Original article

Two-Dimensional Speckle-Tracking Echocardiography to Monitor Left Ventricular Function After Percutaneous Coronary Intervention

A single center experience.

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Abstract:

- *Background*: Conventional 2 D Doppler echocardiographic parameters are inadequate for evaluation and monitoring Left ventricle systolic function recovery of patients with ischemic heart disease (IHD) treated by Percutaneous coronary intervention (PCI). Hence, New strain imaging parameters are studied by using 2 D speckle Tracking Echocardiography. The aim is to compare the conventional echocardiographic parameters (Left ventricle ejection fraction, Wall motion score index, regional wall motion score) with speckle tracking echocardiographic parameters (Global longitudinal strain, Regional longitudinal strain) in patients with ischemic heart disease undergo Percutaneous Coronary Intervention (PCI).

- *Method and patient:* A prospective Interventional Hospital Based study enrolled 50 patients who had ischemic heart disease (IHD), Percutaneous coronary intervention (PCI) was done for them at IbN Al-Bittar Cardiac Surgery Center from October 2014 to April 2015. Both conventional echocardiographic parameters (Left ventricle ejection fraction, Wall motion score index, regional wall motion score according to coronary artery territory) and Speckle tracking echocardiographic parameters (Global longitudinal strain, Regional longitudinal strain according to coronary artery territory) done for them pre PCI, one day post PCI, and one month post PCI.

- *Result:* Regarding conventional echocardiographic parameters: Global LVEF pre PCI 52.34±90% , one month post PCI was (54.00±6.9), there was no significant difference statistically (P value 0.79), also Wall motion score index ,Regional wall motion score according to coronary artery territory were (1.22±0.25,1.44±1.52) respectively, one month post PCI were (1.98±0.26,1.40±0.58) respectively where there's no significant differences statistically (P value 0.25,0.22) respectively.

- Regarding speckle tracking parameters :Global Longitudinal strain for all patients pre PCI was (-14.30±3.54%) ,one day post PCI was (-14.78±3.81%) ;there was no significant differences (p value 0.77).After one month Global Longitudinal Strain was (-16.38±4.15%) where this consider highly significant differences (p value 0.001).Regional Longitudinal Strain according to the coronary artery territory pre PCI was (-14.49±4.47%),post one day post PCI was (-15.08±4.92%) where there's no significant differences (p value 0.10), while one month post PCI was (-17.70±5.27%),this was highly significant different statistically (0.001).Only in STEMI patients there was significant difference one day post PCI(P value 0.041 for Global LS,0.016 for Regional LS).

- *Conclusions:* In all IHD groups (STEMI, NSTEMI∕UA, chronic stable angina) Speckle Tracking Echocardiographic parameters (Global Longitudinal Strain and Regional longitudinal strain) more reliable and effective than conventional echocardiographic parameters (Global LWEF,WMSI, RWMS) for monitoring improvement in LV systolic function post Percutaneous coronary intervention.

    Keywords: Echocardiography, Two-Dimensional Speckle-Tracking Echocardiography, LV function.

INTRODUCTION

Non-invasive imaging detection of myocardial functional recovery is critically important in patients who undergo coronary heart disease (CHD) treatments such as CABG, PCI, and drug therapy. MRI is considered a standard strategy for this purpose. It can analyze myocardial deformation; mechanical characteristic accurately; However, MRI has its limitation for use in multiple point follow ups; high cost and time-consuming nature [1].

Echocardiography is a widely used noninvasive imaging modality for evaluating regional wall motion abnormality and left ventricular ejection fraction (LVEF) in patients with CHD.

Ejection fraction (EF) assessment has been consolidated as an accessible and reliable parameter in the quantification of the ventricular systolic function and it has also shown a huge value in welfare decisions and as prognostic indicator. However, exceptions to linearity between functional class and ejection fraction are large and they are placed at both sides of their value spectrum [4].

A new noninvasive ultrasound imaging technique that allows for an objective and quantitative evaluation of global and regional myocardial function independently from the angle of insonation and from translational movements [12-16]. STE is based on analysis of the spatial dislocation (referred to as tracking) of speckles (defined as spots generated by the interaction between ultrasound beam and myocardial fibers on routine 2-Dimensional sonograms). Before introduction of this sophisticated echocardiographic technique, only tagged magnetic resonance imaging (MRI) had enabled a myocardial dynamics [14].

The term speckle tracking implies that this technique is principally based on the analysis of speckles during the cardiac cycle. Single speckles are merged in functional units(kernels) that are in turn univocally identifiable given the peculiar disposition of the speckles. Speckle tracking echocardiographic –derived measurements has recently been validated sonomicrometry and tagged MRI, showing high feasibility and reproducibility [21]. Substantial potential limitations of this new technique are its strict dependence on the frame rate and high-quality 2-dimensional images. which are necessary for an optimal dentition of the endocardial border of apex and lateral wall [20].

The Aim of current study of this study is to compare the conventional echocardiographic parameters (Left ventricle ejection fraction by M mode, Wall motion score index, regional wall motion score) with speckle tracking echocardiographic parameters (Global longitudinal strain, Regional longitudinal strain) in patients with ischemic heart disease undergoing Percutaneous Coronary Intervention (PCI) for evaluation and monitoring of left ventricular systolic function.

PATIENT and METHOD

A prospective interventional hospital-based study was conducted at Ibn-AL Bittar Cardiac Surgery Center from October 2014 till April 2015.

Inclusion criteria: (1) patients with Recent ST-elevation myocardial infarction (STEMI) were admitted for diagnostic coronary angiography and possible Percutaneous coronary intervention (PCI) excluding cases of primary PCI.

(2) patients with Non STEMI or Unstable angina; admitted with indications for early diagnostic coronary angiography and possible PCI. (3) patients with chronic stable angina with indication for coronary angiography and possible PCI and had elective appointment for coronary angiography and possible PCI.

Exclusion criteria:(1) any patient with above diagnosis and not in sinus rhythm (2) patients with severe valvular heart disease (3) past history of PCI or CABG(4) Results of coronary

angiography revealed normal coronaries; non-significant coronary artery disease and three vessel disease referred for CABG (5) patients with poor acoustic window.

Baseline (1) conventional Two Dimensional Echocardiography (2DDE) parameters (Global left ventricle Ejection fraction by M mode where ≥ 55% consider the lower limit of normal, Wall motion score index and Regional wall motion score according to artery territory (2) Speckle tracking Echocardiography parameters(Global Longitudinal Strain and Regional Longitudinal Strain) taken within 24 hours prior to the diagnostic coronary angiography and possible PCI.

Regarding regional wall motion analysis by Two dimensional Doppler Echocardiography was based on the use of the 17-myocardial segment model that has been recommended by the American Society of Echocardiography and American Heart Association.

RESULTS

The total number of patients enrolled in the study was (56) . Six patients lost from follow up, so 50 patients were complete the follow up post one day and post one month, mean±SD age 54.20±9.47 years ,males were 40(80%),females were 10(20%),Hypertension was present in 23(46%),Diabetes Mellitus in 16(32%),Current smoking in 10(20%), Ex smoking in 17(34%). 20(40%) patients had STEMI, NSTEMI∕unstable angina 20(40%),10(20%) had chronic stable angina. All undergoing PCI for appropriate indications. PCI done for LAD in 34(88%), RCA in 10(20%)and LCX only in (6) patients(12%) .This is showing in a Table (1).

Table 1. Baseline patient characteristics

Parameters	Total number (%)
Male **Female**	40(80%) 10 (20%)
Age ±SD(Years)	54.20±9.470
Hypertension	23 (46%)
Diabetes mellitus	16(32%)
Smoking Current smoking Ex smoking	27 (54%) 10 (20%) 17 (34%)

Coronary artery involved	
LAD	34 (68%)
LCX	6 (12%)
RCA	10 (20%)
Groups	
STEMI	20(40%)
NSTEMI/unstable angina	20(40%)
Chronic stable angina	10(20%)

LAD: left anterior descending coronary artery; LCX: left circumflex coronary artery; RCA: right coronary artery; STEMI:ST elevation myocardial infarction; NSTEMI: Non-ST Elevation myocardial infarction.

Global LVEF pre PCI was (52.34±6.90%),one day post PCI was (52.34±6.90%), one month post PCI Global LVEF was (54.00±6.42%) where there's no significant differences (P-value 0.790). Wall motion score index (WMSI) ,Regional wall motion score (RWMS) for coronary artery territory of the target artery as determined by cardiologist pre PCI was(1.220± 0.25),(1.44± 0.527) respectively, one day post PCI was (1.220± 0.25),(1.44± 0.527) ; and one month post PCI was(1.19 ± 0.26, 1.40 ± 0.58) respectively, where there's no significant differences (P value 0.258, 0.226 respectively).This is showing in table (2).

Table 2. Comparison between conventional 2D echocardiographic parameters before PCI, and after PCI

Parameters	Size of sample	Pre PCI (mean ± SD)	One month post PCI (mean ± SD)	P.value
Global LVEF	50	52.34±6.90%	54.00±6.42%	0.79
WMSI	50	1.22 ± 0.25	1.19 ± 0.26	0.25
RWMS (Target vessel)	50	1.44 ± 0.52	1.40 ± 0.58	0.22

* The P.value> 0.05 is not significant. PCI: Percutaneous coronary intervention, Global LVEF: Global left ventricular ejection fraction, WMSI: Wall motion score index, RWMS: regional wall motion score

Regarding Speckle tracking imaging, The Global Longitudinal strain(GLS) for all patients pre PCI was (-14.30 ± 3.54%) ,one day was(-14.78± 3.81%) , there was no significant differences(0.776) .After one month Global LS was (-16.38 ± 4.15%) where there's highly significant differences (0.001). Regional Longitudinal strain according to coronary artery territory of the target artery determined by cardiologist for all patients: mean Longitudinal

Strain was pre PCI (-14.49 ± 4.47%); one day post PCI was (-15.08 ± 4.92%),where there's no significant differences(p value 0.101) ,one month post PCI Regional LS was(-17.70 ± 5.27%),this was highly significant statistically(0.001). This is shown in Table (3) and figure (I).

Table 3. Comparison of 2 D Speckle tracking Echocardiographic parameters before PCI and after PCI

2 D speckle tracking echocardiograhic parameters							
Parameters	Sample size	Pre PCI (mean ± SD)	One day post PCI (mean ± SD)	P.value	Pre PCI (mean ± SD)	one month post PCI (mean ± SD)	P.value
Global Longitudinal Strain	**50**	**-14.30 ± 3.54%**	**-14.78 ± 3.81%**	**0.776**	**-14.30 ± 3.54%**	**-16.38 ± 4.15%**	**0.001**
Regional Longitudinal Strain of Target vessel	**50**	**-14.49 ± 4.47%**	**-15.08 ± 4.92%**	**0.887**	**-14.49 ± 4.47%**	**-17.70 ± 5.27%**	**0.001**

* The P.value> 0.05 is not significant, The P.value< 0.001 is highly significant PCI: Percutaneous coronary intervention.

Strain values (%)
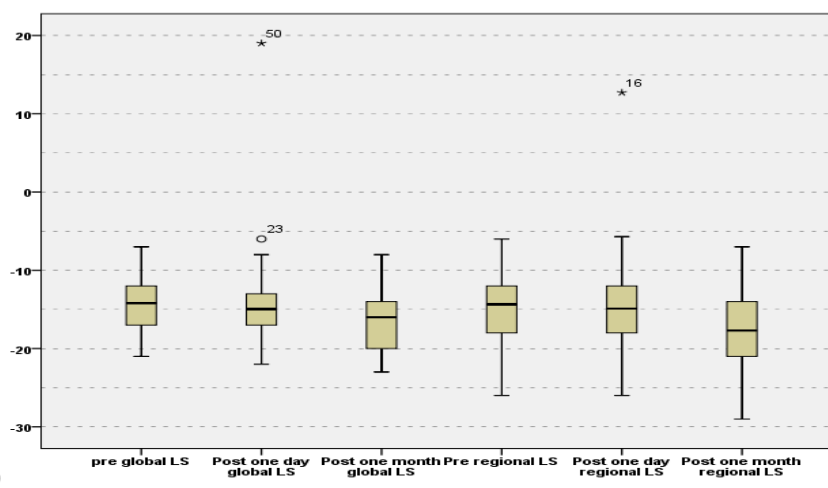
Figure I. Box plot graph comparison between global Longitudinal strain and regional Longitudinal strain pre Percutaneous intervention (PCI), one day PCI and one month post PCI.

Regarding specific groups: In STEMI patients; Global LVEF pre PCI was (49.70±6.18%),one day post PCI was (49.70±6.18%) , one month post PCI was (51.30±6.96%) There no significant difference statistically (0.700).Wall motion index score(WMSI), Regional wall motion score(RWMS) according to coronary artery territory of target artery determined by cardiologist was (1.36 ± 0.29 ; 1.71 ± 0.54) respectively, one day post PCI (1.36 ± 0.29 ; 1.71 ± 0.54), and post one month was(1.34 ± 0.34, 1.68 ± 0.57),also statistically no significant differences (p value 0.416, 0.198 respectively). This is shown in table (4).

Table 4. Comparison between conventional echocardiographic parameters before PCI and after PCI in STEMI patients.

Parameters	Size of sample	Pre PCI (mean ± SD)	one month post PCI (mean ± SD)	P.value
Global LVEF	20	49.70±6.18%	51.30±6.96%	0.70
WMSI	20	1.36 ± 0.29	1.34 ± 0.34	0.41
RWMS (Target vessel)	20	1.71 ± 0.54	1.68 ± 0.57	0.19

* The P.value> 0.05 is not significant, PCI: Percutaneous coronary intervention, LVEF: left ventricle ejection fraction, WMSI: wall motion index score, RWMS: regional wall motion score according to coronary artery territory.

Regarding speckle tracking echocardiography; In STEMI patients pre PCI Global LS was (-12.45 ± 3.17%), one day post PCI was(-13.59 ± 3.58%) and it was significantly different (p value 0.041). After one month post PCI was (-14.58 ± 3.91%) ,this was significant difference (0.002). For Regional LS of coronary artery territory of target artery determined by cardiologist

pre PCI was (-12.68 ± 4.36%), one day post PCI was (-14.00 ± 4.96) ,this was significant difference (p value 0.016);After one month post PCI was (-15.59 ± 6.14%).and it was significantly different.(p value0.001) This showing in table(5);figure(II).

Table 5. Comparison between 2D Speckle tracking echocardiographic parameters before PCI and after PCI in STEMI patients.

2D Speckle tracking echocardiographic parameters							
Parameters	Size of sample	Pre PCI (mean ± SD)	One day post PCI (mean ± SD)	P.value	Pre PCI (mean ± SD)	One Month post PCI (mean ± SD)	P.value
Global Longitudinal Strain	20	-12.45 ± 3.17%	-13.59 ± 3.58%	0.041	-12.45 ± 3.17%	-14.58 ± 3.91%	0.002
Regional Longitudinal Strain (Target vessel)	20	-12.68 ± 4.36%	-14.00 ± 4.96%	0.016	-12.68 ± 4.36%	-15.59 ± 6.14%	0.001

* The P.value< 0.05 is significant. The P.value< 0.01 is highly significant; PCI: Percutaneous coronary intervention, STEMI: ST Elevation myocardial infarction

Strain values(%)
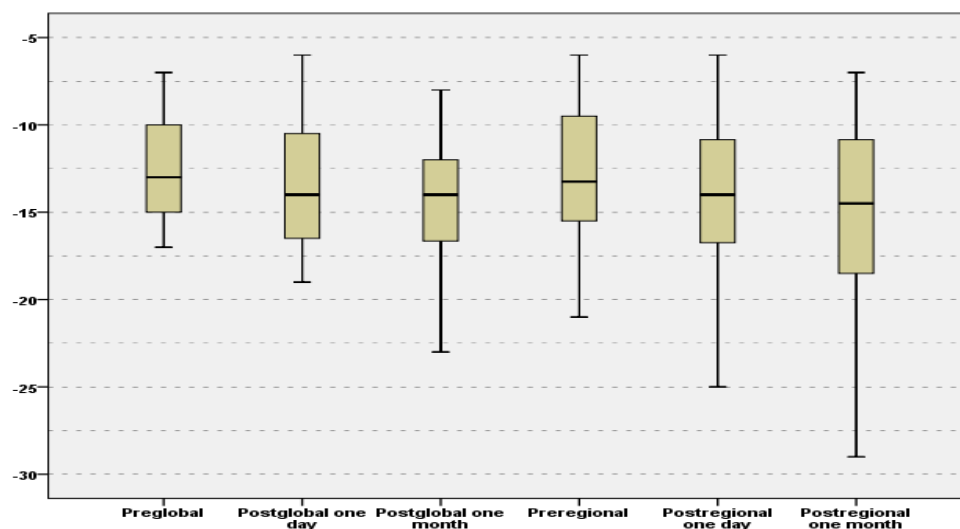
duration of follow up

Figure II. Boxplot comparison between 2D Speckle tracking echocardiographic parameters before Percutaneous coronary intervention (PCI) and after PCI in ST Elevation Myocardial Infarction patients.

Regarding NSTEMI ⁄ Unstable angina patients: Pre PCI global LVEF (54.05± 6.84%), one day post PCI was(54.05± 6.84%) , one month was (55.70 ± 6.79%) where there's no significant differences(p value 0.361). WMSI; RWMS of coronary artery territory of target artery determined by cardiologist pre PCI was(1.15 ± 0.22; 1.33 ± 0.52) respectively .One day PCI was (1.15 ± 0.22; 1.33 ± 0.52) , one month post PCI was (1.13 ± 0.22, 1.29 ± 0.53) respectively ,it was not different significantly (p value 0.185,0.170 respectively).This is showing in table(6)

Table 6. comparison between 2D conventional echocardiographic parameters before PCI and after PCI in NSTEMI ⁄ UA patients

Parameters	Size of sample	Pre PCI (mean ± SD)	one month post PCI (mean ± SD)	P.value
Global LVEF*	20	54.05 ± 6.84%	55.70 ± 6.79%	0.361
WMSI*	20	1.15 ± 0.22	1.13± 0.22	0.185
RWMS (Target vessel)	20	1.33 ± 0.52	1.29 ± 0.53	0.170

The P.value> 0.05 is not significant PCI: Percutaneous coronary intervention, NSTEMI: Non STEMI:UA: unstable angina, Global LVEF: Global left ventricular ejection fraction, WMSI: wall motion score index; RWMS: regional wall motion score.

In NSTEMI ⁄ unstable angina patients the Global LS pre PCI was (-15.40 ± 3.66%),one day post PCI was (-15.33 ± 4.36%),it was not different significantly(0.82), and one month post PCI Global LS (-17.27 ± 4.25%) ,this was significantly different (p value 0.001),also for Regional LS of coronary artery territory of target vessel determined by cardiologist before PCI was(-15.59 ± 4.81%), one day post PCI was(-15.56 ± 5.35%) ,this was not different significantly (p value0.96).One month post PCI it was(-18.91 ± 4.74%) ,this was different significantly(0.001).This is showing in table (7);figure (III).

Table 7. Comparison between 2D Speckle tracking echocardiographic parameters before PCI and after PCI in NSTEMI∕UA patients.

2D Speckle tracking echocardiographic parameters							
Parameters	Samp le size	Pre PCI (mean ± SD)	one day post PCI (mean ±SD)	P.value	Pre PCI (mean ± SD)	One month post PCI (mean ± SD)	P.value
Global Longitudinal Strain	**20**	**-15.40 ± 3.66%**	**-15.33 ± 4.36%**	**0.820**	**-15.40 ± 3.66%**	**-17.27 ± 4.25%**	**0.001**
Regional Longitudinal Strain (Target vessel)	**20**	**-15.59 ± 4.816%**	**-15.56 ± 5.35%**	**0.969**	**-15.59 ± 4.816%**	**-18.91 ± 4.74%**	**0.001**

* The P.value> 0.05 is not significant. The P.value< 0.01 is highly significant; NSTEMI: Non- ST Elevation myocardial infarction, UA: unstable angina

Strain values(%)
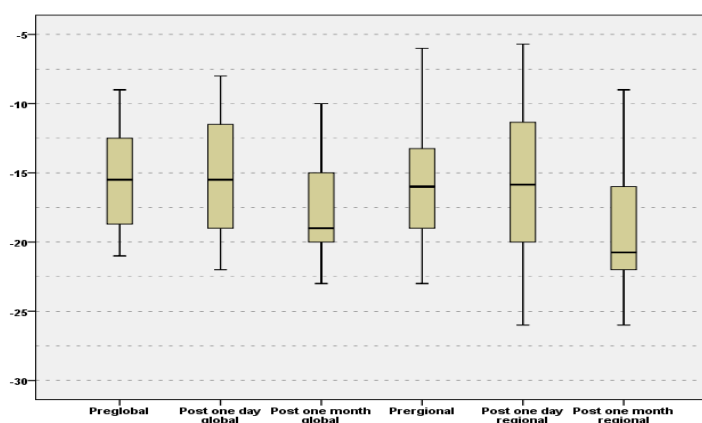
duration of follow up

Figure III. Box plot comparison between 2D Speckle tracking echocardiographic parameters before Percutaneous intervention (PCI) and after PCI in Non -ST elevation myocardial infarction and unstable angina patients.

Regarding chronic stable angina patients pre PCI Global LVEF was (53.70± 5.22%) ,one day post PCI (53.70± 5.22%), one month PCI was (54.80±4.34%),there's no significant differences(p value 0.563).WMSI, RWMS according to coronary artery territory of target artery determined by cardiologist pre PCI (1.13 ± 0.188; 1.16 ± 0.20) one day post PCI and one month post PCI (1.13±0.188;1.16±0.20) there was no statistical difference .This showing in Table(8).

Table 8. comparison between conventional echocardiographic parameters before PCI* and after PCI in chronic stable angina.

Parameters	Size of sample	Pre PCI(mean ± SD)	1 month post PCI(mean ± SD)	P.value
Global LVEF*	10	53.70 ± 5.22%	54.80±4.34%	0.563
WMSI*	10	1.13 ± 0.18	1.13 ± 0.18	---
RWMS Target (vessel)	10	1.16 ± 0.20	1.16 ± 0.20	---

The P. value> 0.05 is not significant The P. value is not calculated because of the mean ± SD are equal (The difference is zero) .PCI: Percutaneous coronary intervention, Global LVEF: Global left ventricle ejection fraction, WMSI: Wall motion score index, RWMS: Regional wall motion score.

In chronic stable angina patients Pre PCI Global LS was (-15.83 ± 2.38%), one day post PCI was (-16.07 ± 2.44%) ,it was not significant (p value0.089),one month post PCI was (-18.28 ± 3.29%),it was significantly different(p value 0.042). For Regional LS according to coronary artery territory of target artery determined by cardiologist pre PCI (-15.91 ± 2.78%), one day post PCI (-16.26 ± 3.83%) was not significant statistically. After one month post PCI was (-19.50 ± 2.71%) this was significant statistically(p value 0.018) as shown in table (9);figure(IV).

Table 9. Comparison between 2D Speckle tracking echocardiographic parameters before Percutaneous coronary intervention (PCI) and after PCI in chronic stable angina

2D Speckle tracking echocardiographic parameters							
Parameters	Sample size	Pre PCI (mean ± SD)	one day post PCI (mean ± SD)	P.value	Pre PCI (mean ± SD)	One month post PCI (mean ± SD)	P.value
Global Longitudinal Strain	10	-15.83 ± 2.38%	-16.07 ± 2.44%	0.089	-15.83 ± 2.38%	-18.28 ± 3.29%	0.042
Regional Longitudinal Strain (Target vessel)	10	-15.91 ± 2.78%	-16.26 ± 3.83%	0.609	-15.91 ± 2.78%	-19.50 ± 2.71%	0.018

* The P.value> 0.05 is not significant., PCI: Percutaneous coronary intervention*

Strain values (%)
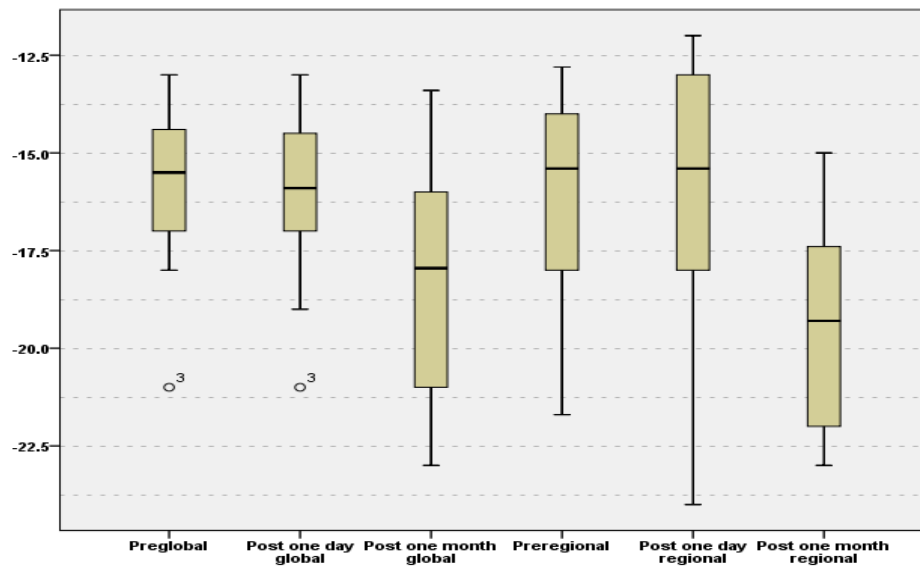
duration of follow up

Figure IV. Box plot comparison between 2D speckle tracking echocardiographic parameters before Percutaneous coronary intervention (PCI) and after PCI in chronic stable angina patients.

DISCUSSION

The current study revealed that the conventional echocardiographic parameters (Global LVEF, WMSI, RWMS according to coronary artery territory of target vessel as determined by cardiologist) measured by conventional echocardiography did not change significantly after successful PCI of the target vessel in all three studied groups of patients (STEMI, NSTEMI∕ Unstable angina, chronic stable angina).This finding may be due to the fact that these parameters are not direct measurement of improvement of myocardial function and depends on many other biological factors such as preload; afterload ;valve function, heart rate and others [48].

Our findings indicate that the speckle tracking parameters (Global Longitudinal Strain; Regional Longitudinal Strain according to coronary artery territory of target vessel as determined by cardiologist) were more effective and better reflected post PCI left ventricle myocardial function recovery than conventional echocardiographic parameters , this is in agreement with Caracciolo et al [24] study which indicate that Longitudinal strain mechanics were the primary predictors of improvement in global LV function rather than radial mechanics and LV wall thickening as determined by WMSI in patients with acute myocardial infarction treated by PCI. Also current study agreed with S. Cimino et al [49] study which indicate that

Longitudinal Strain (GLS) and Regional Longitudinal Strain (RLS) evaluation provides an accurate assessment of global LV myocardial function in patients with acute coronary syndrome where the cardiac MRI was the gold standard in that study, and the study only took into account the Longitudinal strain, where circumferential and radial strain considered not so reliable.

Our finding also agreed with Erdogan et al [50] study which revealed that in patients with chronic stable angina with chronic total occlusion followed before PCI and one month after PCI. In this study they use 3D echocardiography as the gold standard, and they found that the improvement in both left ventricle function based on 2D speckle tracking echocardiography parameters (Global Longitudinal Strain) and 3D Echocardiographic parameters (LVEF) are both correlated ,and are consistent with contrast enhanced MRI in other studies [51].

Our study showed that by speckle tracking echocardiography the significant improvement in LV systolic function in both STEMI and UA/NSTEMI patients was more significant than in patients with chronic stable angina and this may be explained that many patients of recent STEMI and UA/NSTEMI had acutely stunning myocardium, most of them had single vessel disease and the Target vessel for which PCI had been done is mostly the culprit lesion ; while in patients with chronic stable angina may had chronic stunning myocardium , have more than one vessel disease and the Target vessel where PCI had been done not necessarily the culprit lesion.

Recently Global Longitudinal Strain (GLS) included in the American society of echocardiography (ASE) Guidelines 2015 as an important prognostic parameter for evaluation of LV systolic function [44].

If our thinking for assessment of left ventricle systolic function is limited to the Ejection Fraction parameters, we may lose the options of an early diagnosis LV systolic dysfunction and recovery after revascularization. So new speckle tracking parameters facilitate a more comprehensive understanding of the pathophysiology that will allow us more efficient therapeutics.

Conflicts of interest:

There are no conflicts of interest**.**

CONCLUSION

1. LVEF is a different component to deformation parameters and two Dimensional or M-mode is not the true volume measure. Auto EF is now available and may be more reliable.

2. Speckle Tracking Echocardiography being rather objective tool to decrease eye ball effect.

3. Strain imaging is a real myocardial functional parameter and mechanics reflecting the global myocardial function and performance.

4. Two Dimensional speckle tracking echocardiographic parameters (GLS,RLS) superior to conventional two Dimensional echocardiographic parameters (LVEF,WMSI,RWMS) for monitoring of both global and regional LV systolic function recovery post PCI.

RECOMMENDATIONS

(1) Our finding can be applicable in a daily practice as every patient which planned for PCI; conventional echocardiographic parameters especially Global LVEF should be combined with Global LS before the procedure or immediately after the procedure; so that the patient can be followed in the future for the recovery of myocardial function or for the development of new ischemia or complications after PCI as an objective rather than subjective judgment.

(2) In the future more studies can be done for:

1. Judgment of the extent of myocardial jeopardy.

2. Localization of coronary territory of coronary artery lesion.

3. determination of myocardial viability in cases of acute sever Left ventricle dysfunction or chronic ischemic cardiomyopathy before attempting PCI.

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