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Mitral annular plane systolic excursion (MAPSE) and tissue Doppler imaging systolic velocity (TDI S'): Surrogates of left ventricular systolic function

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Abstract

Echocardiography is a valuable method for assessing structural diseases of the heart. Mitral annular plane systolic excursion (MAPSE) and tissue doppler imaging systolic velocity (TDI S') are reproducible assessments of longitudinal heart changes. In cases of sub-optimal echocardiographic imagery caused by artefacts or air trapping, left ventricular ejection fraction (LVEF) may be challenging to assess accurately. The index study determined the relationship between MAPSE, TDI S', and LVEF. It assessed the utility of MAPSE or TDI S' as surrogates to LVEF in determining LV systolic function.

One hundred patients referred for echocardiography at the cardiac laboratory of Delta State University Teaching Hospital, Oghara, Nigeria, were recruited for the study. All patients had trans-thoracic echocardiography done. M-Mode, 2D and Spectral Doppler, and Tissue Doppler echocardiographic images were acquired.

The prevalence of abnormal left ventricular systolic function was 13%, 24% and 28% as determined using LVEF, TDI S' and MAPSE. MAPSE had a higher specificity than TDI S' with statistically significant correlations found between TDI S' ($p<0.001$), MAPSE ($p=0.032$) and LVEF. Multiple linear and binomial logistic regression analysis showed significant relationships (beta=0.423; $p<0.001$) and odds ratio [OR (CI) = 10.80(2.56- 49.07)] respectively between TDI S' and LVEF.

MAPSE's specificity allows for the diagnosis of longitudinal heart functional changes even in cases where the LVEF may be within normal limits.

A combination of both MAPSE and TDI S' offer a greater prognostic significance and can serve as surrogates for LVEF in assessing left ventricular systolic function and prognosticating cardiac disease.

Keywords: Sub-optimal Echocardiography; LV Systolic Function; Longitudinal heart function, MAPSE, TDI S'

Introduction

Echocardiography has become a valuable method for assessing structural diseases of the heart over the past few decades. It is known to explain the heart's structure and functions [1, 2]. Modern-day echocardiography has Doppler assessment routinely incorporated [2]. Before now, the contractile function of the heart was assessed mainly using the left ventricular ejection fraction (LVEF) [3], and fractional shortening. LVEF assesses the fraction of blood ejected from the heart during the systolic phase of the cardiac cycle. These parameters can be measured using M-Mode echocardiography [4]. Tissue Doppler imaging can also be used to assess the systolic function of the heart. It is a more sensitive method for assessing contractile and relaxation properties of the left ventricle [5].

Other echocardiographic parameters have been shown to correlate significantly with left ventricular systolic function. They include mitral annular plane systolic excursion (MAPSE) and tissue Doppler imaging systolic velocity (TDI S'). The complexity of the mitral annulus has been noted in various studies and its usefulness in assessing left ventricular function [6].

It has been shown from existing evidence that assessing the longitudinal function of the heart using MAPSE is more reproducible and less error-prone than using it for radial myocardial function assessment [7]. The S' velocity using tissue Doppler imaging is also known to be independent of loading conditions of the heart as opposed to regular 2D echocardiographic assessment, which is more subject to haemodynamic changes [6].

In some instances, it may appear challenging to assess left ventricular systolic function using M-Mode or 2D assessment, mainly due to suboptimal echocardiographic images caused by air trapping and artefacts. Therefore, using simple tools like MAPSE or TDI S' velocity to assess left ventricular systolic function may help circumvent this challenge. It will also be relevant to determine which surrogate (MAPSE and TDI S') correlates better with left ventricular ejection function (LVEF). However, limited data is available on MAPSE and TDI S' as surrogates of LVEF in Nigeria. Therefore, the index study aimed to determine the relationship between MAPSE, TDI S' and LVEF as left ventricular systolic function parameters.

Methodology

This study was carried out in the Cardiology unit of Delta State University Teaching Hospital (DELSUTH), Oghara, Nigeria. The hospital is main tertiary health institution in Delta State. It receives referral cases from within the State and from neighboring States (Edo, Bayelsa and Anambra).

The study was descriptive and cross-sectional in design. Informed consent was obtained from each patient that participated in the study. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki. Ethical approval was given by the Health Research Ethics Committee of DELSUTH before the study commenced.

A total of one hundred (100) adult patients visiting the cardiology clinic with varying indications for echocardiography were recruited consecutively for the study. All patients had a transthoracic echocardiogram (Xario diagnostics ultrasound system model SSA-660A, Toshiba Medicals) with ECG gating performed according to established recommendations.

The M-mode, two-dimensional (2D) and spectral Doppler and tissue Doppler echocardiographic images were acquired from standard echocardiographic views (parasternal, apical and subcoastal) with subjects in the left lateral decubitus position. The left ventricular ejection fraction was calculated automatically by the echocardiograph machine in all patients. Displacement of the mitral annulus (average of the lateral and septal annulus) was measured in millimeters (mm) by apical 4 chamber view. The average MAPSE ranges between 12 and 15mm [13].

TDI S' of the mitral annulus was taken from the apical 4 chamber view average values of the septal and lateral S velocity, normal range 9.2 (+/- 1.7) cm/sec [26]. The following measurements were made from the recordings: Peak Systolic Velocity (Sm), Early (Em) and Late (Am) diastolic velocities [6].

Calculation of LV systolic Function

A cardiac ejection fraction was calculated automatically by the echocardiograph machine in the subjects using the Two-dimensional (2-D) guided M-mode linear method (teichholz) and calculated thus;

$EF = LVIDd^3\text{-}LVIDs^3/LVIDd^3$ (reduced LVEF <50%).

Data Management

Data was analyzed with the International Business Machines Statistical Product and Service Solutions (IBM-SPSS) version 22. Categorical data are presented as frequencies and percentages. Continuous data are presented as means and standard deviation (SD). Frequencies were compared using the Pearson's Chi Square test. Means were compared using an independent t-test. The Pearson's Correlation test was used to correlate left ventricular systolic function with MAPSE and TDI S'. A p-value of < 0.05 was considered statistically significant for all comparisons / associations. Results are presented as tables and charts.

Results

A total of one hundred patients were consecutively enrolled for the study. Hypertension was the highest indication for an echocardiogram. The mean (SD) age of the patients was 54.83 (16.51) years. The mean (SD) left ventricular ejection fraction was 67.04 (17.27) % while the mean MAPSE was 14.85 (10.81) mm and the mean TDI S' being 7.46 (2.35).

The prevalence of abnormal (reduced) left ventricular systolic function was 13%, 24% and 28% as determined using LVEF, TDI S' and MAPSE, respectively. Table 1 shows the relationship between left ventricular ejection fraction and MAPSE and TDI S' as surrogates for left ventricular systolic function. There was a statistically significant association between the MAPSE ($p<0.001$), TDI's ($p<0.001$) and LVEF. Both surrogates had a similar specificity of 82%. However, MAPSE was more sensitive (100%) than TDI S' (69.2%). MAPSE also showed a higher positive predictive value than TDI S'.

Logistic regression analysis showed a significant odds ratio for comparison between LVEF and TDI S'. (Table 1)

The correlation between LVEF and TDI S' ($r=0.45$; $p<0.001$), and MAPSE ($r=0.21$; $p=0.032$) were positive and significant though weak with MAPSE. (Figure 1 and Figure 2).

Multiple linear regressions also showed statistically significant relationship between TDI S' and LVEF. (Table 2)

Discussion

It is crucial to note that left ventricular ejection fraction (LVEF) is not cast in stone as a measure of left ventricular systolic function though standard [8]. Tissue Doppler Imaging (TDI S') and mitral annular plane systolic excursion (MAPSE) are other methods for measuring systolic function. Both methods are non-invasive techniques and become much more beneficial in poor echocardiographic imaging quality. MAPSE measures global longitudinal function [9, 10], while TDI S'permits a measure of regional and global LV systolic function [11]. MAPSE is an m-mode echocardiographic measure of longitudinal cardiac function [12]. The average MAPSE ranges between 12 and 15mm [13]. The mean MAPSE in this study was 14.85mm, which is within the normal limits. This study showed a sensitivity of 100% and a specificity of 82.8% for MAPSE and a sensitivity of 69.2%, and a specificity of 82.3% for TDI S' in determining abnormal myocardial function. Also, a higher prevalence of abnormal myocardial function was found when MAPSE (28%) or TDI S' (24%) was used. Similar findings in previous studies by Simonson *et al*. showed MAPSE had a sensitivity of 98% and specificity of 82% [13]. In comparison, Khorshid *et al*. also found a sensitivity of 85.5% and specificity of 97.7%. MAPSE predicts early heart disease such as changes in concentric hypertrophy as some early cardiac diseases cause longitudinal functional changes, which can be determined using MAPSE even when the LVEF remains within normal limits [15, 16]. Thus, this may in part account for the higher number of patients with reduced MAPSE than reduced LVEF in this study. Similarly, TDI S' allows for long term prognosis and diagnosis of cardiac diseases, e.g. coronary artery disease and cardiac dyssynchrony [17, 19].

This study also showed a significant positive correlation between MAPSE, TDI S' and LVEF, suggesting that MAPSE and TDI S' can be surrogates to LVEF. Lang *et al*., and Bellenger *et al*., found close significant correlations between MAPSE, TDI S' and LVEF [22, 21]. Likewise, Heinen *et al*., Molgevang *et al*., and Willenhiemer *et al*. further demonstrated that MAPSE and TDI S' could be used as surrogates for LVEF in addition to offering prognostic significance [22-24]. A combination of both methods may offer a greater prognostic significance, especially given poor image quality. These methods also benefit the proper categorization of at-risk patients with cardiac diseases even in the face of a preserved ejection fraction [8, 25, 26].

Conclusion

MAPSE and TDI S' are important surrogates for LVEF, alone or in combination. Both methods are early markers of myocardial dysfunction and thus may be beneficial in assessing the prognosis of cardiac diseases. The routine assessment of MAPSE and TDI S' among adult Nigerians with cardiac disease is highly recommended.

References

1. Qin JX, Shiota T, Tsujino H, Saracino G, White RD, Greenberg NL, *et al*. Mitral annular motion as a surrogate for left ventricular ejection fraction: Real-time three-dimensional echocardiography and magnetic resonance imaging studies. Eur J Echocardiogr. 2004; 5(6):407-415.
2. Oh JK. Echocardiography in heart failure: Beyond Diagnosis. Euro J Echocardiogr. 2007; 8:4-14.
3. Anavekar NS, Oh JK. Doppler echocardiography: A Contemporary review. J Cardiol. 2009; 54:347-358.
4. Chengode S. Left ventricular global systolic function assessment by echocardiography. Ann Card Anaesth 2016; 19(suppl1):S26-S34.
5. Krishna KK, Thomas L. Tissue Doppler imaging echocardiography: value and limitations; Heart Lung Circ. 2015; 24:224-233.
6. Elnoamany MF, Abdelhameed AK. Mitral annular motion as a surrogate for left ventricular function correlate with brain natriuretic peptide levels; Eur J Echocardiogr. 2006; 7(3):187-198.
7. Vinereanu D, Khokhar A, Fraser AG. Reproducibility of pulsed wave tissue Doppler. Echocardiography. J Am Soc Echocardiogr. 1999; 12(6):492-499.
8. Japp AG, Moir S, Mottram PM. Echocardiographic Quantification of Left Ventricular Systolic Function. Heart Lung Circ. 2015; 24(6):532-535.
9. Jones CJ, Raposo L, Gibson DG. Functional importance of the long axis dynamics of the human left ventricle. Br Heart J. 1990; 63(4):215-220.
10. Emilsson K, Wandt B. The relation between mitral annulus motion and ejection fraction changes with age and heart size. Clin Physiol. 2000; 20(1):38-43.
11. Kadappu KK, Thomas L. Tissue Doppler Imaging in Echocardiography: Value and Limitations. Heart Lung Circ. 2015; 24(3):224-233.
12. Adel W, Roushdy AM, Nabil M. Mitral Annular Plane Systolic Excursion-Derived Ejection fraction: A Simple and Valid Tool in Adult Males with Left Ventricular Systolic Dysfunction. Echocardiography 2016; 33(2):179-184.
13. Simonson JS, Schiller NB. Descent of the base of the left ventricle: an echocardiographic index of left ventricular function. J Am Soc Echocardiogr. 1989; 2:25-35.
14. Korshid H, Wadeea B, Sabry E. Correlation of Mitral Annular Plane Systolic Excursion (MAPSE) and Tissue Doppler Systolic Velocity with Left Ventricular Systolic function. J Cardiol Curr Res. 2017; 10(1):00349.
15. Aurigemma GP, Silver KH, Priest MA, Gaasch WH. Geometric changes allow normal ejection fraction despite depressed myocardial shortening in hypertensive left ventricular hypertrophy. J Am Coll Cardiol. 1995; 26:195-202.
16. Alam M. The atrioventricular plane displacement as a means of evaluating left ventricular systolic function in acute myocardial infarction. Clin Cardiol. 1991; 14:588-94.
17. Nikitin NP, Loh PH, Silva R, Ghosh J, Khaleva OY, Goode K, *et al*. Prognostic value of systolic mitral annular velocity measured with Doppler tissue imaging in patients with chronic heart failure caused by left ventricular systolic dysfunction. Heart. 2006; 92:775-779.
18. Kitaoka H, Kubo T, Hayashi K, Yamasaki N, Matsumura Y, Furuno T, *et al*. Tissue Doppler imaging and prognosis in asymptomatic or mildly symptomatic patients with hypertrophic cardiomyopathy. Eur Heart J Cardiovasc Imaging. 2013; 14:544-549.
19. Bax JJ, Bleeker GB, Marwick TH, Molhoek SG, Boersma E, Steendijk P, *et al*. Left ventricular dyssynchrony predicts response and prognosis after cardiac resynchronization therapy. J Am Coll Cardiol. 2004; 44(9):1834-1840.
20. Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA, *et al*. Recommendations for chamber quantification: a report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. J Am Soc Echocardiogr. 2005; 18(12):1440-1463.
21. Bellenger NG, Burgess MI, Ray SG, Lahiri A, Coats AJ, Cleland JG, *et al*. Comparison of left ventricular ejection fraction and volumes in heart failure by echocardiography, radionuclide ventriculography and cardiovascular magnetic resonance; are they interchangeable? Eur Heart J. 2000; 21(16):1387-1396.
22. Willenheimer R, Cline C, Erhardt L, Israelsson B. Left ventricular atrioventricular plane displacement: an echocardiographic technique for rapid assessment of prognosis in heart failure. Heart. 1997; 78(3):230-236.
23. Mogelvang R, Sogaard P, Pedersen SA, Olsen NT, Schnohr P, Jensen JS. Tissue Doppler echocardiography in persons with hypertension, diabetes, or ischaemic heart disease: the Copenhagen City Heart Study. Eur Heart J. 2009; 30(6):731-739.
24. Rydberg E, Arlbrandt M, Gudmundsson P, Erhardt L,

Willenheimer R. Left atrioventricular displacement predicts cardiac mortality in patients with chronic atrial fibrillation. Int J Cardiol. 2003; 91:1-7.

25. Brand B, Rydberg E, Ericsson G, Gudmundsson P, Willenheimer R. Prognostication and risk stratification by assessment of left atrioventricular plane displacement in patients with myocardial infarction. Int J Cardiol. 2002; 83:35-41.
26. Chahal NS, Lim TK, Jain P, Chambers JC, Kooner JS, Senior R. Normative reference values for TDI parameters of left ventricular function. A population-based study. European Journal of Echocardiography. 2010; 11:51-6.