*Original Research Article*

# Speckle tracking as predictor of coronary artery disease in diabetic female with acute chest pain


**Abstract**

**Background:** Cardiovascular disease is the most common reason of mortality and morbidity all-over the world and is the major complication of diabetes. Diabetes mellitus (DM) has reached epidemic proportions worldwide and the consequences of its diagnosis are as severe as a diagnosis of coronary artery disease (CAD). Females are more likely to develop atypical symptoms of coronary CAD than males later in life. Imaging of deformation by two-dimensional speckle-tracking echocardiography (2DSTE) has developed as a highly effective method for quantification of the function of myocardium. **make it one paragraph and also take out subtitles**

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This research aimed to evaluate the accuracy of diagnosis using speckle tracking for prediction of the existence or absence of severe CAD in diabetic female with acute chest pain by using two dimensional echocardiography.

**Methods:** This study is a cohort prospective research which was carried out at the department of cardiology, Tanta University Hospitals and National Heart Institute from the duration of October 2019 to September 2020 on 60 diabetic female patients above 18 years old with acute chest pain may be prolonged for > 20 minutes or transient, changes in ECG in the form of depression of ST segment and/or inversion of T wave (ECG may be normal) and cardiac biomarkers (troponin and CKMB) may be elevated or normal.

**Results:** 2D speckle tracking was good predictor for multi-vessels disease with 95% total accuracy, then for single vessels disease with 85% total accuracy and finally for double vessel disease stenosis with 80% accuracy as shown in table. Among Non-STEMI group, 2D

speckle tracking was good predictor for multi-vessels disease with 95% total accuracy, then for single vessels disease with 80% total accuracy and finally for double vessel disease stenosis with 75% accuracy as shown in table.

**Conclusions:** We found that speckle tracking is effective in predicting presence of CAD in diabetic female patients had acute chest pain and in prediction of affected vessels depending on the distribution of affected segments in longitudinal strain by GLS. In addition, it can be used as non-invasive test for patients with acute coronary syndrome.

**Keywords**: Diabetes mellitus, Coronary artery disease, Speckle tracking, , Acute chest pain

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## Introduction

Cardiovascular disease is the first reason of mortality and morbidity all-over the world, comprising 31% of all deaths. Coronary artery disease (CAD) is defined by atherosclerosis in the epicardial coronary arteries. The reduction in the flow of coronary may be asymptomatic or symptomatic, happens with exertion or at rest, and result in angina or myocardial infarction (MI) , based on the severity of obstruction and the development rapidity [(1)]. **Try to includes clear statement of the problem, objectives, and hypothesis/research questions**

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The principle complication of diabetes is cardiovascular disease, representing 50% of all mortality of diabetes. This is not only because of CAD and associated hypertension, but also because of diabetes's direct adverse effect on the heart, regardless of other cardiovascular risk factors, a condition known as diabetic cardiomyopathy [(2)].

Diabetes mellitus (DM) has reached epidemic proportions worldwide, and its prevalence is increasing. The diagnosis of DM is just as serious as the diagnosis of CAD.

Cardiovascular mortality in all age groups and for both sexes increases equivalently with a history of MI or DM and both are profoundly synergistic [2].

Despite the increasing use of provocative testing and imaging, non-invasive diagnosis of patients with CAD still a clinical challenge; more than half of patients referred for coronary angiography currently have non-obstructive coronary artery disease (CAD) [3].

Over the last years, imaging of deformation by two-dimensional speckle-tracking echocardiography (2DSTE) has developed as a highly effective method for quantification of the function of myocardium. Supporting evidence of the role of 2DSTE-derived strain in daily clinical practice has gathered rapidly in a variety of clinical settings. Additionally, attempts to establish reference values for 2D strain parameters have risen, allowing for the construction of rigorous abnormality criteria and their incorporation into recent guidelines [4].

Women are more exposed than men to acquire atypical CAD symptoms later in life. Additionally, they have a higher mortality and morbidity rate when CAD occurs, including sudden death and MI . Women also have a distinct atherosclerotic profile than men, with microvascular disease predominating in the absence of significant obstructive CAD on imaging [5].

The aim of this research to evaluate the accuracy of diagnosis using speckle tracking to detect the existence or absence of significant CAD in diabetic female with acute chest pain by using two-dimensional echocardiography.

## Patients and Methods

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This study is a cohort prospective research which was conducted at cardiology department, Tanta University Hospitals and National Heart Institute from the duration of October 2019 to September 2020 on 60 diabetic female patients above 18 years old with acute chest pain may be prolonged for > 20 minutes or transient, changes in ECG in the form

of depression of ST segment and/or inversion of T wave (ECG may be normal) and cardiac biomarkers (troponin and CKMB) may be elevated or normal.

Patients with poor echocardiographic window, any rhythm other than sinus rhythm severe valvular lesions except functional mitral incompetence, atrial fibrillation, previous CABG or PCI, bundle branch block and previous MI were excluded.

Written informed consent was obtained from all participants. The trial was approved by ethics committee of faculty of medicine Tanta University.

All patients underwent routine history and physical examination, electrocardiogram , laboratory work-up, transthoracic echocardiography, conventional echocardiography.

**Speckle Tracking Echocardiography (STE):**

**Image acquisition:**

Longitudinal strain imaging was performed using 2DSTE with ECG gated images of high quality from the apical four-chamber, two-chamber and three-chamber views, all of these measurements were taken at very equal heart rates. Improvement of to the gain settings have been made. The depth was reduced to ensure that the LV took up the majority of the image sector. To avoid LV foreshortening, effort was taken to keep the gray-scale framerate between 50 and 90 frames/s and to ensure that each loop acquired a minimum of three cardiac cycles.

**Strain analysis:**

We analyzed the digitally stored clips offline using commercial imaging analysis software on a Philips “epic 7” machine. The operator manually identified three spots for each of the three apical views: two on either side of the mitral valve and one at the apex of the left ventricle. At the end of systole, the software detected the endocardium automatically, tracking myocardial motion throughout the cardiac cycle, and forming inverted U-shaped zones of interest that included the apical, middle and basal regions of two opposing LV walls. The operator evaluated the quality of tracking, which was then scored by the software. If the operator determines that the tracking was insufficient, the operator may repeat the imaging by changing the endocardial tracing or adjusting software settings such as the region of interest's width and smoothing until a better score is obtained. Segments that were not effectively

tracked were excluded from the study automatically. In the apical long-axis perspective, systole duration was defined as the time interval between the ECG's peak R and the first frame in which the aortic valve closed.

The software automatically determined the peak longitudinal strain in each segment of a 17-segment LV model, which is expressed as bull's eye. For each major coronary artery (left circumflex artery (LCX), right coronary artery (RCA), and left anterior descending artery (LAD)) the territorial longitudinal strain (TLS) was defined as the average peak systolic longitudinal strain in segments inside the theoretical perfusion area of the artery.

We utilized a standardized model of myocardial perfusion territories to calculate the following variables in each of the perfusion territories supplied by LAD, LCX, and RCA. Each of the 3 perfusion territories was then named culprit or non-culprit depending on the results of coronary angiography. We utilized the standardized 17 segment model of myocardial perfusion territories recommended by the American Heart Association adapted from assigning one coronary artery for each segment to be able to perform the statistical analysis, for identification of significant coronary stenosis, the lowest absolute territorial strain value for each patient was used as a marker, then the results of bull's eye strain analyses were correlated with the results of coronary angiography.

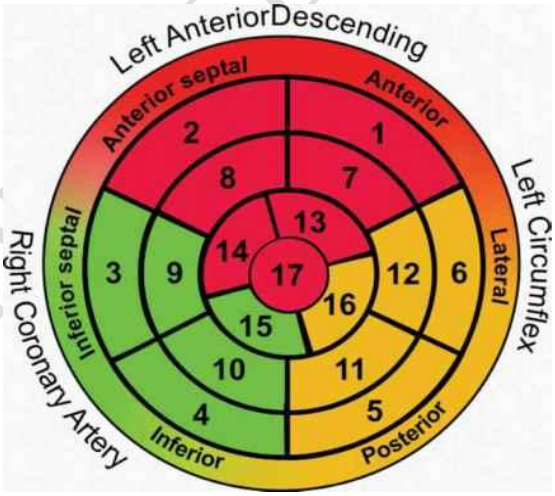


**Figure 1: Assignment of the 17 myocardial segments to the territories of the left anterior descending (LAD), right coronary artery (RCA), and the left circumflex coronary artery (LCX) [6]**

**V-Coronary angiography and revascularization**

By using the standard (Judkins) approach, coronary angiography was conducted, including the acquisition and preservation of digital images. All analyses were conducted offline using a single experienced invasive cardiologist who was unaware of the outcome of the other imaging trials. The infected vessel was identified as the culprit in cases with single vessel illness. CAD was visually assessed in each individual stenosis using several projections to avoid overlapping side branches and foreshortening severe coronary stenoses. Coronary occlusion was known as a TIMI (Thrombolysis in Myocardial Infarction) flow grade of 0 or 1, whereas severe coronary artery stenosis was defined as a vascular diameter decrease of more than 70% in peripheral arteries or more than 50% in the left main artery.

**Statistical analysis**

SPSS v27 (IBM, Chicago, IL, USA) was used to conduct statistical analysis. The Shapiro-Wilks test and histograms were used to determine the distribution of the data. The ANOVA (F) test and a post hoc test (Tukey) were used to determine the mean and standard deviation (SD) of quantitative parametric data.. The Chi-square test was used to examine qualitative variables that were represented in terms of frequency and percentage (percent). Correlations were found using the linear correlation coefficient between two quantitative variables (r). ROC curve analysis was used to evaluate the diagnostic performance of each test. When two tailed tests were used, a P value of 0.05 was considered statistically significant..

## Results

Demographic data and risk factors for studied groups were shown in **(Table 1)**

**Table 1: Sociodemographic data and risk factors among studied groups**

| Demographic data | Unstable angina (n=20) | Non STEMI group (n=20) | Control group (n=20) | Test of significance | | |
|---|---|---|---|---|---|---|
| | | | | P1 | P2 | P3 |
| **Age (years)**<br>Mean ± SD | 50.25±8.34 | 51.00±7.61 | 54.65±8.39 | t=1.66<br>p=0.105 | t=1.44<br>p=0.158 | t=0.297<br>p=0.768 |
| **Smoking**<br>Yes<br>No | 3 (15.0%)<br>17 (85.0%) | 2 (10.0%)<br>18 (90.0%) | 4 (20.0%)<br>16 (80.0%) | FET<br>P=1.0 | FET<br>P=0.661 | FET<br>P=1.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **HTN**<br>Yes<br>No | <br>10 (50.0%)<br>10 (50.0%) | <br>11 (55.0%)<br>9 (45.0%) | <br>11 (55.0%)<br>9 (45.0%) | $\chi^2$=0.1<br>P=0.752 | $\chi^2$=0<br>P=1.0 | $\chi^2$=0.1<br>P=0.752 |
| **Dyslipidemia**<br>Yes<br>No | <br>12 (60.0%)<br>8 (40.0%) | <br>10 (50.0%)<br>10 (50.0%) | <br>11 (55.0%)<br>9 (45.0%) | $\chi^2$=0.102<br>P=0.749 | $\chi^2$=0.10<br>P=0.752 | $\chi^2$=0.404<br>P=0.525 |
| **Hx of ACS**<br>Yes<br>No | <br>11 (55.0%)<br>9 (45.0%) | <br>10 (50.0%)<br>10 (50.0%) | <br>6 (30.0%)<br>14 (70.0%) | $\chi^2$=2.56<br>P=0.11 | $\chi^2$=1.67<br>P=0.197 | $\chi^2$=0.1<br>P=0.752 |
| **BMI**<br>Mean ± SD | 33.10±4.50 | 32.24±4.56 | 27.97±4.63 | t=3.55<br>p=**0.001*** | t=2.93<br>p=**0.006*** | t=0.604<br>p=0.549 |

t: student t- test, $\chi^{2:}$ Chi square test, FET: Fischer exact test, P1: Comparison between Unstable angina and control groups, P2: Comparison between Non-STEMI and control groups, P3: Comparison between Unstable angina and non-STEMI groups

Regarding LV strain data by 2D speckle tracking Echo, **the septal wall** was significantly affected in non-STEMI group at basal segment-12.38±5.04 as compared to -16.13±4.11 in control group. Mid segment was statistically affected in non-STEMI group -14.40±3.80 as compared to -16.85±3.00, -18.40±3.56 in unstable angina and control groups respectively. Apical segment was lower in non-STEMI and unstable angina -19.75±9.03, -22.40±7.51 as compared to -30.65±12.2 in control group. Cumulative strain was statistically affected in non-STEMI group -16.07±3.93 as compared to -18.35±2.94, -19.94±3.41in unstable angina and control groups respectively. **The lateral wall** was significantly affected in non-STEMI group at apical segment -17.95±6.78 as compared to -22.40±6.92 in unstable angina group. **The anterior wall** was significantly affected in non-STEMI group at basal segment -15.70±6.83 as compared to -22.88±9.78 in control group. **The inferior wall** was significantly affected in unstable angina group at mid segment -17.54±4.77 as compared to -20.72±4.06 in control group while apical segment was lower in unstable angina (-20.73±8.02) and non-STEMI group (-21.35±7.47) as compared to -29.98±11.7 in control group. Cumulative strain was statistically affected in unstable angina (-18.36±4.57) and non-STEMI group -18.83±4.48) as compared to -21.57±3.87 in control group. **The Anteroseptal wall** was significantly affected in non-STEMI group at mid segment -14.40±3.89 as compared to -19.92±4.80, -18.02±4.24 in unstable angina and control groups respectively. Apical segment was affected in non-STEMI group -14.65±5.17as compared to -19.44±4.19, -19.22±4.92 in unstable angina and control groups. Cumulative strain was statistically affected in in non-STEMI group -14.11±3.68 as compared to -18.13±3.47, -18.05±3.05 in unstable angina and control groups respectively. Finally, **the global longitudinal strain** of the LV was

significantly affected in non-STEMI group -15.81±1.92 and unstable angina group -16.86±0.99 as compared to -18.17±0.79 in control group p value ≤ 0.05 (**Table 2**)

**Table 2: Speckle tracking Echo (LV strain) among studied groups**

| Speckle tracking ECHO | Unstable angina (n=20) | Non-STEMI group (n=20) | Control group (n=20) | Test of significance | | |
|---|---|---|---|---|---|---|
| | | | | P1 | P2 | P3 |
| **Septal wall** | | | | | | |
| Basal | -14.05±5.30 | -12.38±5.04 | -16.13±4.11 | t=1.38 p=0.174 | t=2.57 **p=0.014*** | t=1.02 p=0.314 |
| Mid | -16.85±3.00 | -14.40±3.80 | -18.40±3.56 | t=1.49 p=0.145 | t=3.43 **p=0.001*** | t=2.26 **p=0.03*** |
| Apical | -22.40±7.51 | -19.75±9.03 | -30.65±12.2 | t=2.57 **p=0.014*** | t=3.20 **p=0.003*** | t=1.01 p=0.319 |
| Cum. | -18.35±2.94 | -16.07±3.93 | -19.94±3.41 | t=1.57 p=0.124 | t=3.33 **p=0.002*** | t=2.08 **p=0.044*** |
| **Lateral wall** | | | | | | |
| Basal | -16.68±4.81 | -18.00±5.02 | -16.35±3.95 | t=0.233 p=0.817 | t=1.15 p=0.257 | t=0.848 p=0.402 |
| Mid | -19.12±6.30 | -16.45±5.56 | -17.12±3.29 | t=1.26 p=0.216 | t=0.464 p=0.646 | t=1.42 p=0.163 |
| Apical | -22.40±6.92 | -17.95±6.78 | -18.62±5.34 | t=1.93 p=0.061 | t=0.350 p=0.729 | t=2.05 **p=0.047*** |
| Cum. | -17.34±3.28 | -17.47±5.21 | -19.22±5.18 | t=1.37 p=0.178 | t=0.095 p=0.925 | t=1.07 p=0.292 |
| **Anterior wall** | | | | | | |
| Basal | -18.43±5.78 | -15.70±6.83 | -22.88±9.78 | t=1.75 p=0.088 | t=2.69 **p=0.01*** | t=1.36 p=0.180 |
| Mid | -15.32±5.72 | -16.70±6.96 | -15.99±4.37 | t=0.419 p=0.677 | t=0.384 p=0.703 | t=0.685 p=0.498 |
| Apical | -17.96±5.49 | -19.55±6.59 | -17.23±6.15 | t=0.393 p=0.696 | t=1.15 p=0.258 | t=0.829 p=0.413 |
| Cum. | -17.38±3.67 | -17.32±6.17 | -18.72±4.46 | t=1.03 p=0.308 | t=0.043 p=0.966 | t=0.824 p=0.415 |
| **Inferior wall** | | | | | | |
| Basal | -15.08±5.94 | -16.85±5.94 | -17.08±6.10 | t=1.05 p=0.30 | t=0.121 p=0.905 | t=0.942 p=0.352 |
| Mid | -17.54±4.77 | -18.30±4.85 | -20.72±4.06 | t=2.26 **p=0.029*** | t=1.71 p=0.095 | t=0.496 p=0.622 |
| Apical | -20.73±8.02 | -21.35±7.47 | -29.98±11.7 | t=2.90 **p=0.006*** | t=2.77 **p=0.009*** | t=0.253 p=0.802 |
| Cum. | -18.36±4.57 | -18.83±4.48 | -21.57±3.87 | t=2.39 **p=0.022*** | t=2.07 **p=0.046*** | t=0.332 p=0.742 |
| **Posterior wall** | | | | | | |
| Basal | -14.95±7.52 | -13.62±8.26 | -16.22±5.67 | t=0.603 p=0.550 | t=1.16 p=0.253 | t=0.532 p=0.598 |
| Mid | -13.65±5.86 | -11.04±7.75 | -14.92±5.28 | t=0.717 p=0.478 | t=1.84 p=0.073 | t=1.20 p=0.237 |
| Apical | -13.65±3.99 | -11.72±8.52 | -15.82±5.23 | t=1.47 p=0.149 | t=1.83 p=0.075 | t=0.237 p=0.365 |
| Cum. | -14.19±5.05 | -12.13±7.04 | -15.65±4.12 | t=0.996 p=0.326 | t=1.93 p=0.061 | t=1.07 p=0.292 |

| Anteroseptal wall | | | | | | |
|---|---|---|---|---|---|---|
| Basal | -14.59±3.04 | -13.30±3.77 | -15.46±3.58 | t=0.832<br>p=0.410 | t=1.86<br>p=0.071 | t=1.19<br>p=0.241 |
| Mid | -19.92±4.80 | -14.40±3.89 | -18.02±4.24 | t=1.32<br>p=0.193 | t=2.81<br>**p=0.008*** | t=3.99<br>**p≤0.001*** |
| Apical | -19.44±4.19 | -14.65±5.17 | -19.22±4.92 | t=0.156<br>p=0.877 | t=2.86<br>**p=0.007*** | t=3.21<br>**p=0.003*** |
| Cum. | -18.13±3.47 | -14.11±3.68 | -18.05±3.05 | t=0.078<br>p=0.939 | t=3.68<br>**p=0.001*** | t=3.55<br>**p=0.001*** |
| **GLS** | -16.86±0.99 | -15.81±1.92 | -18.17±0.79 | t=4.58<br>**p≤0.001*** | t=5.06<br>**p≤0.001*** | t=2.18<br>**p=0.036*** |

GLS: global longitudinal strain

Regarding the vessel affected as suspected by 2DSTE, LAD was affected in 75% of unstable angina and 80% in non STEMI group as compared to 30% in control group with statistically significant difference. Two vessels and three vessels affection were higher in both unstable angina and non STEMI group 45%, 20% as compared to 15% and 0% in control group **(Table 3).**

**Table 3: Vessels affection as suspected by speckle tracking**

| **Coronary ECHO** | **Unstable angina (n=20)** | **Non stemi group (n=20)** | **Control group (n=20)** | **Test of significance** | | |
|---|---|---|---|---|---|---|
| | | | | **P1** | **P2** | **P3** |
| **LAD** | 15 (75.0%) | 16 (80.0%) | 6 (30.0%) | $\chi^2$=8.12<br>P=0.004* | $\chi^2$=10.1<br>P≤0.001* | FET<br>P=1.0 |
| **LCX** | 6 (30.0%) | 8 (40.0%) | 3 (15.0%) | FET<br>P=0.451 | $\chi^2$=3.13<br>P=0.077 | $\chi^2$=0.44<br>P=0.741 |
| **RCA** | 12 (60.0%) | 12 (60.0%) | 9 (45.0%) | $\chi^2$=0.902<br>P=0.342 | $\chi^2$=0.902<br>P=0.342 | $\chi^2$=0<br>P=1 |
| **No. of vessels**<br>No<br>One<br>Two<br>Three | <br>0 (0%)<br>9 (45.0%)<br>9 (45.0%)<br>2 (20.0%) | <br>0 (0%)<br>7 (35.0%)<br>9 (45.0%)<br>4 (20.0%) | <br>5 (25.0%)<br>12 (60.0%)<br>3 (15.0%)<br>0 (0.0%) | <br>MC<br>P=0.007* | <br>MC<br>P=0.002* | <br>MC<br>P=0.467 |

Regarding the 2DSTE validity in detection of stenosis of LAD in unstable angina group, it was good predictor for stenosis of LAD with 75% specificity and 87.5% sensitivity, 93.3% PPV, 60% NPV and 85% accuracy. Among Non STEMI group, 2DSTE was good predictor for stenosis of LAD with 100% specificity and 88.9% sensitivity, 100% PPV, 50% NPV and 90% accuracy Regarding 2DSTE validity in identification of LCX stenosis in

unstable angina group, it was good predictor for LCX stenosis with 100% specificity and 75% sensitivity, 100% PPV, 85.7% NPV and 90% accuracy. Among Non-STEMI group, 2D speckle tracking was good predictor for LCX stenosis with 100% specificity and 72.7% sensitivity, 100% PPV, 75% NPV and 85% accuracy (**Table 4**).

Concerning 2DSTE validity of in evaluation of stenosis of RCA in unstable angina group, it was good predictor for stenosis of RCA with 100% specificity and 85.7% sensitivity, 100% PPV, 75% NPV and 90% accuracy. Among non-STEMI group, 2D speckle tracking was good predictor for stenosis of RCA with 100% specificity and 85.7% sensitivity, 100% PPV, 75% NPV and 90% accuracy (**Table 4**).

Concerning 2DSTE validity in detection of LCX stenosis in unstable angina group, it was good predictor for LCX stenosis with 100% specificity and 75% sensitivity, 100% PPV, 85.7% NPV and 90% accuracy. Among Non STEMI group, 2DSTE was good predictor for LCX stenosis with 100% specificity and 72.7% sensitivity, 100% PPV, 75% NPV and 85% accuracy (**Table 4**).

Concerning 2DSTE validity in detection of stenosis of RCA in unstable angina group, it was good predictor for RCA stenosis with 100% specificity and 85.7% sensitivity, 100% PPV, 75% NPV and 90% accuracy. Among Non STEMI group, 2DSTE was good predictor for RCA stenosis with 100% specificity and 85.7% sensitivity, 100% PPV, 75% NPV and 90% accuracy (**Table 4**).

**Table 4: Validity of speckle tracking in detection of LAD, LCX and RCA compared to coronary angiography**

| **Speckle tracking (LAD)** | **Unstable angina** | | | **Non-STEMI** | | |
|---|---|---|---|---|---|---|
| | **Coronary angiography** | | **Total** | **Coronary angiography** | | **Total** |
| | **Positive** | **Negative** | | **Positive** | **Negative** | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Positive** | 14 | 1 | 15 | 16 | 0 | 16 |
| **Negative** | 2 | 3 | 5 | 2 | 2 | 4 |
| **Total** | 16 | 4 | 20 | 18 | 2 | 20 |
| **Validity tests** | | | | | | |
| **Sensitivity** | 87.5% | | | 88.9% | | |
| **Specificity** | 75% | | | 100% | | |
| **PPV** | 93.3% | | | 100% | | |
| **NPV** | 60% | | | 50% | | |
| **Accuracy** | 85% | | | 90% | | |
| **Speckle tracking (LCX)** | | | | | | |
| | **Coronary angiography** | | **Total** | **Coronary angiography** | | **Total** |
| **Positive** | 6 | 0 | 6 | 8 | 0 | 8 |
| **Negative** | 2 | 12 | 14 | 3 | 9 | 12 |
| **Total** | 8 | 12 | 20 | 11 | 9 | 20 |
| **Validity tests** | | | | | | |
| **Sensitivity** | 75% | | | 72.7% | | |
| **Specificity** | 100% | | | 100% | | |
| **PPV** | 100% | | | 100% | | |
| **NPV** | 85.7% | | | 75% | | |
| **Accuracy** | 90% | | | 85% | | |
| **Speckle tracking (RCA)** | | | | | | |
| | **Coronary angiography** | | **Total** | **Coronary angiography** | | **Total** |
| **Positive** | 12 | 0 | 12 | 12 | 0 | 12 |
| **Negative** | 2 | 6 | 8 | 2 | 6 | 8 |
| **Total** | 14 | 6 | 20 | 14 | 6 | 20 |
| **Validity tests** | | | | | | |
| **Sensitivity** | 85.7% | | | 85.7% | | |
| **Specificity** | 100% | | | 100% | | |
| **PPV** | 100% | | | 100% | | |
| **NPV** | 75% | | | 75% | | |
| **Accuracy** | 90% | | | 90% | | |

**PPV: positive predictive value, NPV: Negative predictive value**

Concerning the validity of 2DSTE in identification of number of coronary arteries with stenosis in unstable angina group as compared to coronary angiography, it was good predictor for multivessels disease with 95% total accuracy, then for single vessels disease with 85% total accuracy and finally for double vessel disease stenosis with 80% accuracy as shown in table.

Among non-STEMI group, 2D speckle tracking was good predictor for multivessels disease with 95% total accuracy, then for single vessels disease with 80% total accuracy and finally for double vessel disease stenosis with 75% accuracy as shown in table **(Table 5)**.

**Table 5: Validity of speckle tracking in detection of number of stenosis vessels compared to coronary angiography**

| Speckle tracking (No of vessels) | Unstable angina | | | Non STEMI | | |
|---|---|---|---|---|---|---|
| | Coronary angiography | | | Coronary angiography | | |
| | Single | Double | Three | Single | Double | Three |
| **Single** | 6 | 3 | 0 | 3 | 4 | 0 |
| **Double** | 0 | 8 | 1 | 0 | 8 | 1 |
| **Three** | 0 | 0 | 2 | 0 | 0 | 4 |
| **Validity tests** | | | | | | |
| **Sensitivity** | 100% | 72.7% | 66.7% | 100% | 66.7% | 80% |
| **Specificity** | 78.6% | 88.9% | 100% | 76.5% | 87.5% | 100% |
| **PPV** | 66.7% | 88.9% | 100% | 42.8% | 88.9% | 100% |
| **NPV** | 100% | 72.7% | 94.4% | 100% | 63.6% | 93.7% |
| **Accuracy** | 85% | 80% | 95% | 80% | 75% | 95% |

**PPV: positive predictive value, NPV: Negative predictive value**

The best cut-off value considering GLS in in prediction of unstable angina severity was -16.69with 85% sensitivity and 70% specificity, 73.9% PPV, 82.3% NPV and 77.5% accuracy **Figure 2**. The best cut-off value considering GLS in in evaluation of severity of Non STEMI was -15.7 with 90% sensitivity and 70% specificity, 75% PPV, 87.5% NPV and 80% accuracy **Figure 3**.

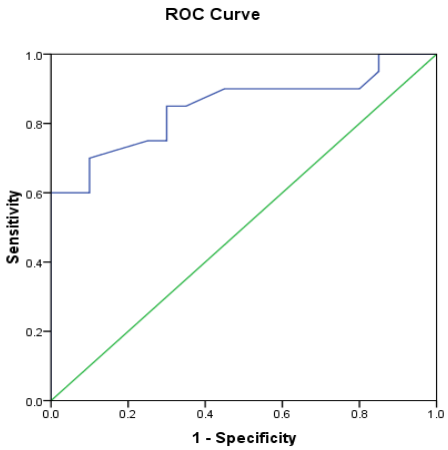


**Figure 2: ROC curve for prediction of unstable angina by GLS**

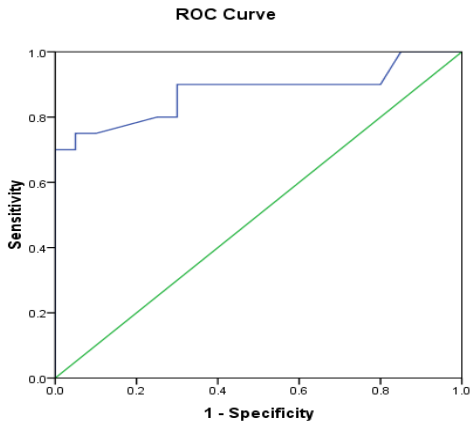


**Figure 3: ROC curve for prediction of Non-STEMI by GLS**



## Discussion

**Demographic data and risk factors:**

Mean age in unstable angina group was 50.25±8.34 as compared to 54.65±8.39 in control group and 51.00±7.61 in non-STEMI with no statistically significant difference p value >0.05.

Smokers represent (15 %, 10%, 20%), HTN (50%, 55%, 50%), dyslipidemia presented in (60%, 50% 55%) and history of ACS (55%, 50%, 30%) in unstable angina, non-STEMI and control groups, respectively with no statistically significant difference.

Mean BMI was statistically significantly higher in unstable angina and non-STEMI groups 33.10±4.50, 32.24±4.56 as compared to 27.97±4.63 in control group

In **concordance** to our results ***Liszka et al.,*** founded that there is no significant correlation between the studied population as regarding demographic data, hypertension, smoking and dyslipidemias. [7]

In **contrary** to our results, Conte et al., [8] who assessed the degree of dysfunction of longitudinal fibers using STE in obese and diabetic cases and reported decrease in GLS in those cases.

Also, ***Rostamzadeh et al.,*** reported that of conventional risk factors, hypertension (67%) and DM (55%) were more common in the studied population. There was a trend toward the ACS group to have more patients with dyslipidemia when compared with the normal and low-risk groups ($P$=0.063) [9]**.**

**Conventional Echo parameters:**

Our study showed that the mean LVESD was 3.41±0.51, 3.43±0.47, mean LVEDD was 5.06±0.62, 5.00±0.64, mean LVEF was 60.47±4.71, 59.00±4.23, mean PWD was 1.11±0.13, 1.13±0.12, mean IVS was 0.99±0.15, 1.02±0.17 in unstable angina and non-STEMI groups.

***Şahin et al*** indicated a significant difference in EF percent between the study population with preserved coronary flow and the study group with impaired coronary flow in 880 consecutive patients receiving coronary intervention. [10].

In a trial by *Liszka et al*, they informed that the baseline examination revealed significantly larger LVEDD and lower LVEF in ACS group (high risk group) compared to stable angina group (low risk group).[7]

**2D Speckle tracking parameters:**

A statistically significant correlation between presence of obstructive CAD and decreased values of the GLS by coronary angiography with a cutoff value of -16.69, -15.7 in unstable angina and non-STEMI group lower than those non-diabetics, it could be explained by the prevalence of diabetes in 100% of the population of our study and the fact that diabetes is an independent risk factor for decreased LV GLS. Due to the presence of DM, the strain's projected cut-off point would be thrown off. That is why, in the current investigation, GLS was compared at rest in two identical groups with no statistically significant difference in DM prevalence or duration.

H.ZUO et al. [8] previously discovered that CAD patients with DM had significantly lower global and segmental longitudinal strains than patients without DM, as well as a decreased specificity and sensitivity across the study, but particularly in those with DM (sensitivity and specificity (61.1 percent and 52.9 percent, respectively) with a cutoff point of GLS at rest of 17.15 percent vs. 18.35 percent in patients without DM. GLS at rest had an AUC of 0.67 and a P value of 0.048 in patients with diabetes mellitus. Later that year, H.ZUO et al. revealed that the cutoff for serious CAD in non-DM patients was 19.05 percent (higher than previously) with a higher accuracy in diagnosis.

In agreement with our findings, J. Schroeder et al. reported that cutoff values of LVGLS>-18:8 percent had a high sensitivity and specificity (86 and 73%, respectively) for evaluating patients with chest pain and inconclusive electrocardiographic (ECG) and blood test results for significant coronary stenosis [11].

In concordance to our results, Maria **Concetta Pastore et al** showed that ability of LVGLS to detect CAD, showing satisfactory results for this noninvasive marker. The mean values of LVGLS for those with and without CAD were -16.5% [95% confidence interval (CI): -15.8% to -17.3%] and -19.7% [95% CI: -18.8%and-20.7%]. Moreover, abnormal LVGLS detected moderate-to-severe CAD with a pooled 74.4% sensitivity, 72.1% specificity [12].

***Madhavan et al***., stated that in female patients with effort angina, GLS by 2DSTE strongly correlates with severity of CAD angiography and can evaluate substantial coronary lesions with a sensitivity of 94% and specificity of 76%. Thus, GLS by 2DSTE can be utilised as a noninvasive screening test for substantial coronary artery stenosis and can be used in conjunction with TMT for risk stratification and patient selection for coronary angiography. ***[13]*****.**

This finding was in line with ***Deep Chandh et al*** hypothesis who reported that longitudinal myocardial deformation is of a good predictive value for diagnosis of obstructive CAD [14].

***Radwan and Hussein*** ***[15]*** also informed that measurements of GLS by 2DSTE is an sensitive & specific technique for evaluation of severity and presence of obstructive CAD in diabetic patients.

***Moustafa et al.*** [16] and ***Hubbard et al.*** [17] also reports that cases with normal LV function on 2D echocardiography at rest but significant CAD angiographically could be identified by of lower GLS values in STE.

*Also,* ***Farokhnejad's et al.*** [18] opinions were favourable to our findings about the role of STE-derived deformation parameters in diagnosing coronary artery stenosis in diabetic individuals with chronic stable angina. .

Also, in **agreement** with us ***Huang et al.*** [19] informed that GLS changes of LV aid in early diagnosis coronary atherosclerotic disease in high-risk patients .

Additionally, we discovered a positive connection between global longitudinal strain of the LV as determined by speckle tracking and HBA1C with a p value of 0.042.

Findings of ***Rostamzadeh et al.,*** *concurred* with our findings and indicated that left ventricle GLS had a significant correlation with CAD severity [9] .

This was also described by **Motgomery,** ***et al*** who correlated values of AGS with coronary angiography and discovered that they can help in identification of patients with normal coronary arteries [20].

**Radwan and Hussein, et al** disagreed with our findings and reported that global strain is not a good negative test to exclude existence of obstructive CAD [15]**.**

We found that LV longitudinal strain showed a high specificity and sensitivity for the single vessel CAD diagnosis (100% and 86%, respectively) in unstable angina group and (100%,76.5%, respectively) in non-STEMI group two vessels disease (72.7%, and 88.9%, respectively) in unstable angina group and (66.7% and 87.5%, respectively in non-STEMI group. For three vessels CAD (66.7%, and 100%, respectively) in unstable angina group and (80%, and 100%, respectively) in non-STEMI group, which similar to other studies [21]**.**

According to the angiographic findings, left circumflex coronary artery (LCX) stenosis was reported in (43.3%) of patients, and RCA stenosis was reported in (66.6%) of patients and left anterior descending coronary artery (LAD) stenosis was reported in (86%) of patients whereas Montgomery et al. found stenosis in the LAD only (21%), LCX only (9%) and (7 %) [22].

While in **Moustafa et al**, (43%) had LCX, (61.7%) had LAD , and (40.5%) had the RCA disease [15]**.**

The longitudinal strain revealed that there was a good performance in evaluation of LAD stenosis with high sensitivity, fair specificity and high accuracy (87.5%, 75%, and 85%; respectively) in unstable angina group and high sensitivity, high specificity and high accuracy (88.9%, 100%, and 90%; respectively). Regarding RCA stenosis, 2-D LV longitudinal strain had a sensitivity of (85.7%), specificity of (100%) and accuracy of (90 %). LCX artery stenosis (sensitivity 75%, specificity 100%, and accuracy 90%) in unstable angina group and (sensitivity 72.7%, specificity 100%, and accuracy 85%) in non-STEMI group. Additionally, this trial showed the longitudinal strain validity in the identification of stenosis in different number of coronary arteries.

This relationship between the reduction of segmental longitudinal strain values by STE and the location of coronary artery lesion as determined by coronary angiography is also declared [(16)].

While Vrettos et al. found that the systolic strain had the highest specificity for detecting obstructive CAD in the LAD, it is followed by the RCA and LCX strains [(23)].

***Fang et al***, using tissue Doppler imaging reported that augmentation of radial function in diabetic patients was used to compensate the reduced longitudinal function [(24)]

According to Nakai et al., univariate analysis demonstrated that a decrease in GLS was significantly linked with the duration of diabetic disease (P = 0.0006). There was no correlation between the decrease in GS and either fasting blood glucose (P = 0.7489) or glycosylated hemoglobin (P = 0.7524). A multivariate linear regression analysis revealed that the duration of diabetes was the sole significant predictor of LS decrease (t = 2.22, P = 0.0313) [(25)]

The findings contribute to our understanding of the connection between CAD and GSL and support the clinical utility of STE in coronary angiography assessment.

**Conclusions**

In conclusion, we found that speckle tracking is effective in predicting presence of CAD in diabetic female patients with acute chest pain and in prediction of vessels' affected based on the affected segments distribution in longitudinal strain by GLS. In addition, it can be used for patients with acute coronary syndrome as non-invasive test.. **Try revisiting the conclusion section and includes recommendation.**

:|5u|Comment

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## References:


1. McAloon CJ, Boylan LM, Hamborg T, Stallard N, Osman F, Lim PB, et al. The changing face of cardiovascular disease 2000-2012: An analysis of the world health organisation global health estimates data. Int J Cardiol. 2016;224:256-64.

2. Berry C, Tardif JC, Bourassa MG. Coronary heart disease in patients with diabetes: part I: recent advances in prevention and noninvasive management. J Am Coll Cardiol. 2007;49:631-42.

3. Fraker TD, Jr., Fihn SD, Gibbons RJ, Abrams J, Chatterjee K, Daley J, et al. 2007 chronic angina focused update of the ACC/AHA 2002 guidelines for the management of patients with chronic stable angina: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines Writing Group to develop the focused update of the 2002 guidelines for the management of patients with chronic stable angina. J Am Coll Cardiol. 2007;50:2264-74.

4. Kocabay G, Muraru D, Peluso D, Cucchini U, Mihaila S, Padayattil-Jose S, et al. Normal left ventricular mechanics by two-dimensional speckle-tracking echocardiography. Reference values in healthy adults. Rev Esp Cardiol (Engl Ed). 2014;67:651-8.

5. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an

update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging. 2015;16:233-70.

6. Maurice Termeer, Javier Oliván Bescós, Marcel Breeuwer, Anna Vilanova, Frans Gerritsen, M. Eduard Gröller, et al. Patient-Specific Mappings between Myocardial and Coronary Anatomy. In: Hagen H, editor. Scientific Visualization: Advanced Concepts: Schloss Dagstuhl--Leibniz-Zentrum fuer Informatik, Dagstuhl, Germany; 2010. p. 196--209.

7. Liszka J, Haberka M, Tabor Z, Finik M, Gąsior ZJAomsA. Two-dimensional speckle-tracking echocardiography assessment of left ventricular remodeling in patients after myocardial infarction and primary reperfusion. 2014;10:1091.

8. Conte L, Fabiani I, Barletta V, Bianchi C, Maria CA, Cucco C, et al. Early Detection of Left Ventricular Dysfunction in Diabetes Mellitus Patients with Normal Ejection Fraction, Stratified by BMI: A Preliminary Speckle Tracking Echocardiography Study. J Cardiovasc Echogr. 2013;23:73-80.

9. Rostamzadeh A, Shojaeifard M, Rezaei Y, Dehghan KJIjoc, medicine e. Diagnostic accuracy of myocardial deformation indices for detecting high risk coronary artery disease in patients without regional wall motion abnormality. 2015;8:9412.

10. Şahin DY, Gür M, Elbasan Z, Yıldız A, Kaya Z, Icen YK, et al. Predictors of preinterventional patency of infarct-related artery in patients with ST-segment elevation myocardial infarction: Importance of neutrophil to lymphocyte ratio and uric acid level. 2013;18:e77.

11. Zuo HJ, Yang XT, Liu QG, Zhang Y, Zeng HS, Yan JT, et al. Global Longitudinal Strain at Rest for Detection of Coronary Artery Disease in Patients without Diabetes Mellitus. Curr Med Sci. 2018;38:413-21.

12. Schroeder J, Hamada S, Gründlinger N, Rubeau T, Altiok E, Ulbrich K, et al. Myocardial deformation by strain echocardiography identifies patients with acute coronary syndrome and

non-diagnostic ECG presenting in a chest pain unit: a prospective study of diagnostic accuracy. Clin Res Cardiol. 2016;105:248-56.

13. Madhavan S, Narayanapillai J, Paikada JS, Jayaprakash K, Jayaprakash VJJoC, Cardiology P. Two-dimensional speckle tracking echocardiography as a predictor of significant coronary artery stenosis in female patients with effort angina who are treadmill test positive: An angiographic correlation. 2019;8:126.

14. Madhavan S, Jayaprasad N, Paikada J, Jayaprakash K, Jayaprakash VL. Two-dimensional speckle tracking echocardiography as a predictor of significant coronary artery stenosis in female patients with effort angina who are treadmill test positive: An angiographic correlation. Journal of Clinical and Preventive Cardiology. 2019;8:126.

15. Radwan H, Hussein E. Value of global longitudinal strain by two dimensional speckle tracking echocardiography in predicting coronary artery disease severity. The Egyptian Heart Journal. 2017;69:95-101.

16. Moustafa S, Elrabat K, Swailem F, Galal A. The correlation between speckle tracking echocardiography and coronary artery disease in patients with suspected stable angina pectoris. Indian Heart Journal. 2017.

17. Hubbard RT, Arciniegas Calle MC, Barros-Gomes S, Kukuzke JA, Pellikka PA, Gulati R, et al. 2-Dimensional Speckle Tracking Echocardiography predicts severe coronary artery disease in women with normal left ventricular function: a case-control study. BMC Cardiovasc Disord. 2017;17:231.

18. Farokhnejad S, Dastani M, Fazlinejad A, Narenji Sani R. Two-dimentional speckle tracking strain imaging in the assessment of myocardial diastolic function in patients with stable angina pectoris. Reviews in Clinical Medicine. 2015;2:112-7.

19. Huang K-w, Liu H, Bai G, Zhang W-j. Change in left ventricular global longitudinal peak strain for early diagnosis of high-risk coronary atherosclerotic heart disease in elderly patients: study protocol for a single-center diagnostic trial2017.

20. Ogunyankin KO, Montgomery DE, Puthumana JJ, Schuster DJ. LONGITUDINAL TWO-DIMENSIONAL SPECKLE TRACKING INDICES ON REST ECHOCARDIOGRAPHIC IMAGES PREDICTS SIGNIFICANT CORONARY DISEASE. Journal of the American College of Cardiology. 2010;55:A86.E818.

21. Montgomery DE, Puthumana JJ, Fox JM, Ogunyankin KO. Global longitudinal strain aids the detection of non-obstructive coronary artery disease in the resting echocardiogram. Eur Heart J Cardiovasc Imaging. 2012;13:579-87.

22. Liou K, Negishi K, Ho S, Russell EA, Cranney G, Ooi SY. Detection of Obstructive Coronary Artery Disease Using Peak Systolic Global Longitudinal Strain Derived by Two-Dimensional Speckle-Tracking: A Systematic Review and Meta-Analysis. J Am Soc Echocardiogr. 2016;29:724-35.e4.

23. Raja D, Khanna R. Detection and location of obstructive coronary artery disease in patients of chronic stable angina by strain and strain rate (myocardial deformation parameters) in the resting echocardiogram2015. S88-S9 p.

24. Fang ZY, Leano R, Mwewick TH. Relationship between longitudinal and radial contractility in subclinical diabetic heart disease. J Clinical science. 2004;106:53-60.

25. Nakai H, Takeuchi M, Nishikage T, Lang RM, Otsuji YJEJoE. Subclinical left ventricular dysfunction in asymptomatic diabetic patients assessed by two-dimensional speckle tracking echocardiography: correlation with diabetic duration. 2009;10:926-32.

**Try to use appropriate referencing styles in alphabetical order** :|6u|Comment