using various magnetic resonance imaging techniques immediately after primary percutaneous coronary intervention of ST elevation myocardial infarction patients and at midterm follow up.
Methods: The current study was conducted on 30 patients referred to Aswan heart center or Cardiology department, Tanta University hospital with a diagnosis of ST elevation myocardial infarction during the period from august2017 to December 2017. All patients were subjected to history taking ,clinical assessment ,12 lead ECG, Laboratory biomarkers including cardiac enzyme biomarkers, complete blood count, liver function test, renal function test and lipid profile primary then primary percutaneous coronary intervention was done then cardiac magnetic resonance imaging within 3 days and after 3 months including the following sequences: Steady-state free precession, T2 weighted triple inversion recovery sequence and Early and late gadolinium enhancement to measure the area at risk and myocardial salvage index.

**Corresponding author: E-mail: dr_asmaa_ramadan@yahoo.com;*

Results: Myocardial salvage index was found to improve with improving thrombolysis in myocardial infarction (TIMI) flow post intervention (p value=0.004), also the presence of microvascular obstruction (p value =0.034) and intramyocardial hemorrhage (p value=0.014) had a negative impact on myocardial salvage index. Peak cardiac enzyme biomarkers (troponin p value=0.001,CK p value=0.005,CKMB p value=0.002) were also associated with increased area at risk however did not affect the myocardial salvage index.

Conclusion: Proper management of the occluded coronary artery is a corner stone in improving myocardial salvage index which can be properly assessed with cardiac MRI.

Keywords: Primary percutaneous coronary intervention; cardiac magnetic resonance imaging; myocardial salvage index.

ABBREVIATION

AAR	*Area at risk*
AAR	*Area at risk*
BMS	*Bare metal stent*
BSA	*Body surface area*
CK	*Creatinine kinease*
CK-MB	*The MB fraction of Creatine Kinase*
CMR	*Cardiac magnetic resonance*
CX	*Circumflex artery*
DES	*Drug eluting stent*
DM	*Diabetes Mellitus*
ECG	*Electrocardiogram*
EF	*Ejection fraction*
EGE	*Early gadolinium enhancement*
FIS	*final infarct size*
HDL	*High density lipoprotein*
HTN	*Hypertension*
IMH	*intramyocardial hemorrhage*
LAD	*Left anterior descending artery*
LDL	*Low density lipoprotein*
LGE	*Late gadolinium enhancement*
LV	*Left ventricle*
LVEDV	*left ventricular end diastolic volume*
LVEDVI	*Left ventrcular end diastolic volume indexed*
LVESVI	*Left ventricular end systolic volume indexed*
LVSVI	*Left ventrcular end systolic volume indexed*
MI	*myocardial infarction*
MRI	*Magnetic resonance imaging*
MSI	*Myocardial salvage index*
MVO	*Microvascular obstruction*
PCI	*percutaneous coronary intervention*
RCA	*Right coronary artery*
RVEDVI	*right ventricular end diastolic indexed to body surface area*
RVESVI	*Right ventricular end systolic volume indexed*
RVSVI	*right ventricular stroke volume indexed to body surface area*
SD	*Standard deviation*
SPECT	*Single-photon emission computed tomography*
SSFP	*Steady-state free precession*
STEMI	*ST- segment elevation myocardial infarction*
TE	*Time of Echo*
TI	*Time of inversion*
TIR	*Triple inversion recovery*
TR	*Time of Repetition*
True FISP	*True fast imaging with steady state precession*

1. INTRODUCTION

Ischemic heart disease is responsible for 5% of the deaths among patients [1].

Primary percutaneous coronary intervention (PCI) is the best available reperfusion strategy in patients with acute ST- segment elevation myocardial infarction (STEMI) [2] Up to 95% of occluded coronary vessels can be reopened in the setting of STEMI [3,4,5].

Magnetic resonance imaging (MRI) is a non-invasive tool and free of radiation, it is suitable for longitudinal monitoring of treatment effect and follow-up of disease progress. Cardiac magnetic resonance (CMR) faces specific challenges from cardiac and respiratory Therefore, CMR requires synchronous cardiac and respiratory gating or breath-holding techniques to overcome motion artifacts [6].

Historically, myocardial scar has been visualized and measured directly on histological sections using stains specific for the connective tissue in the extracellular space [7], however cardiac MRI can visualize fibrosis using late gadolinium enhancement (LGE). LGE has a high sensitivity and specificity to detect and quantify the magnitude of fibrotic tissue due to myocardial infarction(MI) [8,9], LGE and phase sensitive inversion recovery are considered as the gold standards for myocardial viability assessment [10].

Myocardial salvage is the principal mechanism by which patients with acute myocardial infarction benefit from reperfusion therapies [11]. To assess the efficacy of reperfusion therapy, it is necessary to determine how much myocardium is salvaged by measuring the final infarct size in relation to the initial myocardium at risk.

Trials demonstrated that myocardial salvage assessment by CMR is a reproducible tool that identifies and quantifies myocardium salvage with excellent agreement with Single-photon emission computed tomography (SPECT) and angiographic scores of myocardial salvage [12,13,14].

2. MATERIALS AND METHODS

The study included 30 Egyptian patients with STEMI referred to Aswan heart center or Cardiology department, Tanta University hospital during the period from august2017 to December 2017 and underwent primary PCI and cardiac MRI.

2.1 Inclusion Criteria

STEMI patients who were reperfused using PCI.

2.2 Exclusion Criteria

Patient refusal to PCI or MRI, contraindications to MRI, previous myocardial infarction in the same coronary artery territory,rheumatic heart diseases and congenital heart disease,patients with hematological, immunological or severe renal impairment and patients who did not show in the follow up visit were excluded from the study.

3. METHODS

All patients were subjected to the following:

History taking & clinical examination including:Personal history with special reference to age, sex,body surface area,diabetis,hypertension ,smoking,addiction to narcotics mainly then symptoms including chest pain character,onset,time from chest pain till primary PCI mediated reperfusion was measured to calculate total ischemic time followed by full general and local examination and 12-lead ECG .All patients fulfilling STEMI criteria were subjected to primary PCI and Cardiac MRI within 3 days of STEMI and after 3 months in the follow up visit. Laboratory biomarkers including cardiac enzyme biomarkers, complete blood count, liver function test, renal function test and lipid profile were measured.

3.1 Primary Percutaneous Coronary Intervention

Coronary angiography was performed under local anesthesia. The procedure was sterile, and access site was disinfected, shaved, and sterilized.The initial primary PCI procedure was performed using radial or femoral artery access [15]. A conventional approach to primary PCI was adopted with conventional bare metal or drug eluting stents were used in line with guideline recommendations and clinical judgement [15].

The standard transcatheter approach for reperfusion involves minimal intervention with aspiration thrombectomy only or minimal balloon

angioplasty, glycoprotein IIb IIIa inhibitor therapy according to thrombus burden with tirofiban (25ug/kg/bolus) then an intravenous infusion of 0.15ug/kg/min for up to 18 hours with management of no reflow according to clinical judgement and indications of the guidelines [16]. In patients with multivessel coronary disease, infarct related artery PCI was recommended, in line with clinical guidelines [4] Post revascularization patients TIMI flow was assessed [17].

3.2 Cardiac Magnetic Resonance Imaging (CMR) in the Baseline and Follow Up Visit

MR was performed on clinical 1.5T Siemens MAGNETOM Aera scanner (Siemens Healthcare, Erlangen, Germany scanner with a 12-element phased array cardiac surface coil). All patients underwent a standard protocol and had ECG monitoring during the CMR exam. Steps as following:

3.2.1 Steady-state free precession (SSFP) – "Cine" imaging [18]

SSFP cine imaging (using multi-slice single-shot breath-hold true fast imaging – True fast imaging with steady state precession (true FISP) was used for functional assessment and a short-axis cine stack of the left ventricle (LV) from base to apex was acquired, consisting of 8 mm thick slices, with a distance factor20%. Cine images were also obtained in the 3-chamber, horizontal long-axis and vertical long-axis planes.Typical sequence parameters were echo time (TE) 1.2 ms, repetition time (TR) 72 ms, slice thickness 8mm flip angle 56º, field of view 450x338mm, matrix size 2016X288.

3.2.2 T2 weighted triple inversion recovery sequence (TIR)

The oedema sequence, we used a triple-inversion recovery black-blood turbo-spin echo pulse sequence with slice thickness 8 mm inversion time (TI) 170 ms, bandwidth 849 Hz, TE 100 ms, and 1 signal averages. detected by 2SD the remote healthy myocardium then the mass is measured to detect the initial area at risk [19].

3.2.3 Early and late gadolinium enhancement

Early gadolinium enhancement (EGE) imaging was acquired 3minutes postcontrast injection using a TrueFISP readout and fixed inversion time (TI) of 330 ms. Late gadolinium enhancement images covering the entire LV were acquired 10-15 minutes after IV injection of the contrast. Typical imaging parameters were:slice thickness 8 mm matrix = 187 x 256, flip angle = 50, TE = 1.06 ms, bandwidth = 130 Hz/pixel, echo spacing = 8.7ms and trigger pulse = 2. The voxel size was 2.0 x 2.0 x 0.8 mm3. A Look-Locker scout scan was undertaken to determine the inversion times associated with optimal nulling of the myocardial signal [20]. The inversion times were in the range 240 to 350 ms.Late gadolinium enhancement was assessed in the sixteen segment in all patients in baseline and follow up and divided into either no enhancement,25%-50%enhancement,50%-75% enhancement and transmural enhancement.

3.2.4 Cardiac magnetic resonance image analyses

LV dimensions, volumes and ejection fraction were quantified using commercially-available Argus software (Siemens,Erlangen) and segment software(Medviso,Lund,Sweden).

- **Assessment of LV mass and function**

Post-processing was performed using the number of slices required to cover the LV in end-diastole and end-systole varied from scan to scan dependent on the long axis diameter of the LV. End-systole was chosen as the point where the total LV blood pool was smallest and end-diastole as the point where it was largest. The most basal LV slice at both end-systole and end-diastole was defined as that in which the blood pool was surrounded by 50% or more of ventricular myocardium. Once selected, the endocardial and epicardial borders were manually outlined. Papillary muscles were included as part of the myocardial blood pool. Following tracing of the myocardial borders for each slice, an automated calculation was carried out by the Argus software to obtain left ventricular mass, end-systolic volume, end-diastolic volume (then indexed to BSA) and left ventricular ejection fraction using a sum of discs method [21] as in (Fig. 1) which shows endocardial contouring of a basal cut at short axis stack.

3.2.5 TIR sequence (oedema detection) and area-at-risk

Area-at-risk was defined as LV myocardium with pixel values (T2) a from remote myocardium

[15,21] Contouring the area of oedema then was done to detect the mass as in Fig. (2) which shows one of the six cuts showing oedema with its contouring to get its mass.

3.2.6 Myocardial salvage

Myocardial salvage was calculated by first measuring the final infarct mass this was done by contouring the LGE enhanced mass in the follow up visit as in Fig. (3) then measuring its percent of the total left ventricular mass to get the final infarct size (FIS).

Then calculating the area at risk(AAR)(calculated by the percent of the mass oedema segments (ie,showing oedema in T2 weighted sequence in baseline visit)of left ventricular mass [19,22].

The myocardial salvage index was calculated by dividing the myocardial salvage area (AAR-FIS) by the initial area-at-risk.

MSI=AAR-FIS/AAR [23]

According to the median level of myocardial salvage index : the patients were divided into two groups : group A(above or equal the median),group B (below the median),Also area at risk were divided also according to the median level into group I (above or equal the median) and group II which is below the median.

Microvascular obstruction

Microvascular obstruction (MVO) was defined as a dark zone on early GE imaging post-contrast injection that remained present within an area of LGE at 15 minutes as in Fig. (4) which shows MVO in the septal wall [24].

3.2.7 Statistical analysis of the data

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0**.** **(**Armonk, NY: IBM Corp**)** Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level.p value<0.05.

The used tests were used:Chi-square test For categorical variables, to compare between different groups, **Fisher's Exact for** Correction for chi-square when more than 20% of the cells have expected count less than 5, **Student t-test for** For normally distributed quantitative variables, to compare between two studied groups**, F-test (ANOVA) for**

For normally distributed quantitative variables, to compare between more than two groups, and Post Hoc test (Tukey) for pairwise comparisons, **Paired t-test for**

For normally distributed quantitative variables, to compare between two periods ,**Wilcoxon signed ranks test for** For abnormally distributed quantitative variables, to compare between two periods and **Spearman coefficient** To correlate between two distributed abnormally quantitative variables.

4. RESULTS

1) Patent characteristics:

The mean age was 54 years (range:29-84) years. The thirty patients were 23 male (76.6%), and 7 female (23.3%).

There were 16.7% patients with diabetes ll was on oral hypoglycemic drugs, 16.7% diagnosed with hypertension, (66.7%) smoking and addiction was reported in 6 patients (20%).

The average systolic blood pressure ranged from 90 to 180mmHg with a mean of 120± 22.5 and average diastolic blood pressure ranged from 55 to 100mmHg with a mean of 76±13.6. The heart rate ranged from 59 to 120beat/minute with a mean 87.5±15.9.

2) Myocardial infarction presentation and primary percutaneous coronary intervention

66.7% of patients presented with anterior MI with LAD as a culprit while 20% presented with inferior MI and , 10% percent of the patients presented with inferior and right myocardial infarction and one patient of 3.3% with inferior and posterior infarction ,66% patient had left anterior descending artery (LAD) as culprit vessel,23.3% with right coronary artery (RCA),6.7% with circumflex artery (CX) ,and 3.3% with double CX and RCA lesions.

18 patients were done via radial approach (60%),while 12 patients(40%) with a femoral approach.

In 83% of patients (25), drug eluting stent (DES) was deployed,and three patients had bare metal stent (BMS) while two patients after thrombus aspiration ,there was no significant lesion at the site of previously total thrombus occluded segment either in acute setting or after 24 hour control angiogram so no stenting approach was adopted.

3) Cardiac MRI data results

There was statistically significant difference in aortic stroke volume between the baseline and follow up study,p value <0.001.

The baseline and follow up studies showed that there was statistically significant differences regarding the EF% and the left ventricular end diastolic volume (LVEDV) (indexed to BSA) results ,however no statistically significant difference regarding left ventricular end systolic volume indexed to BSA(LVESVI) and left ventricular stroke volume indexed to BSA(LVSVI) Table (1).

Right ventricular volumes results at baseline and follow up: Table (2):There was statistically significant difference between the ejection fraction (EF%) p value: 0.004 ,right ventricular end diastolic indexed to BSA(RVEDVI) p value: 0.033 and right ventricular stroke volume indexed to BSA(RVSVI) p value: 0.001.,however no statistically significant difference regarding right ventricular end systolic indexed to BSA (RVESVI) p value: 0.315.

According to Myocardial salvage index results :Table (3): Patients were divided into two groups according to the median MSI of 0.5: group A≥ 0.5 and group B<0.5 and compared regarding the age,weight,height,body surface area and there was no significant results.

Comparing with diabetis, hypertension, smoking, addition, positive family history, Hypertension only showed significant difference result p value 0.032.

The significant relation found between TIMI flow and MSI as MSI improves with TIMI 3 flow p value 0.004 but no significance regarding IV antiplatelet p value 0.176 ,aspiration catheter used p value 0.558 ,culprit vessel difference p value 0.245 ,type of stent p value 0.457, and total ischaemic time p value 0.171 (Table 4).

Comparing between myocardial selavage index and peak cardiac enzyemes: Troponin, CKMB, CK, complate blood count,renal function test including urea and creatinine,liver finction test including serum albumin,liver enzymes,sodium and potassium level,haemoglobin A1C level, lipid rofile including: LDL. HDL: there was no significant different result.

There was a significant result between MVO and intramyocardial haemorrhage(IMH) between both groups as lower MSI value<0.5 was associated with MVO(p value : 0.034 and IMH p value :0.014).

As regarding the area at risk :patients were divided according to the median of 49 into two groups: group I ≥ 49,group II <49.

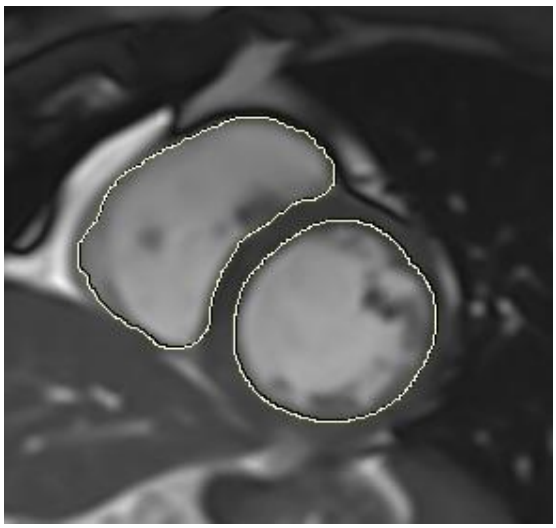

Fig. 1. Short axis view with endocardium contouring of both ventricles

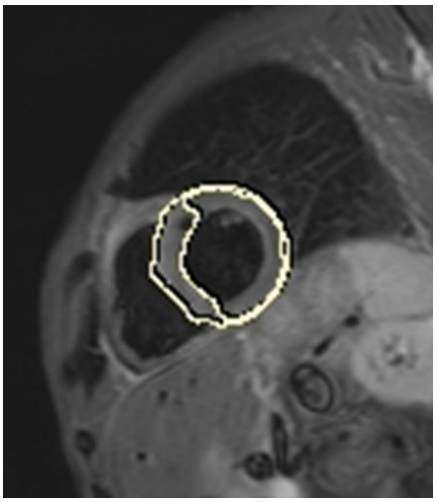

Fig. 2. Contouring the segment with oedema to measure the area at risk

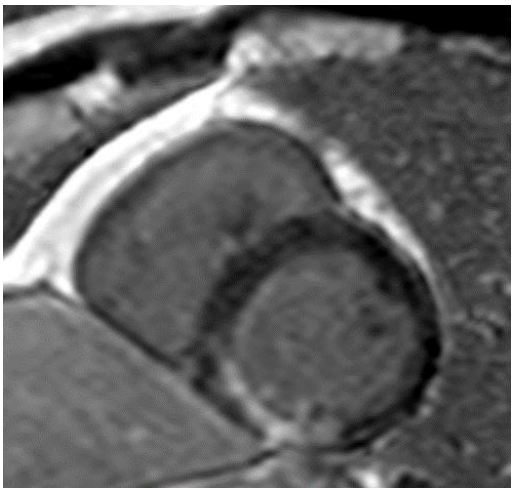

Fig. 3. late gadolinium sax cut showing hyper enhanced inferior segment.

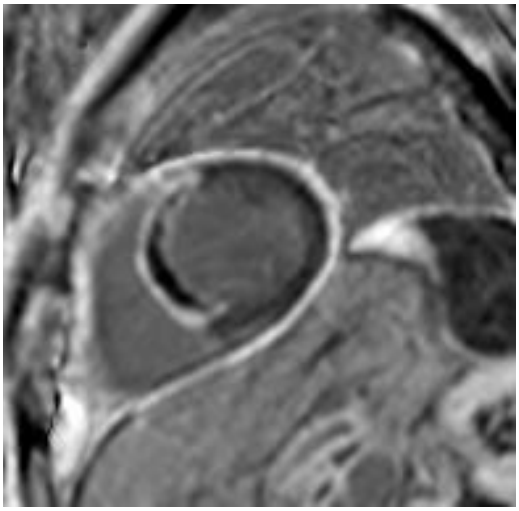

Fig. 4. Hyper enhanced segment with area of microvascular obstruction in the mid septal wall (arrow)

Table 1. The baseline and Follow-up of the left ventricular volumes and ejection fraction assessed by cardiac magnetic resonance imaging

LV data	Baseline	Follow-up	Test of significance	P
LV EF %				
Range	18.0 – 69.0	15.0 – 75.0	T=3.3.03*	0.003*
Mean ±SD.	44.70 ± 12.52	49.17 ± 15.19		
LVEDVI				
Range	49.0 – 119.0	59.0 – 147.0	t=3.564*	0.001*
Mean ±SD.	83.63 ± 17.18	95.47 ± 21.37		
LVESVI				
Range	17.0 – 74.0	15.0 – 120.0	Z=1.550	0.121
Mean ±SD	47.10±16.14	52.07± 25.59		
LVSVI				
Range	12.0 – 54.0	14.0 – 67.0	T=1.630	0.114
Mean ±SD.	36.90 ± 9.73	44.53 ± 10.50		

LV:Left venticle,LVEDVI:left ventrcular end diastolic volume indexed ,LVESVI:Left ventricular end systolic volume indexed ,LVSVI:left ventrcular end systolic volume indexed, t: Paired t-test Z: Wilcoxon signed ranks test

Table 2. The baseline and Follow-up of the right ventricular volumes and ejection fraction assessed by cardiac magnetic resonance imaging

RV	Baseline	Follow-up	Test of significance	P
RV EF %				
Range	25.0 – 80.0	35.0 – 73.0	t=3.164*	0.004*
Mean ±SD.	55.23 ± 11.79	59.93 ± 10.41		
RVEDVIml/m^2				
Range	43.0 – 107.0	47.0 – 94.0	t=2.235*	0.033*
Mean ±SD.	67.97 ± 14.33	72.97 ± 10.60		
RVESVI ml/m^2				
Range	9.0 – 76.0	16.0 – 47.0	Z=1.004	0.315
Mean ±SD.	35.52± 13.62	29.40 ±8.61		
RVSVI ml/m^2				
Range	17.0 – 51.0	22.0 – 61.0	t=5.149*	<0.001*
Mean ±SD.	36.27 ± 8.53	43.63 ± 9.63		

RV:Right ventricle% :Ejection fraction RVEDVI:right ventricular end diastolic volume indexed,RVESVI: right ventricular end systolic volume indexed ,RVSVI: right ventricular stroke volume indexed to BSA, t: Paired t-test , Z: Wilcoxon signed ranks test.

Area at risk was compared with the same variables as in myocardial salvage index and it was found that there was significantly different result with cardiac enzymes biomarkers :troponin (p value=0.001)CK MB (p value=0.002),CK (p value=0.005), the culprit vessels(p value=0.003) and MVO (p value=0.003) ,otherwise no significance.

5. DISCUSSION

The present study included thirty patients presented with STEMI Primary PCI then cardiac MRI at baseline then after 3 months.

Measuring myocardial salvage index and studying its significance was conducted by Eital et al,2010 who studied 208 patients and concluded that the MSI assessed by CMR predicts the outcome in acute reperfused ST-segment elevation myocardial infarction. Therefore, MSI assessment has important implications for patient prognosis and the design of future trials intended to test new reperfusion therapy efficacy [22].

Regarding the patient characteristics: In this study age and gender did not affect MSI ,this comes in agreement with Eitel et al,2012 ,their study included 96 women and 239 men ,they found also no sex difference regarding MSI and area at risk and concluded that female sex was not an independent predictor of mortality and major adverse cardiac events [25].

Table 3. MSI relation to different risk factors

MSI			< 0.5	≥ 0.5	P-value
Sex	Male	N	10	13	0.977
		%	76.9%	76.5%	
	Female	N	3	4	
		%	23.1%	23.5%	
DM	Yes	N	2	3	0.869
		%	15.4%	17.6%	
	No	N	11	14	
		%	84.6%	82.4%	
HTN	Yes	N	0	5	0.032*
		%	.0%	29.4%	
	No	N	13	12	
		%	100.0%	70.6%	
Smoker	Yes	N	9	11	0.794
		%	69.2%	64.7%	
	No	N	4	6	
		%	30.8%	35.3%	
Addict	Yes	N	4	2	0.197
		%	30.8%	11.8%	
	No	N	9	15	
		%	69.2%	88.2%	
Family h	Yes	N	0	4	0.060
		%	.0%	23.5%	
	No	N	13	13	
		%	100.0%	76.5%	

MSI:Myocardial salvage index ,DM:Diabetis Mellitus,HTN:Hypertension

Table 4. Comparison between myocardial salvage index and angiogram procedure

MSI		< 0.5			≥ 0.5	P-value
IV anti platelet		Yes	N	7	5	0.176
			%	53.8%	29.4%	
		No	N	6	12	
			%	46.2%	70.6%	
Aspiration catheter		Yes	N	9	10	0.558
			%	69.2%	58.8%	
		No	N	4	7	
			%	30.8%	41.2%	
Type of stent		DES	N	11	14	0.457
			%	84.6%	93.3%	
		BMS	N	2	1	
			%	15.4%	6.7%	
Complication		Yes	N	7	7	0.491
			%	53.8%	41.2%	
		No	N	6	10	
			%	46.2%	58.8%	
Culprit vessel	LAD	N		8	12	0.245
		%		61.5%	70.6%	
	RCA	N		3	5	
		%		23.1%	29.4%	
	CX	N		2	0	
		%		15.4%	.0%	

MSI:Myocardial salvage index,LAD:Left anterior descending artery, RCA:Right coronary artery,CX: Circumflex artery, DES:Drug eluting stent,BMS:Baremetal stent

Our study reported no statistically significant difference regarding risk factors as diabetes, smoking and addiction in relation to MSI and area at risk this comes in accordance with Ndrepepa et al,2004 [26] however in their study hypertension did not affect the MSI which come in the contrary to the current study and such controversy could be explained by the larger left ventricular mass of the current study hypertensive patients which may carry a some sort of cardioprotective effect.

Regarding the angiographic results: There was statistically significant result between TIMI flow 3 post reperfusion and MSI as it was associated with better MSI .this comes in agreement with Ndprepa et al [27] where they studied 1140 patients with ST-segment– elevation myocardial infarction undergoing primary PCI and paired scintigraphic examinations (before intervention and 7 to 14 days thereafter and concluded that no reflow after primary PCI was associated with reduced myocardial salvage, larger infarct size, worse left ventricular ejection fraction at 6 months, and increased risk of 1-year mortality.

Regarding cardiac biomarkers:Peak cardiac enzyme results showed a statistically significant result with area at risk however did not show a significant correlation with myocardial salvage index ,this come in accordance with Leoncini et al. [28] who used SPECT in 43 patients to determine the myocardial salvage and they concluded that patients with high troponin I on admission have a larger initial risk area, but no unfavorable relationship between high troponin I values on admission and myocardial salvage was registered.

Regarding using IV antiplatelet(tirofiban) and aspiration catheter: No statistically significance was found either in AAR or MSI this comes in accordance with Young et al who studied 39 patients divided their patients into two groups,one with facilitated tirofiban and the other without, their study showed that upstream use of high dose tirofiban before primary PCI did not reduce infarct size measured by MRI [29].

Despite in the current study using aspiration catheter showed improvement in the myocardial salvage index ,however it was not statistically significant ,this was in contrary with Ciszewski et al. [30] they randomized 137 patients either to aspiration thrombectomy followed by standard PCI with stent implantation or to standard primary PCI. MSI was larger in aspiration thrombectomy group and concluded that aspiration thrombectomy improves myocardial salvage in high risk STEMI patients with angiographic evidence of thrombus.however in their study they depended on 99mTc-sestamibi SPECT imaging to measure MSI, also this study comes in agreement with Ge et al. [31] studied trials and meta-analysis regarding using thrombus aspiration from 2008 till 2016 and concluded that thrombus aspiration currently remains uncertain because of the many controversial facts in the trials and, they reinforced the necessity of additional large, randomized clinical trials to determine the clear indications of aspiration thrombectomy.

Regarding cardiac MRI ventricular volumes and functions results: This study showed significantly difference between the baseline and after 3 months in the follow up this matches with the ESC STEMI guildlines where primary PCI is class 1 recommendation level of evidence A [16].

Also in Baks et al. [32] studied left ventricular volumes and function assessment with MRI in STEMI patients and found a marked increase in overall mean EF%.

Regarding microvascular obstruction: Microvascular obstruction (MVO) showed a statistically significant result with area at risk which increased with MVO and with MSI which decreased with MVO and this come in line with Limalanathan et al. [33] who studied 94 patient with STEMI at baseline and after 4 months follow up , and found that myocardial salvage was significantly reduced in patients with microvascular obstruction, compared to those without.

Intramyocardial hemorrhage was found to have a significant negative impact on MSI and this comes in accordance with Bulluck et al. [34].

Also in agreement with Kandler et al. [35] who studied 151 patients and that IMH was associated with significant lower left ventricular ejection fraction and myocardial salvage index, larger left ventricular volume and infarct size.

5.1 Study Limitations

Sample size is relatively small and Multi-center studies can give a more validated data.

6. CONCLUSION

Primary PCI is crucial in improving MSI ,Cardiac MRI is a leading tool to assess the myocardial changes after acute ischaemia.

CONSENT

Informed written consent was obtained from all patients after a full explanation of the benefits and risks of the study.

ETHICAL APPROVAL

Permission obtained from Research Ethics Committee as a part of Quality Assurance Unit in Faculty of Medicine at Tanta University to conduct this study and to use the facilities in the hospital.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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