Value of Speckle Tracking Echocardiography in the Detection of Left Ventricular Dysfunction in Heart Failure Patients with Preserved Ejection Fraction

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Abstract

Objectives: The study aimed to assess two-dimension Speckle Tracking Echocardiography (2D-STE) in discovering left ventricular (LV) dysfunction in heart failure patients associated with preserved ejection fraction early.

Patients and Methods: The study was done on fifty heart failure patients with preserved ejection fraction (HFP EF) perform the patients’ group (1) and fifty apparently healthy subjects represent the control group (2) matched in age and sex with the patients. Conventional echocardiography and 2D-STE were performed to all participants.

Results: All the conventional echocardiographic parameters showed a statistically non-significant difference in HFP EF group than the control group (P > 0.05) except left ventricular end diastolic pressure (LVEDP) which was statistically significant (P < 0.05). 2D-STE parameters showed statistical significant differences in the patient group than control group. Global circumferential strain (GCS), the mean global longitudinal strain (GLS), time to peak early diastolic strain rate standard deviation (Te-SD), time to peak systolic strain standard deviation (Ts-SD), diastolic longitudinal strain rate (Global SRe), Systolic longitudinal strain rate (Global SRs) and estimated septal time speed (E/S’) were (-21.7, -7.98, 41.6, 66.7, 0.42, -0.44, and 15.96), respectively in the HFP EF group and (-30.3, -19.8, 22.9, 32.4, 1.65, -1.15, and 7.32), respectively in the control group and showed statistically significant differences between the two groups (P < 0.05).

Conclusions: It is concluded that Speckle tracking echocardiography is proved to be more effective than conventional echocardiography in early detection of left ventricular dysfunction in heart failure patients with preserved ejection fraction.

Keywords: Global Strain, heart failure, preserved ejection fraction, speckle-tracking echocardiography, Systolic strain.
**Introduction:**

Myocardial failure may be a reason of heart failure however it can also occur in persons having semi-normal heart functions under high demand cases. Circulatory failure always results from heart failure, but the contrary is not a must case, because different non-cardiac states (e.g., hypovolemic shock, septic shock) can lead to circulatory failure in the existence of stable, mild impairment, or even excellent heart functions. To preserve the heart pumping function, blood volume, heart rate, cardiac muscle mass and cardiac filling pressure are increased by compensatory mechanisms. However, there is a gradual drop in the capacity of the heart to relax and contract despite these mechanisms which worsen heart failure. There are many causes responsible for heart failure exacerbation, so finding a definite cause is very important to use optimum therapeutic manners (Yancy et al., 2013).

Heart failure Patients with preserved ejection fraction (HFpEF) are clinically presented with signs and evidences of heart failure (HF) with classic or relative normal left ventricular ejection fraction (LVEF). Large portion of LVEF in advancing researches extend >50% as the cutoff value for preserved LVEF (Aung et al., 2017).

The cornerstone of (HFpEF) is Left ventricular diastolic dysfunction (LVDD) (Massie et al., 2008).

Patients with decreased or preserved EF have equal mortality rates. It is very important to put conclusions and suitable treatment of HFpEF as early as possible (Tadic et al., 2017).

Speckle tracking echocardiography (STE) is a firm evaluation technique to assess mechanical dyssynchrony which obtained from the simple organized unwinding and withdrawal of the myocardium (Santos et al., 2014).

New echocardiographic techniques permit the evaluation of myocardial strain. Strain can assess myocardial dysfunction which is an essential mechanical feature of the myocardium. Evaluation of strain inverts myocardial systolic function directly more than traditional cavity-established echocardiographic parameters. The conventional volume assessment-based echocardiographic parameters are indirect methods for evaluating myocardial function which are insensitive to myocardial function early
changes. Ejection fraction is the most common parameter used for evaluation ventricular function however, its evaluation represents a number of challenges and is restricted to evaluate changes in ventricular cavity size during the cardiac cycle (Tsai et al., 2011).

Myocardial disease can occur before structural myocardial changes demonstrated by conventional radiological techniques. Proper evaluation of myocardial function is very important in patients with high risk to develop severe cardiac disorder. Myocardial strain by 2D speckle tracking echocardiography has shown to be an accurate way for evaluating ventricular function in early myocardial disorder (Mor-Avi et al., 2011).

Aim of the work
The objective of this study was to estimate the value of 2D- STE in left ventricular dysfunction early detection in heart failure patients with preserved ejection fraction.

Patients and Methods
The study was done in Benha university hospital in the time from 1-3-2018 to 5-3-2019. Conventional echocardiography and 2D-speckle tracking echocardiography were done for each patient and control subject. This study was performed on 50 patients had manifestations of HFpEF represent the patients’ group (1) and 50 healthy subjects apparently used as control group (2) matched in sex and age with the patients group.

Inclusion criteria included 50 patients presented with signs of HFpEF represent the patients’ group (1) and 50 apparently healthy subjects used as control group (2) matched in age and sex with the patients group.

Exclusion criteria included Patients refusal, Heart muscle disease (severe heart failure and cardiomyopathy), Severe Valvular disease, Severe myocarditis, Significant arrhythmia, Previous pacemaker implantation and Very poor image quality. The protocol and informed consent were obtained in every subject and had been confirmed by the hospital ethics committee.

All members included in this study were subjected to:
- Informed consent: each participant has to perform written consent
- Full history taking: including smoking, hypertension and diabetes mellitus.
- General and local examinations of the heart
- Routine laboratory tests including: complete blood picture, liver functions, renal functions and lipid
profile. Determination of type B (Brain) natriuretic peptide (BNP). Many studies tried to detect the accurate value of BNP for diagnosis of HF. It had a great variability as it ranged between 100 to 450 pg/ml according to the patient age; at age of 60 years, it is 100 pg/ml and at age of 75 years it is 350 pg/ml but a BNP level of 350 pg/mL was reported as the most accurate for clinical use (Felker et al., 2006).

- 12 leads ECG
- Conventional echocardiography and speckle tracking echocardiography were done for all the participants.

**Conventional echocardiography:**

Doppler studies with Standard echocardiography were done using the ultrasound vivid seven Dimension framework (Waukesha healthcare of GE, USA, WI) provided with a 2-4 MHz organized display test. LV volumes, widths, hypertrophic LV mass, LA, LVEF, LV diastolic and volume capacity of LA were evaluated as per the ASE criteria (Lang et al., 2015).

The LV end-diastolic and systolic diameters (LVEDD and LVESD), left atrial diameter (LAD), posterior wall thicknesses, inter-ventricular septum diameter (PWD and IVSD) and LV mass index (LVMI) were estimated. LVEF was evaluated using the changed biplanes of Simpson's technique. Pinnacle late (A) and early (E) diastole speeds were evaluated on mitral valve, and their proportion was measured. The pinnacle early annular speed of mitral diastole (e') was estimated at the stages of septum annulus of mitral (e'sep) and horizontal annulus (e'lat) with an apical 4-chamber view, then E/e' proportion was evaluated. The LV end-diastolic pressure (LVEDP) was determined at (11.96 ± 0.596) (Nagueh et al.,).

**2D Speckle tracking echocardiography:**

LV strain and Strain rate are investigated by Dynamic two-dimensional ultrasound pictures of 3 cardiovascular cycles from apical 4-chamber, and two-chamber views were got at a casing average of 57-72 outlines for every moment. The images were examined using altered programming with the Echo PAC work station. The LV endocardium boundary was described physically and afterward the result consequently drew the epicardium boundary. The locales of intrigue widths were physically adjusted to coordinate the genuine limits of endocardium and epicardium. A consequently produced locale of intrigue was separated into six
sections. The LV Global longitudinal strain GLS < -16% is considered abnormal, GLS > -18% is considered normal, and GLS -16% to -18% is considered borderline, GCS is used to evaluate the reduction in the circumference of ventricular cavity, its normal value in adults is about -21% to -31% (Leong et al., 2015).

Statistical analysis:

Measurable investigations were performed utilizing SPSS variant 23.0 programming (SPSS Inc., Chicago, IL, USA). Clear informations abridged as the rate recurrence for all out factors and the mean ± standard deviation (SD) for ceaseless factors. Consistent factors between two gatherings were investigated utilizing the unpaired Mann-Whitney U-test or t-test of student, and straight out information were broke down utilizing chi-squared test or careful test of Fisher, as proper. Contrasts between different gatherings were thought about utilizing single direction investigation LSD fluctuation, rectification for the minimum noteworthy distinction. Pearson grade was applied for relationship investigation. Receiver-operating characteristic (ROC) bend examination was picked to distinguish the best parameters connected with HF side effects. Best accurate qualities were selected at the most noteworthy entirety of affectability and explicitness. Two followed likelihood (p) esteem < 0.05 was seen measurably critical. between and intra spectator fluctuation was dictated by figuring the grades of variety, which were shown as the standard deviations of contrasts between rehashed estimations isolated by the normal estimation of those estimations and communicated as rates. P-esteem deciphered in this investigation as; p1: examination between gathering 1 and 2, p2: correlation between gathering 1 and 3 and p3 examination between gathering 2 and 3, while p indicated correlation between the three gatherings.

Results

Study population:

This study included 50 patients with signs of HFpEF (group 1) with age ranged between 56 to 62 years and 50 apparently healthy subjects as control (group 2) with age ranged between 59 to 69 years. No significant differences between the two groups regarding age and sex.
Table (1): Age distribution of the studied groups

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Range</th>
<th>Mean ± SD</th>
<th>F-test</th>
<th>p. value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFpEF</td>
<td>59 – 69</td>
<td>62.40 ± 5.14</td>
<td>0.1322</td>
<td>0.172</td>
</tr>
<tr>
<td>Control</td>
<td>56 – 62</td>
<td>58.87 ± 8.73</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P > 0.05 = non-significant

Table (2): Gender distribution of the studied groups

<table>
<thead>
<tr>
<th>Gender</th>
<th>Male</th>
<th>Female</th>
<th>p. value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFpEF</td>
<td>32</td>
<td>18</td>
<td>0.414</td>
</tr>
<tr>
<td>Control</td>
<td>28</td>
<td>22</td>
<td></td>
</tr>
</tbody>
</table>

P > 0.05 = non-significant

Risk factors in the studied group

No statistical significant difference in the risk factors between the two groups except for Diabetes was more significant in group (1) than control group (2)

Table (3): Risk factors in the studied groups

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>HFpEF (n=50)</th>
<th>Control (n=50)</th>
<th>Chi square</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>N (%)</td>
<td>23 (46%)</td>
<td>21 (42%)</td>
<td>0.2287</td>
</tr>
<tr>
<td>Diabetes</td>
<td>N (%)</td>
<td>36 (72%)</td>
<td>11 (22%)</td>
<td>0.6261</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>N (%)</td>
<td>21 (42%)</td>
<td>19 (38%)</td>
<td>0.2318</td>
</tr>
<tr>
<td>Smoking</td>
<td>N (%)</td>
<td>15 (30%)</td>
<td>10 (20%)</td>
<td>0.2689</td>
</tr>
</tbody>
</table>

P <0.01 is a statistically highly signific

BNP values in the studied groups:

Regarding BNP, Group (1) showed statistical significant difference more than control group (2).
Fig. (1): BNP values in the studied groups

**Conventional echocardiography:**

There were no statistical significant differences in the conventional echocardiographic parameters between the two groups except for LVEDP was more significant in group (1) than in control group (2).

**Table (4): Comparison of conventional echocardiography of patient group versus control group**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HFP EF (n=50)</th>
<th>Control (n=50)</th>
<th>t-test</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEDD (mm)</td>
<td>52.8 ± 5.71</td>
<td>48.9 ± 4.16</td>
<td>0.122</td>
<td>0.089</td>
</tr>
<tr>
<td>LVESD (mm)</td>
<td>36.8 ± 7.33</td>
<td>33.1 ± 3.15</td>
<td>0.175</td>
<td>0.079</td>
</tr>
<tr>
<td>IVS (mm)</td>
<td>8.51 ±1.28</td>
<td>7.97 ± 0.91</td>
<td>0.097</td>
<td>0.164</td>
</tr>
<tr>
<td>LVMI (g/m²)</td>
<td>72.9 ± 18.5</td>
<td>69.7 ± 11.1</td>
<td>0.206</td>
<td>0.069</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>59.2 ± 5.23</td>
<td>61.1 ± 5.17</td>
<td>0.248</td>
<td>0.062</td>
</tr>
<tr>
<td>LVEDP&lt;sub&gt;echo&lt;/sub&gt;</td>
<td>26.1 ± 3.33</td>
<td>11.5 ± 1.71</td>
<td>12.35</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

*P <0.05 statistically significant.

LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; LVMI, left ventricular mass index; LVEF, left ventricular ejection fraction; LVEDP, left ventricular end diastolic pressure; IVS, interventricular septum.
2D Speckle tracking echocardiography:

There were more statistical significant differences as regard 2D-STE parameters in group (1) than control group (2).

Table (5): Comparison of LV function between groups by 2D-STE in mean ±SD

<table>
<thead>
<tr>
<th></th>
<th>HFpEF (n=50)</th>
<th>Control (n=50)</th>
<th>t-test</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Te-SD (ms)</td>
<td>41.6 ± 15.4</td>
<td>22.9 ± 6.8</td>
<td>9.524</td>
<td>0.001*</td>
</tr>
<tr>
<td>Ts-SD (ms)</td>
<td>66.7 ± 15.5</td>
<td>32.4 ± 11.7</td>
<td>12.65</td>
<td>0.000*</td>
</tr>
<tr>
<td>GLS (%)</td>
<td>-7.98 ± 2.65</td>
<td>-19.8 ± 3.15</td>
<td>4.851</td>
<td>0.011*</td>
</tr>
<tr>
<td>GCS</td>
<td>-21.7 ± 5.91</td>
<td>-30.3 ± 3.25</td>
<td>3.982</td>
<td>0.016*</td>
</tr>
<tr>
<td>Global SRs (1/s)</td>
<td>-0.44 ± 0.23</td>
<td>-1.15 ± 0.19</td>
<td>3.566</td>
<td>0.032*</td>
</tr>
<tr>
<td>Global SRe (1/s)</td>
<td>0.42 ± 0.16</td>
<td>1.65 ± 0.41</td>
<td>5.025</td>
<td>0.009*</td>
</tr>
<tr>
<td>E/S’ (cm/s)</td>
<td>15.96 ± 2.92</td>
<td>7.32 ± 2.30</td>
<td>3.864</td>
<td>0.028*</td>
</tr>
</tbody>
</table>

*P <0.05 = statistically significant. GLS, Global longitudinal strain; GLS, Global circumferential strain; Te-SD, standard deviation of time to peak early diastolic strain rate; Ts-SD, standard deviation of time to peak systolic strain; SRs, systolic longitudinal strain rate; SRe, diastolic longitudinal strain rate. E/S’ (cm/s), estimated septal time speed.
Fig. (3): Two-dimension speckle tracking echo findings in the studied groups.

Fig. (4): Receiver-operating characteristic (ROC) curve analyses of 2D-STE parameter (GLS) for diagnosis of heart failure. AUC: area under the curve.

AUC = 0.852
95% CI: 0.827 - 0.936
P < 0.001
**Discussion**

Heart failure with preserved LVEF is a clinical disorder where patients have side effects and indications of heart failure, ordinary or close typical LVEF, typical or close typical LV volume, and proof of diastolic dysfunction (Aung et al., 2017).

Noninvasively, blood stream Doppler and tissue Doppler evaluations can be utilized. The proportion of E, early mitral valve stream speed, to E’, early tissue Doppler extending speed (E/E’), has been recommended as the best parameter for deciding LV filling weight (Paulus et al., 2007).

Whenever E/E’ is more prominent than 15, raised LV filling weight is built up, and HFpEF can be analyzed, while an E/E’ of under 8 rejects a raised LV filling weight. At the point when the E/E’ is in the marginal zone of >8 to <15, more parameters are expected to affirm the analysis (Aung et al., 2017). Using GLS with other parameters (E/e’, E/A, LAVI) and biomarkers, for example, BNP could essentially build up the finding of HFpEF (Tadic et al., 2017).

This study was conducted on 50 patients presented with signs of HFpEF represent the patients’ group (1) and 50 apparently healthy subjects used as control group (2) matched in age and sex with the patients group. It has been found in this study that there was a statistically non-significant difference between the two groups regarding age and sex (P >0.05).

In this study, there were no significant differences between the two groups as regard cardiac risk factors (hypertension, dyslipidemia and smoking) except diabetes mellitus as it was significant (P <0.05).

In contrast with this study, Liu et al. (2018) found fundamental reasons for HFpEF, including hypertension, diabetes mellitus, and dyslipidemia.

In this study, conventional echocardiographic parameters (LVEDD, LVESD, IVS, LVMI, and LVEF) were not statistically significant in comparing between HFpEF and control groups (P > 0.05), while only LVEDP showed a statistically significant difference (P <0.01).

Agreeing with these results, Wang et al. (2012) stated that left ventricular diastolic dysfunction (LVDD) parameters were not special to patients with HFpEF and happened also in HFrEF.

Opposing these results Paulus et al. (2007) stated that LV unwinding,
filling, diastolic dysfunction, and diastolic firmness can be obtained obtrusively, and considered as distinct proof of HFpEF.

In contrast to conventional echocardiography, 2D-STE parameters: Te-SD, Ts-SD, GLS (%), GCS, Global SRs (1/s), Global SRe (1/s) and E/S’ were between statistically significant (P <0.05) and highly statistically significant difference (P <0.01) in HFpEF patients than controls.

In this study, both global longitudinal strain (GLS) and global circumferential strain (GCS) were diminished in HF patients. There were statistically highly significant values (P <0.001) between them and the control group. This was concordant with Kraigher-Krainer et al. (2014) who expressed that GLS and GCS decreased in HFpEF.

**Conclusions**

Speckle tracking echocardiography is proved to be more effective than conventional echocardiography in early detection of left ventricular dysfunction in heart failure patients with preserved ejection fraction.

**Study limitations**

The limited follow-up period beside the low sample size were the most important study limitations.

**References**


5. **Hadano Y, Murata K, Yamamoto T. et al.** Usefulness of mitral annular velocity in predicting exercise tolerance in patients with


