Speckle Tracking Echocardiography in Diabetic Patients with STEMI

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Abstract

Background: Noninvasive assessment of MI based on strain is of growing interest because of its clinical value in the detection of early myocardial dysfunction and stratifying patient prognosis. Cardiovascular MR imaging techniques are considered reference techniques, especially MR tagging, which remains the most widely available and validated cardiovascular MR modality for myocardial strain quantification. Diabetes not only increases the risk of MI but also increases the mortality associated with the acute event. DM is a strong independent predictor of short and long-term recurrent ischemic events, including mortality, in patients with ACS. Correlation between the GLPSS by speckle tracking echocardiography with traditional echocardiographic indices in diabetic patients with STEMI in 24hrs after primary PCI.

Methods: 30 patients with STEMI (58 ± 8, 9 diabetic, 21 non diabetic) all patients underwent 1ry PCI. Conventional 2D echocardiography to asses LVEF, WMSI, EDV and ESVI and speckle tracking echocardiography to asses LV GLPSS was done within 24hr of 1ry PCI.

Results: All patients with STEMI had low LV avge GLPSS (–10.57 ± 2.67%) with significant between diabetic (–9.00 ± 2.3%) and non diabetec (–11.2 ± 2.6%) with significant \( p:0.03 \), at Avge GLPSS –9.5% all dibetic patients uncontrolled diabetis with HbA1C ≥10 with sensitevity 66% and specificity 72% and AUC 0.7, no significant between diabetic and non diabetic patients as regarding LVEDV with \( p:0.7 \), LVESV with \( p:0.4 \), EF with \( p:0.6 \), or WMSI with \( p:0.7 \). Significant proportional correlation found between Avg GLS and EF with \( p:0.01 \) and significant inverse correlation between Avg GLS and WMSI was found with \( p:0.04 \) no significant between Avg GLS and ESVI with \( p:0.08 \).

Conclusion: Assessment of myocardial strain in diabetic patients by speckle tracking echocardiography may efficiently detect early contractile changes which may precede functional alterations observed with conventional M-mode echocardiography.

Key Words: Diabetics mellitus – STEMI – Speckle tracking echocardiography.

Introduction

AFTER ST-Segment Elevation Myocardial Infarction (STEMI), patients with diabetes mellitus have shown similar changes in Left Ventricular (LV) volumes and Ejection Fraction (EF) compared with patients without diabetes. Previous studies in diabetic patients with normal LVEF have demonstrated the presence of subclinical LV dysfunction as assessed with 2-dimensional Global Longitudinal Strain (GLS) speckle-tracking echocardiography [4-6].

Echocardiography is a useful tool for risk stratification and prognosis assessment following Acute Myocardial Infarction (AMI). Several echocardiographic parameters, such as LV volume, EF, Wall Motion Score Index (WMSI), presence of mitral regurgitation, and left atrial volume, have been shown to provide prognostic information [1]. LV volume and EF are the primary means for assessing myocardial systolic function and myocardial damage after AMI. Nevertheless, it must be taken into account that these indices are global and load-dependent. The development of Cardiac Magnetic Resonance imaging (CMR) with the tagging approach and echocardiography with the speckle-tracking strain imaging has provided additional tools to assess global and regional functions according to myocardial fiber orientation and position within the myocardial thickness [2]. As a result, longitudinal, radial, and circumferential functions can be distinctively assessed. Using speckle-tracking imaging, several studies have demonstrated the usefulness of longitudinal and circumferential strains in differentiating between sub-endocardial and transmural AMI, and assessing post-AMI prognosis [2].
Aim:

Our study aimed to correlate between the Global Longitudinal Peak Systolic Strain (GLPSS) by speckle tracking echocardiography with traditional echocardiographic indices in diabetic patients with STEMI in first 24hrs after primary PCI.

Patients and Methods

The study population consisted of thirty patients who were admitted to the Critical Care Department, Cairo University, Kasr El-Aini Hospitals from September 2014 to November 2015.

Inclusion criteria:

Patients with ST Segment Elevation Myocardial Infarction (STEMI) with symptoms onset less than twelve hours who underwent successful primary PCI in first twenty four hours from hospital admission.

All patients underwent immediate coronary angiography and primary Percutaneous Coronary Intervention (PCI).

Exclusion criteria:

Patients with pre existing cardiomyopathy, Moderate and severe valvular heart disease, age younger than 18 years, morbid obesity and bad echocardiographic windows. The study was approved by the Regional Committee for Medical Research Ethics. Written informed consent was obtained from all patients.

On admission all patients were subjected to the following:

- Full history taking and full systemic examination for other associated medical or surgical problems.
- Standard 12-lead ECG was performed using 3-channel direct writing recorder with a paper speed 25mm/second and standardization adjusted to 1mm/mv. ECG was done on admission, six hourly in the first 24 hours then daily during the hospital course.
- Laboratory investigation including cardiac enzymes (CK, CK-MB, and LDH) were estimated on admission, post intervention 6 hourly in the first 24 hours and then once daily till normalization, troponine analysis was done as well, random blood sugar hemoglobin A 1 C, coagulation profile, kidney function tests, liver function tests and serum electrolytes including serum sodium and potassium were also done.

Echocardiography (within 24hrs after 1ry PCI): Patients were imaged in the left lateral decubitus position using a commercially available system (Philips iE33 X matrix system with X 5-1MH pure wave crystal probe. at a depth of 16cm in the parasternal (long-axis images) and apical (2, 3 and 4-chamber images) views. Standard 2D images triggered to the QRS complex, were saved in cine loop format.

A- Two-dimensional echocardiography:

The following were assessed:

- LV End-Diastolic Volume (LVEDV) and LV End-Systolic Volume (LVESV) were measured in the apical four-chamber view, LV Ejection Fraction (LVEF) was calculated using the (modified simpson's rule), LV End-Diastolic Diameter (LVEDD) and LV End-Systolic Diameter (LVESd) were measured from M mode, End Systolic Volume Index (ESVI) was calculated by dividing ESV by body surface area, Wall Motion Score Index (WMSI), the LV was divided into 16 segments. A semi-quantitative scoring system (1, normal; 2, hypokinesia; 3, akinesia; 4, dyskinesia) was used to analyze each study. Global WMSI was calculated by the standard formula: Sum of the segment scores divided by the number of segments scored.

B- Speckle tracking echocardiography for estimating the global LV longitudinal strain and strain rate:

For 2D-strain analysis, apical four three, and two-chamber views, were stored in cine-loop format, triggered to the QRS complex during one heart cycle with frame rates between 55 and 70 frames/sec. These cine loops were then analyzed off-line on the (Philips iE33 X matrix system), based on frame-by-frame tracking of natural acoustic markers. Peak systolic longitudinal strain was determined for each of the 16 segments, and longitudinal global strain was then calculated.

For this analysis three points were anchored inside the myocardial tissue, two placed at the basal segments along the mitral valve annulus and one at the apex followed by automated tracing of endocardial and epicardial borders defining the Region of Interest (ROI). Manual readjustment of endocardial tracing and ROI will be performed in order to achieve optimal alignment if necessary. In segments with poor tracking, the observer readjusted the endocardial trace line until a better tracking score was achieved. If this was impossible, the segment was excluded [7].
ROI outlining the entire left ventricular wall will be divided into 6 segments. A computer algorithm calculated peak systolic strain values within each segment together with global peak systolic strain (GLPS) from each view and lastly overall averaged global peak systolic strain (aGLPS) of the AP4C, AP2C, and AP3C views was combined in a single bull's-eye summary, which presents the analysis for each segment along with a global strain value for the LV can be assessed.

There are three different strain parameters were measured during 1 heart cycle by STE, peak systolic strain was defined as the peak positive or peak negative strain value during systole. End systolic strain was defined as the magnitude of deformation at the time of aortic valve closure, and peak negative strain was the maximum negative strain value during systole or early diastole post-systolic shortening was calculated as the difference between deformation after aortic valve closure and end systolic strain. Strain measurement from 16 segments were averaged to assess a LV global longitudinal parameter based on peak systolic, end systolic, and peak negative strain [8].

- Normal value for LV avg GLPSS assessed by speckle tracking technique is in the range of −18 to −22%.

**Statistical analysis:** Data were statistically described in terms of mean ± standard deviation (±SD), and range, or frequencies (number of cases) and percentages when appropriate. Comparison of numerical values was done using student’s t-test for normal data and Mann Whitney test for non-normal data. Correlation between various variables was done using Pearson moment correlation equation for linear relation in normally distributed variables and Spearman rank correlation equation for non-normal variables. p-values less than 0.05 was considered statistically significant, Area Under the Curve (AUC), negative predictive value, positive predictive value, and accuracy (overall fraction correct) are reported. The AUC is a measure of discriminating power and represents the probability of the model to assign a higher probability to a correct case than to an incorrect case for all possible pairs of cases.

All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) release 15 for Microsoft Windows (2006).

**Results**

This is an observational prospective study that was conducted at the Critical Care Department, Faculty of Medicine, Cairo University between September 2014 and November 2015 on thirty patients with ST Segment Elevation Myocardial Infarction (STEMI) with symptoms onset less than 12hrs who underwent successful primary PCI on admission.

- **Demographics & cardiovascular risk factors:**
  Mean age of our study population was 58±8.01 years ranging from 38 to 68 years old, there were 25 males (83.3%) with mean BSA of the study population was 2.03±0.17m².

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<th>Frequency</th>
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<tr>
<td>DM</td>
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<td>HTN</td>
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<td>FH-CAD</td>
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- There were 18 patients (60%) had anterior wall myocardial infarction, 6 patients (20%) had inferior wall myocardial infarction and 6 patients (20%) had infarctions in other sites (inferolateral & posterolateral MI), one patient had RV myocardial infarction, the culprit lesion in our study population was LAD in 17 patients (56.7%), RCA in 5 patients (16.7%), LCX in 6 patients (20%) and OM in 2 patients (6.7%), fifty percent only of patients had associated lesions in addition to the culprit vessele, 10 patients had one associated lesion (33.3%), 4 patients had two associated lesions (13.3%) and only one patient had three associated lesions in addition to the culprit.

- **Echocardiographic data:**

| Mean ± SD |
|-----------|-----------|
| Diabetic (9) | Non diabetic (21) |
| LVEDV (ml) | 106.1±19.7 | 103.14±24.9 |
| LVESE (ml) | 59±13 | 55±14.4 |
| LVESEVI (ml/m²) | 30.23±6.6 | 26.7±6.9 |
| EF% by 2D | 44.4±5.1 | 48±4.4 |
| WMSI (1) | 1.5±0.3 | 1.4±0.3 |
| Avg GLPSS | -9.00±2.3 | -11.2±2.6 |
There was no statistically significant difference between diabetic and non diabetic patients as regarding LVEDV with $p$-value: 0.7, LVESV with $p$-value: 0.4, LVESVI with $p$-value 0.2, EF with $p$-value 0.6, or WMSI with $p$-value 0.7.

The only echocardiographic parameter which showed significant difference between diabetic and non diabetic was Avge GLPSS where it was $-9.00 \pm 2.3\%$ at diabetic patients and $-11.2 \pm 2.6\%$ at non diabetic with significant $p$-value 0.03.

In our study population we also found that at Avge GLPSS $-9.5\%$ all diabetic patients having uncontrolled diabetes with HbA1C $\geq 10$ with sensitivity 66% and specificity 72% and AUC 0.7.

Fig. (1): Peak systolic longitudinal strain for the apical four chamber view ($-8\%$) inpatient number 5 with anterior MI.

Fig. (2): Peak systolic longitudinal strain for the apical two chamber view ($-9\%$) in patient number 5 with anterior MI.

Fig. (3): Peak systolic longitudinal strain for the apical three chamber view ($-9\%$) in patient number 5 with anterior MI.

Fig. (4): Bull’s-eye view provides an overview of longitudinal strain of all individual LV segments and a value for global LV longitudinal strain, GL. Strain (Avg.) $= -9\%$ in patient number 5 with anterior MI.

Fig. (5): Strain rate (time to peak) in patient number 5 with anterior MI.

Fig. (6): ROC curve for prediction of uncontrolled diabetic patients by Avge GLS (sensitivity 66%, specificity 72%, area under the curve, AUC=0.7).
Statistically significant proportional correlation was also found between Avg GLS and EF with $p$-value: 0.01 and $r$: 0.35 and statistically significant inverse correlation between Avg GLS and WMSI was also found with $p$-value: 0.04 and $r$: 0.507 while no statistically significant correlation was found between Avg GLS and ESVI with $p$-value: 0.08 and $r$: 0.33.

Discussion

Diabetes not only increases the risk of Myocardial Infarction (MI) but also increases the mortality associated with the acute event. The presence of DM is a strong independent predictor of short-term and long-term recurrent ischaemic events, including mortality, in patients with Acute Coronary Syndrome (ACS). Studies have demonstrated poorer outcomes among patients with diabetes following ACS, the 7-year incidence of recurrent MI in a large population-based study was 45% in diabetic patients versus 19% in nondiabetic patients. Cardiovascular mortality during that period was 42.0% and 15.4% in DM patients with and without history of acute MI, respectively [9]. The prognosis for DM patients who undergo coronary revascularisation procedures is worse than that for nondiabetic subjects [9]. Mortality rates for DM patients with acute MI are 1.5-2.0 times those of non-DM patients. The negative impact of DM on the outcomes is maintained across the ACS spectrum, including unstable angina and Non-ST Elevation Myocardial Infarction (NSTEMI) [10], ST Elevation Myocardial Infarction (STEMI) treated medically, and ACS undergoing Percutaneous Coronary Intervention (PCI) [24]. DM patients have more progressive, diffuse, and multivessel coronary disease compared to nondiabetic patients and have poorer outcomes after both PCI (especially with Bare Metal Stent (BMS)) and Coronary Artery Bypass Graft surgery (CABG), compared to nondiabetic patients [11].

In our study we aimed to correlate between the Global Longitudinal Peak Systolic Strain (GLPSS) by speckle tracking echocardiography with traditional echocardiographic indices in diabetic patients with STEMI in first 24hrs after primary PCI. The only echocardiographic parameter which showed significant difference between diabetic and non diabetic was Avge GLPSS where it was $-9.00\pm2.3\%$ at diabetic patients and $-11.2\pm2.6\%$ at non diabetic with significant $p$-value 0.03 and our study agreed with Georgette E. Hoogslag et al., [12] (2015) who compared changes in global longitudinal peak systolic strain after STEMI in patients with versus without diabetes mellitus.

His study included 143 diabetec patients (age $64\pm12$ years; 68% men; 50% left anterior descending artery as culprit vessel) and 290 patients with first STEMI and without diabetes matched on age, gender, and infarct location, LV volumes and function and 2-dimensional LV GLS were measured after primary PCI (baseline) and at 6-month follow-up he concluded that after STEMI, diabetic patients show more impaired LV GLS at both baseline and
follow-up compared with matched group of patients without diabetes, despite having similar infarct size and LVEF at baseline and follow-up.

Our study also agreed with Zoroufian A Razmi T et al., [13] (2014) who evaluate subclinical left ventricular dysfunction in diabetic patients by longitudinal strain using two-dimensional speckle tracking echocardiography, their study include 37 diabetic patients with LV ejection fraction >50% and compared to 39 nondiabetic patients. The cases underwent standard conventional TTE and STE to assess GLPSS, they concluded that in diabetic patients with normal coronary and ejection fraction, segmental and global end-systolic longitudinal ST decreased these results suggest that there might be early detectable changes in systolic function in the natural course of diabetes mellitus by STE study.

Also our results agreed with Danielle Shepherd, et al., [14] (2012) who assessed longitudinal strain by speckle-tracking at type I diabetes mellitus, the study was done on small animal models of acute pathological insult. The findings indicate that assessment of myocardial strain may efficiently detect early contractile changes which may precede functional alterations observed with conventional M-mode echocardiography Laura Ernande et al. [15] (2012) investigated systolic myocardial dysfunction in patients with type 2 diabetes mellitus using MR Imaging with cine displacement encoding with stimulated echoes.

Cine DENSE is a motion-encoding MR imaging technique for myocardial strain assessment with high spatial resolution that allows identification of subclinical myocardial dysfunction in patients with DM, they concluded that cine DENSE allows identification of subclinical myocardial dysfunction in patients with DM.

In our results we found also that there was statistically significant correlation between Avg GLS and EF at diabetec and non diabetec patients with \( p \)-value: 0.01 and \( r=0.3 \) and between Avg GLS and WMSI with \( p \)-value: 0.04 and \( r=0.507 \). These findings agreed with Cimino et al., [16] (2013) who assessed the global and regional longitudinal strain (GLS-RLS) by 2D-STE in 20 STEMI patients and tested whether they could identify early myocardial dysfunction they found that GLS showed a significant correlation with both LVEF and WMSI by CMR and by 2D-echo.

Also we agreed with Nisha et al., [17] (2011) who compared GLS with different non-invasive imaging modalities for the assessment of LV function in 163 STEMI patients. They found that global strain is associated well with EF measured by all modalities. Global strain was found to be the best predictor of low EF measured by the gold standard MRI. Since global strain is an inexpensive test, these data may be of health economic interest.

**Conclusion:**

Diabetic patients have lower values of Avge GLPSS than non diabetic patients and at value of \(-9.5\%\) all diabetic patients have uncontrolled diabetes. Assessment of myocardial strain in diabetic patients by speckle tracking echocardiography may efficiently detect early contractile changes which may precede functional alterations observed with conventional M-mode echocardiography.

**References**

12. GEORGETTE E.H., et al.: Comparison of Changes in Global Longitudinal Peak Systolic Strain After ST Segment


