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Research Article

Mitral annular plane systolic excursion by cardiac MRI versus Global longitudinal strain analysis by speckle tracking echocardiography for prognostic assessment in ST-elevation myocardial infarction patients

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Abstract

Background: The main factor influencing left ventricular pump function is the LV's longitudinal function. Mitral annular plane systolic excursion (MAPSE) determined by Cardiac Magnetic Resonance (CMR) can predict poor outcomes following STEMI. **Objectives:** This study was performed to investigate the feasibility of CMR-derived MAPSE to predict major adverse cardiovascular events (MACE) in first time reperfused STEMI patients by primary percutaneous coronary intervention (pPCI) and to Compare its predictive value with speckle-tracking echocardiography- derived LV global longitudinal strain. **Methods:** LV Global longitudinal strain analysis by speckle tracking echocardiography and MAPSE assessment by cardiac MRI were performed in 70 reperfused first time STEMI patients by (pPCI) within 2 days after infarction. One year follow up registration for MACE was done involving death, non-fatal myocardial re-infarction, stroke and new congestive heart failure. **Results:** Patients with MACE ($n = 12$, 17.1%, median follow-up 1 year) showed significantly lower MAPSE and lower LV GLS in comparison to those without MACE (6.25±1.1 mm vs. 9.67±1.6 mm, $p < 0.001$) , (10.4 ±1.1% vs. 13.6±1.9 %, $p < 0.001$) respectively .Reduced MAPSE (<7 mm, optimal cut-off value by c-statistics) and reduced LV GLS (< 11%, optimal cut-off value by c-statistics) was associated with increased incidence of MACE that remained significant even after controlling other independent clinical predictors of MACE. The MAPSE AUC for the MACE prediction was 0.96 that was significantly higher than that of LV GLS which was 0.90 ($p < 0.001$). **Conclusions:** Reduced MAPSE measured by CINE CMR independently predicts long term prognosis following STEMI. Additionally, MAPSE had a greater predictive value compared to GLS analysis by speckle tracking echocardiography.

Key Words: CMR, MAPSE, LV GLS, Speckle tracking echocardiography.

Key Points:

•After STEMI, the longterm prognosis is independently predicted by MAPS-E assessed by CMR.

• Patients with MAPSE ≥ 7 mm had a significantly greater MACE-free survival than those with MAPSE < 7 mm.

• Prognostic value of MAPSE is greater than that of GLS analysis by STE.

Introduction

Myocardial structure and function are significantly impacted by acute myocardial ischemia [(1).] A reliable predictor of a worse clinical prognosis in individuals with acute STEMI is left ventricular ejection fraction (LVEF) [(2).]

Major adverse cardiac events (MACE) are predicted by lower MAPSE as assessed by CMR [3]. Left ventricular (LV) myocardial strain imaging is useful tool to quantify myocardial deformation and thickening/ thinning of the myocardial wall during the cardiac cycle[4].

It is not well established that CMR derived MAPSE is better than LV GLS analysis by STE in predicting MACE following STEMI. This study's objective was to investigate ability of CMR-derived MAPSE to predict MACE in first time STEMI reperfused patients and to assess its prognostic value compared to the left ventricular global longitudinal strain determined by speckle-tracking echocardiography.

Patients and methods

This prospective non-randomized study included 70 patients with STEMI who were followed up at Al-Minya University hospital Cardiology department during the period from October 2021 to July 2023

Patients:

Included patients were: STEMI patients (newly diagnosed ischemic heart disease), all patients underwent successful primary percutaneous coronary intervention (p PCI) within 24 hours after onset of symptoms, STEMI was defined according to American College of Cardiology committee / the redefined European Society of Cardiology criteria (5), all included patients had Killip class <3 and estimated glomerular filtration rate > 30 mL/min per 1.73 m2 at time of CMR and STE.

Left bundle branch block (LBBB) patients, age < 18 years old, and contraindications to CMR examination (pacemaker, cerebral aneurysm clip) were the exclusion criteria.

Methods:

All patients underwent the following:

1- Complete history taking and clinical evaluation.

3- Resting 12 leads Electrocardiogram within 10 minutes of patient evaluation.

4- Laboratory investigations:

Renal function, Liver function, serum electrolytes, CBC and INR. –

5- Trans Thoracic Echocardiography (TTE):

was performed immediately at admission for evaluation of:

LV dimensions and Systolic Function, Diastolic dysfunction, resting wall motion abnormalities, valvular Lesions and any Mechanical complications

6- Coronary Angiography and Primary PCI to all patients once diagnosed as STEMI patients within 24 hours after onset of symptoms.

7- Speckle-tracking analysis

At (a frame rate of 60–80 frames per second), specific 2D image loops were captured during breath-hold of 3 stable consecutive cardiac cycles in the apical 2, 3, and 4 chamber views. All recordings were acquired then analyzed from which global LS values were obtained **(Fig. 2).**

8- Cardiac magnetic resonance imaging within 2 days after successful reperfusion by pPCI all patients were investigated. On a long-axis four-chamber image, the end-diastolic and end-systolic mitral annular planes were identified by connecting the mitral valve's lateral and septal attachments to the myocardium.

The largest diameter of the left ventricle was used to define end-diastole on the corresponding long-axis stack images, and the image just prior to mitral valve opening was used to define end-systole. The term (Septal MAPSE) was defined and measured as the distance of septal attachment of the mitral valve between end diastole and end-systole. Similarly, the term (lateral MAPSE) was defined and measured as the distance of the lateral attachment of the mitral valve between end diastole and end-systole. The estimated mean of the lateral and septal MAPSE was identified as the average MAPSE[13]**(Fig. 1)**

9- Follow-up data for evaluating clinical end points:

A telephone interview with a standardized questionnaire occurred 12 months following STEMI (for the purpose of evaluating the occurrence of MACE, which is defined as a composite of all-cause death, congestive heart failure, non-fatal myocardial re-infarction and stroke)

Statistical Methods

The statistical software SPSS for Windows version 20 was used for data entry and analysis. Graphs were done using Microsoft office 2013. The mean and standard deviation were used to display quantitative data. comparison differences between the two independent groups were done by using independent sample T-test. The lowest accepted level of significance was 0.05 or less.

Results

patients Characteristics:

The Current Study included 70 STEMI patients, 55 male and 15 female patients. Their mean ages were 52±12 years,21 patients (30%) were diabetic, 29 patients (41%) were hypertensive, 36 patients (51%) were smokers.

35 patients (50%) in this study had anterior STEMI, 31 patients (44.3%) in this study had inferior STEMI and only 4 patients (5.7%) patients in this study had lateral STEMI.

Mean LVEDV (ml) was 135.4±10.38ml, Mean LVESV (ml) was 69.77±19.07 ml and mean IVSs was 0.9±.07 cm, Mean LVPWD was 0.89±.078 cm, Mean LVEF was 47.76±10.9%. Mean GLS was 13.03±2.1%.

Mean Lateral MAPSE was 10.8 ±.2 mm, mean septal MAPSE=9.09±1.9 mm and mean Average MAPSE was 9.8±2 mm.

12 patients (17.1%) had MACE while 58 patients (82.9%) had no MACE patients who had MACE: 6 patients (50%) had HF, 5 patients (41.7%) had MI and 1 patient (8.3%) died (Table 1)

Prognostic value of MAPSE, GLS and LVEF in our study population:

Mean lateral MAPSE was 7.9±1.4 mm in patients with MACE while it was 11.4±1.8 mm in patients without MACE, mean septal MAPSE was 6.2±1.1 mm in patients with MACE while it was 9.7±1.6 mm in patients without MACE, Mean Average MAPSE was 7.1±1.2 mm in patients with MACE while it was 10.3±1.6 mm in patients without MACE

There was significant increase in incidence of MACE with decreasing lateral, septal and Average MAPSE ($p \leq 0.001$) (Table 2).

Mean GLS was 10.4±1.1% in patients with MACE while it was 13.6±1.9% in patients without MACE, Mean LVEF was 36.3±7.4 % in patients with MACE while it was 51.1±9.85% in patients without MACE, there was significant increase in incidence of MACE with decreasing GLS and LVEF ($p \leq 0.001$) (Table 2).

Prognostic value of lateral MAPSE versus that of septal MAPSE versus that of LVEF versus that of GLS:

Cut off value was 9 mm for lateral MAPSE below which there was increase in incidence of MACE, AUC was 0.94, specificity was 86.2%, sensitivity was 91.7%, PPV was 57.9%, NPV was 98% (Table 3).

Cut off value was 7 mm for septal MAPSE below which there was increase in incidence of MACE, AUC was 0.97, specificity was 91.4%, sensitivity was 91.7%, PPV was 68.8 %, NPV was 98.1% (Table 3).

while cut off value was 40% for LVEF below which there was increase in incidence of MACE, AUC was 0.89, specificity was 72.4%, sensitivity was 91.7%, PPV was 40.7%, NPV was 97.7(Table 3).

while cut off value was 11% for GLS below which there was increase in incidence of MACE, AUC was 0.90, specificity was 86.2%, sensitivity was 83.3%, PPV was 55.6%, NPV was 96.2% (Table 3).

So (comparing septal MAPSE, lateral MAPSE, GLS and LVEF) septal MAPSE had more prognostic value than lateral MAPSE, lateral MAPSE had more prognostic value than GLS, GLS had more prognostic value than LVEF for detection of MACE, septal MAPSE had highest prognostic value and LVEF had lowest prognostic value for detection of MACE (Table 3).

Table 1: Patients Characteristics:

Patients Characteristics	Frequency N=70	Percentage %
Age Range	21-80	
Mean ± SD	52.96±12.5	
Gender Male	55	78.6%
Female	15	21.4%
Dm Yes	21	30%
No	49	70%
HTN Yes	29	41.4%
No	41	58.6%
Smoking Yes	36	51.4%
No	34	48.6%
STEMI type Anterior	35	50%
Inferior	31	44.3%
Lateral	4	5.7%
LVEDV (ml) Mean ± SD	135.4±10.38	
IVSs Mean ± SD	0.9±.0761	
LVPWD Mean ± SD	0.887±.0779	
LVESV (ml) Mean ± SD	69.77±19.07	
LVEF% Mean ± SD	47.76±10.968	
GLS% Mean ± SD	13.03±2.180	
Lateral MAPSE (mm) Mean ± SD	10.83±2.200	
Septal MAPSE (mm) Mean ± SD	9.09±1.998	
Average MAPSE (mm) Mean ± SD	9.793±2.0403	
Major adverse (cardiovascular events =70)		
Yes	12	17.1%
No	58	82.9%
MACE type if yes (n=12)		
Cardiovascular death	1	8.3%
Heart failure	6	50%
Myocardial infarction	5	41.7%

SD: Standard deviation., DM: Diabetes Mellitus, HTN: Hypertension, STEMI: ST segment elevation myocardial infarction, LVEDV: left ventricular end diastole volume, IVSs: Interventricular septum systole, LVPWD: Left ventricular posterior wall diastole, LVESV: Left ventricular end systolic volume, LVEF: Left ventricular ejection fraction, GLS: Global

Longitudinal Strain, MAPSE: Mitral annular plane systolic excursion, MACE: Major adverse cardiovascular events.

Table 2: Prognostic value of MAPSE, GLS and LVEF in our study population:

	MACE (N=12) Mean ± SD	NO MACE (N=58) Mean ± SD	P
Lateral MAPSE (mm)	7.92±1.379	11.43±1.827	≤0.001
Septal MAPSE (mm)	6.25±1.138	9.67±1.594	≤0.001
Average MAPSE (mm)	7.083±1.2401	10.353±1.6963	≤0.001
GLS%	10.42±1.084	13.57±1.948	≤0.001
LVEF%	36.33±7.426	51.16±9.832	≤0.001

MAPSE: Mitral annular plane systolic excursion, GLS: Global Longitudinal Strain, LVEF: Left ventricular ejection fraction

Table 3: Prognostic value of lateral MAPSE versus that of septal MAPSE versus that of LVEF versus that of GLS:

	Cut off value	AUC	Sensitivity	Specificity	PPV	NPV	P
Lateral MAPSE	**9**	0.938	91.67%	86.21%	57.9%	98%	≤0.001
Septal MAPSE	7	0.962	91.67%	91.38%	68.8%	98.1%	≤0.001
LVEF	40	0.885	91.67%	72.41%	40.7%	97.7%	≤0.001
GLS	11	0.904	83.33%	86.21%	55.6%	96.2%	≤0.001

MAPSE: Mitral annular plane systolic excursion, LVEF: Left ventricular ejection fraction, GLS: Global Longitudinal Strain,

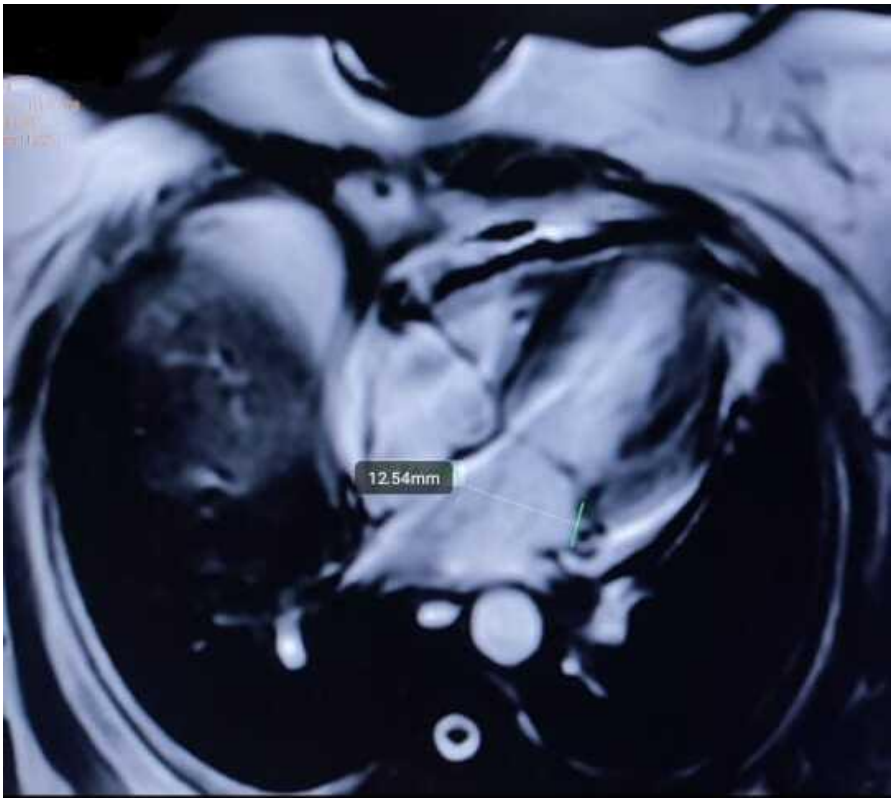

Figure 1: MAPSE measurement by cardiac MRI

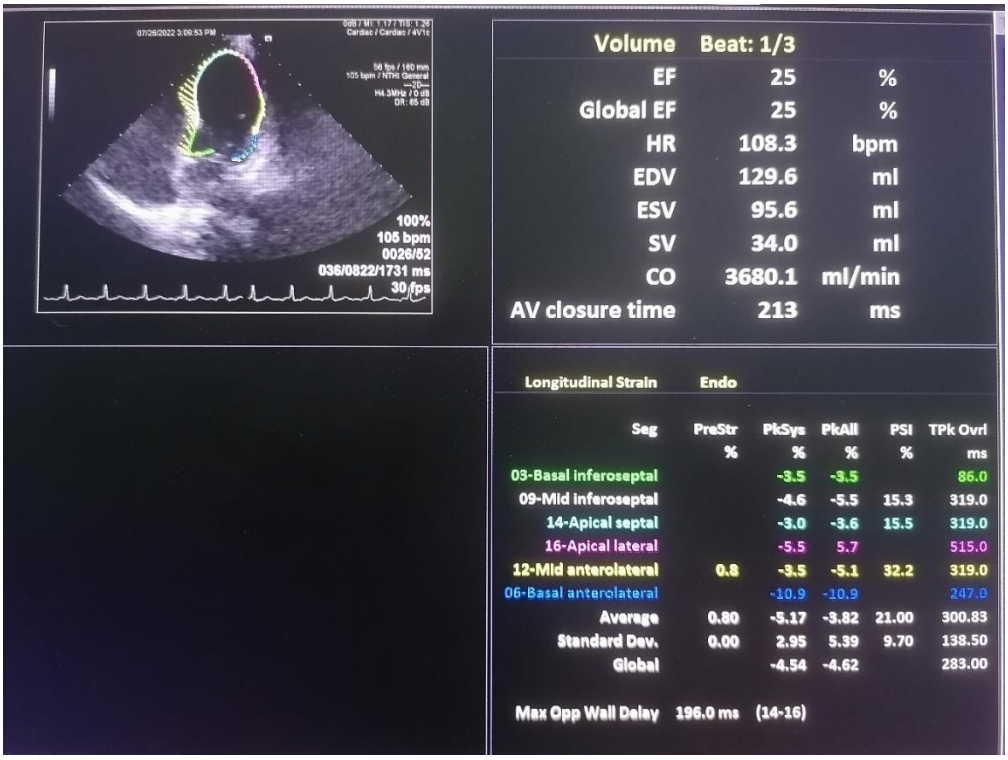

Figure 2: LV GLS measurement by STE

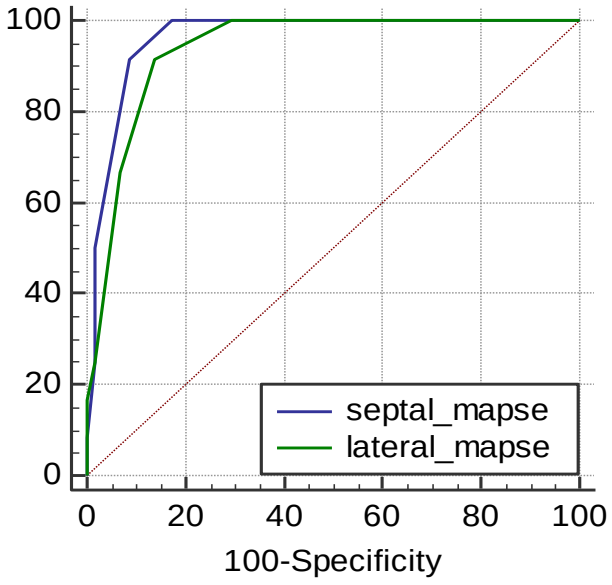

Figure 3: Prognostic value of septal MAPSE versus prognostic value of lateral MAPSE

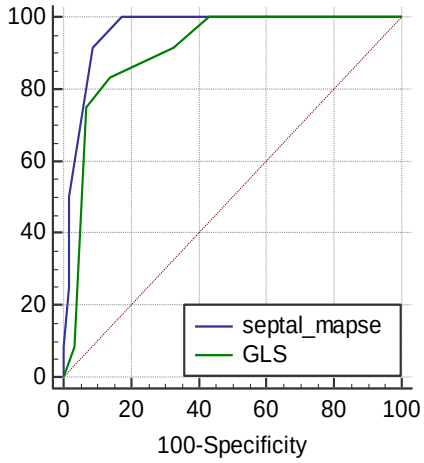

Figure 4: Prognostic value of septal MAPSE versus prognostic value of GLS

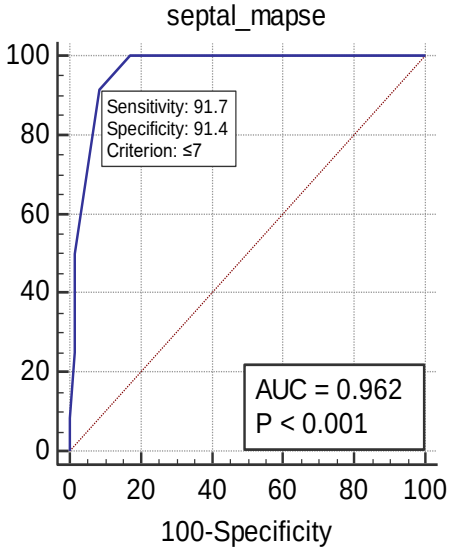

Figure 5: Roc curve of prognostic value of septal MAPSE

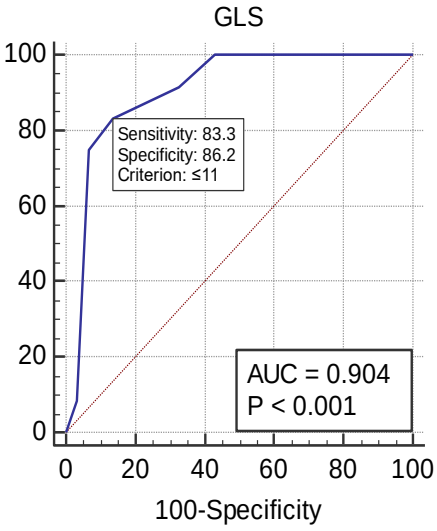

Figure 6: Roc curve of prognostic value of GLS

Discussion

In STEMI patient the strategy for maintaining the ischemic myocardial viability and reducing the extent of an infarct is early reperfusion.

In order to start the proper treatment for STEMI, an early diagnosis must be made within ten minutes of the initial medical contact [5].

In our study we aimed to investigate ability of CMR-derived MAPSE to predict MACE in first time STEMI reperfused patients and to assess its prognostic value compared to LV GLS determined by STE.

The main study findings can be summarized as follows:

1. CMR-derived Septal MAPSE early in reperfused STEMI patients is a reliable, independent predictor of MACE at one year duration follow-up and Patients with Septal MAPSE ≥ 7 mm had a significantly greater MACE-free survival than those with Septal MAPSE < 7 mm.
2. LV GLS analysis by speckle tracking echocardiography in reperfused STEMI patients is also a predictor of MACE and its predictive value exceeded that of LVEF.
3. Septal MAPSE's predictive value was significantly higher than that of LV GLS analysis by STE.

In agreement with our study:

Regarding (Septal MAPSE determined by CMR)

Agnes Mayr et al., proved that decreased MAPSE measured using CINE CMR independently predicts long-term prognosis following STEMI. Septal MAPSE has a higher predictive value than lateral and average MAPSE, and the predictive value of MAPSE is significantly greater than that of conventional LVEF measurement. in this study, 255 STEMI patients had CMR two days following their infarction. Patients' major adverse cardiovascular events (MACE) were monitored. LVEF AUC for the prediction of MACE was (0.61 [CI 95% 0.50–0.71] and it was lower than that of MAPSE that was 0.74 (CI 95% 0.65–0.82) ($p < 0.001$) [6].

Rangarajan V et al., proved that decreased lateral MAPSE measured during cine-CMR is an independent predictor of MACE. 400 patients undergoing Cardiac magnetic resonance were prospectively enrolled. Using the 4-chamber cine view, MAPSE was measured. A prospective monitoring program was established for MACE. Incidence of MACE was substantially greater in individuals with lateral MAPSE <1.11 cm (median) than in those with MAPSE ≥1.11 cm (p = 0.027). Lateral MAPSE was found to be a substantial independent predictor of MACE even after controlling of other clinical risk variable [7].

Simone Romano et al., proved that in individuals with left ventricular dysfunction, a reliable independent predictor of death is lateral MAPSE measured during cine cardiac MR imaging [8].

Regarding (LV GLS analysis by speckle tracking echocardiography)

Olzknecht M, et al., studied 445 patients with acute STEMI who subjected to pPCI in this observational cohort research. MACE was the primary outcome. The variables MAPSE (p<0.001), GLS (p<0.001), and LVEF (p = 0.023) showed a significant correlation with MACE. They proved that after adjusting for (LV function, myocardial damage, angiographical features, and clinical features), GLS became an independent predictor of MACE with greater prognostic value than LVEF.[9].

Kalam K et al., proved that strong evidence was found for the predictive value of GLS, which seems to be more reliable than EF in predicting significant adverse cardiac events. this study compared GLS against LVEF in predicting MACE, GLS was found to have more predictive value than LVEF [10].

Bertini M et al., proved that in patients with ischemic heart disease with impaired LV systolic function, evaluation of LV GLS by STE was substantially correlated with long-term prognosis. Transthoracic echocardiography and baseline clinical assessment were performed to 1060 patients. Individuals with an LV GLS ≤−11.5% exhibited better outcomes in comparison to

those with an LV GLS >−11.5%. GLS was independently correlated with all-cause mortality on multivariate analysis. [11].

Grove GL et al., layer-specific GLS was carried out in STEMI patients undergoing pPCI just two days following the STEMI. The composite of cardiovascular death and/or hospitalization for heart failure was the outcome. After multivariable adjustment, they demonstrated that only GLS Mid myocardial and GLS Epicardial are independent predictors of MACE. GLS endocardial was not one of the independent predictors of MACE [12] and this supports our study in using CMR-derived MAPSE as a predictor of MACE as its prognostic value was higher than that of GLS that was proved in our study and GLS endocardial was not one of the independent predictors of MACE that was proved in Grove GL et al., study [12].

Limitations:

- Owing to our inclusion criteria, the findings of this study were limited to a specific group of patients and not applied to patients with other cardiac conditions involving left ventricular remodeling or recurrent myocardial infarction.
-When interpreting MAPSE in individuals with paradoxical septal motion, caution should be taken due to presence of significant right heart dysfunction, septal MAPSE in these conditions indicate both RV and LV dysfunction. Therefore, the lateral MAPSE should be applied to these individuals.
-Relatively small sample size

Conclusion:

Reduced MAPSE measured by CINE CMR independently predicts long term prognosis following STEMI. Additionally, MAPSE had a greater predictive value compared to GLS analysis by speckle tracking echocardiography**.**

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Author's Contributions :

Dr. Amr salah amin, Dr. Mohamed Aboulfotouh Mourad and Dr. Ahmed M Dardeer contributed through planning, execution, analysis and revision of this manuscript **.**

Dr. Khaled Sayed Mahmoud contributed through supervising, planning, interpretation and revising of this manuscript.

Dr. Mohsen Nasser Sayed contributed through data collection, analysis, interpretation and statistical analysis of this manuscript.

Conflict of interest:

The authors have no conflicts of interest to declare.

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