Is there a Relation between Left Ventricular Ejection Fraction by conventional Simpson's method and Systolic Myocardial Velocity by Tissue Doppler in Heart Failure Patients?

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Abstract

Background: Heart failure is a condition of high morbidity and mortality and its incidence is increasing with the aging of the population. Echocardiography parameters have been shown to correlate well with left ventricular (LV) systolic function.

Aim: This study sought the correlation between systolic myocardial velocity (Sm) obtained by Tissue Doppler imaging (TDI) and left ventricular ejection fraction (LVEF) measured by conventional Simpson's method in patients with heart failure.

Method: This study involved 85 patients with heart failure whose LVEF < 50% (mean age 58 (11) years), with LV EF measured by conventional Simpson's method correlating with average Sm measured at septal, lateral, anterior and inferior side of mitral annulus by tissue Doppler echocardiography.

Results: The mean age of the 85 patients in the study was 58.48 (11) years, with 11 (12.9 %) female; 74 (87.1%) male. The mean LVEF was 33.53 (9.94). A significant correlation was detected between systolic mitral annulus velocity Sm and LV ejection fraction EF (R: 0.609, p: 0.000). LV mean Sm obtained by TDI is a parameter that is easily obtained and practical, and can be used to evaluate LV systolic function in patients with HF.

Conclusion: The assessment of average systolic myocardial velocity (Sm) could be used as an alternative to LVEF. This approach may be useful especially when the image quality is poor and maintains high accuracy in prediction of LV systolic dysfunction.

Key words: Systolic function, myocardial velocities, ejection, fraction

Background

Heart failure is a condition of high morbidity and mortality and its incidence is increasing with the aging of the population(1). Left ventricular ejection fraction (LVEF) is the most widely used index to assess cardiac function in clinical studies(2). This is especially due to the lack of an ideal measure of cardiac contractility, as its measurement and understanding are relatively easy, LVEF has remained the most commonly used index. Although LVEF measurement has some prognostic value in certain situations, it is influenced by preload, post load, heart rate, myocardial contractility and dyssynchrony (2).

The distribution of myocardial fibers is not uniform throughout the LV wall. The bundles of subendocardial and subpericardial muscles are arranged longitudinally, while the fibers located in the middle of the wall are aligned circumferentially. This group of muscle fibers is primarily responsible for LV radial axis contraction (3). On the other hand, the longitudinal contraction of the cardiac muscles plays an important role in the pump function of the ventricles(4,5). As the fibers of the longitudinal axis at the heart base correspond to the atrioventricular ring, changes in the longitudinal axis can be measured by the movement of the atrioventricular ring(3).

Longitudinal systolic function of the myocardium can now be evaluated by tissue Doppler imaging (TDI). TDI is a new echocardiography technique that enables the evaluation of the global and regional LV longitudinal functions by the analysis of systolic and diastolic myocardial velocities obtained from mitral annuli and is not affected by the quality of the images or the geometric shapes of the left ventricle (6,7). In recent years, systolic myocardial velocity (Sm) obtained by TDI has been suggested to be an alternative method in the assessment of systolic myocardial functions of various cardiac diseases(8-15) and a cutoff value of (S') greater than 7.5 cm/s had a sensitivity of 79% and a specificity of 88% in predicting normal global function of LV(13).

Objective

The objective of this study was to see whether the assessment of myocardial systolic velocity Sm (average) can be used as an alternative to ejection fraction obtained by Simpson's method. The advantage of this approach is that Sm is not dependent on image quality and therefore could apply to subjects with poor image quality.

Patients and methods

The study enrolled 85 patients with heart failure who presented to Algamhouria Teaching Hospital and private clinic between January 2016 and July 2017 with signs and symptoms matching the European Society of Cardiology Clinical Practice Guidelines for Heart Failure(16). The study was approved by the local ethics committee Faculty of Medicine and Health Sciences, University of Aden (REC-31-2018).

Resting ECGs of the patients were obtained and echocardiographic examinations were performed on all patients. Exclusion criteria included inadequate visualization, severe renal failure, congenital heart disease, cor pulmonale, atrial fibrillation pacemaker and valvular diseases, LVEF ≥ 50%.

Echocardiography evaluation

All echocardiography examinations were performed by an experienced cardiologist using standard protocol, using ALPINUN medical system E-CUPE 9 echocardiography machine with a 3.5 MHz transducer. Echocardiographic parameters were measured according to the American Society of Echocardiography(17). Values for each parameter were obtained by one examiner averaging measurements from three successive cardiac cycles. Left ventricular ejection fraction was measured by 2D echocardiography obtained by modified Simpson's method from apical four- chambers view. Pulsed-wave TDI was performed by activating the TDI function in the same echocardiographic system. A 3.5 mm sample volume was used. In the apical four-chamber view, the TDI cursor was placed at the septal and lateral side of the mitral annulus in such a way that the annulus moved along the sample volume line. In the apical two-chamber view, the TDI cursor was placed at the anterior and inferior side of the mitral annulus in the same manner. Sm was measured at each segment and final LV mean Sm value was represented as the average of four sites (Figure1).

Statistical analyses

Data were analyzed using the Statistical Package for the Social Sciences version 20 for Windows statistical software program (SPSS, Chicago, USA). Numeric variables were expressed as mean (±SD). Category variables were expressed as percentage. The Pearson correlation coefficient was used for analysis of linear correlation between variables. A P-value < 0.05 was considered statistically significant.

Results

The mean age of the 85 patients in the study was 58.48 (11) years, 11 (12.9 %) female; 74 (87.1%) male. Of these patients, 56 (65.9%) were hypertensive, 37 (43.6%) were diabetic, 70 (82.4%) had a history of CAD and 61 (71.8%) had dyslipidemia. The mean LVEF was 33.53 (9.94).

Demographic characteristics, 2D echocardiography and TDI parameters for the patients with HF are given in Table 1.

LVEF and Sm values were found to be lower in patients with HF, a stronger correlation was detected between LVEF and Sm (R = 0.609, P < 0.0001) (Figure 2). The time required to obtain LV average Sm was shorter than the time required calculating LVEF by Simpson's method.

Figure 1: Recording of myocardial velocities by TDI from mitral annuli

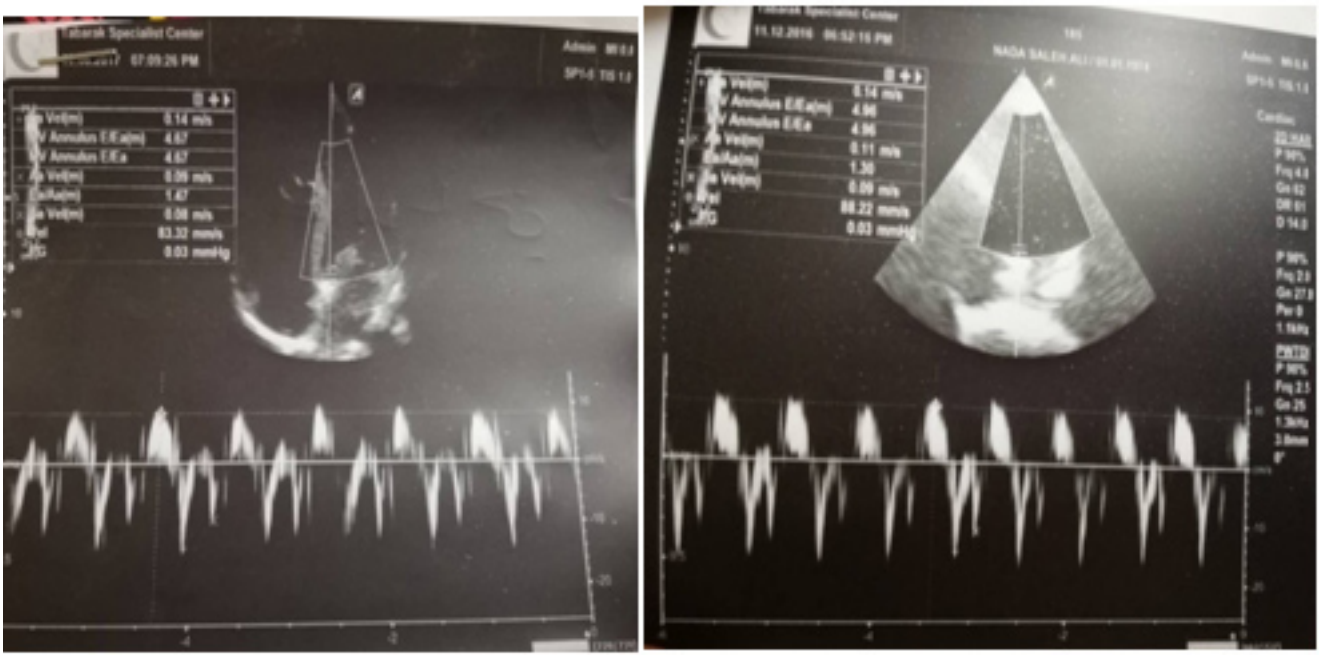
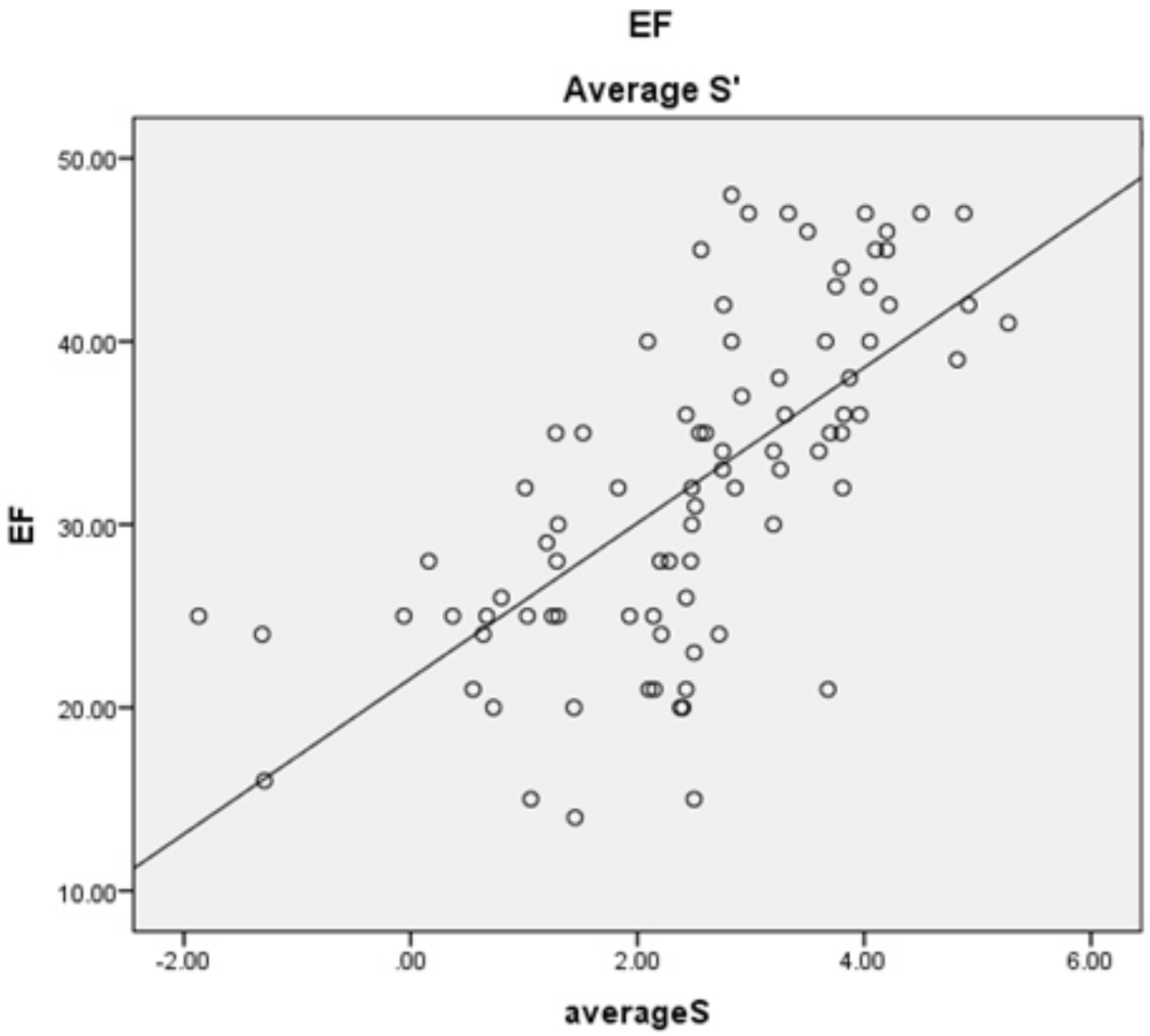


Table 1: Demographics and Echocardiography Data

Variables	Study sample (n = 85)
Age (years)	58.48 (11)
Males	74 (87%)
Females	11 (12.9%)
Cause of heart failure	
Ischemic	70 (82.4 %)
Non-ischemic	15 (17.6 %)
HT	56 (65.9%)
DM	37 (43.6%)
Dyslipidemia	61 (71.8%)
LV ejection fraction	33.53 (9.94)
LV average Sm (cm/s)	2.67 (1.43)

HT = hypertension; DM = diabetes mellitus; LVEF = left ventricular ejection fraction.

Figure 2: Correlation between LV average Sm and LVEF in patients with heart failure. LVEF = left ventricular ejection fraction; Sm = systolic myocardial velocity



Discussion

This study is the first of its kind in Yemen that evaluates the relation between EF and Sm or the prediction of EF by Sm in patients with heart failure. Spectral TDI could be used as an alternative examination when EF is difficult to assess due to poor image. The study demonstrated a simple quantitative approach to predicting EF using Sm (average) from spectral TDI.

This study found a strong correlation between the two parameters EF and Sm in patients with HF. In daily clinical practice, LV systolic function are mostly evaluated by ejection fraction, which is calculated according to modified Simpson's method, but this method is largely dependent on the quality of images and LV geometric shapes and is therefore technically difficult in patients with poor image quality. TDI method is clinically useful due to the minimal dependency of Sm on the image quality. In contrast, EF demonstrates strong dependency on the visibility of the endocardial contour when using Simpson's method and reported to be impossible in an about half of the patients with acute myocardial infarction due to poor image quality(18). Moreover, the calculation of LVEF by this method is time consuming and has a high inter and intra-observer variability (19).

The longitudinal contraction of the cardiac muscles plays an important role in the pump function of the ventricles (4, 5). Longitudinal systolic function of myocardium can now be evaluated by TDI. TDI is a recent technique that allows better assessment of regional and global LV functions by the quantification of myocardial velocities, thereby providing a new way of assessing LV function (20). Assessment of cardiac function by TDI may be more sensitive than traditional methods (6,7). Thus, Sm obtained by TDI has been suggested to be an alternative method in recent years in the assessment of systolic myocardial functions of various cardiac diseases (8-15). In the studies so far, it has been demonstrated that in mixed groups, there has been an agreement between Sm derived from PWD-TDI or color Mmode TDI and LVEF obtained by radionuclide or echocardiographic Simpson's method (8,15).

In the studies conducted in patients with HF, a strong correlation was found between Sm and LVEF (21, 22). A study done by Duzenli et al, including a large number of patients, evaluated the correlation between LVEF derived by modified Simpson's method and Sm obtained by TDI, found a strong correlation in patients with HF (23).

It was reported that in patients with HF, it has been shown that Sm is decreased in parallel to LVEF (24,25). In HF circumferential dysfunction, as well as longitudinal myocardial dysfunction, can account for the strong correlation between Sm and LVEF in these patients.

The result of this study suggests that in patients with HF in whom the measurement of LVEF is suboptimal because of poor acoustic windows and distorted LV geometry, Sm may be a valuable parameter to select an optimal therapy (pharmacological therapy, cardioverter-defibrillator implantation, etc).

The findings from this study suggest that since Sm is not affected by the quality of the images or geometric shape and is more practical, it can be an alternative parameter to EF in identifying patients with abnormal LV systolic function in patients with HF.

Limitation

One important limitation of this study was that the results were not valid for patients with preserved EF and normal subject. Another limitation was the lack of subgroups with atrial fibrillation, conduction abnormalities, pacemakers and prosthetic valves, therefore we could not make any inferences about these specific conditions.

Conclusion

LV myocardial systolic velocities Sm (average) obtained by TDI, a parameter that is easily obtained and practical, can be used to evaluate LV systolic function in patients with HF. The prediction of EF by Sm (average) is a simple method and not time consuming.

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