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# Segmental Tissue Doppler Image-Derived Tei Index in Patients With Regional Wall Motion Abnormalities

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## ABSTRACT

**Background and Objectives**: Although the Tei index is a useful predictor of global ventricular function, it has not been investigated at the level of regional myocardial function. We therefore investigated the segmental tissue Doppler image derived-Tei index (TDI-Tei index) in patients with regional wall motion abnormalities. **Subjects and Methods**: We prospectively studied 17 patients (mean age 62±9 years, 5 women) with left ventricular (LV) regional wall motion abnormalities. The Tei index, defined as the sum of isovolumetric contraction time (IVCT) and isovolumetric relaxation time (IVRT) divided by ejection time (ET), was measured in the basal and mid segments of the LV walls from standard apical views (4-, 2-, and 5-chamber views). We also obtained TDI velocity data in each segment. LV wall motion was classified as normal, hypokinetic, or akinetic, based on visual analysis. The TDI-Tei index, peak systolic myocardial velocity (Sm), early diastolic myocardial velocity (Em), and late diastolic myocardial velocity (Am) were analyzed in a total of 203 segments. **Results**: Mean LV ejection fraction was 41.8±8.5%. TDI-Tei indices of dysfunctional segments (akinesis or hypokinesis, n=63) were significantly higher than those of normal segments (n=140) (0.714±0.169 vs. 0.669±0.135, $p=0.041$, respectively). Average values of TDI-Tei index, Sm, Em, and Am were 0.742±0.201, 4.206±1.336, 5.258±1.867, and 5.578±2.354 in akinetic segments; 0.677±0.101, 4.908±1.615, 5.369±2.121, and 5.542±2.492 in hypokinetic segments; and 0.669±0.135, 5.409±1.519, 6.108±2.356, and 6.719±2.466 in normal segments, respectively. A significant negative correlation was apparent between the TDI-Tei index and Sm ($r=-0.302$, $p<0.001$). **Conclusion**: These data suggest that the value of the segmental TDI-Tei index differs significantly according to regional function grade. **(Korean Circ J 2010;40:114-118)**

**KEY WORDS**: Echocardiograph, Doppler; Myocardial contraction; Ventricular function.

## Introduction

Since its introduction by Dr. Tei in 1995, the Tei index, a Doppler index of myocardial performance,[1)2)] has proven its usefulness as a unique indicator of global ventricular function and as a prognostic predictor in post-myocardial infarction patients. For example, Bruch et al.[3)] demonstrated the sensitivity of the Tei index for detection of cardiac dysfunction, even in patients with mild congestive heart failure, and Møller et al.[4)] reported that the Tei index is an important and independent prognostic predictor in long-term follow-up of myocardial infarction patients. Although the Tei index has been regarded as a marker for global myocardial function, its association with regional myocardial function has remained uncharacterized. The tissue Doppler image derived Tei index (TDI-Tei index) has recently been used to assess left ventricular (LV) function, and, like the conventional Tei index, it was also found to be useful for global function.[5-7)] Although the TDI-Tei index is a simple and reliable indicator in assessment of overall LV function,[8)] there have been no reports on whether or not the TDI-Tei index measured at myocardial segments varies

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according to grade of regional function. We therefore investigated segmental TDI-Tei index in patients with regional wall motion abnormalities.

## Subjects and Methods

### Study population

This study was performed in 17 post-myocardial infarction patients with regional wall motion abnormalities. Exclusion criteria included inadequate echocardiographic visualization, presence of a left bundle branch block on the electrocardiogram, and severe valvular heart disease. Clinical information was retrieved from past medical records.

### Echocardiographic evaluation

Echocardiography was performed using an iE33 ultrasound system and 2.5 MHz transducers (Philips Ultrasound Company, USA). Standard M-mode, 2-dimensional (2D), and pulsed wave echocardiography were performed according to 2005 American Society of Echocardiography recommendations.[9] Interventricular septal wall thickness, posterior wall thickness, and LV end diastolic dimension were measured at the chordae tendinae level. LV ejection fraction was measured using the modified Simpson method. LV regional wall motion was assessed according to the conventional 16-segment model and classified as normal, hypokinetic, and akinetic based on visual analysis. The conventional Tei index was calculated from the sum of isovolumetric contraction time (IVCT) and isovolumetric relaxation time (IVRT), divided by ejection time (ET). For conventional Tei index calculation, IVCT, IVRT, and ET were measured from pulsed wave Doppler imaging of the trans-mitral inflow and LV outflow tracts. Using tissue Doppler, we measured the systolic (Sm), early (Em), and late diastolic myocardial velocities (Am) of each segment. For TDI-Tei index calculation, IVCT, IVRT, and ET were measured from tissue Doppler myocardial velocity images. IVCT was defined as the duration of the bidirectional spike between Am and Sm in the tissue Doppler tracing. IVRT was defined as the duration of the bidirectional spike between Sm and Em. ET was defined as the duration of Sm. The TDI-Tei index was calculated from the same equation used for the conventional Tei index (Fig. 1). TDI-velocities and TDI-Tei index were measured at the basal and mid segments of the LV walls from standard apical 4-, 2-, and 5-chamber views. Velocities and time interval measurements were obtained from one cardiac cycle. Myocardial segments of patients with LV regional wall motion abnormalities were subdivided into 3 groups: normal, hypokinetic, and akinetic segment groups. Average values of TDI-velocities and TDI-Tei indices were obtained in normal, hypokinetic, and akinetic segments, and results from each group were compared.

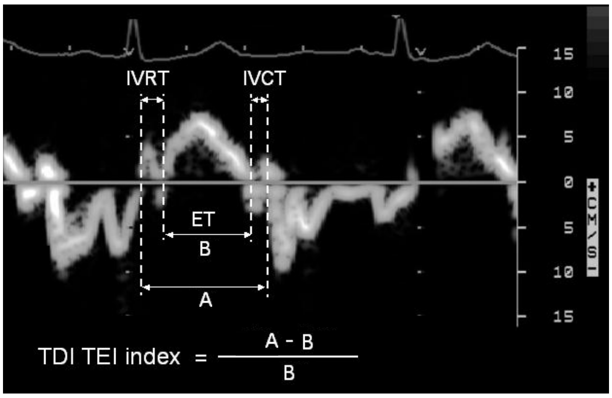


**Fig. 1.** A representative case of measurements for calculation of the TDI-Tei index. IVRT: isovolumetric relaxation time, IVCT: isovolumetric contraction time, ET: ejection time, TDI-Tei index: tissue Doppler image derived Tei index.

### Statistical analysis

Continuous data were expressed as mean values ± 2 SD and categorical data were expressed as percentages. One-way analysis of variance (ANOVA) was applied to assess statistical significance of differences of the Sm, Em, Am, and TDI-Tei indices among the three subgroups, i.e., the normal, hypokinetic, and akinetic segments. Pearson's correlation analysis was performed to examine the association between the TDI-Tei and conventional Tei indices. Inter-observer variability was calculated as the SD of the differences between 2 observers, expressed as a percent of the average value. Measurements for TDI-Tei index calculation were performed twice on 5 patients for assessment of reproducibility.

## Results

### Study population

Clinical characteristics of the study population are summarized in Table 1. All patients had sinus rhythm.

### Echocardiographic measurements

Echocardiographic measurements are summarized in Table 2. The TDI-Tei index, Sm, Em, and Am were measured at a total of 203 segments. Both the conventional Tei and TDI-Tei indices were 0.661±0.095 and 0.679±0.095, respectively. Fig. 2 shows the strong correlation between the conventional and TDI-Tei indices ($r=0.811$, $p<0.001$). Sm, Em, and Am were 5.3±0.9, 5.9±1.6, and 6.6±2.0 cm/s, respectively. Average values of TDI-Tei indices of dysfunctional segments (akinetic or hypokinetic segments, n=62) were significantly higher than those of normal segments (n=141) (0.714±0.169 vs. 0.669±0.135, $p=0.041$, respectively) (Table 3). TDI-Tei indices from akinetic segments of the anterior wall were not significantly different from those from of akinetic segments of the inferior wall (0.777±0.111 vs. 0.751±0.272, $p=0.771$, respectively) (Table 3). Average values of TDI-Tei indices were 0.742±0.201, 0.677±0.101, and 0.669±0.135 in akinetic, hypokinetic, and normal segments, respectively (Table 3). Average values of Sm, Em, and Am were 4.2±1.3, 5.3±1.9, and 5.6±2.4 cm/s in akinetic segments; 4.9±1.6, 5.4±2.1, and 5.5±2.5 in hypokinetic segments; and 5.4±1.5, 6.1±2.4, and 6.7±2.5 in normal segments, respectively (Table 3). ANOVA analysis showed that the TDI-Tei index and Sm were significantly different between akinetic and normal segments ($p=0.020$, $p<0.001$, respectively) (Fig. 3). A weak, but statistically significant negative correlation was observed between the TDI-Tei index and Sm in the patient group ($r=-0.302$, $p<0.001$) (Fig. 4). Inter-observer variability for the TDI-Tei index was 8±6%. Reproducibility for the TDI-Tei index was 95±4%.

**Table 1.** Clinical characteristics of the study population

| | |
|---|---|
| Age (years) | 62.0±8.8 |
| Gender (women, %) | 9 (52.9) |
| Systolic blood pressure (mmHg) | 120±15 |
| Diastolic blood pressure (mmHg) | 76±10 |
| Heart rate (beats/min) | 68±11 |
| Hypertension (n, %) | 8 (47.1) |
| Diabetes mellitus (n, %) | 3 (17.6) |
| Hyperlipidemia (n, %) | 1 (5.9) |
| Smoking (n, %) | 6 (35.3) |

**Table 2.** Echocardiographic measurements

| | |
|---|---|
| LVEDD (mm) | 52.6±4.8 |
| LVEF (%) | 41.8±8.5 |
| Pulsed wave Doppler E/A | 1.1±0.8 |
| Tissue Doppler Ea (cm/s) | 7.3±2.9 |
| Conventional Tei index (msec) | 0.661±0.095 |
| IVCT | 85.0±11.5 |
| IVRT | 99.0±18.6 |
| ET | 282.3±26.7 |
| TDI-Tei index (msec) | 0.672±0.880 |
| IVCT | 85.1±10.3 |
| IVRT | 105.8±21.4 |
| ET | 282.8±29.0 |
| Sm (cm/s) | 5.3±0.9 |
| Em (cm/s) | 5.9±1.6 |
| Am (cm/s) | 6.6±2.0 |

LVEDD: left ventricular end diastolic diameter, LVEF: left ventricular ejection fraction, Ea: peak early diastolic mitral annulus velocity, IVCT: isovolumetric contraction time, IVRT: isovolumetric relaxation time, ET: ejection time, TDI-Tei index: tissue Doppler image derived Tei index, Sm: peak systolic myocardial velocity, Em: peak early diastolic myocardial velocity, Am: peak late diastolic myocardial velocity

## Discussion

The Tei index is used as a reasonable index of global LV function because it simultaneously reflects systolic and diastolic LV function[10)11)]; and also allows prediction of prognosis of post-myocardial infarction in patients.[12-14)] The conventional Tei index was originally calculated from measurement of time intervals at mitral inflow and LV outflow using pulsed wave Doppler. Recent studies have shown that this index could be measured at mitral annulus using TDI and that it correlated well with the conventional Tei index.[15)16)] Moreover, measurement of the TDI-Tei index is simple, and provides a reliable indicator of overall LV function.[8)] However, in previous observations the TDI-Tei index was measured at mitral annulus, and not at myocardium. To the best of the authors' knowledge, the segmental value of the TDI-Tei index has not been studied systemically, and there have been no studies to confirm the difference of this index among myocardial segments.

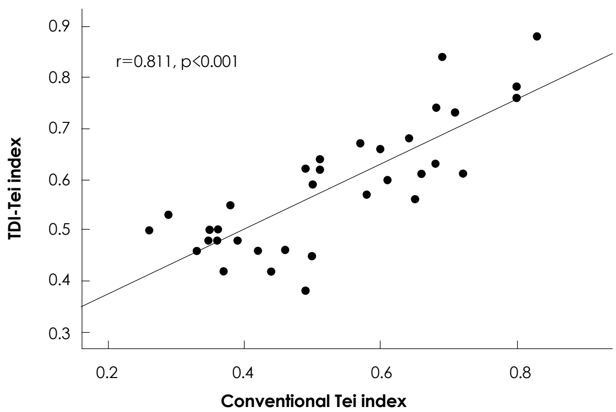


**Fig. 2.** Correlation of conventional Tei index and TDI-Tei index. TDI-Tei index: tissue Doppler image derived Tei index.

**Table 3.** Tissue Doppler imaging indices of myocardial function in patients with regional wall motion abnormalities

| | Akinetic segment (n=36) | Hypokinetic segment (n=26) | Normal segment (n=141) | p |
|---|---|---|---|---|
| TDI-Tei index (msec) | 0.742±0.201 | 0.677±0.101 | 0.669±0.135 | 0.028 |
| ET | 272.9±33.8 | 269.2±26.9 | 286.2±32.0 | 0.009 |
| IVCT | 86.1±17.9 | 81.2±20.6 | 86.4±16.6 | 0.371 |
| IVRT | 112.6±33.0 | 104.2±32.0 | 107.3±47.9 | 0.736 |
| Sm (cm/s) | 4.2±1.3 | 4.9±1.6 | 5.4±1.5 | <0.001 |
| Em (cm/s) | 5.3±1.9 | 5.4±2.1 | 6.1±2.4 | 0.065 |
| Am (cm/s) | 5.6±2.4 | 5.5±2.5 | 6.7±2.5 | 0.009 |

TDI-Tei index: tissue Doppler image derived Tei index, ET: ejection time, IVCT: isovolumetric contraction time, IVRT: isovolumetric relaxation time, Sm: peak systolic myocardial velocity, Em: peak early diastolic myocardial velocity, Am: peak late diastolic myocardial velocity

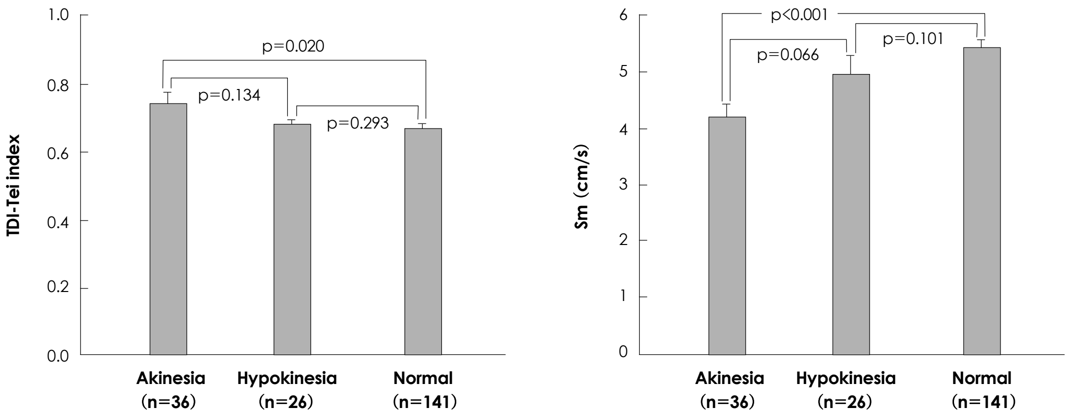


**Fig. 3.** Differences in TDI-Tei indices and peak systolic myocardial velocities among akinetic, hypokinetic, and normal myocardial segments. Sm: peak systolic myocardial velocity, TDI-Tei index: tissue Doppler image derived Tei index.

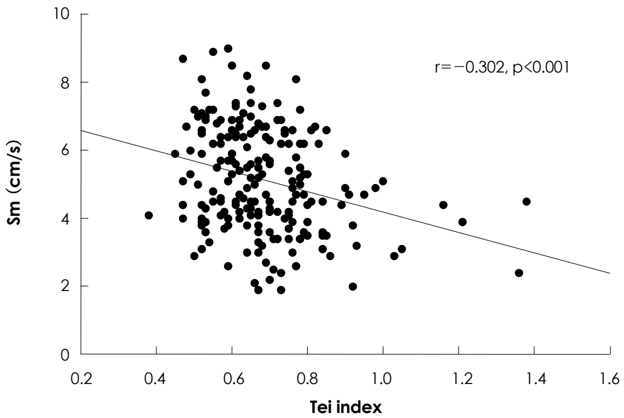


**Fig. 4.** Correlation of TDI-Tei index and peak systolic myocardial velocity. Sm: peak systolic myocardial velocity, TDI-Tei index: tissue Doppler image derived Tei index.

We therefore investigated the segmental TDI-Tei index in patients with regional wall motion abnormalities. Regional function was divided by visual assessment into normal, hypokinetic, or akinetic, which is a routine method for evaluation of regional function in clinical practice.

Myocardial TDI-Tei indices in this study were significantly increased in dysfunctional segments, as compared with normal segments. In addition, there was a significant negative correlation between the TDI-Tei index and Sm. These results suggest that myocardial TDI-Tei index may reflect regional as well as global function. Average values of myocardial TDI-Tei indices from all myocardial segments actually showed strong correlation with conventional Tei indices, demonstrating that the sum of segmental values can be used for estimation of global LV function. ANOVA analysis showed no statistically significant difference between normal and hypokinetic segments, or between hypokinetic and akinetic segments; however, a significant difference was observed between normal and akinetic segments. Sm showed similar differences between those segments.

Although the sum of segmental TDI-Tei indices correlated with the conventional Tei index, each value was significantly different according to degree of wall motion abnormalities. It is thus likely that the individual segmental TDI-Tei indices are insufficient to represent global LV function in patients with regional wall motion abnormalities. Our study showed variations among segmental TDI-Tei indices in myocardial segments with regional wall motion abnormalities, and it demonstrated that differing values of this index in each segment were related to the grade of regional wall motion.

## Acknowledgments

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