Introduction

Heart failure (HF) is still globally distributed with raising prevalence reaching to more than sixty millions[1]. patients with severe phases are high in number and echocardiographic derived ejection fraction (EF) is still the main parameter in assessment these patients[2].

Although EF is easy measure and applicable and familial to doctors of different degrees, still there are several limitation regarding, its dependence on resolution of echo views besides its affected afterload and preload[3]. Also there are inter and intraobserver variation[4].

parameter derived from echocardiographic measurement of LV stroke volume by continuity equation that is derived by pulsed Doppler measurement of integral time LV out flow velocity with diastolic assessment by measuring Mitral valve E/e` that reflects the LV end diastolic filling pressure,and blood pressure also incorporated in the measurement, so, this index reflects LV systolic and diastolic state[5]. LVSWI.

Several trials and studies in order to get simple valuable and rapidly measured parameter that can reflect functional state of the heart with high accuracy[6], one can conclude that it reflects ventriculoarterial coupling and so it seems more informative than LVEF[7]. The prognostic effect of stroke volume index (SVI) and the filling-pressure of LV which are measured invasively in MI and shocked patients with cardiac cause so this gave the possibility of assessing these measures noninvasively in HF patients[8-13].

several previous studies assess LVSWI which reflects the diastolic and systolic performance of LV depending on echo pulsed Doppler in measuring SV, this index is superior to EF[14,15], We suggest to measure SV by volumetric measures by assessing end diastolic and end systolic volumes of LV determined by 2D and 3D derived echocardiography and then to determine whether a low LVSWI, as to reflect the severity of cardiac dysfunction.

Aim of the study: Role of left ventricular stroke work index in assessment the cardiac dysfunction in heart failure patients, by different echocardiographic modalities (2D and 3D modalities).

Materials and methods

Subjects: This cross sectional study was achieved in Marjan Teaching hospital in Hilla city –Babylon province. From 2022 to the 2023. Fifty patients with congestive heart failure were included in this study, with mean age and SD (63±6) years. Ethical approval was granted by the Ethics Committee at the University of Babylon College of Medicine, and verbal consent was obtained from the participants.

-Echocardiogrphy: echocardiographic assessment was done by VIVID 9 GE, with a 3.5-MHz transducer for 2D measures and matrix transducer for 3D assessment.

Methods: After taking history and information regarding age, Wt and Ht so as to calculate BSA according to following equation[16]:

$$BSA = \sqrt{Ht(cm)} \times Wt(Kg)/3600$$

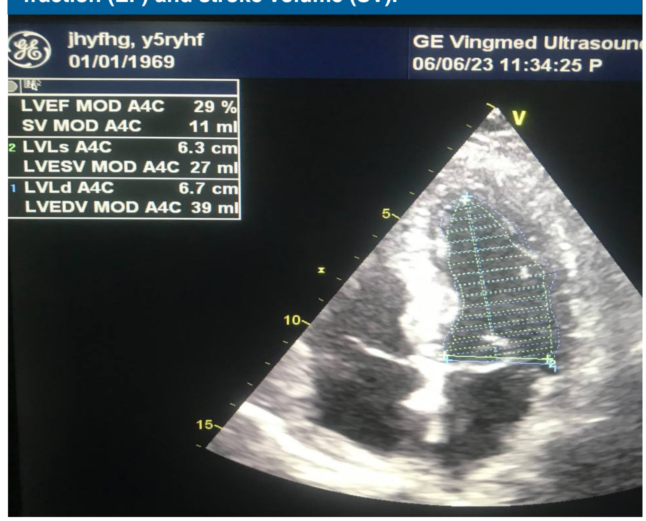
Mean blood pressure is obtained from the following equation:

MBP= Diastolic BP+1/3 Pulse pressure

After putting the ECG electrodes at patient chest, 2D Echo assessment is done to each patient.

-EF: by modified 2D-Simpson method: patient lying on his left lateral position and by apical windows acquisition, so by manual tracing the endocardium of LV at end diastolic volume (LV EDV) with exclusion of trabeculation and papillary muscles, then by the same maneuver tracing the end systolic volume (ESV), stroke volume is calculated automatically by taking the difference between the EDV and ESV, EF is equal to SV divided by EDV[17]. Figure 1

Figure 1. 2D –echocardiographic assessment of ejection fraction (EF) and stroke volume (SV).

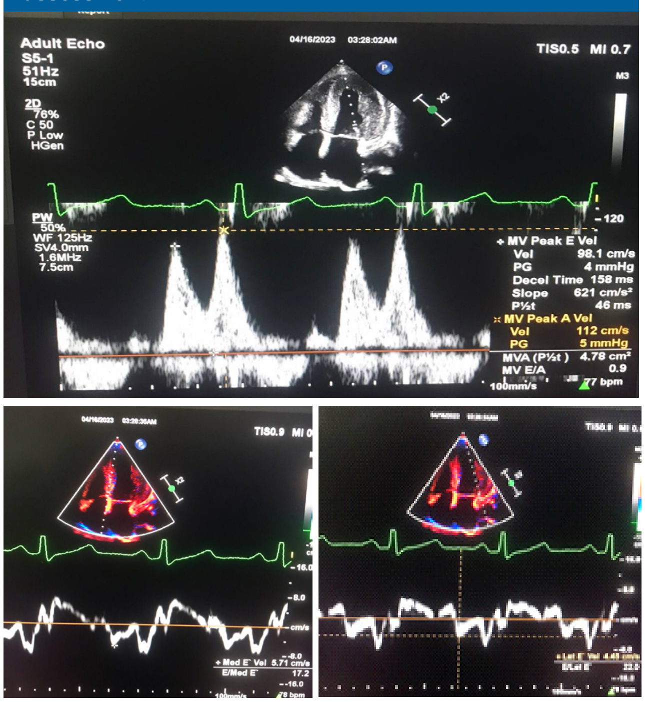


Three-dimensional analysis of left ventricular volumes was performed using the 4D Auto LVQ software. Volumetric assessment by 3D echo was taken by multi-beat modality, so needs that the patient hold his breath and the 4D transducer is fixed in order to avoid stitch artifact. by fixing the apex of LV and middle mitral annular plane, the 4D software will automatically measure EDV, ESV, SV and EF, although 4D echo assess these volumes by auto-method, we can help in tracing endocardial borders and cut any trabeculation and the papillary muscle[18]. Figure 2

Figure 2. 3D –echocardiographic assessment of ejection fraction (EF) and stroke volume (SV).

Diastolic LV function assessed by pulsed Doppler technique by placing the cursor at tip of mitral valve and by applying the pulse Doppler, early(E) and late (A) mitral flow will be obtained. tissue Doppler was used so by placing the cursor at medial and then the lateral MV annulus to get the e` of medial and lateral one and then taking the mean of E/e` of lateral and medial. Figure 3

Figure 3: left ventricular diastolic function assessment by a.E/A ratio of mitral valve flow, b and c TDI for assessment of medial and lateral mitral valve annulus velocity and E/e` assessment.



The mitral E/e′ ratio was used for assessment of LV end-diastolic pressure (LVEDP) using the formula LVEDP=4.9+(0.62×mitral E/e′ velocity ratio)[15].

LVSWI was intended by the formula
0.0136×[SVI×(MAP–LVEDP)][15]

Pearson Correlation coefficient was used to study the correlation of LVSWI and LV systolic parameters 2D and 3D -EF.

Results

This cross sectional study involved fifty patients diagnosed with congestive heart failure, mean age of the patients was 60±7, other demographic data and echocardiographic measures were demonstrated at table 1, data expressed as mean±SD.

Parameters	Mean±SD
Age(yr)	60±7
weight	79.8±10
height	169.8±5.81
BSA (cm2)	1.89±0.077
E/e`	12.8794±4.23
mBP	89±2.2
SVI(2D)	29.42903±10.06
SVI(3D)	21.6092±8.84
LVSWI(2D)	30.58±11.43
LVSWI(3D)	22.51±9.72
EF(3D)	35%±2.4
EF(2D)	38%±9.1

Correlation study between LVSWI-2D with 2D-EF revealed a positive correlation but statistically not significant (r= 0.23, p= 0.1) figure 4.

A positive Correlation of LVSWI-2D with 3D-EF, but also statistically not significant (r= 0.117, p= 0.412) figure 5.

Correlation study between LVSWI-3D with 2D-EF revealed a positive correlation which is statistically significant (r= 0.315, p= 0.021) figure 6.

A positive Correlation of LVSWI-3D with 3D-EF, also statistically highly significant (r= 0.413, p= 0.003) figure 7

Figure 4. Correlation study between 2D –echo derived Left ventricular stroke work index and 2D echo derived ejection fraction (2D-EF).

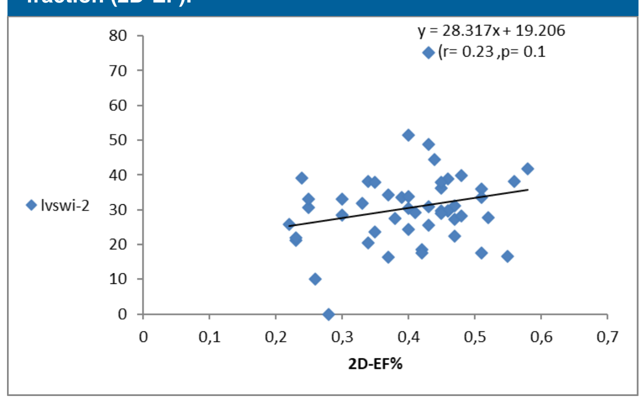


Figure 5. Correlation study between 2D –echo derived Left ventricular stroke work index and 3D echo derived ejection fraction (3D-EF).

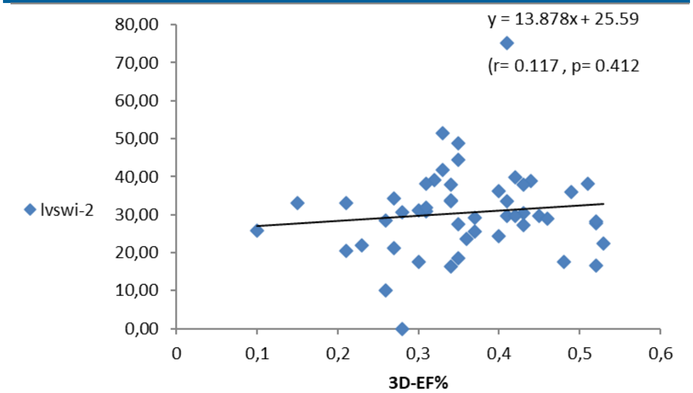


Figure 5 Comparison between 2D –echo derived Left ventricular stroke work index (2D-LVSWI) and 3D –echo derived Left ventricular stroke work index (3D-LVSWI).

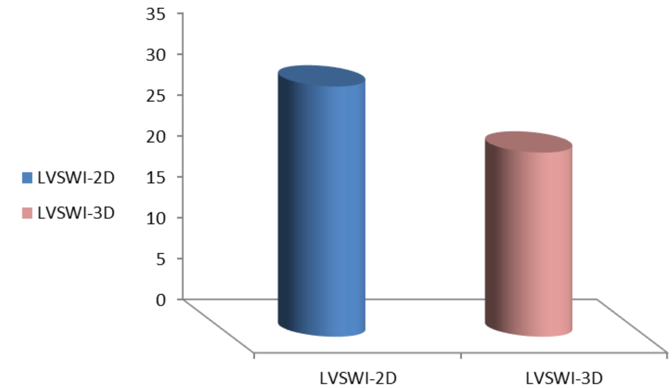


Figure 6. Correlation study between 3D –echo derived Left ventricular stroke work index and 2D echo derived ejection fraction (2D-EF).

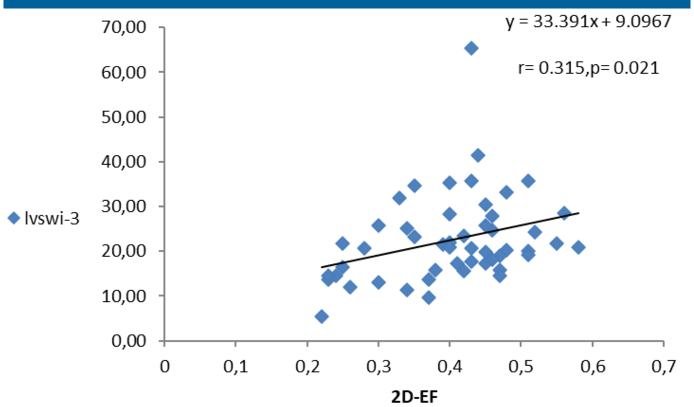
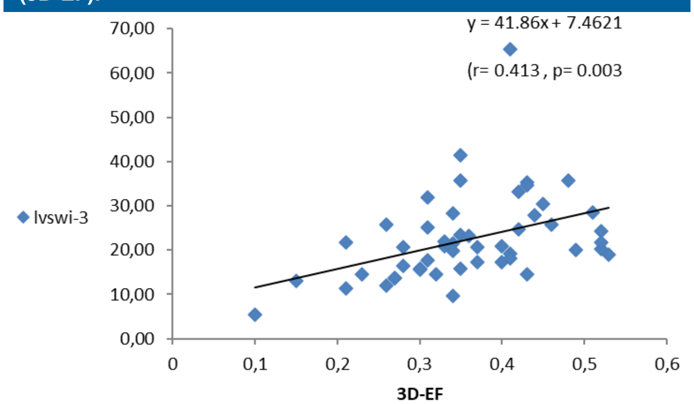


Figure 7. Correlation study between 3D –echo derived Left ventricular stroke work index and 3D echo derived ejection fraction (3D-EF).



Comparison between 2D-LVSWI and 3D-LVSWI showed statistically significant difference with higher value of 2D-LVSWI (p=0.000), figure 5.

Discussion

The left ventricular stroke work index (LVSWI) is a measure of integrated left ventricular systolic and diastolic function that can be calculated noninvasively using Doppler echocardiography based on the left ventricular outflow tract velocity-time integral (LVOT-VTI), mitral E/e′ ratio, and blood pressure, jacob[5].

Measurement of stroke volume depending on Doppler measurement of LVOT-VTI are affected by several factors like the heart rate and after load condition , besides SV measured by this method could be subjected to error if LVOT diameter over or underestimated (SV= 0.685 *LVOT-D^2* LVOT-VTI), So in this study SV was measured by volumetric measurement of LV-EDV and LV-ESV by 2D and 3D modalities .

Correlation study between 2D and 3D echocardiographic derived LVSWI showed a positive correlation with EF (measured by 2D and 3D echocardiography), A lower SVI reflects deterioration of LV systolic function so the more reduction of SVI is associated with more reduced EF. Diastolic dysfunction is the condition in which the relaxation process of the heart is disturbed with increase stiffness of LV, in those patients with heart failure with subsequent increases in LV end diastolic pressure and this is reflected by the increase of E/e` ratio. This is in line with other studies finding that revealed A lower SVI has been associated with bad prognoses in shocked patients with cardiac pathology (this was measured by invasive method), same finding when measured by non-invasive method in HF-patients[6,12]. These explained with deterioration of shock-stage this is accompanied by reduction of SVI and raising in E/e`, so the worse systolic and diastolic LV performance and so the lower LVSWI[12].

Jentzer JC et al., evaluate LVSWI in patients in ICC to assess the death rate among patients with MI, HF, and shocked patients with underlying cardiac pathology, they depends on pulsed Doppler TTE to assess the stroke volume[19]. .J. Kanelidis and colleague found that Low LVSWI in patients with left ventricular assist devices is associated with poor prognosis and increased hospitalization of HF patients and increased death rate[20]The other important finding of this study that 3D-derived LVSWI is more significant in its correlation with EF, especially 3D derived EF, this could reflect the valuable role of 3D echo in assessment LVSWI because three-dimensional echo does not require geometric assumptions, it is felt to be the optimal way of measuring LVSWI and LVEF using echocardiography. LVEF measured by 4D echo modality is three dimensional with no need for geometric assumption as that in case of 2D echocardiography, previous study showed that 3D echo measures are more precise than other echo modalities and more correct volumetric estimation[21].

So by comparison between LVSWI measured by 2D echocardiographic modality with that measured by 3D echo showed that 2D-LVSWI is higher than 3D-LVSWI , this difference could be explained by several studies that showed that LV EDV and ESV are underestimated by 3D-echocardiography in comparison with 2D echocardiography due to inclusion of LV trabeculae and papillary muscles within the cavity[18], besides the problem in obtaining apical chamber views with true apex without foreshortening in case of 2D-imaging .

Conclusion: 2D,3D echo derived LVSWI is simple and reproducible and can reflect LV systolic and diastolic grade in HF patients as routine echocardiographic assessment involves SV and mitral E/e′ ratio, it is easy to measure LVSWI which reflects the global function of LV and it is more informative than LVEF.

3D assessment has a valuable role than 2D-echo LVSWI, so it seems better if we intended to measure LVSWI to depend on 3D echo modality.

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