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Research Article

Utility of Tei Index as a Potential Diagnostic and Prognostic Index for Decompensated Heart Failure-Perception of Practicing Medical Professionals

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Abstract

Background and Objectives: Tei index is a Doppler-derived myocardial performance index, which is a measure of the combined systolic and diastolic myocardial performance of both the left and right ventricles. The Tei index is a new echocardiographic/Doppler index, calculated as isovolumic relaxation time and isovolumic contraction time divided by ejection time. The purpose of the study was to explore the utility of Tei index as a potential diagnostic tool for decompensated heart failure among medical professionals. **Methodology:** There were 47 medical professionals included in the study and enquired about the utility of Tei index using three different methods direct face-to-face interview, telephonic interview and e-mail survey. **Results:** According to the response, 25 professionals were not using Tei index, 18 of them were using Tei index when needed even though not regularly and only four of them were using Tei index frequently for the diagnosis and to know the prognosis of heart failure patients. **Conclusion:** The study findings did conclude that the difficulty of using Tei index is that it takes more time and it needs expert knowledge. Hence, the study emphasizes a clear need for education about the applications and technicalities of using Tei index as a diagnostic index for heart failure patients. This study also suggests that an algorithm can be created to make Tei index more applicable and user friendly.

Key words: Tei index, decompensated heart failure, isovolumic relaxation time, isovolumic contraction time, doppler echocardiography

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Heart Failure (HF) is one of the most common diseases of the heart in adults and is evidenced by the large number of hospital admissions and a poor prognosis¹. The HF is sometimes referred to as a "Final stage" condition, among cardiovascular diseases². In India, the estimated prevalence of heart failure is 1.3-4.6 million with an annual incidence of 491,600-1.8 million³.

According to Heart Failure Society of America, it is a syndrome of cardiac dysfunction, generally resulting from myocardial muscle dysfunction or loss, characterized by left ventricular dilatation or hypertrophy, leading to neurohormonal and circulatory abnormalities and characteristic symptoms like fluid retention, shortness of breath and fatigue, especially on exertion⁴.

Different avenues of tests are available to diagnose and test the severity of heart failure. An ideal test for heart failure should be non-invasive, the integrated assessment of both systolic and diastolic Left Ventricular (LV) function that does not artificially un-couple systolic from diastolic function, independent of ventricular loading conditions and reproducible during serial follow-ups¹.

Some of the most widely used diagnostic tests are Doppler echocardiography, an important technique in evaluating cardiac structure and function due to its non-invasive nature, high availability and minimal risk profile⁵. Echocardiography is a non-invasive method, which is used for the assessment of either systolic or diastolic LV function, the findings of which are known to influence the management decisions and outcomes¹. The velocity of blood flow across the valves, within the chambers of the heart and through aorta and other greater vessels can be measured by using Doppler echocardiography, which uses ultrasound reflecting off moving red blood cells. Both normal and abnormal blood flow patterns can be assessed non-invasively using the echocardiography technique. According to ACC/AHA guidelines as well as ESC guidelines, echocardiography is the single most useful test in the diagnosis of heart failure⁶ since systolic dysfunction, diastolic dysfunction, structural abnormality or a combination of these abnormalities can be documented in patients who present with resting and/or exertional symptoms of heart failure to establish a definitive diagnosis of heart failure⁷. Thus, it has become an ideal imaging modality for cardiac emergencies⁸.

B-Type Natriuretic Peptide (BNP) is a neuro-hormone, which is released from ventricular myocardium (myocytes) in

response to volume or pressure overload⁹. Myocardial wall strain or ischemia induces the secretion of BNP. A number of randomized trials have proved that increased BNP serum level allows for a reliable diagnosis and assessing the prognosis of HF, mainly systolic heart failure¹⁰. The main limitation of BNP is that it gives false positive results in conditions like coronary heart disease, atrial fibrillation, chronic obstructive pulmonary disease, pulmonary embolism, renal insufficiency, stroke, sepsis and in populations with low risk for left ventricular dysfunction, which requires further verification¹¹.

Myocardial Performance Index (MPI), also known as the Tei Index (TI) is used for the quick evaluation of left ventricle function by means of echocardiograph, which reflects both left ventricular systolic and diastolic function¹¹. The normal value of tei index should be <0.4 and its increasing values are related to deteriorated left ventricular function¹¹. Tei Chuwa and his colleagues first described MPI or TI in 1995 as a "Simple and reproducible Doppler index of combined systolic and diastolic myocardial performance in patients with primary myocardial systolic dysfunction¹²". Normal value of TI is 0.28 ± 0.04 in the right ventricle and 0.38 ± 0.04 in the left ventricle. If the value is 0.40 or higher in the right ventricle or 0.45 or higher in the left ventricle, it is regarded as abnormal¹³.

A study conducted by Karasek *et al.*¹¹ proved a strong positive correlation between BNP serum level and the TI value ($r = 0.80$, $p < 0.0001$). This relationship may be due to increasing pressure load of the left ventricle in patients with more advanced diastolic and systolic dysfunction associated with growing end-diastolic pressure leading to BNP hypersecretion¹¹.

All the existing indices of cardiac functions were designed to assess systolic function alone (including left ventricular ejection fraction, positive dP/dt and E_{max}) or diastolic function alone (including left ventricular negative dP/dt and compliance)¹⁴. The TI, on the other hand, is used for the quick evaluation of left ventricle function by means of echocardiograph, which reflects both left ventricular systolic and diastolic function¹¹.

The index was found to reflect the severity of LV dysfunction in patients with dilated cardiomyopathy and was proved to be an independent prognostic factor for mortality, similar to the ejection fraction¹⁵. The values of the Tei index increases in heart failure patients than in healthy individuals (0.85 ± 0.32 versus 0.37 ± 0.05) because of the prolongation of the isovolumic intervals and a shortening

Table 1: Left ventricular function assessment across NYHA classes

Variables	NYHA II	NYHA III	NYHA IV
Mean EF	65.48±16.38	53.69±15.59	37.92±14.35
Mean EDV	91.50±62.77	160.33±76.42	233.73±98.27
Mean Tei index	0.59±0.14	0.79±0.12	1.15±0.30

EF: Ejection fraction, EDV: End diastolic volume

of Ejection Time (ET). The values of Tei index correlates with NYHA class (Table 1), Ejection Fraction (EF) and ventricular volumes significantly, while the values greater than 0.77 were associated with higher 1, 3 and 5 year mortality. In mild-to-moderate heart failure patients, the usefulness of the index was studied by Sutton and Wieggers¹⁴. The TI was correlated with LV end-diastolic pressures and was significantly greater in 43 patients with heart failure than in 38 controls and the index greater than 0.47 identified heart failure patients with a sensitivity of 86% and a specificity of 82%¹⁶. In a cross-sectional study, MPI has been shown to be a sensitive indicator for symptomatic heart failure, but whether MPI predicts future development of heart failure independently of other echocardiographic measurements is still to be examined¹⁷.

Ogunmola *et al.*¹ investigated the relationship between clinically assessed heart failure severity and the TI in Nigerian patients. Seventy five newly presenting patients with HF of NYHA class II to IV were analyzed for Tei index using conventional two-dimensional and Doppler echocardiography techniques. The mean Tei index of patients was significantly higher than that of controls and ranged from 0.33 to 1.94 in patients and from 0.56-1.24 in controls. The mean Tei indices of patients with HF of NYHA classes II, III and IV showed statistically significant differences among all three groups that were compared¹.

Applications of Tei index in cardiology are:

- In heart transplant patients, TI can be used as a non-invasive technique to replace endo-myocardial biopsy to find out acute rejection, since systolic and diastolic dysfunction are often both present during episodes of cardiac rejection⁹
- According to the value of TI, the severity of coronary artery disease can be predicted¹⁸
- The value of the TI is increased in patients with severe symptomatic aortic stenosis (orifice $0.7 \pm 0.2 \text{ cm}^2$), as there was a shortening of IVRT and IVCT and a prolongation of ET¹⁹
- Right ventricular TI can be used as the most powerful Doppler parameter to distinguish patients with primary pulmonary hypertension from healthy individuals²⁰

- The TI can be a useful quantitative measure of ventricular function in patients with Ebstein's anomaly, since there will be a frequent coexistence of left and right ventricular dysfunction²¹
- The increased value of the TI can be used to determine the subclinical dose-related cardio-toxicity in patients undergoing chemotherapy with anthracyclines for treatment of malignant neoplasms²²
- The TI can be calculated in order to determine the myocardial involvement in amyloidosis as the cause of death is most commonly related with cardiac participation in the disease, which is manifested by disturbances of relaxation in the early stages and concomitant systolic dysfunction in the advanced stages¹⁶

It is pretty clear that TI has many applications in the field of Cardiology. So, the aim of this study is to analyze the perception of practicing cardiologists and echo-cardiographers regarding utility of TI as a potential diagnostic tool in decompensated heart failure patients.

MATERIALS AND METHODS

A list of Interventional Cardiologists was prepared, mainly through referral from the doctors and using internet database. Technicians in Cardiology Department like echo-cardiographers were also asked to take part in the study. The selected interventional cardiologists and echo-cardiographers were enquired about the utility of Tei index by administering a questionnaire prepared exclusively for this study. The questionnaire was prepared by a panel of cardiologists (three interventional cardiologists and two cardio-thoracic surgeons) in a tertiary care hospital and a professor of Pharmacy Practice Department according to the method given by Lynn²³. The questionnaire was administered to the selected cardiologists and technicians using three different methods viz., direct face-to-face interview, telephonic interview and mail survey. The cardiologists were explained about the details of the study and their willingness was ascertained. The cardiologists who were willing to take part in the study were either asked the questions present in the questionnaire or were e-mailed the questionnaire. The questionnaire used for this study contains the questions as follows:

- How many Heart Failure patients you are consulting per month?
- What is the most common cause for Heart Failure?
- Whether Tei index is used as a tool for diagnosing Heart Failure patients in your practice setting?
- If yes, the applicability of Tei index over other indices already available for diagnosing Heart Failure patients
- If no, can you enumerate the practical difficulties in using Tei index in diagnosing Heart Failure patients?
- Are there any suggestions to make the index user friendly?

The data collection period was set as one month. At the end of the one month, the interviewer consolidated the mails that have been received, consolidated the telephonic answers and results were charted down.

RESULTS

A total of 53 medical professionals both cardiologists and echo-cardiographers were randomly selected for the study, out of which 44 were cardiologists and 9 were echo-cardiographers. The selected 53 medical professionals were contacted either through phone, e-mail or directly and

explained about the study. Only 47 medical professionals (43 cardiologists and 4 echo-cardiographers) expressed their willingness to participate in the study and six professionals opted not to participate in the study because of disinterest and lack of time. The 47 medical professionals were enrolled in the study and enquired about the utility of Tei index by using three methods as mentioned, out of which again only 45 of them responded and two of them did not respond to the questions. The demographics and response to survey of medical professionals interviewed by using each method was recorded and is depicted in Table 2. The response of Medical professional regarding the Utility of Tei index was illustrated in the Fig. 1. According to the response, 25 professionals out of 47 were not using Tei index at all for the diagnosis of heart failure, 18 of them were using Tei index when needed even though not regularly and only four of them were using Tei index frequently for the diagnosis and to know the prognosis of heart failure. From the study response, different advantages of Tei index were obtained and were recorded in the Table 3. The main advantage of the Tei index was that it is a non-invasive technique and is highly reproducible. There were 12 (25.5%) medical professionals agree that the index is simple and is easy to estimate, 24 (51%) medical professionals accept that it is the only index that takes into account both systolic

Table 2: Medical professionals demographics and response to survey

Details of medical professionals	Cardiologist	Echo-cardiographer	Total
N (sample size)	43	4	47
Demographic details			
Men	43	1	
Women	0	3	
Age (years), Mean (Range)	53 (40-58)	51 (41-48)	
Years in practice	26	16	
Current practice setting			
Private	23	3	
Nonacademic medical center	17	1	
Academic medical center	3	-	
Survey responses			
Direct personal interview	5	4	09
Telephonic interview	20	-	20
E-mail	16	-	16
No response	02	-	02

No.: Number, Mean: Upper value+lower value/2, Range: Lowest value to highest value

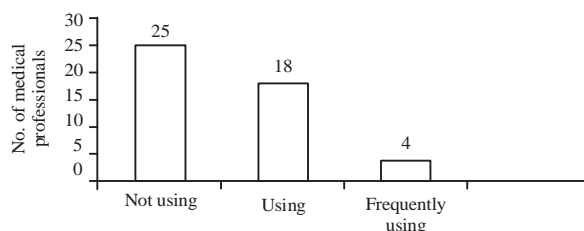


Fig. 1: Utility of Tei index by different cardiologists and technicians

Table 3: Advantages of Tei index over other indices

Advantages of Tei index	Percentage of response (%)
Simple and easy to estimate	25,5
Takes into account both systolic and diastolic functions	51
Independent of heart rate, blood pressure and gender	49
Non-invasive	98
Has prognostic value	21
Reproducible	89

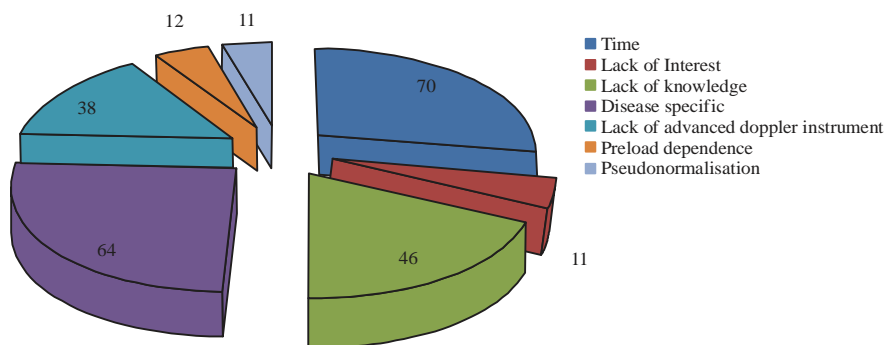


Fig. 2: Practical difficulties in using Tei index

and diastolic functions, 23 (49%) of the medical professionals told that Tei index is independent of heart rate, blood pressure and gender and 10 (21%) medical professionals agree that the Tei index has a good prognostic value. The practical difficulties in using the Tei index were obtained from the study population and recorded in Fig. 2. Almost all medical professionals agree that the main difficulty of using Tei index is the time taken for the detection of the index from echocardiography. There were 30 (64%) medical professionals accept that specific diseases like atrial fibrillation, frequent ventricular ectopic stimuli, disturbances of intraventricular or atrioventricular conduction causes difficulties in the calculation of Tei index. Lack of technical knowledge and lack of advanced Doppler instrument was reported by 20 (46%) and 18 (38%) professionals, respectively. Lack of interest, pseudonormalisation and preload dependence were also the disadvantages of Tei index.

DISCUSSION

In the present study, the utility of Tei index as a potential diagnostic and prognostic index for decompensated heart failure among practicing medical professionals was assessed. According to the response from the study, approximately 40% of the medical professionals were using and 10% of them were frequently using Tei index and 50% of the physicians and technicians were not at all using Tei index.

In a study conducted by Karatzis *et al.*²⁴, they cited the advantages of Tei index as it is simple, noninvasive, easy to

estimate, reproducible, independent of arterial pressure, heart rate. Stipac *et al.*¹⁵ in their study indicated that the prognostic value of Tei index was shown to be similar to that of ejection fraction. The advantages found out in the study coincide with the results of the above said study. In regards to the practical difficulties in using Tei index, it found that specific diseases like atrial fibrillation, frequent ventricular ectopic stimuli, disturbances of intraventricular or atrioventricular conduction causes difficulties in the calculation of Tei index. These data were related to the study by Lakoumentas *et al.*¹⁶.

In two independent studies done by Oh *et al.*²⁵ and Nijland *et al.*²⁶, it was found that pseudonormalisation is a main limitation of the index which agrees with the results of our study. Arnlov *et al.*¹⁷ concluded in their study that Tei index seems to be a clinically relevant indicator of cardiac function and may prove to be a valuable tool in assessing the risk of future CHF.

The utility of Tei index can be extended to explore the utility of Tei index to specific diseases like myocardial infarction, hypertension, neonatal respiratory distress, perinatal asphyxia, amyloidosis, Ebstein's anomaly, pulmonary hypertension, coronary artery disease, etc. There were no literature evidences that deal with the utility of Tei index in a clinical setting. The responses from physicians and technicians from this study emphasize a clear need for education about the applications and technicalities of using Tei index as a diagnostic index for decompensated heart failure patients. Most of the cardiologists felt that it is difficult to use the Tei index in their practice setting because the Tei index takes

more time to analyze and technicians need expert knowledge in applying the index. On the contrary, most of the physicians and echo-cardiographers accept that Tei index is a good diagnostic test for analyzing the severity of decompensated heart failure patients and it also has some prognostic value. Some of the suggestions to make Tei index are as follows:

- Appropriate teaching of Medical professionals especially Echo cardiographers and cardiologists
- Algorithm relating Tei index and Heart Failure can be proposed
- Increase the Doppler scale
- Increase the gain of image and sometimes the Doppler audio

RECOMMENDATIONS

This study suggests that the difficulties of using Tei index may be overcome by proper education to the cardiologist as well as the technicians on proper use of Doppler echocardiography. An algorithm can also be created to make Tei index more applicable and user friendly. Optimum Doppler speed should be used to ensure accuracy and appropriateness of measurement of Tei index. As a final note, the study recommends that Tei index can be used along with existing indices in diagnosing and estimating the prognosis of heart failure. This study needs to be extended to explore the utility of Tei index to specific diseases like myocardial infarction, hypertension, etc.

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