Evaluation of the applicability and usefulness of Myocardial Performance Index in predicting the development of heart failure in comparison with other cardiac indices.

Ahlam Kadhim Abood AL-Hamdany,
College of medicine , Babylon University.
Correspondence to Ahlam Kadhim at email : udayjanabia@yahoo.com

الخلاصة :

خلفية الموضوع : مؤشر أداء عضلة القلب هو مؤشر يجمع الاختلال الوظيفي الانقباضي والانبساطي، ولقد ثبت انها من الممكن ان تكون مؤشرا في أمراض القلب والأوعية الدموية

الهدف: تقييم دورMPI في تقييم قصور القلب مقارنة مع مؤشرات القلب الاخرى .

طريقة العمل : بواسطة موجات صدى القلب نوع M-Mode (تم قياس حجم الدم الذي يضخ بالنبضة الواحدة و قياس نسبة الجزء المقذوف من الدم الى حجم الدم في نهاية الانبساط للقلب وتم قياس كتلة البطين الايسر وهذا عن طريق البعد الداخلي للبطين الايسر في حالة الانبساط والانقباض-ويضاف لها قياس سمك الحاجز بين البطينين وسمك الجدار الخلفي في حالة الانبساط للقلب ومن ثم تطبيق معادلة خاصة للحصول على كتلة البطين الايسر-وبقسمة قيمة هذه الكتلة على مساحة سطح الجسم نحصل مؤشر كتلة البطين الايسر . وبواسطه الدوبلر تم قياس مؤشر اداء عضلة القلب (MPI) وذلك بقياس IVCTو IVRT وجمعهما ثم القسمه على LVET.

النتائج: اظهر MPIنسبه غير طبيعية تقريبا 82% (القيمة الطبيعية هي)(0.39±0.05) مقارنة مع EF وSV 39% و54.2% على التوالي. اظهرت الدراسة العلاقة السلبية بين MPI و EF وSV ولكن العلاقة كانت موجبه مع كتلة البطين الايسر ومؤشره .كانت العلاقة سلبية بين EF و(IVCT، IVRT و LVET .

الاستنتاج :استخدام MPI لتقييم أداء القلب لديه الميزة السريرية الاقوى على استخدام مؤشرات صدى القلب الكلاسيكية الأخرى.

Abstract:

Back ground: The myocardial performance (MPI) is a combined index of systolic and diastolic dysfunction and has been shown to be a predictor of cardiovascular outcome in heart diseases.

Aim : Evaluate the role of MPI in assessment of heart failure in comparison with other echocardiographic parameters. **Methods** : By M-mode echocardiography, measurement of ejection fraction (EF) and stroke volume (SV) had been done, then measurement of left ventricular mass (LVM) by measurement of left ventricular internal dimension in diastole (LVIDd) and systole (LVIDs), posterior wall thickness in diastole (PWTd), and interventricular septal thickness in diastole (IVSd). Left ventricular mass (LVM) was calculated from the measurements of the left ventricle (LV) using the equation: LVM (g) = 0.81 [1.04 (interventricular septal thickness + posterior wall thickness + LV end-diastolic internal dimension)3 – (LV end-diastolic internal dimension)3] + 0.6. Left ventricular mass index calculated by dividing LVM on body surface area. Measurement of MPI by the apical five-chamber view with Doppler study . the sum of the isovolumic relaxation time (IVRT) and isovolumic contraction time (IVCT) divided by the left ventricular ejection time (LVET) obtained from the left ventricular inflow and outflow. **Results**: The percentage of abnormal MPI in this study is about 82% (normal value is 0.39±0.05) in comparison to EF and SV which are 39% and 54.2% respectively. MPI showed weak but negative correlation with EF and SV (r = -0.163, -0.044) respectively, and positive correlation with LVM and LVMI (r = 0.416 , 0.413) respectively. EF showed negative correlation with LVET, IVCT and IVRT(r = -0.03 , -0.028 , -0.25) respectively . **Conclusion** : Use of MPI for assessing cardiac performance has a potential clinical advantage over the use of other classical echocardiographic indices.

Key words : MPI , LVM , LVMI .

Introduction: Congestive heart failure (CHF) is a major cause of morbidity and mortality (1).There are many limitations to the use

of classical echocardiograph indices for the estimation of systolic and

diastolic left ventricular (LV) function. The ejection fraction (EF, an index of systolic function) and LV volumes are subject to large errors when the ellipsoid shape of the heart becomes spherical. Age, rhythm and

conduction disturbances, and changes in loading all affect the Doppler signal of transmitral flow, which is the most commonly used method for studying diastolic function (2). Previous studies have demonstrated that patients with heart failure may have gone through a phase of asymptomatic left ventricular (LV) dysfunction, where objective LV measurements reveal impairment of cardiac contractility but overt heart failure is not present (3-6).

The Doppler-derived myocardial performance index (MPI, also denoted the TEI-Doppler index), a fairly new index of combined systolic and diastolic function, is defined as the sum of isovolumic contraction time and isovolumic relaxation time divided by the ejection time (7). MPI has previously been shown to be a sensitive indicator for symptomatic heart failure in a cross-sectional study(8). but whether MPI predicts future development of heart failure independently of other echocardiographic measurements is still to be examined (9).

The index is simple, noninvasive, easy to estimate and reproducible (10-12). The mean normal value of the Tei index is 0.39± 0.05 for the left ventricle (10).
Aim of this study is to evaluated the applicability and usefulness of MPI in predicting the development of heart failure in comparison with other cardiac indices.

Methods: Forty-six patients (30 male and 16 female; mean age ± SD, 52 ± 15.1 years; range, 35–67 years) in echocardiograph out patients of Shaheed AL-Muhrab Center for cardiac catheterization in Babylon Province, between December 2014 and July 2015 were enrolled for this cross sectional study. Inclusion criteria include diabetic and hypertension patients with no sign or symptom of heart failure, other exclusion criteria patients with myocardial infarction or heart block. Of these, 27 patients had hypertension, and 19 had diabetes mellitus.

Two-dimensional (2D) echocardiography and Doppler examination was performed with a 2.5 MHz transducer (Sonos 1500, Hewlett Packard Andover, MA, USA). All examinations were performed with the subjects in the standard left lateral position. An experienced physician (B.A.) did both the examination and the reading of the images.

LV dimensions were measured with M-mode. The measurements included LV diameter in end-diastole and end-systole. LV volumes were calculated according to the Teichholz M-mode formula volume=$7D^3/(2.4+D)$, D=diameter(13-14), and from that, ejection fraction was calculated (LV end-diastolic volume−LV end-systolic volume)/LV end-diastolic volume. By M-Mode measurement of stroke volume was done also by measuring LVIDd and LVIDs.

LVM measurement : LVM was determined by using the M-mode formula of Troy according to the recommendations by the American Society of Echocardiography (ASE)(15). They included left ventricular internal dimension in diastole (LVIDd) and systole (LVIDs), posterior wall thickness in diastole (PWTd), and interventricular septal thickness in diastole (IVSd). Left ventricular mass (LVM) was calculated from the measurements of the left ventricle (LV) using the equation:

LVM (g) = 0.81 [1.04 (interventricular septal thickness + posterior wall thickness + LV end-diastolic internal dimension)3 – (LV end-diastolic internal dimension)3] + 0.6.(16).

LV mass was divided with body surface area giving the LV mass index.

The Tei index reflects both systolic and diastolic function. It is defined as the sum of the isovolumic relaxation time and isovolumic contraction time divided by the ejection time obtained from the left ventricular inflow and outflow (17) . The isovolumic relaxation time was determined from the apical five-chamber view as the time from the end of left ventricular ejection to the beginning of the early mitral inflow (E) wave. Isovolumic contraction time was defined as the time from the peak of the R wave or the end of the late atrial filling (A) wave to the beginning of left ventricular ejection (18) .

Statistical analysis : Descriptive statistics (the mean values, standard deviations, and percentages) were used to describe the quantitative study variables. Pearson Correlation study was used to assess the correlation between parameters measured in the study. P value <0.05 was considered statistically significant.

Results: Echocardiographic parameters that were measured in this study were expressed as mean ±SD in table-1.

Table-1 Echocardiographic hemodynamic parameters :

Parameter	Mean ±SD
IVCT(sec)	0.075±0.03
IVRT(sec)	0.099±0.032
LVET (sec)	0.278±0.038
MPI	0.629±0.174
EF	54.086±12.06
SV(ml/beat)	68.58±20.13
LVM (g)	192.29±96.71
LVMI(g/m^2)	105.57±0.167

IVCT: Isovolumetric contraction time, IVRT: Isovolumetric relaxation time, LVET: Left ventricular ejection time, MPI: Myocardial performance index, EF: Ejection fraction, SV: Stroke volume, LVM: Left ventricular mass, LVMI: Left ventricular mass index.

The percentage of abnormal MPI in this study is about 82% (normal value is

0.39±0.05) in comparison to EF and SV respectively.Figure-1 which are 39% and 54.2%

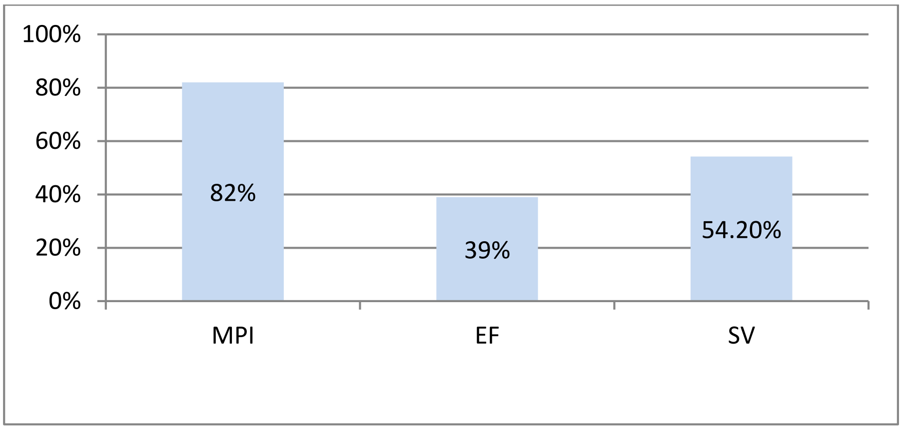

Figure-1:Percentage of abnormal values of echocardiographic-hemodynamic parameters in this study : MPI (myocardial performance index), EF (ejection fraction, and SV (stroke volume) .

Correlation studies between MPI with EF and SV were made and showed weak correlation but it reflected a negative correlation (r= -0.163 , -0.044 respectively).Figure-2,3.

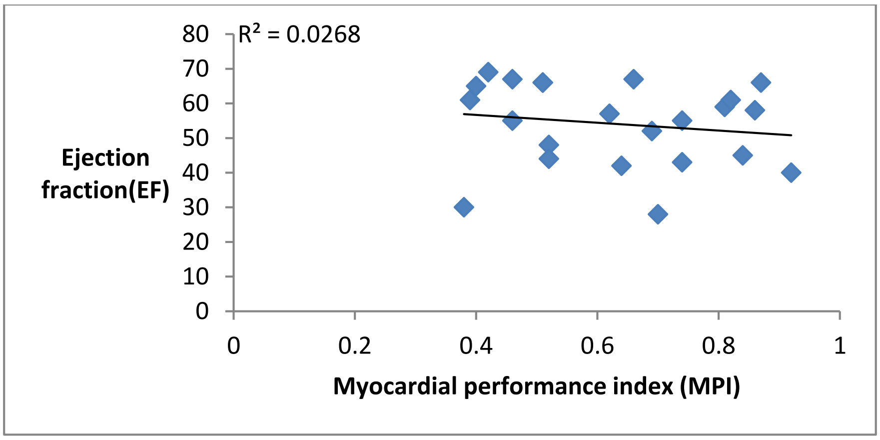

Figure.2 Linear regression plot of Myocardial performance index(MPI) and ejection fraction (EF).

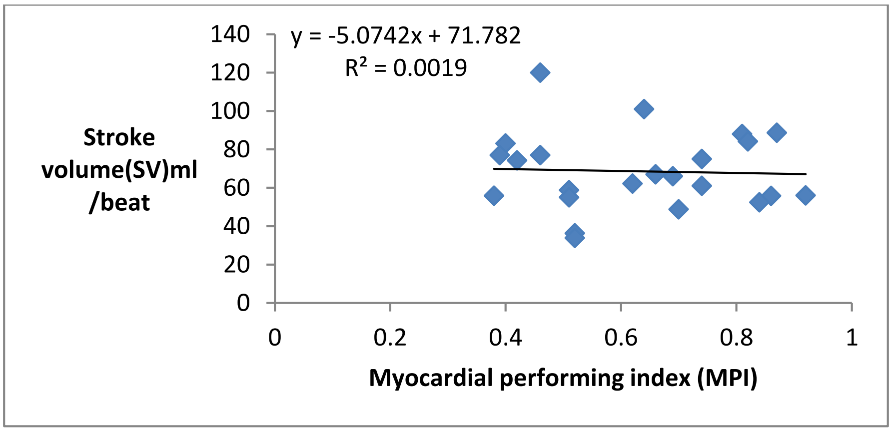

Figure.3 Linear regression plot of Myocardial performance index(MPI) and stroke volume(SV).

Correlation study of MPI with LVM and LVMI showed positive correlation (r=0.416, r=0.413 respectively).Figure.4,5

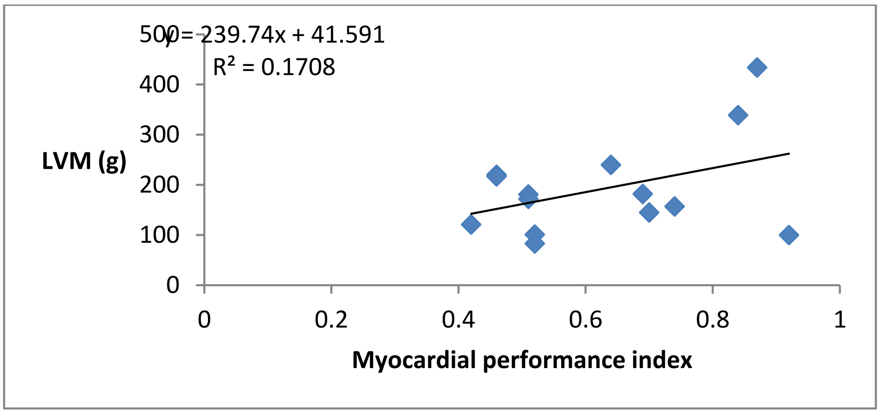

Figure.4 Linear regression plot of Myocardial performance index(MPI) and left ventricular mass (g).

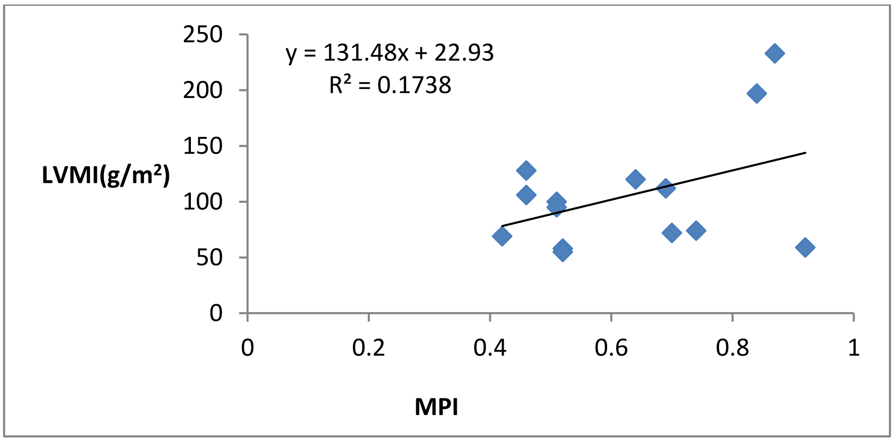

Figure.5 Linear regression plot of Myocardial performance index(MPI) and left ventricular mass index (LVMI).

Correlation studies of EF with LVET, IVCT and IVRT were weak correlation but they reflected negative correlation (r = -0.03, -0.028 and -0.25) respectively.Figure.6,7,8.

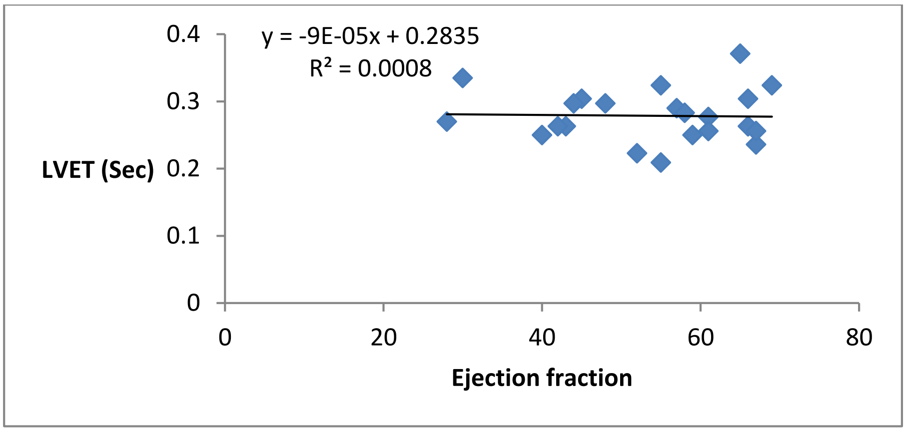

Figure.6 Linear regression plot of ejection fraction (EF) and left ventricular ejection time (LVET).

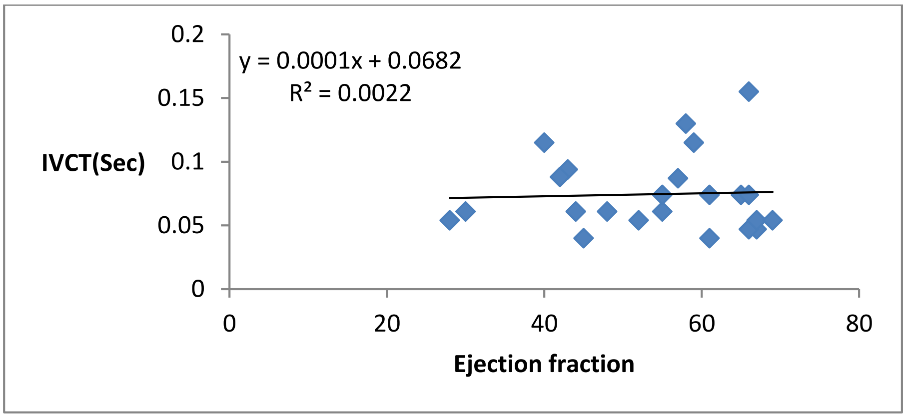

Figure.7 Linear regression plot of ejection fraction (EF) and isovolumetric contraction time (IVCT).

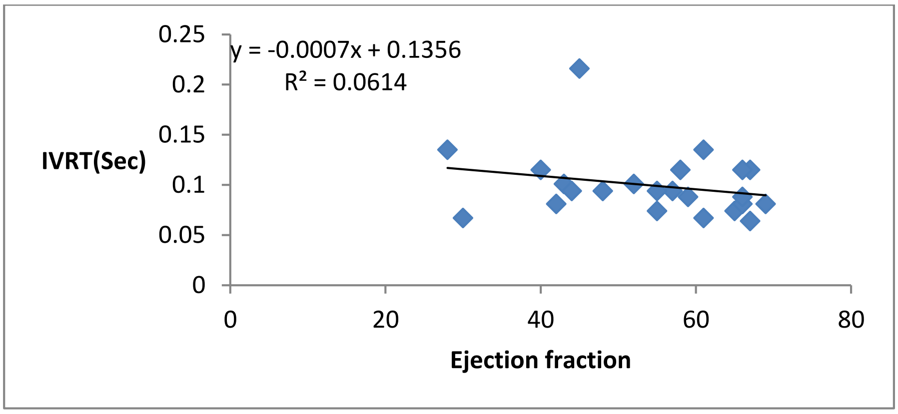

Figure.8 Linear regression plot of ejection fraction (EF) and isovolumetric relaxation time.

Discussion : It is apparent from the present observation that MPI had the highest percentage of abnormal values (82%) in comparison of EF (39%) and SV (52.2%),MPI has previously been shown to be a sensitive indicator for symptomatic heart failure in a cross-sectional study (8). MPI could provide prognostic information independently of other measurements of cardiac function and of traditional risk factors for heart failure and this is in accordance with Johan et al (9). Because of the potent systolic parameters that contribute to the MPI , such as isovolumic contraction time (ICT) and ejection time (ET), the index detects with reliability current alterations of LV systolic function (19-22). Thus, the index maintains a strong inverse relation with ejection fraction (21). The higher the value of the index, the lower the ejection fraction and *vice versa* (23) , this is the same for stroke volume which reflects systolic function of the left ventricle.

Negative correlation between EF and LVET is in accordance with Clifford et al studies. reflects the combined influence of the opposite relationship of each of the systolic intervals to the ejection fraction (24) and this is also for correlation of EF with IVCT .

The use of these conventional indices when left ventricular geometry is altered may be further error-prone . Ejection fraction and left ventricular volumes, as we mentioned previously , are prone to large errors when the ellipsoid shape of the heart is altered.

The MPI is not affected by these changes and is therefore more likely to be a better estimate of diastolic and systolic function in a large group of the population (18).

Adeseye A Akintunde,et al (18) in 2011 studied relationship between Tei index of myocardial performance and left ventricular geometry in Nigerians with systemic hypertension and found that among Nigerian hypertensive, LV systolic and diastolic functions (using the MPI) were impaired in all subgroups of hypertensive patients according to their left ventricle geometry compared to the control group. This impairment was more advanced in patients with concentric and eccentric hypertrophy, so this goes with our finding of the positive correlation between MPI and LVM and LVMI .

Conclusion : Use of the MPI for assessing cardiac performance has a potential clinical advantage over the use of other classical echocardiographic indices for estimating left ventricular diastolic and systolic function.

References

1. Cowie MR, Mosterd A, Wood DA, et al. The epidemiology of heart failure Eur Heart J1997;18:208-225.

2.John A.L. ,Fotis K P,Vasiliki K K, Konstantinia IA, Panagiotis KH. The Tei Index of Myocardial Performance: Applications in Cardiology. Cardiol J 2005; 46: 52-58.

3.VasanRS, Larson MG, Benjamin EJ, et al. Left ventricular dilatation and the risk of congestive heart failure in people without myocardial infarction New Engl J Med1997;336:1350-1355.

4.AurigemmaGP, Gottdiener JS, Shemanski L, et al. Predictive value of systolic and diastolic function for incident congestive heart failure in the elderly: the cardiovascular health study J Am Coll Cardiol2001;37:1042-1048.

5.GottdienerJS, Arnold AM, Aurigemma GP, et al. Predictors of congestive heart failure in the elderly: the cardiovascular health study J Am Coll Cardiol2000;35:1628-1637.

6.WangTJ, Evans JC, Benjamin EJ, et al. Natural history of asymptomatic left ventricular systolic dysfunction in the community Circulation2003;11:11.

7. TeiC, Nishimura RA, Seward JB, et al. Noninvasive Doppler-derived myocardial performance index: correlation with simultaneous measurements of cardiac catheterization measurements J Am Soc Echocardiogr1997;10:169-178.

8. BruchC, Schmermund A, Marin D, et al. Tei-index in patients with mild-to-moderate congestive heart failure Eur Heart J2000;21:1888-1895.

9. Johan Ärnlöv , Erik Ingelsson , Ulf Risérus , Bertil Andrén , Lars Lind. Myocardial performance index, a Doppler-derived index of global left ventricular function, predicts congestive heart failure in elderly men. European Heart Journal 2004; Volume 25, Issue 24.

10. Tei C, Ling L, Hodge D, et al. New index of combined systolic and diastolic myocardial

performance: a simple and reproducible measure of cardiac function—a study in normals

and dilated cardiomyopathy. J Cardiol. 1995; 26: 357-366.

11. Tei C. New non-invasive index of combined systolic and diastolic ventricular function. J Cardiol. 1995; 26: 135-136.

12. Tei C, Dujardin K, Hodge D, Kyle R, Tajik A, Seward J.Doppler index combining systolic and diastolic myocardial performance: clinical value in cardiac amyloidosis. J Am CollCardiol. 1996; 28: 658-664.

13.TeichholzLE, Kreulen T, Herman MV, et al. Problems in echocardiographic volume determinations: echocardiographic–angiographic correlations in the presence of absence of asynergy Am J Cardiol1976;37:7-11.

14.WallersonDC, Ganau A, Roman MJ, et al. Measurement of cardiac output by M-mode and two-dimensional echocardiography: application to patients with hypertension Eur Heart J1990;11(Suppl I):67-78.

15. ParkSH, Shub C, Nobrega TP, et al. Two-dimensional echocardiographic calculation of left ventricular mass as recommended by the American Society of Echocardiography: correlation with autopsy and M-mode echocardiography J Am Soc Echocardiogr1996;9:119-128.

16. Devereux RB, Alonso DR, Lutas EM. et al. Echocardiographic assessment of left ventricular hypertrophy: comparison to necropsy findings. Am J Cardiol. 1986;57:450–458.

17. 11. Tei C, Ling LH, Hodge DJ. et al. New index of combined systolic and diastolic myocardial performance; a simple and reproducible measure of cardiac function – a study in normals and dilated cardiomyopathy. J Cardiol. 1995;26:327–366.

18. Adeseye A Akintunde, Patience O Akinwusi, George O OpadijoRelationship between Tei index of myocardial performance and left ventricular geometry in Nigerians with systemic hypertension. Cardiovasc J Afr. 2011 Jun; 22(3): 124–127

19. Tei C, Dujardin K, Hodge D, Kyle R, Tajik A, Seward J. Doppler index combining systolic and diastolic myocardial performance: clinical value in cardiac amyloidosis. J Am Coll Cardiol. 1996; 28: 658-664.

20. Tei C, Nishimura R, Seward J, Tajic A. Noninvasive Dopplerderived myocardial performance index: correlation with simultaneous measurements of cardiac catheterization measurements.J Am Soc Echocardiogr. 1997; 169-178.

21. Lacorte J, Cabreriza S, Rabkin D, et al. Correlation of the Tei index with invasive measurements of ventricular function in a porcine model. J Am Soc Echocardiogr. 2003; 16: 442-447.

22. Dujardin K, Tei C, Yeo T, Hodge D, Rossi A, Seward J. Prognostic value of a Doppler index combining systolic and diastolic performance in idiopathic dilated cardiomyopathy. Am J Cardiol. 1998; 82: 1071-1076.

23.Emmanouiln NK, Anna TG ,John EP, Athanassios VK,Nearchos SN. Myocardial Performance Index (Tei Index):Evaluating its Application to Myocardial Infarction. Hellenic J Cardiol 2009; 50: 60-65.

24. Clifford L. Garrard, JR., Arnold M. Weisseler and Harold TD. Patients with Cardiac Disease The Relationship of Alterations in Systolic Time Intervals to Ejection Fraction in Patients with Cardiac Disease.Circulation. 1970;42:455-462.