The Egyptian Journal of Hospital Medicine (January 2025) Vol. 98, Page 822- 827

Value of Myocardial Performance Index as a Parameter for Left Ventricular Cardiac Function in Heart Failure Patients

Jane Aboulenein *, Sherif Abdelsalam Sakr, Hoda Mohamed Mohamed Soltan
Cardiovascular Medicine Department, Faculty of Medicine, Mansoura University, Mansoura, Egypt.
* **Corresponding author:** Jane Aboulenein, **Email:** janenader@mans.edu.eg, **Phone:** +20 120 135 5599

ABSTRACT

Background: Ejection fraction (EF) and left ventricular volumes may have significant errors due to the heart's ellipsoidal shape becoming more spherical during dysfunction.

Objective: This study aimed to evaluate the myocardial performance index (MPI) as a parameter for left ventricular function in heart failure (HF) cases.

Patients and methods: This descriptive study was conducted at The Cardiovascular Medicine Department, Mansoura Specialized Internal Medicine Hospital, Mansoura University. It included 80 individuals divided into two groups: Group A (HF group) included 40 patients with HF symptoms (NYHA class 1-4) and impaired LV systolic function, selected from consecutive HF admissions. Group B (Control group) included 40 healthy adults with no cardiovascular disease, no HF symptoms (NYHA class 1), and normal echocardiography findings.

Results: MPI at both septal and lateral mitral annuli was significantly higher in HF cases than in controls. A strong correlation was found between MPI values and NYHA classification. Septal MPI also correlated significantly with age and EF. ROC analysis confirmed MPI's predictive value for HF. For lateral-MPI, AUC was 0.894 at a cut-off of 0.455, with 87.5% sensitivity, 95% specificity, 97.2% PPV, 79.2% NPV, and 90% accuracy. For septal-MPI, AUC was 0.881 at a cut-off of 0.465, with 90% sensitivity, 90% specificity, 94.7% PPV, 81.8% NPV, and 90% accuracy. Both MPI calculations showed comparable predictive value.

Conclusion: MPI is a reliable predictor of LV function in HF cases.

Key words: Myocardial performance index, Left ventricular function, Heart failure.

INTRODUCTION

Traditional echocardiographic methods have significant limitations in evaluating both diastolic and systolic left ventricular (LV) function. Measurements like ejection fraction and LV volumes are often inaccurate, especially as the heart's shape changes from ellipsoidal to spherical. Additionally, factors such as heart rhythm, age, conduction abnormalities, and changes in loading conditions can affect the Doppler signal of trans-mitral flow, which is the most commonly, used technique for assessing diastolic function. In 1995, developed and published a myocardial performance index, known as Tei index, which assesses left ventricular diastolic and systolic function concurrently. Tei index has demonstrated reliability in assessing LV diastolic and systolic function, offering clear advantages over established indices and possessing prognostic significance for numerous heart diseases. While, they stated that the myocardial performance index encompasses both diastolic and systolic functions of the myocardium and correlates with morbidity and mortality in cardiovascular disease. The calculation is simple and exhibits a limited range in typical healthy individuals [1, 2].

The Tei index measurement is non-invasive and readily accessible, requiring no highly experienced echocardiographer and doesn't significantly extend the examination duration. Index calculation isn't predicated on a geometric model or volumetric assessments, it primarily constitutes a ratio of time intervals, independent of ventricular geometry. It is additionally independent of heart rate, blood pressure, age, it seems to possess significant prognostic value across several clinical contexts [3].

Therefore, the aim of this work was to study the value of MPI as a parameter for Left Ventricular cardiac function in heart failure cases.

PATIENTS AND METHODS

This descriptive study included 80 individuals carried out at Cardiovascular Medicine Department, Mansoura Specialized Internal Medicine Hospital, Mansoura University.

Sample size: The study enrolled a total of 80 individuals, classified into two groups:

Group A (HF group) involved 40 cases with heart failure (HF) symptoms [NYHA functional class 1, 2, 3, 4] and impaired LV systolic function, selected from consecutive cases hospitalized for HF who met the specified criteria.

Group B (Control group) included 40 healthy adults without any cardiovascular disease or HF symptoms [NYHA functional class 1] and with normal echocardiography findings.

Inclusion criteria: Cases with heart failure symptoms and decreased ejection fraction.

Exclusion criteria: Age less than 18 years old, chronic renal failure, chronic liver failure and atrial fibrillation (AF).

All enrolled cases were subjected to a comprehensive evaluation, which included full history taking with special emphasis on personal history such as age,

Received: 18/09/2024
Accepted: 26/11/2024

gender, and occupation, as well as risk factors such as hypertension (HTN), diabetes mellitus (DM), smoking, and dyslipidemia. Additionally, a thorough clinical examination was conducted, focusing on pulse, neck veins, cardiac auscultation, blood pressure, and clinical manifestations of HF. A resting 12-lead surface electrocardiogram (ECG) was performed utilizing a paper speed of twenty-five mm/s and a standardization of one mV/10 mm. Furthermore, all subjects underwent trans-thoracic echocardiography (TTE) in accordance with the recommendations of the American Society of Echocardiography (ASE). The TTE study was carried out utilizing a commercially available echocardiography system (Vivid 9, General Electric-Vingmed, Horton, Norway), and calculations have been made utilizing internal analysis software of echocardiographic device. All subjects were examined in the left lateral decubitus position, and LV measurements, including wall and chamber dimensions, were obtained during both systole and diastole.

EF measurement using simpson's method: LV end-diastolic and end-systolic volumes, as well as EF, have been determined utilizing Simpson's biplane formula from apical 2- and 4-chamber views. Endocardial borders have been traced in end-diastole and end-systole during the technically best cardiac cycle to ensure accuracy.

Tissue Doppler imaging (TDI): Pulsed-wave TDI has been carried out utilizing tissue Doppler function of the same echocardiography machine to calculate the myocardial performance index (MPI). Mitral annular peak systolic (S'), peak early diastolic (E'), and peak late diastolic (A') velocities have been estimated with sample volume positioned at lateral and septal corners of mitral annulus in apical 4-chamber view.

Calculation of the MPI: Isovolumic relaxation time (IVRT) has been estimated from end of S' wave to start of E' wave, while the isovolumic contraction time (IVCT) has been estimated from end of A' wave to start of S' wave. Ejection time (ET) has been represented by the duration of S' wave. These measurements have been utilized to derive the MPI, providing a comprehensive assessment of diastolic and systolic function.

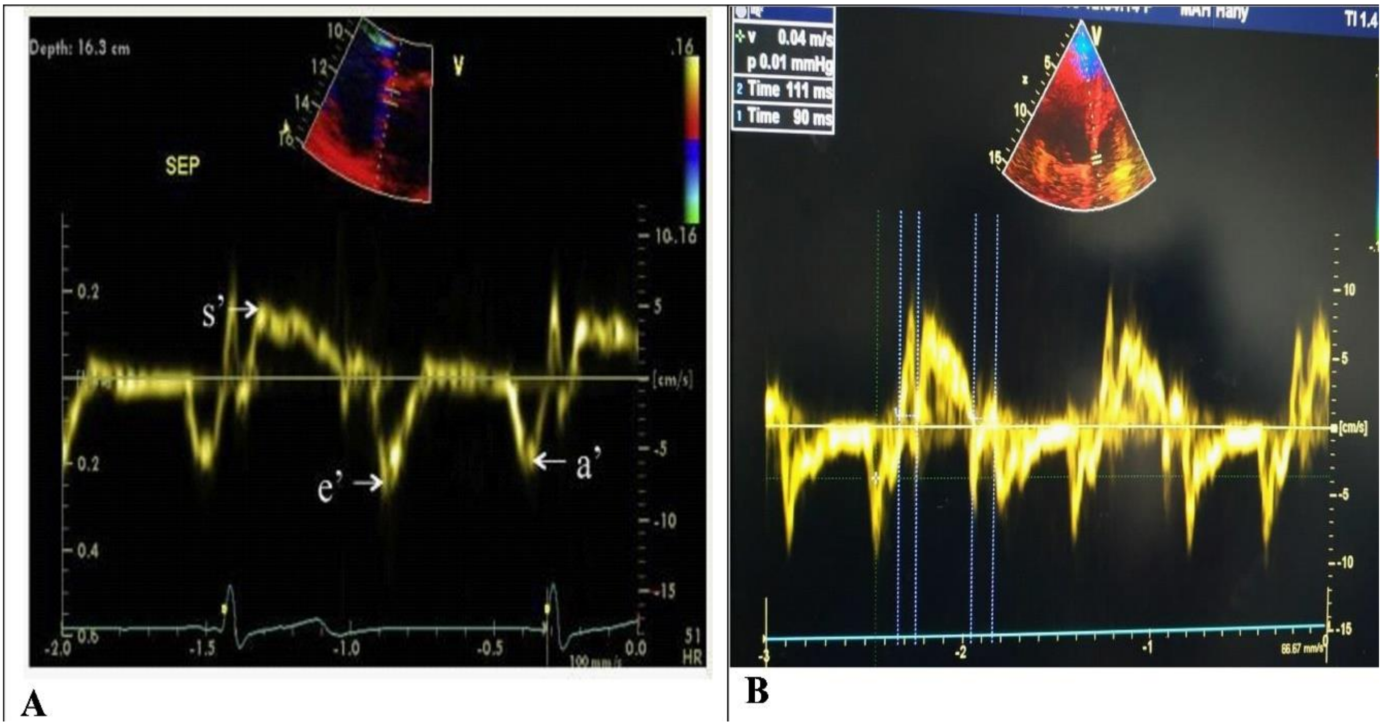

Figure (1): (A): Pulsed wave tissue Doppler imaging from apical 4 chamber view sampling from septal mitral annulus [4] and (B): An image of the echocardiographic study of one of our studied cases.

Ethical considerations: Scientific approval was obtained from The Cardiology Department's Scientific Ethical Committee, and administrative approval was granted by Mansoura Faculty of Medicine Institutional Research Board. Informed consent was obtained from each participant or 1ST degree relative, ensuring confidentiality and explaining the procedure in simple language. Participants had the right to withdraw from the study at any time, and their data were used solely for research purposes, preserving their privacy. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The information has been evaluated utilizing SPSS version 21. Kolmogorov-Smirnov test was utilized to evaluate normality. Qualitative data was described as percentage and numbers, with associations evaluated utilizing the Chi-square test. Continuous variables were expressed as mean ± SD for normal distribution or median (min-max) for non-normal distribution. Group comparisons have been conducted utilizing the Student's t-test for normally distributed data or the Mann-Whitney test for non-normally distributed data. Correlations was assessed utilizing Pearson (parametric) or Spearman (non-parametric) tests. Sensitivity and specificity was assessed via ROC curves. A p-value ≤ 0.05 was deemed statistically significant.

RESULTS

The mean age was 60.40 ± 7.53 years. They were 28 males and 12 females in addition to 40 healthy individuals as a control group. Control group involved 24 males and 16 females whose mean age was 57.67±5.92 years. A statistically insignificant distinction has been observed among case and control groups regarding age or sex (Table 1).

Table (1): Baseline characteristics among cases and control groups

Variables	Cases group (number=40	Control group (number=40	Test of significance	P-value
Age (years) Mean ± SD	60.40 ± 7.53	57.67 ± 5.92	t=1.79	0.076
Sex			$\chi2$=0.879	0.348
Male	28 (70.0%)	24 (60.0%)		
Female	12 (30.0%)	16 (40.0%)		

t: student t- test, $\chi2$: Chi square test

As regards the case group, 40% of cases were current smokers. HTN was observed in 70% of cases while DM was observed in 55% of them. 55% of cases were admitted once in hospital, while 22.5% were admitted twice, 12.5% were admitted three times and 10% were admitted four times. In the cases' group dyspnea has been observed in all cases while 85% of them were complaining of PND. 75% of cases had chest pain and 60% complained of orthopnea. Congested neck veins were found in 15%, while lower limb edema was observed in 47.5% of total cases. Regarding NHYA classification, most of cases were grade II (45%) followed by both grade I and grade IV (each of them had a percentage of 25%) then grade III (5%) (Table 2).

Table (2): Risk factors, clinical data, and NYHA classification among cases' group

Medical history	Cases group (number=40)
Smoking	16 (40%)
HTN	28 (70%)
DM	22 (55%)
Hospital admission	
Once	22 (55%)
Twice	9 (22.5%)
Three times	5 (12.5%)
Four times	4 (10%)
Clinical data	**Cases group (number=40)**
Dyspnea	
Yes	40 (100%)
No	0 (0%)
Orthopnea	
Yes	24 (60%)
No	16 (40%)
Paroxysmal nocturnal dyspnea (PND)	
Yes	34 (85%)
No	6 (15%)
Chest pain	
Yes	30 (75%)
No	10 (25%)
Lower limb edema	
Yes	19 (47.5%)
No	21 (52.5%)
Congested neck veins	
Yes	6 (15%)
No	34 (85%)
NYHA classification	**cases group (number=40)**
1	10 (25%)
2	18 (45%)
3	2 (5%)
4	10 (25%)

EF was significantly decreased in cases' group than control group. Regarding TDI waves, septal S', E' and A' waves demonstrated a significant decrease in velocities among cases' group than control group. Lateral S' wave showed a significant reduction in velocity in case group than control group as well, while insignificant distinction was found regarding lateral E' and A' waves among both groups (Table 3).

Table (3): Tissue Doppler imaging (TDI) and Ejection fraction (EF) among case and control groups

Pulsed tissue Doppler cursor placement	**Tissue Doppler wave**	**Wave velocity**		**Test of significance**	**P value**
		Cases group (number=40)	**Control group (number=40)**		
(Lateral) mitral annulus	**S' wave** Median (Min-Max)	0.06 (0.03-0.5) (m/s)	0.08 (0.07-0.13) (m/s)	Z=1.98	0.048*
	E' wave Median (Min-Max)	0.1 (0.04-0.6) (m/s)	0.14 (0.12-0.16) (m/s)	Z=1.51	0.13
	A' wave Median (Min-Max)	0.075 (0.04-0.7) (m/s)	0.09 (0.08-0.13) (m/s)	Z=1.02	0.305
(Septal) mitral annulus	**S' wave** Median (Min-Max)	0.04 (0.02-0.4) (m/s)	0.07 (0.06-0.1) (m/s)	Z=6.03	≤0.001*
	E' wave Median (Min-Max)	0.03 (0.02-0.50) (m/s)	0.09 (0.07-0.12) (m/s)	Z=4.91	≤0.001*
	A' wave Median (Min-Max)	0.045 (0.01-0.5) (m/s)	0.08 (0.07-0.12) (m/s)	Z=5.91	≤0.001*
EF (with **Simpson's** method		35.70±4.78	60.55±4.71	t=23.41	≤0.001*

Z: Mann Whitney test, *: statistically significant t: student t- test, EF: Ejection Fraction, *: statistically significant.

MPI estimated at both septal and lateral mitral annuli demonstrated a significant increase in cases' group than control group (Table 4).

Table (4): MPI values among case and control groups

	Cases group (number=40)	**Control group (nmber=40)**	**Test of significance**	**P value**
MPI **(Lateral)** mitral annulus Mean ± SD	0.688±0.19	0.337±0.08	t=7.54	≤0.001*
MPI **(Septal)** mitral annulus Mean ± SD	0.941±0.39	0.422±0.16	t=5.68	≤0.001*

*: statistically significant

MPI estimated at both septal and lateral mitral annuli demonstrated a significant correlation with NYHA classification. MPI measured at septal mitral annulus demonstrated a significant correlation with age and EF as well (Table 5).

Table (5): Correlation between MPI at lateral and septal mitral annuli with other variables

	MPI (at **lateral** mitral annulus)		**MPI** (at **septal** mitral annulus)	
	r	**P value**	**r**	**P value**
Age	-0.073	0.655	-0.333	0.036*
NYHA classification	0.436	≤0.001*	0.479	≤0.001*
EF (with Simpson's method)	-0.205	0.205	-0.355	0.024*

*: statistically significant

ROC curve of MPI (measured at both lateral and septal mitral annuli) was conducted for prediction of HF. AUC of lateral-MPI was 0.894 at cut off value of 0.455 with 87.5% sensitivity and 95% specificity while PPV was 97.2%, NPV was 79.2% and accuracy was 90%. AUC of septal-MPI was 0.881 at cut off value of 0.465 with 90% specificity and 90% sensitivity while PPV was 94.7%, NPV was 81.8% and accuracy was 90%. Calculation of the MPI either at the lateral or the septal mitral annulus was found to be similar in prediction of HF (Table 6).

Table (6): Receiver operating characteristics curve (ROC) for prediction of HF by MPI measured at both lateral and septal mitral annuli

	AUC	95%CI	Cutoff	Sensitivity	Specificity	PPV	NPV	Accuracy
Lateral- MPI	0.894	0.808- 0.981	0.455	87.5%	95%	97.2%	79.2%	90%
Septal- MPI	0.881	0.785- 0.976	0.465	90%	90%	94.7%	81.8%	90%

CI: confidence interval, AUC: area under the curve, NPV: Negative predictive value, PPV: positive predictive value, MPI: myocardial performance index.

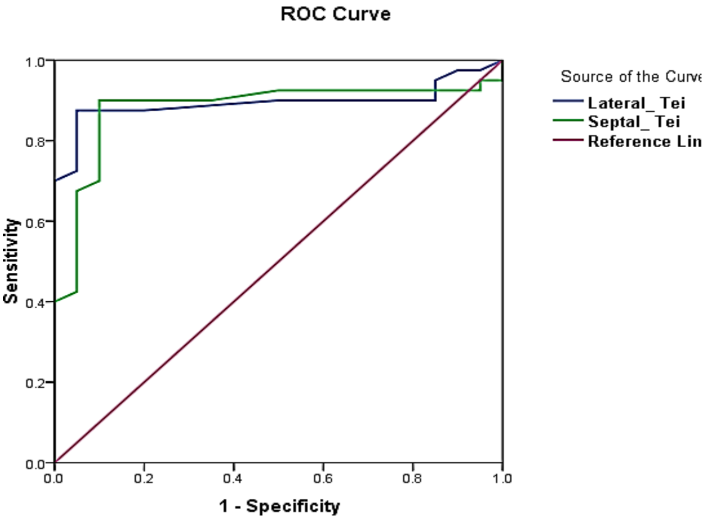

Figure (2): ROC for prediction of HF by MPI.

DISCUSSION

In our study showed that, the mean age was 60.40 ± 7.53. They were 28 males and 12 females in addition to 40 healthy individuals as a control group. The control group involved 24 males and 16 females whose mean age was 57.67 ± 5.92. A statistically insignificant distinction has been observed among case and control groups regarding age or sex. In agreement with our outcomes, **Meric *et al.*** [5] found that a statistically insignificant distinction has been observed among cases with congestive heart failure and asymptomatic cases regarding age**.**

Our study showed that, congested neck veins were found in 15%, while lower limb edema was observed in 47.5% of total cases. As regards the case group, 40% of cases were current smokers. HTN was observed in 70% of cases while DM was observed in 55% of them. 55% of cases were admitted once in hospital while 22.5% were admitted twice, 12.5% were admitted three times and 10% were admitted four times. In the cases' group dyspnea has been observed in all cases, while 85% of them were complaining of PND. 75% of cases had chest pain and 60% complained of orthopnea. **Mwita *et al.*** [6] studied 193 consecutive cases admitted with AHF at Princess Marina Hospital in Gaborone they found that the most frequent concomitant medical conditions were HTN (54.9%), orthopnea (78.2%), anemia (23.3%) and prior DM (15.5%)**.** Our study showed that, regarding NHYA classification, most of cases were grade 2 (45%) followed by both grade 1 and grade 4 (each of them had a percentage of 25%) then grade 3 (5%). **Dujardin *et al.*** [7] previously have shown Tei index prognostic importance in a sample of seventy-five cases with idiopathic DCM, exhibiting a mean left ventricular ejection fraction of twenty-three percent. Over fifty percent of the cases in their research exhibited NYHA class 1 or 2 symptoms. Our study showed that, regarding EF, it was significantly decreased in cases' group than control group. **Ogunmola *et al.*** [8] found that ejection fraction has been reduced in cases with heart failure than in controls (50.4 ± 19.01% v.s. 68.37 ± 7.79%) and distinction was statistically significant.

Our study showed that, as regards TDI in our investigation, MPI estimated at both septal and lateral mitral annuli demonstrated a significant elevation in cases' group than in control group. This is in agreement with our **Meric *et al.*** [5] selected one hundred twenty-six cases and divided them into two groups. Group 1 (asymptomatic group) comprised fifty-nine cases (thirty-two men and twenty-seven women with mean age of 61 ± 10 without heart failure symptoms, while group 2 consisted of sixty-seven cases (thirty-four men and thirty-three women with mean age of 60 ± 9 with congestive heart failure, classified as NYHA functional class not less than two. The MPI was markedly elevated in congestive heart failure group compared to asymptomatic group**. Abuomara *et al.*** [9] found that MPI has been markedly increased in cases who developed in-hospital heart failure (Killip class not less than eleven) than those without heart failure (Killip class one) (0.88 ± 0.18 versus 0.58 ± 0.11, correspondingly) (p-value equals .0001)**. Ascione *et al.*** [10] selected two groups based on their in-hospital course: Group one included seventy-five cases with an uncomplicated course, whereas group two consisted of twenty-one cases with a complicated in-hospital course (including mortality, heart failure, post-AMI angina, or arrhythmias). The average MPI was markedly elevated in those with cardiac events compared to those without events (0.65 ± 0.20 versus 0.43 ± 0.16, P-value equals .0001)**. Bia *et al.*** [11] examined one hundred one cases of congenital heart disease from the investigation group and forty-six control cases without heart disease, all cases were over sixty years of age, incorporating Doppler spectra registration and myocardial performance index calculation. The mean MPI in congestive HF cases was significantly elevated compared to control cases. The MPI values in congenital heart disease cases, regardless of low or normal LVEF, significantly exceeded those in the control group.

Our investigation showed that MPI estimated at both septal and lateral mitral annuli demonstrated a significant correlation with NYHA classification. This finding is in line with **Ogunmola *et al.*** [8] who revealed a correlation among clinically assessed heart failure severity and MPI. They studied 75 newly presenting cases with heart failure of NYHA class 2 to 4 and found that the mean MPI was higher with elevated heart failure severity, and a statistically significant distinctions have been observed among all three groups (NYHA 2, 3, and 4)**.**

Our investigation showed that regarding TDI waves velocities, our study demonstrated a significant reduction in septal S', E' and A' among cases' group than among control group. Also, lateral S' demonstrated a significant reduction in cases' group than in control group. However, insignificant distinction was found regarding lateral E' and A' waves between the two groups. Similar findings are reported by **Mejia *et al.* [12]** who studied 25 pediatric HF cases and found that E' and S' measured at the septal mitral valve annulus as well as S' measured at the lateral annulus were significantly decreased in their studied cases. However, their measured lateral E' was significantly decreased as well.

Our study showed that the ROC curve of MPI was conducted for prediction of HF. AUC of lateral-MPI was 0.894 at cut off value of 0.455 with 87.5% sensitivity and 95% specificity, while PPV was 97.2%, NPV was 79.2% and accuracy was 90%. AUC of septal-MPI was 0.881 at cut off value of 0.465 with 90% sensitivity and 90% specificity while PPV was 94.7%, NPV was 81.8% and accuracy was 90%. **Bruch [13]** found that the MPI yielded an area under the curve of 0.88± 0.04 (+/- SEM) for separation of cases with or without CHF **[13]. Meric *et al.* [5]** used receiver operating characteristics to evaluate predictive feature of MPI, they chose cut-off values to detect cases with HF. This value was 0.74 for tissue Doppler Imaging–Myocardial Performance Index. Using this value, they diagnosed CHF with 92.5 % (82.7–97.2) sensitivity and 91.5 % (80.6–96.8) specificity for Tissue Doppler Imaging–Myocardial Performance Index.

In our study, calculation of the MPI either at the lateral or the septal mitral annulus was found to be similar in prediction of HF. **Sanchez *et al.* [12]** demonstrated that tissue Doppler imaging derived septal-MPI is a more sensitive indicator of disease severity than the tissue Doppler imaging derived left ventricular free wall MPI**.**

LIMITATIONS

The limited number of cases examined and the way the investigation has been conducted at one center may have yielded results that are not representative of those from other centers. The small number of cases may weaken the validity of the investigation's results. A monitoring period is necessary to see whether there are significant distinctions in the results and echocardiographic variables among the groups. We excluded cases involving chronic renal failure, chronic liver failure, atrial fibrillation, and individuals under eighteen years of age. Consequently, our results may not be relevant to them.

RECOMMENDATIONS

It is important to enhance knowledge and mindfulness among clinicians concerning MPI and methods for its calculation in order to help in prediction of HF. Study of MPI should be carried out for cases with other heart diseases accompanied with a good follow up of them to evaluate any significant distinctions in the outcomes. A similar investigation with a larger number of cases is recommended to be carried out in order to enhance the strength of the results.

CONCLUSION

MPI is a good predictor of LV function in cases with HF.

Conflict of interest: none declared.

Funding: non-fundable.

REFERENCES

1. **Tei C, Ling L, Oh J *et al.* (1995):** Evaluation of a new Doppler index of myocardial performance. J Am Soc Echocardiogr., 3: 357.
2. **Askin L, Cetin M, Tasolar H, Akturk E (2018**): Left ventricular myocardial performance index in prediabetic patients without coronary artery disease. Echocardiography, 35: 445-9.
3. **Lakoumentas J, Panou F, Kotseroglou V *et al.* (2005):** The Tei index of myocardial performance: applications in cardiology. Hellenic J Cardiol., 46: 52-8.
4. **Kadappu K, Thomas L (2015):** Tissue Doppler imaging in echocardiography: value and limitations. Heart Lung Circ., 24: 224-33.
5. **Meric M, Yesildag O, Yuksel S *et al.* (2014):** Tissue Doppler myocardial performance index in patients with heart failure and its relationship with haemodynamic parameters. Int J Cardiovasc Imaging, 30: 1057-64.
6. **Mwita J, Dewhurst M, Magafu M *et al.* (2017):** Presentation and mortality of patients hospitalised with acute heart failure in Botswana. Cardiovasc J Afr., 28: 112-7.
7. **Dujardin K, Tei C, Yeo T *et al.* (1998):** Prognostic value of a Doppler index combining systolic and diastolic performance in idiopathic-dilated cardiomyopathy. Am J Cardiol., 82: 1071-6.
8. **Ogunmola O, Akintomide A, Olamoyegun A (2013):** Relationship between clinically assessed heart failure severity and the Tei index in Nigerian patients. BMC Res Notes, 6: 1-6.
9. **Abuomara H, Hassan O, Rashid T *et al.* (2018):** Myocardial performance index as an echocardiographic predictor of early in-hospital heart failure during first acute anterior ST-elevation myocardial infarction. Egypt Heart J., 70: 71-5.
10. **Ascione L, De Michele M, Accadia M *et al.* (2003):** Myocardial global performance index as a predictor of in-hospital cardiac events in patients with first myocardial infarction. J Am Soc Echocardiogr., 16: 1019-23.
11. **BIa B, Larina V, Alekhin M *et al.* (2008):** Diagnostic value of Tei index in detection of chronic heart failure in elderly patients. Ter Arkh., 80: 15-21.
12. **Sanchez A, Simpson K, Hildebolt C *et al.* (2014):** Tissue Doppler septal Tei index indicates severity of illness in pediatric patients with congestive heart failure. Pediatr Cardiol., 35: 411-8.
13. **Bruch C, Schmermund A, Marin D *et al.* (2000):** Tei-index in patients with mild-to-moderate congestive heart failure. Eur Heart J., 21: 1888-93.