# Two-Dimensional Speckle Tracking Echocardiography as Predictor of Major Adverse Cardiac Events in Patients With Non–ST-Elevation Myocardial Infarction and Unstable Angina

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## Abstract

**INTRODUCTION:** This study was conducted to determine the utility of two-dimensional speckle tracking echocardiography (2D STE) in predicting major adverse cardiac events (MACEs) in patients with non–ST-elevation acute coronary syndrome (NSTE-ACS).

**METHODOLOGY:** This is a prospective cohort study that included 91 patients diagnosed to have NSTE-ACS. In-hospital and 6-month MACEs were evaluated in relation to their baseline echocardiographic parameters, 2D speckle strain, and strain rate analyses.

**RESULTS:** Among the conventional echocardiographic parameters, only left ventricular end-systolic diameter (LVESD) and wall motion scores showed significant difference between those with and without outcomes after 6 months. Significant higher wall motion scores (24.06 vs 20.91 $P = 0.0320$) and LVESD (3.36 vs 2.97 cm, $P = 0.0125$) were noted among those who had MACE after 6 months. There were no significant differences among the 2D STE strain and strain rate between those patients with and without MACE during their hospital admission. However, after 6-month follow-up, significantly lower mean left ventricular global longitudinal strain (GLS) (–14.22% ± 4.45% vs –16.44% ± 4.19%, $P = 0.0261$) and strain rate (–0.69 ± 0.36 $s^{-1}$ vs –0.94 ± 0.25 $s^{-1}$, $P = 0.009$) were observed among patients with MACE compared with those without. Incidence of reduced GLS strain and strain rate was significantly higher in those with MACE after 6 months. Left ventricular GLS sensitivity and specificity were 64.64% and 61.70%, respectively, at a cutoff value of less than –15.0% for detecting MACE within 6 months. Left ventricular GLS cutoff point less than –12.0%, which detects severe LV dysfunction in previous studies, have a sensitivity of 40% but a high specificity of 82.98% for predicting MACE after 6 months.

**CONCLUSION:** Both LV GLS strain and strain rate can be used to predict major adverse cardiovascular events after NSTE-ACS.

**KEYWORDS:** speckle tracking echocardiography, non–ST-elevation acute coronary syndrome, cardiac events

## INTRODUCTION

Acute coronary syndrome (ACS) remains the leading cause of mortality and loss of disability life-years worldwide[1]. Electrocardiogram (ECG) has been pivotal in early risk stratification of patients presenting with chest pain at the emergency department—differentiating ST elevation from non–ST-elevation ACS (STE-ACS vs NSTE-ACS)—which helps in the decision-making for timely reperfusion therapy. [2-4] However, ECG has only 70% sensitivity in detecting acute coronary occlusion commonly observed among ST-elevation myocardial infarction, and there remains less certainty in a much larger and more heterogeneous group of NSTE-ACS patients. Risk is highest at the time of presentation of NSTE-ACS patients but remains to be elevated past the acute phase, by 6 months. Mortality rates in NSTE-ACS may equal or exceed those of STE-ACS, and by 12 months, rates of death, MI, and recurrent instability in contemporary registries are greater than 10%.[2]

Aside from cardiac biomarkers such as high-sensitivity troponin and periodic ECG analyses, myocardial imaging has added significant information in the assessment of these patients. Echocardiography should be routinely performed in all patients admitted for NSTE-ACS in the emergency department or chest pain units to assess wall motion abnormality and evaluate global and regional left ventricular (LV) function.[2,3] Through the years, LV ejection fraction (LVEF) has been a major determinant of early outcomes in this cohort of ischemic heart disease patients. Novel echocardiographic techniques such as tissue Doppler imaging and myocardial strain quantifications can improve the diagnostic and prognostic value of conventional echocardiography by detecting subclinical LV dysfunction. Two-dimensional speckle tracking echocardiography (2D STE) utilizes the presence of natural acoustic markers in B-mode gray-scale images created by interference of ultrasound beams within myocardial tissue, denoted as "speckles," and their relative positions are being tracked through each frame of the cardiac cycle providing information on regional myocardial deformation or strain.[4]

Different studies have emphasized the usefulness of 2D STE and other myocardial deformation measures focusing on its prognostic value in patients with coronary artery disease.[4,5,8] In ACSs, 2D STE was used in diagnosis and risk stratification more often on ST-elevation myocardial infarction (STEMI) patients. This study was conducted to determine the utility and accuracy of this 2D STE in predicting major cardiac events in patients who had NSTE-ACS/unstable angina (UA).

## METHODS

This is a prospective cohort study approved by the Philippine Heart Center Institutional Ethics Review Board. The study was conducted at the Philippine Heart Center from April 2019 to July 2020.

All adult patients 19 years or older diagnosed with non–ST-elevation myocardial infarction (NSTEMI)/UA were included in this study. NSTE-ACS diagnosis was based on European Society of Cardiology NSTE-ACS 2017 guidelines defined as prolonged chest pain lasting for more than 20 minutes, ECG changes in the form of ST-segment depression and/or T-wave inversion in two or more consecutive leads (in some cases of ACS, the ECG shows no abnormality) and elevation of serum levels of cardiac biomarkers such as troponins and creatine kinase–MB value more than twice of the highest reference laboratory value. The following patients were excluded in this study: those with history or ECG evidence of old myocardial infarction; previous coronary artery bypass graft (CABG) surgery or percutaneous coronary artery intervention; with ventricular arrhythmias, pacing, or pre-excitation syndrome; with congenital heart disease; with severe valvular heart diseases; previously diagnosed with cardiomyopathy; and with poor echocardiographic images. Patient who were lost to follow-up were withdrawn from the study.

A minimum of 82 patients are required for this study based on an area under the curve of 0.689 of segments with reduced strain to predict an outcome, 10% desired half width of the confidence interval an 5% level of significance.[4]

Written informed consent was obtained by the researcher from the patient or legally authorized representative at the emergency room. Review of charts, electronic medical records, and interviews were done for the patient's baseline characteristics. Patients were then subjected to 2D echocardiography with Doppler study within 48 hours of NSTE-ACS diagnosis. Echocardiographic cine loops were obtained by recording three consecutive heart cycles. Offline image processing and data analysis were performed using the Velocity Vector Imaging Technology (Siemens SC 2500; Munich, Germany) by one technician who is well trained in 2D STE, and one level III echocardiographer specializing in STE, interpreted the acquired images and results. Strain parameters included were LV longitudinal and circumferential strain and strain rate, as well as right ventricular (RV) free wall global longitudinal strain. Left ventricular global longitudinal strain (GLS) and strain rate were averaged from all the segments recorded from three standard longitudinal views. Global circumferential strain (GCS) and strain rate were obtained from the mid-LV short-axis plane. Right ventricular GLS was obtained from the average values from all the six segments—encompassing basal, mid, and apical RV free wall and interventricular septum. Bull's-eye display of the regional and global longitudinal and circumferential strain was generated, an example is shown in Figure 1.

Results of the strain and strain rates were classified based on the study by Potter and Marwick[12] and Lang et al[13] as to normal (–18% to 20%), borderline (–16% to 17.9%), and reduced (<–16%) for the LV GLS; normal (≥1.1 $s^{-1}$) and reduced (< 1.1 $s^{-1}$) for LV GLS strain rate; normal (≥–22%) and reduced (<–22%) for LV GCS; normal (≥0.9 $s^{-1}$) and reduced (<0.9 $s^{-1}$) for LV GCS strain rate; and normal (≥–22%) and reduced (<–22%) for RV GLS. Outcomes—both in-hospital outcomes and after 6 months—were identified and followed up. Major adverse cardiac event (MACE) is defined as all-cause mortality, another myocardial infarction, progression to

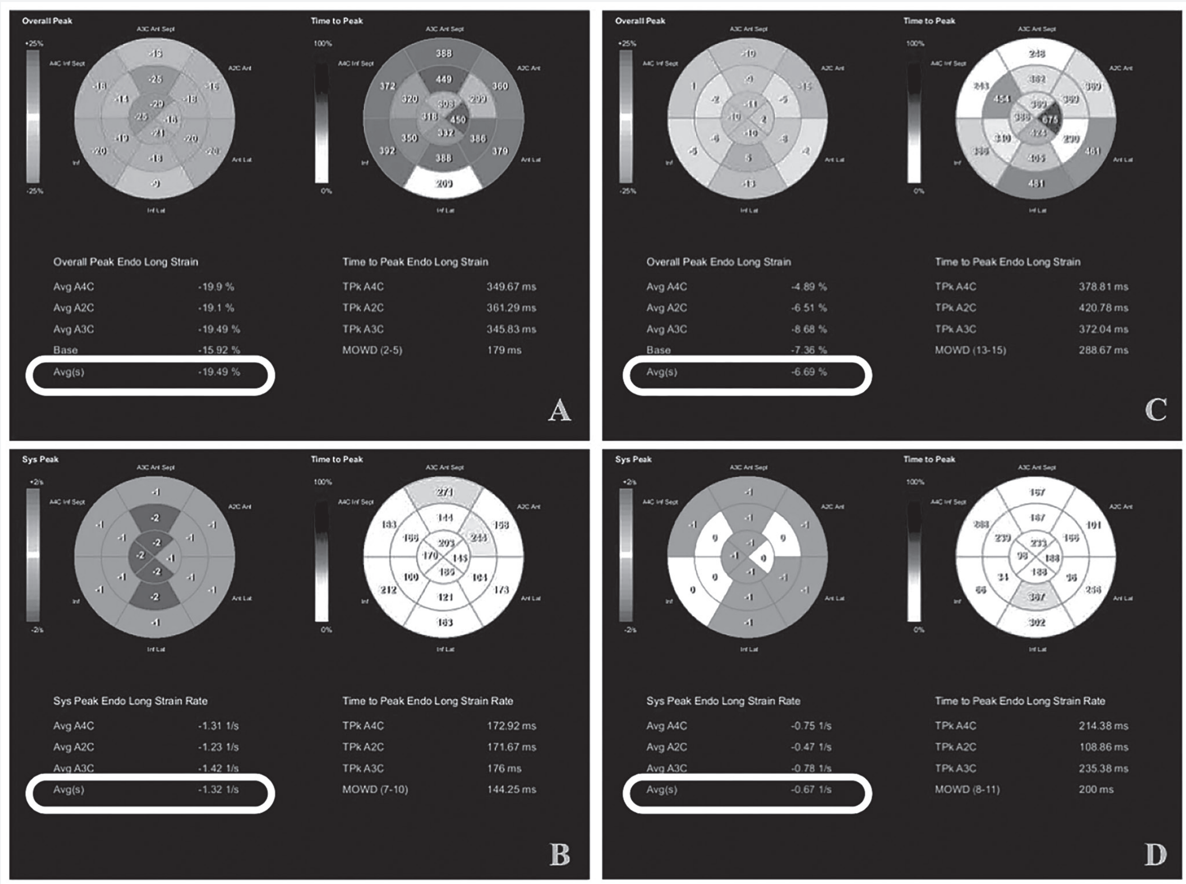


**Figure 1.** Example bull's-eye plot display from two different NSTE-ACS patients. First patient had LV GLS strain (A) and strain rate (B) with normal values at –19.49% and –1.32 $s^{-1}$, respectively, whereas another patient had bull's-eye plot of strain values showing markedly reduced LV GLS (C) at –7.36% and reduced strain rate (D) at –0.67 $s^{-1}$

heart failure, admission for any ischemic cardiovascular events (e.g., cardiovascular disease, peripheral artery disease), and admission for coronary angiogram or revascularization by percutaneous coronary intervention (PCI) or CABG. The patient or family member was asked for any of the cardiac events through phone calls or during their follow-up visits.

Descriptive statistics was used to summarize the demographic and clinical characteristics of the patients. Independent-sample *t* test, Mann-Whitney *U* test, and Fisher exact/$\chi^2$ test were used to determine the difference of mean and frequency, respectively, between NSTEMI/UA patients with and without cardiac events. Area under the receiver operating characteristic curve analysis was used to determine the diagnostic parameters of 2D speckle tracking parameters to predict outcome. *P* value was considered significant if less than 0.05. Missing variables were neither replaced nor estimated.

## RESULTS

A total of 91 NSTE-ACS patients were included in this study. Table 1 shows the baseline characteristics, risk factors, and medications of the patients.

Mean (±SD) age of patients who had NSTEMI and angina was 60 (11) years, and most were male. Eighty-nine (97.8%) were diagnosed NSTEMI on admission, whereas the remaining two (2.2%) had UA. Most common comorbidities were hypertension, diabetes, and chronic kidney disease in 65 (71.4%), 28 (31.1%), and 15 (16.5%) of the patients, respectively. Most patients were nonsmokers (41 patients [45.1%]), followed by smokers (35.2%), and those who were previous smokers made up the remaining 18 (19.8%). Most of the patients have New York Heart Association functional class II (60 [65.9%]), followed by New York Heart Association functional classes I and III comprising 29 (31.9%) and 2 (2.1%) patients, respectively. Medications prior to the myocardial infarction include angiotensin-receptor blocker (29.7%), statins (20.9%), calcium-channel blockers (21.1%), antiplatelets (18.7%), β-blockers (15.4%), and angiotensin-converting enzyme inhibitors (13.2%).

Table 2 and Figure 2 show the outcomes of the patient during admission and after 6 months of myocardial infarction. Of the 91 patients who had NSTE-ACS, 16 (17.58%) had in-hospital outcome, whereas the remaining 75 (82.4%) were discharged

**Table 1.** Baseline Characteristics of NSTEMI and Unstable Angina Patients

| | Frequency | % |
|---|---|---|
| | N = 91 | |
| Age, mean (SD), y | 60 (11.64) | |
| Sex | | |
| Male | 64 | 70.3 |
| Female | 27 | 29.7 |
| NSTEMI | 89 | 97.8 |
| Unstable angina | 2 | 2.2 |
| Comorbidities | | |
| Hypertension | 65 | 71.4 |
| Atrial fibrillation | 3 | 3.2 |
| Diabetes mellitus | 28 | 31.1 |
| Dyslipidemia | 8 | 8.7 |
| CKD | 15 | 16.5 |
| CVD | 3 | 3.3 |
| PAD | 1 | 1.1 |
| NYHA class | | |
| Class I | 29 | 31.9 |
| Class II | 60 | 65.9 |
| Class III | 2 | 2.1 |
| Class IV | 0 | 0.0 |
| Smoking history | | |
| Smoker | 32 | 35.2 |
| Nonsmoker | 41 | 45.1 |
| Previous smoker | 18 | 19.8 |
| Medications | | |
| Antiplatelets | 17 | 18.7 |
| Statins | 19 | 20.9 |
| β-Blockers | 14 | 15.4 |
| ACE inhibitor | 12 | 13.2 |
| ARBs | 27 | 29.7 |
| Calcium-channel blockers | 20 | 21.1 |

*ACE=angiotensin-converting enzyme; ARB=angiotensin-receptor blocker; CKD=chronic kidney disease; CVD=cardiovascular disease; NSTEMI=non–ST-elevation myocardial infarction; PAD=peripheral artery disease.*

stable. Four patients (4.40%) died, 15 (16.48%) had immediate coronary angiogram, and 5 (5.49%) had revascularization (either by PCI or CABG) on admission. After 6 months, a total of 80 patients were followed up (7 were lost to follow-up). Thirty-five patients (43.75%) had MACEs—most of them (23 [28.75%]) had symptoms of heart failure; 15 (18.75%) had readmission for any cardiovascular events, usually cerebrovascular disease, whereas 4 (5.0%) were readmitted for another myocardial infarction. Four patients (5%) died after 6 months of their NSTE-ACS. There were eight patients (10.0%) who had coronary angiogram, and two (2.50%) had targeted revascularization within 6 months of myocardial infarction.

Among the conventional echocardiographic parameters of the patients, there were no significant differences between those who had outcome and those without during their admission (Table 3). However, after 6 months of their NSTE-ACS, LVESD and wall motion score were associated with MACEs with *P* values of 0.0125 and 0.0320, respectively. Significantly higher wall motion scores were noted among those who had MACE after 6 months. Although there was no significant difference noted regarding LVEF by the Simpson method, lower LVEF was noted among those with MACE (55.18% vs 59.78% for those without outcome).

There were no significant differences among the 2D speckle tracking strain parameters between those patients with and without major cardiac events during their admission, as shown in Table 4. Incidence of reduced global longitudinal strain was observed more in patients with in-hospital outcome, which is 62.50% as compared with 56.00% for those without hospital outcome.

However, after 6-month follow-up, there were significant differences regarding the mean GLS and strain rate between those with and without MACE. Also, incidences of reduced GLS strain and strain rates were significantly higher in those with outcomes after 6 months (66.67% vs 44.68% for the reduced GLS strain and 90.63% vs 65.22 for reduced GLS rate). Although no significant differences were noted with the rest of the 2D speckle strain parameters, higher incidences of patients with lower GCS strain, GCS strain rate, and RV GLS were observed among those with outcome after 6 months as compared with those without MACE.

The cutoff value of LV GLS was found to be –14.9% with a sensitivity of 56.25%, specificity of 50.67%, and likelihood ratio of 1.14 in the detection of in-hospital cardiovascular outcome. There were a higher sensitivity (64.64%) and specificity (61.70%) of GLS in predicting MACE after 6 months, with a cutoff value of –15.0%. Also, the cutoff value for LV GLS strain rate was –0.75 $s^{-1}$ with sensitivity of 57.53 and specificity of 54.55%, positive likelihood ratio of 0.942, and negative likelihood ratio of 1.043. Likewise, higher specificity, sensitivity, and positive and negative likelihood ratios were also observed in predicting 6-month outcome for the cutoff value of –0.8 $s^{-1}$. (Table 5, Figure 3).

Cutoff for GCS was –23.1% with sensitivity of 45.83% and specificity of 46.51% in predicting in-hospital outcome, whereas GCS cutoff value of –23.0% has higher sensitivity of 58.06% and specificity 57.78% in predicting 6-month MACE. Same pattern of increased sensitivity, specificity, and positive and negative likelihood ratios was noted with the rest of the parameters in predicting 6-month outcome after NSTE-ACS as compared with in-hospital outcome.

## DISCUSSION

Limiting infarct size and preserving LV function through timely revascularization were still the main aims in the management

**Table 2.** In-Hospital and 6 Months' Major Adverse Cardiac Events After Non–ST-Elevation Acute Coronary Syndrome

| | In-Hospital | | 6 mo | |
|---|---|---|---|---|
| | Frequency | % | Frequency | % |
| | n = 91 | | n = 80 | |
| Without | 75 | 82.4 | 45 | 56.25 |
| With cardiac events | 16 | 17.58 | 35 | 43.75 |
| Mortality | 4 | 4.40 | 4 | 5.00 |
| Coronary angiogram | 15 | 16.48 | 8 | 10.00 |
| Revascularization | 5 | 5.49 | 2 | 2.50 |
| Readmission | — | | 15 | 18.75 |
| Another MI | — | | 4 | 5.00 |
| Heart failure | — | | 23 | 28.75 |

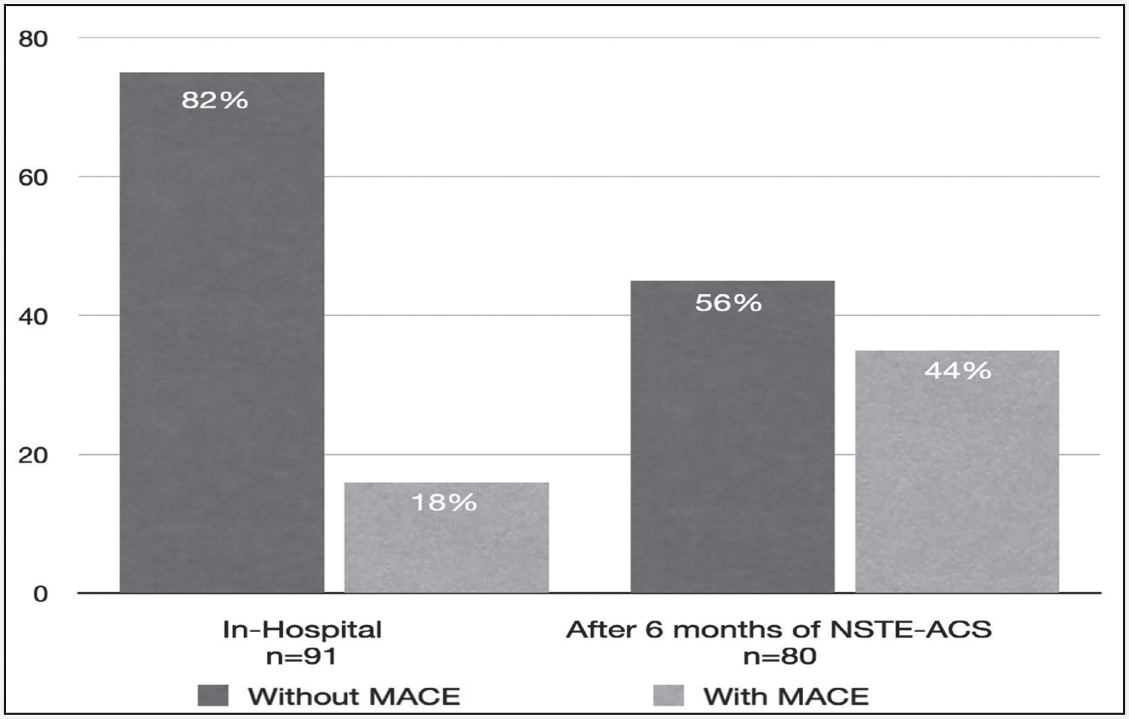


**Figure 2.** In Hospital and 6 months MACE after NSTE-ACS

of myocardial infarction. In ST-elevation acute coronary syndromes, total occlusion of epicardial coronary artery was perceived, and immediate thrombolysis or PCI was the norm to restore blood flow. On the other hand, NSTE-ACS patients are initially stabilized medically and then stratified who will need invasive strategy within 48 to 72 hours. Most often, LVEF was used to quantify overall systolic function and to determine high-risk NSTEMI patients guiding management, especially early coronary angiogram and subsequent revascularization.

Speckle tracking echocardiography is a relatively new approach that uses conventional 2D cine loop images for calculation of strain or myocardial deformation.[14] This study was designed to determine the utility of 2D STE in predicting MACEs in patients with NSTE-ACS during their admission and after 6-month follow-up.

Above data showed that only 17.58% of the patients had major in-hospital outcomes, which increases to 43.75% after

**Table 3.** Conventional Echocardiographic characteristics of the patients

| | In-Hospital | | | After 6 mo | | |
|---|---|---|---|---|---|---|
| | Without Outcome | With Outcome | *P* | Without Outcome | With Outcome | *P* |
| LVEDD, mean ± SD, cm | 4.59 ± 0.67 | 4.68 ± 0.34 | 0.575 | 4.45 ± 0.52 | 4.71 ± 0.67 | 0.053 |
| LVESD, mean ± SD, cm | 3.19 ± 0.81 | 3.20 ± 0.49 | 0.944 | 2.97 ± 0.55 | 3.36 ± 0.83 | 0.013 |
| LVEF, mean ± SD, % | 56.98 ± 11.04 | 56.87 ± 11.52 | 0.971 | 59.78 ± 9.39 | 55.18 ± 12.09 | 0.059 |
| Normal, n (%) | 52 (69.33%) | 11 (68.75%) | 0.449 | 38 (80.85%) | 20 (60.61%) | |
| Borderline, n (%) | 14 (18.67%) | 4 (25.00%) | | 6 (12.77%) | 8 (24.24%) | 0.198 |
| Nonsevere LVD, n (%) | 7 (9.33%) | 0 (0%) | | 2 (4.26%) | 4 (12.12%) | |
| Severe LVD, n (%) | 2 (2.67%) | 1 (6.25%) | | 1 (2.13%) | 1 (3.20%) | |
| RVFAC, mean ± SD, % | 49.11 ± 8.65 | 51.86 ± 5.81 | 0.244 | 51.07 ± 7.41 | 49.53 ± 8.17 | 0.402 |
| Normal, n (%) | 67 (97.71%) | 15 (100%) | 1.000 | 44 (97.78%) | 30 (100%) | |
| RV dysfunction, n (%) | 3 (4.29%) | 0 (0%) | | 1 (2.22%) | 0 (0%) | 1.000 |
| TAPSE, mean ± SD, cm | 2.09 ± 0.03 | 2.075 ± 0.32 | 0.795 | 2.10 ± 0.27 | 2.11 ± 0.29 | 0.804 |
| Normal, n (%) | 71 (95.95%) | 15 (93.75%) | 0.550 | 45 (97.83%) | 32 (96.97%) | |
| RV dysfunction, n (%) | 3 (4.05%) | 1 (6.25%) | | 1 (2.17%) | 1 (3.03%) | 1.000 |
| Wall motion score, mean ± SD | 22.81 ± 6.79 | 23.93 ± 7.2 | 0.554 | 20.91 ± 6.47 | 24.06 ± 7.71 | 0.032 |

*LVD=left ventricular dysfunction; LVEF=left ventricular ejection fraction; LVEDD=left ventricular end-diastolic diameter; LVESD=left ventricular end-systolic diameter; RV=right ventricular; RVFAC=right ventricular fractional area change; TAPSE=tricuspid annular place systolic excursion.*

6 months. There was no significant difference noted between the baseline echocardiographic parameters during admission. Left ventricular end-systolic diameter and wall motion score were significantly higher in those patients with 6-month MACE. However, the subjective measurement of wall motion abnormality is a major limitation in assessing contractility. Different advances in tissue Doppler and 2D speckle tracking strain and strain rate analyses are used to have more precise and reproducible measures of myocardial contractility.

Left ventricular EF by the Simpson method showed no significant difference between the two groups both during admission and after 6 months of follow-up. This was also in concordance with the study done by Scharrenbroich et al[8] in 2018, which showed that LV parameters (LVEF, end-diastolic volume, and end-systolic volume) did not show any alterations in patients having a cardiac event after acute myocardial infarction.

In our study, different speckle strain parameters were evaluated to predict outcomes post–NSTE-ACS. Left ventricular GLS strain was significantly different with respect to occurrence of MACEs after 6 months. Similar results were observed by Ersbøll et al[15] and Scharrenbroich et al[8]; however, their study population also included STE-ACS patients with preserved EF. Additional prognostic information was given by the LV GLS strain rate that is also significantly lower in patients with MACE after 6 months.

Cutoff value of –15.0% for the LV GLS in predicting 6-month outcome is somehow near the GLS cutoff value of –15.5% in the study by Keddeas and colleagues[4] in predicting patients with total occlusion after NSTEMI. As compared with the study by Cakmak et al,[16] where baseline GLS less than –12.9% predicted the development of adverse events 6 months after STEMI with 75% sensitivity and 70% specificity, this study's GLS sensitivity of 64.64% and specificity of 61.70% were lower in detecting 6-month post–NSTE-ACS outcomes. Furthermore, this study showed similar results of no statistically significant difference between those with and without MACE in terms of LV GCS.

Through the years, measurement of global systolic function is important in risk stratification and management of all patients with cardiovascular disease. Although the normal range of LVEF is greater than 53%, the most prognostic value is present when EF is less than 40%. Global longitudinal strain improves detection of global systolic function beyond LVEF. Reduced GLS at a cutoff value less than –12% to 16% can detect severe LV dysfunction, usually with LVEF of less than 35%.[12]

**Table 4.** Two-Dimensional Speckle Tracking Strain Parameters With and Without MACE During In-Hospital and After 6 Months of NSTE-ACS

| | In-Hospital Outcome | | | After 6 mo | | |
|---|---|---|---|---|---|---|
| | Without Outcome | With Outcome | *P* | Without Outcome | With Outcome | *P* |
| LV strain | | | | | | |
| Global longitudinal strain, mean ± SD, % | −15.26 ± 4.45 | −13.89 ± 4.93 | 0.275 | −16.44 ± 4.19 | −14.22 ± 4.45 | 0.026 |
| Supranormal, n (%) | 6 (8.0) | 0 (0.0) | | 3 (6.38) | 3 (9.09) | |
| Normal, n (%) | 15 (20.00) | 4 (25.00) | 0.886 | 14 (28.79) | 4 (12.12) | 0.154 |
| Borderline, n (%) | 12 (16.00) | 2 (12.50) | | 9 (19.15) | 4 (12.12) | |
| Reduced, n (%) | 42 (56.00) | 10 (62.50) | | 21 (44.68) | 22 (66.67) | |
| Global longitudinal systolic strain rate, mean ± SD, $s^{-1}$ | −0.82 ± 0.32 | −0.81 ± 0.29 | 0.884 | −0.94 ± 0.25 | −0.69 ± 0.36 | 0.009 |
| Normal, n (%) | 15 (20.55) | 4 (26.67) | 0.731 | 16 (34.78) | 3 (9.38) | 0.015 |
| Reduced, n (%) | 58 (79.45) | 11 (73.33) | | 30 (65.22) | 29 (90.63) | |
| Global circumferential strain, mean ± SD), % | −22.97 ± 7.68 | −22.6 ± 6.82 | 0.869 | −24.82 ± 6.87 | −21.45 ± 7.36 | 0.061 |
| Normal, n (%) | 41 (56.94) | 8 (57.14) | 1.000 | 30 (66.67) | 17 (54.84) | 0.342 |
| Reduced, n (%) | 31 (43.06) | 6 (42.86) | | 15 (33.33) | 14 (45.16) | |
| Global circumferential systolic strain rate mean ± SD, $s^{-1}$ | −1.30 ± 0.56 | −1.27 ± 0.50 | 0.874 | −1.34 ± 0.56 | −1.29 ± 0.58 | 0.755 |
| Normal, n (%) | 58 (81.69) | 8 (61.54) | 0.140 | 38 (84.44) | 21 (70.00) | 0.159 |
| Reduced, n (%) | 13 (18.31) | 5 (38.46) | | 7 (15.56) | 9 (30.00) | |
| RV strain | | | | | | |
| RV global Longitudinal strain, mean ± SD | −18.62 ± 5.73 | −20.61 ± 6.27 | 0.231 | −20.08 ± 5.8 | −18.36 ± 6.05 | 0.207 |
| Normal, n (%) | 29 (38.67) | 6 (40.00) | 1.000 | 23 (48.94) | 11 (34.38) | 0.250 |
| Reduced, n (%) | 46 (61.33) | 9 (60.00) | | 24 (51.06) | 21 (65.63) | |

*P < 0.05 is considered to be significant.*
*LV=left ventricular; RV=right ventricular.*

In this study, GLS strain at a cutoff value of less than −12% had 39.39% sensitivity and 82.98% specificity, with positive likelihood ratio of 2.3 of predicting MACE 6 months after myocardial infarction.

The prognostic value of LV global longitudinal strain was reported in different studies of acute myocardial infarction, which were mostly among STE-ACS patients. Keddeas et al,[4] in 2017, used peak GLS as noninvasive predictor for acute coronary artery occlusion in patients with NSTE myocardial infarction who may benefit from early revascularization. This study is the first local published report on the use of 2D STE as predictors of MACE among NSTE-ACS patients. This study showed the prognostic value of LV GLS strain and strain rate in detecting outcomes among this subset of patients.

Right ventricular global longitudinal strain was also included in the parameters since in the study done by Lorenzana et al[17] in 2020, RV function 2D STE is impaired among STE-ACS patients even after primary PCI, and RV GLS RV $GLS_{total}$ and RV $GLS_{free\_wall}$ are reduced among patients with in-hospital clinical outcomes. Similar to that study, no association between the RV GLS and their clinical outcomes, but higher incidence of patients with reduced RV GLS, was observed among those patients with outcome after 6 months as compared with those without MACE.

## CONCLUSION

Left ventricular global longitudinal strain and strain rate can predict MACEs in patients who had NSTE-ACS. Patients with increased wall motion score and baseline detected LV GLS of

**Table 5.** Sensitivity, Specificity, and Likelihood Ratio of 2D Speckle Tracking Echocardiography in Predicting Cardiovascular Outcomes

| Parameter | Cutoff Point | Sensitivity, % | Specificity, % | LR+ | LR− | Accuracy, % |
|---|---|---|---|---|---|---|
| LV GLS (%) | | | | | | |
| In-hospital | –14.9 | 56.25 | 50.67 | 1.14 | 0.863 | 51.65 |
| 6 mo | –15.0 | 64.64 | 61.70 | 1.66 | 0.58 | 62.50 |
| LV GLS rate, $s^{-1}$ | | | | | | |
| In-hospital | –0.75 | 57.53 | 54.55 | 0.942 | 1.043 | 54.55 |
| 6 mo | –0.83 | 59.38 | 65.22 | 1.707 | 0.623 | 62.82 |
| LV GCS, % | | | | | | |
| In-hospital | –23.1 | 45.83 | 46.51 | 0.923 | 1.091 | 46.51 |
| 6 mo | –23.0 | 58.06 | 57.78 | 1.375 | 0.726 | 57.89 |
| LV GCS rate, $s^{-1}$ | | | | | | |
| In-hospital | –1.2 | 42.25 | 44.05 | 0.933 | 1.092 | 44.05 |
| 6 mo | –1.1 | 46.34 | 65.12 | 1.329 | 0.824 | 55.95 |
| RV GLS, % | | | | | | |
| In-hospital | –19.3 | 44.0 | 44.56 | 0.952 | 1.061 | 45.56 |
| 6 mo | –19.6 | 56.25 | 51.06 | 1.150 | 0.857 | 53.16 |

*GCS=global circumferential strain; GLS=global longitudinal strain; LV=left ventricular; RV=right ventricular.*

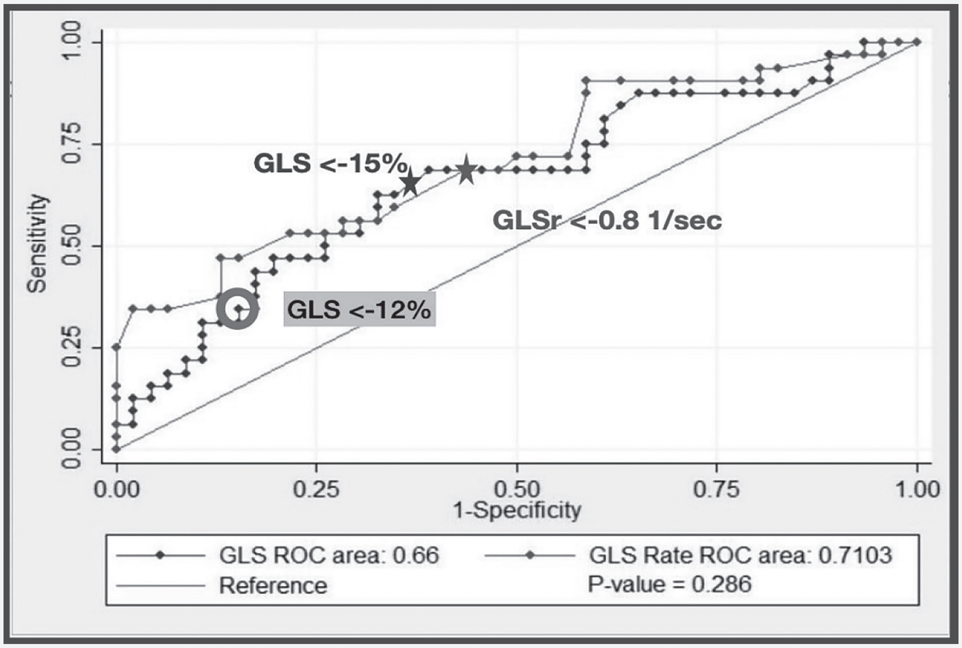


**Figure 3.** Graph showing the ROC curve of LV global longitudinal strain and strain rate of patients with MACE after 6 months of NSTE-ACS

less than –15% and strain rate of less than –0.8 $s^{-1}$ have poorer outcomes 6 months after myocardial infarction.

Two-dimensional STE can be included in our routine echocardiography during acute myocardial infarction, which may give additional information to guide early invasive management and determine prognosis of patients with NSTE-ACS.

## LIMITATIONS OF THE STUDY AND RECOMMENDATIONS

This study has relatively small number of patients enrolled. Multicenter and multivendor studies with a larger population are encouraged with longer follow-up periods to assess more the prognostic value of 2D STE among patients with NSTE-ACS. Also, association with the 2D strain parameters and their angiographic findings was not done in this study because of the small number of patients who had invasive strategy. Association of 2D speckle strain parameters and coronary artery occlusions in this subset of patients may give additional insights for further managements. Other confounding factors such as compliance to medications and follow-up to their physician should also be considered, which can also lead to MACE along the 6-month observation.

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