Evaluation Of Myocardial Function In Patients With Chronic Stable Angina And Apparent Normal Ventricular Function (Tissue Doppler Study Before And After PCI)

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ABSTRACT

Background: It has been reported that impaired left ventricular longitudinal function may precede circumferential ventricular dysfunction in patients with coronary artery disease.

Objective: To determine the impact of PCI on myocardial function assessed by tissue Doppler echocardiography in patients with chronic stable angina.

Patients and methods: Twenty-five consecutive patients with chronic stable angina and preserved systolic LV function (EF % > 50%) underwent PCI were studied by pulsed wave tissue Doppler at different time intervals before and after PCI. All patients were subjected to the following: Full history and physical examination, ECG, echocardiography before PCI to evaluate baseline systolic and diastolic function as well as 1 day and 6 weeks after intervention, and pulsed-wave tissue Doppler echocardiography was done before PCI, as well as 1 day and 6 weeks after intervention to detect mitral and tricuspid inflow velocities, including E and A wave peak velocities (in centimeters per second).

Results: We found that LV systolic myocardial peak velocities improved significantly after PCI at the septal, lateral, anterior, and inferior walls of LV and insignificantly at posterior wall by tissue Doppler imaging (TDI). There was a significant increase of E’ wave, A’wave, and E’/A’ ratio at anterior angle of mitral valve annulus after PCI by TDI. The right ventricle showed significant improvement in tissue Doppler measurements of systolic function, 1 day and 6 weeks after PCI compared with baseline values (P < 0.001), while it was not detected by conventional echocardiography.

Conclusions: Tissue Doppler echocardiography is a noninvasive and widely available diagnostic technique that allows the sensitive detection of right and left myocardial dysfunction.
INTRODUCTION

The effect of PCI on systolic and diastolic function in patients with preserved baseline left ventricular systolic function is unknown. Tissue Doppler echocardiography has emerged as a sensitive and quantitative measure of both systolic and diastolic longitudinal myocardial function. (1)

Unlike conventional visual assessment of regional wall motion abnormalities, requiring subjective interpretation, tissue Doppler velocities can be quantified objectively. The potential of tissue Doppler-derived measurements in identifying ischemia has been established in different experimental and clinical settings. (2)

AIM OF THE WORK

The aim of this study is to determine the impact of percutaneous coronary intervention (PCI) on myocardial function assessed by tissue Doppler echocardiography in patients with chronic stable angina.

PATIENTS AND METHODS

- Twenty-five consecutive patients with chronic stable angina and preserved left ventricular systolic function (EF% more than 50%) and underwent for PCI were studied by pulsed wave tissue Doppler during the period from January 2010 to September 2010. Patients who had LV systolic dysfunction by echocardiography (EF% less than 50%) and patients who had a prior myocardial infarction or acute coronary syndrome were excluded from this study.

All patients were subjected to the following:

1- Full history taking with emphasis on chest pain and risk factors as DM, HTN, obesity, cigarette smoking, and history of IHD.
2- ECG was done for all patients.
3- Echocardiography before PCI to evaluate baseline systolic and diastolic function as well as 1 day and 6 weeks after intervention, and also to exclude segmental wall motion abnormalities at rest.
4- Pulsed-wave tissue Doppler echocardiography was done before PCI, as well as 1 day and 6 weeks after intervention. Myocardial tissue Doppler velocities were measured (in centimeters per second).

- Peak systolic ($S'$) velocities. (Normal Mitral valve =10.8 ± 1.4 )
  (Normal tricuspid valve =15.2 ± 1.9)
- Early diastolic ($E'$) velocities. (Normal Mitral valve = 17.7 ± 2.4 )
  (Normal tricuspid valve =15.7 ± 3.4)
- Late diastolic ($A'$) velocities. (Normal Mitral valve =10.4 ± 2.3 )
  (Normal tricuspid valve = 15.2 ± 3.4)
The sample volume was taken at: septal, lateral, anterior, posterior, and inferior angles of mitral annular ring, and also at lateral angle of tricuspid valve. (3).

In addition, pulsed-wave Doppler mitral and tricuspid inflow velocities, including E and A wave peak velocities (in centimeters per second), were obtained from the apical 4-chamber view.

5- Coronary angiography and PCI were performed in a single session at our hospital.

Aspirin 150 mg once daily, clopidogrel 300 mg oral loading dose day before PCI, then 75 mg per day and i.v., 10000 unit unfractionated heparin during PCI in addition to conventional treatment (4). The performed intervention, as well as the choice whether or not to use coronary stents, was at the treating cardiologists’ decision.

6- Patients clinically were evaluated for 6 weeks follow up period for the following:
   a) In hospital acute and sub-acute thrombosis.
   b) In hospital bleeding.
   c) Major adverse cardiac events (MACE) as, sudden death, acute myocardial infarction, repeat revascularization, and heart failure.

The statistical analysis

Data were statistically described in terms of mean ± standard deviation (± SD). Percent change between pretreatment and 6 weeks values was calculated along with the 95% CI when appropriate. Comparison between pre, 1 day post and 6 weeks post PCI was done using Friedman’s test for repeated measures with Conover test for paired (matched) samples as posthoc multiple 2-group comparisons. A probability value (p value) less than 0.05 was considered statistically significant. (5).

RESULTS

Twenty-five consecutive patients 12 men and 13 females and their mean age was 57±8 years, with normal systolic left ventricular function underwent elective PCI at our hospital were included in this study.

We found that 16 patients (64%) were diabetics, 16 patients (64%) were hypertensive, 14 patients (56%) had dyslipidemia, 9 patients (36%) were smokers (36%), and only 5 patients (20%) had a strong positive family history of IHD.

Coronary angiography and PCI data

Eighteen patients had single-vessel disease (72% of the patients), 11 (44%) of them at left anterior descending [LAD] coronary artery, 2 patients (8%) with left circumflex coronary artery disease, and only 5 patients (20%) had right coronary artery [RCA] disease, but 7 patients (28%) had two-vessel disease.

The mean value of diameter stenosis was (84.8 ± 8.4%) in comparison with normal segments of the coronary arteries.

Successful PCI were done for all significant stenotic lesions using 25 bare metal stents and 7 drug eluting stents (Cypher) (DES). The mean values of, stent diameter was (3 ± 0.5) mm, stent length was (22.5 ± 6.2) mm, and the maximum inflation pressure was (13.1 ± 1.2) atmospheric pressure. Two PTCA were done using 2 driver balloons both were (2 X 20) mm and both inflated at 14 atmospheric pressure.
There were no procedural complications and no re-interventions required during the 6 weeks follow up period.

**Conventional echocardiography results of the study, Table (1):**

There was an insignificant correlation between echocardiography measurements at baseline, and 1 day, or 6 weeks after intervention. The mean value of trans-mitral E/A ratio before PCI was (1± 0.3), while one day after PCI became (0.8± 0.2), and after 6 weeks was (0.9± 0.3) (p value > 0.05), but there was no change on the mean value of trans-tricuspid E/A ratio after PCI, and also no change on the mean value of LV EF %.

**Tissue Doppler study in Myocardial Function before and After PCI:**

1. **Diastolic function:** by sample volume at anterior mitral annulus for LV and lateral annulus of tricuspid valve for RV.fig.(2)

   - **Early and late diastolic function:**
     E’ and A’ trans-mitral velocities were improved significantly after PCI (p < 0.001) and less improved at trans-tricuspid valve. (p < 0.05).

   - **Diastolic E’/A’ ratio:**
     There was a significant improvement of E’/A’ ratio at mitral valve annulus after PCI (p<0.05), but E’/A’ ratio at tricuspid valve annulus before PCI was not improved after PCI. (P>0.05)

2. **LV and RV systolic function:**

   There was highly significant improvement of systolic peak velocities after PCI at lateral, inferior walls of LV, and lateral wall of RV (P<0.001 for each), and also improved significantly after PCI at anterior, and septal walls of LV (p<0.01), while there was insignificant improvement at posterior wall of LV (p>0.05).fig. (1)

**Comparison between area territories target by the intervention and area outside the target :**

To assess whether improvement in myocardial left ventricular function was related to revascularization, myocardial velocities before and after PCI were compared in areas targeted by the intervention with those outside the target areas of the intervention. We found a significant improvement in septal E’-wave velocities, the mean value before PCI was (8.2 ± 2.3), 1 day after PCI was (10.3 ± 2.3) and became (11.4± 2.2 cm/s) 6 weeks after intervention (P <0.05), also there was highly significant improvement of septal S wave velocities, it was (7.0 ± 1.3), 1 day after PCI( 9.9 ± 1.9 ), and became(11.6 ± 1.6 cm/s) 6 weeks after intervention( P< .0001). While there were insignificant changes at lateral E- and S waves velocities (outside target area) (p >0.05).Table (2).
Table (1) Conventional echocardiography parameters of studied patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Before PCI</th>
<th>1 day after PCI</th>
<th>6 weeks after PCI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trans mitral E-wave (cm/s)</td>
<td>76.6±26.5</td>
<td>68.6±20.9</td>
<td>70.6±16.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Trans mitral A-wave (cm/s)</td>
<td>70.3±19.4</td>
<td>74.4±20.0</td>
<td>70.7±21.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Trans mitral Mean EA ratio</td>
<td>1.0±0.3</td>
<td>0.8±0.2</td>
<td>0.9±0.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Trans mitral E-wave (ms)</td>
<td>190±42.0</td>
<td>224.8±42.0</td>
<td>214.6±53.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Trans tricuspid E-wave (cm/s)</td>
<td>55.1±13.4</td>
<td>53.0±12.3</td>
<td>51.8±11.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Trans tricuspid A-wave (cm/s)</td>
<td>62.7±16.3</td>
<td>60.1±15.6</td>
<td>58.2±15.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Trans tricuspid E-wave d (ms)</td>
<td>261.6±67.1</td>
<td>235.3±62</td>
<td>255.7±57.7</td>
<td>0.3</td>
</tr>
<tr>
<td>Trans tricuspid EA ratio</td>
<td>0.8±0.3</td>
<td>0.8±0.1</td>
<td>0.8±0.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Ejection fraction %</td>
<td>65.8±6.8</td>
<td>63.4±5.7</td>
<td>64.5±4.6</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Table (2) Comparison between areas targeted by PCI & outside target area:

<table>
<thead>
<tr>
<th>Area targeted by PCI of LAD</th>
<th>Outside target area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Septal velocities</td>
<td>Lateral velocities</td>
</tr>
<tr>
<td>E wave</td>
<td>S wave</td>
</tr>
<tr>
<td>Before PCI</td>
<td>After 1 day</td>
</tr>
<tr>
<td>8.2±2.3</td>
<td>10.3±2.3</td>
</tr>
<tr>
<td>P&lt;0.001</td>
<td>P=0.2</td>
</tr>
</tbody>
</table>
(A) S wave velocities at anterior wall of LV

P<0.01

(B) S wave velocities at inferior wall of LV

P<0.01

(C) S wave velocities at septal wall of LV

P<0.01

(D) S wave at lateral wall of LV

P<0.001

(E) S wave velocities at posterior wall of LV

(P>0.05)

(F) S wave velocities at lateral wall of RV (P<0.001)

Fig. (1) Improvement of both LV and RV systolic function after PCI
Fig. (2) Both LV & RV diastolic function before and after PCI
TDI is a promising technique in the evaluation and follow up of patients with ischemic heart disease. Tissue Doppler echocardiography has emerged as a sensitive and quantitative measure of both systolic and diastolic longitudinal myocardial function. (1).

Myocardial hibernation represents chronically impaired myocardial function, which is fully reversible upon reperfusion. (6)

The aim of this study is to determine the impact of percutaneous coronary intervention (PCI) on myocardial function assessed by tissue Doppler echocardiography, and our target also is to find out if ischemia causes impairment of longitudinal myocardial function in absence of circumferential myocardial dysfunction (normal EF%), and also to find out if after PCI and reperfusion this longitudinal myocardial impairment will improve or not.

**Effect of PCI on systolic myocardial velocities in this study:**

In our study there is high significant increase in systolic myocardial velocity S wave at inferior, anterior, septal, and lateral walls of LV, and also lateral wall of RV 1 day, and 6 weeks after intervention, while it is insignificant at posterior wall of LV. Fig. (1)

**Gerhard-Paul Diller et al,** agree with our study, they examined Twenty-four consecutive patients with chronic stable angina and preserved systolic left ventricular function underwent PCI, patients had PW-TDI and conventional echocardiography before PCI, 1day, and 6 weeks after PCI. The results of this study showed that the systolic peak velocity improved in the septal, lateral, inferior, and right ventricular areas (P < .05 for each), but insignificant trend toward an improvement in the posterior wall (P = .06) was found. (7)

**Effect of PCI on diastolic myocardial velocities in this study.fig(2):**

A) **Early diastolic myocardial velocities:**

In our study there was significant increase in early diastolic myocardial velocities trans-mitral and trans-tricuspid valves after intervention.

**Gerhard-Paul Diller et al,** agree with our study, the results of their study showed that the early diastolic velocities improved at all sites (P < .05 for each). The most pronounced improvement occurred in the septal area (7).

**Hashemi et al** agree with our result, they examined thirty patients who had single vessel disease (LAD disease), and underwent elective PCI providing that their systolic ejection fraction was > 40%. All patients had pulsed wave TDI before PCI and 48
hours and 3 months after PCI, their study showed significant increase of early diastolic E’ wave of the septal angle of mitral valve annulus. (P value < 0.05). (8).

B) Late diastolic myocardial velocities:

In our study there was also a significant increase in late diastolic myocardial velocities at LV and RV.

*Gerhard-Paul Diller et al* study as mentioned above agree with our study, their results showed increase of late diastolic myocardial velocities after PCI (7).

*Hashemi et al* study as mentioned above do not agree with our result their results showed significant increase of late diastolic A’ wave velocity of the septal angle of mitral valve annulus after PCI (P value < 0.05) (8). This is because they did select only the patient with LAD disease, while our search was done on single and also two vessels disease.

C) Myocardial diastolic E'/A' ratio:

In our study there was a significant increase of E'/A' ratio at anterior angle of mitral valve annulus after PCI. (P< 0.05) , but there was insignificant correlation between E'/A' ratio at lateral angle of tricuspid valve annulus before and after PCI.

These result was not agree with *Hashemi et al*, who showed significant increase of E’/A’ ratio of septal angle of mitral valve annulus after PCI. (P value < 0.05). (8), this is because they did select only the patient with LAD disease, while our search was done on single (LAD, RCA, and LCX) and also two vessels disease.

*Conventional echocardiographic measures in this study:*

In our study there was an insignificant relation in all conventional echocardiography measures at baseline, 1 day, and 6 weeks after intervention. Table (1).

*Gerhard-Paul Diller et al*, agree with our study that showed that Trans -mitral and trans- tricuspid flow Doppler parameters and ejection fraction failed to reflect any improvement after PCI 1 day and after PCI 6 weeks. (7).

But *Carluccio et al* was not agree with our study , who reported that left ventricular volumes and contractile dysfunction as assessed by conventional echocardiography improve  8 ± 3 months after revascularization in patients with impaired left ventricular function. (9). This is because we selected the patients with preserved systolic function, and may be due to short period follow up of our patients (6 weeks).
Comparison between area targeted by the intervention of LAD and area outside it:

In our study to assess whether improvement of left ventricular function was related to revascularization, myocardial velocities before and after PCI were compared in areas targeted by the intervention with those outside the target areas of the intervention, we found that a significant improvement in septal E'-wave velocities and septal S'-wave velocities at 1 day, and 6 weeks after intervention compared to base line, (respectively; $P <0.05$ and $P < .0001$), but there is insignificant changes were found in lateral E'-wave, and lateral S'-wave velocities(outside target area) 1 day, and 6 weeks after intervention, ($P >0.05$).

Hashemi et al., was agreed with our result, their study was done on patients had only single coronary artery disease (LAD) pulsed wave TDI was done before, 48 hours after, and 3 months after PCI, their results showed significant increase of early diastolic E’ wave ($P$ value < 0.05). (8).

Conclusions

In this study, we found that both diastolic and systolic function improved within hours after successful angioplasty, and this effect persists for $\geq 6$ weeks after intervention. This suggests that despite normal baseline cardiac function, unnoticed reduced regional contractile function is present in patients with chronic stable angina, leading to improved cardiac function after successful revascularization. Furthermore, Trans- mitral and Trans-tricuspid flow velocities as traditional measures of diastolic function failed to reflect this improvement in diastolic function.

References


4- Raymond and Bayarri. 2003: P Values are not Error Probabilities. A working paper that explains the difference between Fisher's evidential p-value and the Neyman–Pearson Type I error rate $\alpha$.


9- **Carlucio E., Biagioli P., Murrone A., et al. 2006**: Patients with hibernating myocardium show altered left ventricular volumes and shape, which revert after revascularization: evidence that dyssynergy might directly induce cardiac remodeling. *J Am CollCardiol* 47. 969-977.

### List of Abbreviation

<table>
<thead>
<tr>
<th>Subject</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>DES</td>
<td>Drug eluting stent</td>
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<tr>
<td>DM</td>
<td>Diabetes mellitus</td>
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<td>EF</td>
<td>Ejection fraction</td>
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<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
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<tr>
<td>HF</td>
<td>Heart failure</td>
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<tr>
<td>HTN</td>
<td>Hypertension</td>
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<tr>
<td>IV</td>
<td>Intra venous</td>
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<td>IHD</td>
<td>Ischemic heart disease</td>
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<tr>
<td>LAD</td>
<td>Left anterior descending</td>
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<tr>
<td>LCX</td>
<td>Left circumflex</td>
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<tr>
<td>LVEF</td>
<td>Left ventricular ejection fraction</td>
</tr>
<tr>
<td>Min.</td>
<td>minute</td>
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<tr>
<td>M.S.</td>
<td>Mill second</td>
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<tr>
<td>RV</td>
<td>Right ventricle</td>
</tr>
<tr>
<td>RCA</td>
<td>Right coronary artery</td>
</tr>
<tr>
<td>PCI</td>
<td>Percutaneous coronary intervention</td>
</tr>
<tr>
<td>TDI</td>
<td>Tissue Doppler integral</td>
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