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Myocardial Tei Index in Dilated Cardiomyopathy and Mitral Valve Disease Affected Dogs

K. Rajkumar* **and C. Ansar Kamran**

Department of Veterinary Medicine, Veterinary College, Karnataka Veterinary Animal and Fisheries Sciences University, Bangalore, Karnataka, INDIA

**Corresponding author: K Rajkumar; Email: rajvet10@gmail.com*

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ABSTRACT

Tei proposed an index of myocardial performance (IMP), which was devised to investigate combined measurement of systolic and diastolic function. The present study was undertaken to study importance of myocardial tei index in Dilated cardiomyopathy (DCM) and Mitral valve disease (MVD) affected dogs. A total of 63 dogs were examined for calculation of TEI index. Out of 63 dogs, 37 and 26 dogs suffering from DCM and MVD were taken as separate groups. LV Tei index was increased in both DCM and MVD affected dogs. The mean and standard error of the Tei index in DCM and MVD were 0.51±0.11 and 0.63±0.11, respectively and no significant difference was observed between these groups. Tei index appeared to correlate with severity of disease and can be used for early diagnosis of DCM.

Keywords: Tei index, dilated cardiomyopathy, mitral valve disease, dog

In an endeavour to measure both systolic and diastolic dysfunction in Dilated Cardiomyopathy (DCM) patients, Tei proposed an index of myocardial performance (IMP), which was devised to investigate combined measurement of systolic and diastolic function whether or not could improve the accuracy of detecting left ventricular dysfunction compared with measurements of systolic and diastolic function alone (Tei, 1995). IMP is defined as the sum of isovolumic contraction and relaxation times divided by ejection time (Tei, 1995).

A number of research findings have documented that the Tei index is independent of arterial pressure (Tei *et al*., 1996; Nearchou *et al*., 1999; Bruch *et al*., 2000; Goroshi and Chand, 2016), heart rate, ventricular geometry, atrioventricular valve regurgitation (Lengyel, 1998), afterload, and preload. To assess the overall cardiac performance for clinical application the Tei index appears to have close correlation with the widely accepted systolic and diastolic hemodynamic parameters.

Index of myocardial performance appears to correlate with severity of cardiac disease in dogs and may be of use in the early diagnosis of affected dogs during screening for the presence of DCM (Lee *et al*., 2002). Further the Tei index has been shown to be significantly correlated with the left ventricular peak dp/dt in healthy dogs (Tei, 1995). Tei index also been shown to increase with the progression of clinical signs in dogs with mitral valve disease (MVD) due to a ejection time shortening (Teshima *et al*., 2007).

In moderate to severe mitral regurgitation , isovolumic contraction and relaxation times can be extremely short or absent due to the presence of an opening in the mitral valve area. Therefore, in that case, the Tei index seems to be inaccurate for assessing myocardial function (Chetboul and Tissier, 2012). Further number of research findings depicted use of tei index in DCM and MVD affected dogs is scarce hence present study was undertaken to study importance of myocardial tei index in dilated cardiomyopathy and mitral valve disease affected dogs.

MATERIALS AND METHODS

Dogs presented to the cardiology service of the Veterinary

Teaching Hospital, Veterinary College Bangalore eligible for entry into the study. A total of Sixty three dogs were enrolled into two groups based on the following criteria:

Dilated Cardiomyopathy (DCM)

Dogs referred to the cardiology service for evaluation of suspected DCM, including those with ventricular arrhythmias or with clinical signs of dyspnea, tachypnea, ascites, syncope, lethargy, or exercise intolerance; echocardiographic evidence of dilated cardiomyopathy (fractional shortening < 23%).

Mitral valve disease (MVD)

Dogs with a left apical systolic murmur thickened, nodular, or prolapsing mitral valve leaflets on 2-dimensional echocardiogram; moderate to severe mitral valve regurgitation subjectively determined by color flowdoppler study (turbulent color flowjet occupying greater than one-third of the left atrial chamber)

Echocardiography

Echocardiographic examination was performed as suggested by Seiler *et al*. 2008) using LOGIC BOOK XP ultrasound system with a cardiac probe of 6 to 10 Megahertz (MHz) to obtain two dimensional, M-mode, pulsed wave and color flow Doppler echocardiographic images of the heart.

Pulsed wave Doppler Echocardiography assessment of Aortic outflow

Image plane: Left apical three chamber or five chamber view (Fig. 1).

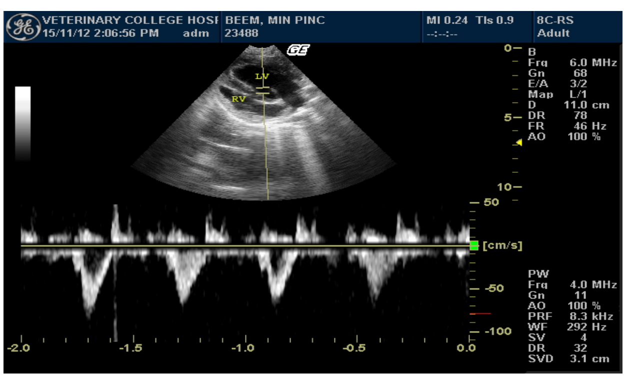

Fig. 1: Pulsed wave Doppler sample volume placed within the aorta, just beyond the aortic valves, to record aortic flow profiles in a dog

Sample volume position: Cursor as parallel as possible with aortic outflow (must be within 20 degrees) distal to the aortic valve (Boon, 2011).

Pulsed wave Doppler Echocardiography assessment of Mitral inflow

Image plane: Left apical four chamber view (Fig. 2).

Sample volume position: Mitral valve leaflets cusps (Boon, 2011).

Mitral inflow was recorded, so that the time from mitral valve closure to opening was measured.

Aortic outflow was recorded to measure the Ejection Time (ET)

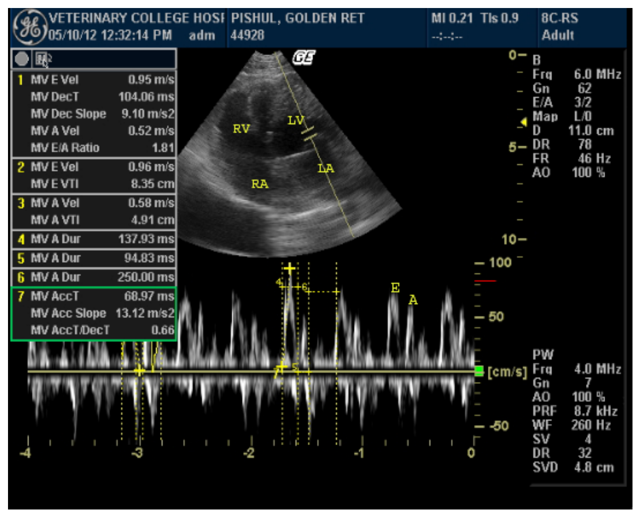

Fig. 2: Pulsed wave Doppler sample volume is placed between the tips of the mitral valve to record mitral inflow profile in a dog

The Tei index was calculated by:

IMP = (IVCT + IVRT)/ET (IVCT – Isovolumic contraction time, IVRT-Isovolumic relaxation time) (Fig. 3 & 4)

- The time from mitral valve closure (MVC) to mitral valve opening (MVO) = IVCT + ET + IVRT
- To determine IVCT + IVRT, subtract ET from MVC-MVO
- IMP can then be calculated (Tei, 1995; Lee *et al*., 2002; Teshima *et al*., 2007; Boon, 2011; Chetboul and Tisser, 2012)

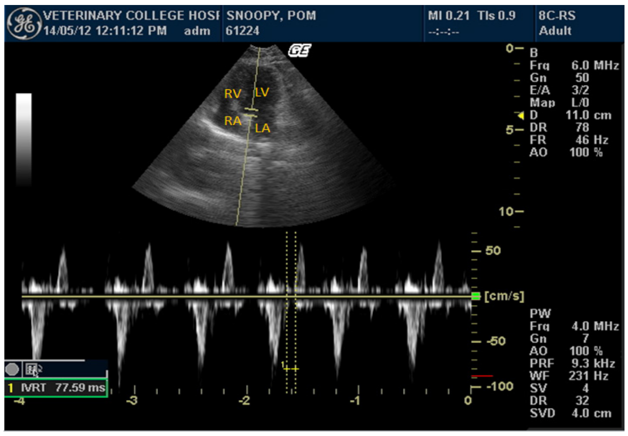

Fig. 3: Pulsed wave Doppler sample volume is placed between mitral inflow and left ventricular outflow to record mitral inflow and aortic outflow profile in a dog

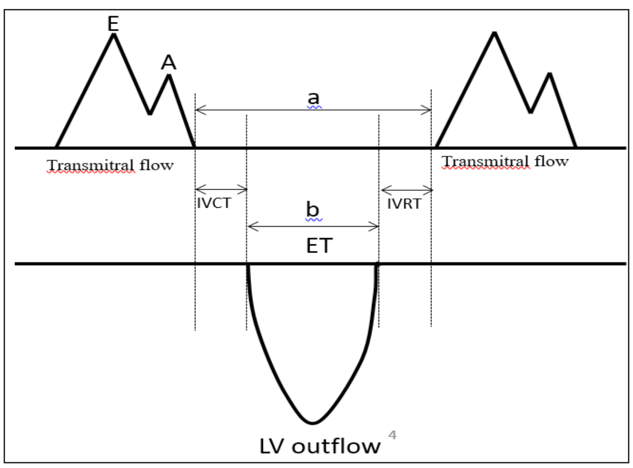

Fig. 4: Index of myocardial performance (IMP) (the Tei Index)

Index of myocardial performance =

$$\frac{a-b}{b}=\frac{(IVCT+IVRT)}{ET}$$

Statistical analysis

Data obtained were recorded as Mean ±SE and data between DCM and MVD were analysed by unpaired t test.

RESULTS AND DISCUSSION

Dilated Cardiomyopathy (DCM) was recorded in 37(45.1%) cases followed by Mitral Valve Disease (MVD) in 26(31.7%)

Pulse wave Doppler assessment of Aortic outflow

The mean and standard error of pulse wave Doppler assessment of aortic outflow are given in Table 1. Significant difference (P≤0.05) in peak aortic velocity, mean acceleration, maximum pressure gradient and mean pressure gradient were seen between DCM and MVD affected dogs.

Table 1: Association of diagnosis with Pulse wave Doppler of Aortic outflow assessment in cardiac disease in dogs

Echocardiographic variables	DCM	MVD
Peak Aortic Flow (m/s)	0.75±0.06	0.97±0.06**
Mean aortic flow (m/s)	0.46±0.03	0.57±0.05*
VTI (cm)	6.96±0.85	8.83±1.1^{ns}
ET (ms)	157.2±6.96	144.1±6.35 ^{ns}
Max PG (mmHg)	2.48±0.51	4.88±1.06*
Mean PG (mmHg)	1.05±0.15	1.76±0.33^{ns}
Env TI (ms)	126.48±14.29	136.55±16.7 ^{ns}
PHT (ms)	70.9±37.93	40.1±2.93 ^{ns}
Dec Time (ms)	114.06±16.88	144.93±15.34 ^{ns}

Results are in Mean ± SE; **: Significant (P≤0.01); *: Significant (P≤0.05); ^{ns}: Non-significant.

Pulse wave Doppler assessment of mitral inflow

The mean and standard error of pulse wave Doppler assessment of mitral inflow are given in Table 2. Highly significant difference (P ≤0.01) in peak A velocity and significant difference in E:A ratio and A Velocity time integral (VTI) were seen between DCM and MVD affected dogs. High E:A ratio and low A VTI was observed in DCM affected dogs.

Table 2: Association of diagnosis with Pulse wave Doppler of mitral inflow assessment in cardiac disease in dogs

Echocardiographic variables	DCM	MVD
Peak E Velocity (m/s)	0.98±0.17	0.84±0.09^{ns}
Peak A Velocity (m/s)	0.3±0.04	0.54±0.06**
E:A	4±0.57	1.98±0.38*
E Wave Duration (ms)	123.76±7.11	143.24±9.21 ^{ns}
E Wave Deceleration Time (ms)	92.04±8.55	110.83±10.77 ^{ns}
A Wave Duration (ms)	108.45±11.79	131.47±8.02 ^{ns}

E VTI (cm)	5.09±0.48	6.14±0.86 ns
Acc Time(ms)	61.38±4.74	71.12±11.82 ns
Acc Slope (m/s^2)	13.84±1.52	16.95±3.91 ns
Acc Time/Dec Time	1.17±0.35	0.63±0.08 ns
A VTI (cm)	2.83±0.38	4.93±0.73*
Time Interval From MVC to MVO (ms)	250.49±24.21	230.91±12.85 ns

Results are in Mean ± SE; **: Significant (P≤0.01); *: Significant (P≤0.05); ns: Non-significant.

Index of myocardial performance (the Tei index) assessment

The mean and standard error of the Tei index in DCM and MVD were 0.51±0.11 and 0.63±0.11, respectively (Table 3). There is no significant difference between these groups (Fig. 5).

Table 3: Assessment of Index of myocardial performance (the Tei index) in cardiac disease in dogs

Echocardiographic variables	DCM	MVD	Total	P value
ET	157.2 ± 6.96	144.1 ± 6.35	150.61 ± 4.5	0.373 ns
MVC-MVO	250.49 ± 24.21	230.91 ± 12.85	236.9 ± 15.32	0.215 ns
IVCT+IVRT	153.77 ± 33.58	114.23 ± 17.6	133.81 ± 20.78	0.395 ns
IVRT	111.45 ± 16.03	106.25 ± 21.78	106.74 ± 12.64	0.814 ns
IMP	0.51 ± 0.11	0.63 ± 0.11	0.54 ± 0.08	0.334 ns

ns statistically non-significant (P>0.05).

Pulse wave Doppler assessment of Aortic outflow showed significant difference in peak aortic velocity, mean acceleration, maximum pressure gradient and mean pressure gradient were seen between the two groups. Peak aortic velocity, acceleration time and VTI were significantly decreased in DCM and MVD when compared to the normal values (Boon, 2011).

Pulse wave Doppler assessment of mitral inflow reflects diastolic function (relaxation and compliance, volume and recoil) as well as LV filling pressure (Oyamaand Sisson, 2004; Schober *et al*., 2008a; Schober *et al*., 2008b; Schober *et al*., 2010; Schober *et al*., 2011).

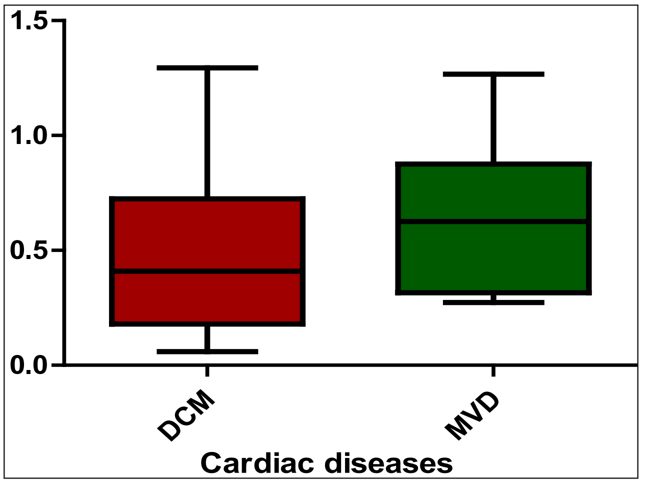

Fig. 5: A box and whiskers plot illustrating index of myocardial performance in cardiac diseases in dogs. The bold line indicates the median. Whiskers represent the 5th and 95th percentiles with lines below and above representing the 0-5th and 95-100th percentiles, respectively

Significant difference (P ≤0.05) in peak A velocity and significant difference in E:A ratio and A VTI were seen between the two groups. High E:A ratio, low A wave velocity, decreased E wave deceleration time, decreased E and A wave duration time, decreased acceleration time, decreased acceleration slope, increased acceleration time/ deceleration time ratio and low A VTI were observed in DCM affected dogs. The present findings concur with that of earlier workers (O'sullivan *et al*., 2007; Chetboul and Tissier, 2012). In the present study high E: A ratio was observed in MVD affected dogs similar to the finding of (Borgarelli *et al*., 2008; Chetboul *et al*., 2009; Serres *et al*., 2009; Chetboul and Tissier, 2012) who demonstrated that high velocity E wave or high E/A ratio were associated with higher risk of death or decompensation in dogs with MVD

Index of myocardial performance is a Doppler index which appears to correlate with severity of disease and may be of use in the early diagnosis of affected dogs during screening for the presence of DCM (Lee *et al*., 2002). It has also been shown to increase with the progression of clinical signs in dogs with MVD due to a shortening of the ejection time (Teshima *et al*., 2007). Tei index was found to be independent of age, sex and body surface area.

The mean values of the Tei index in DCM and MVD were 0.51±0.11 and 0.63±0.11, respectively. There was no significant difference between these groups. Normal LV Tei index reported by Lee *et al*. (2002) was 0.28 and Teshima *et al*. (2007) was 0.38. In the present study Left Ventricular (LV) Tei index was increased in both DCM and MVD affected dogs.

CONCLUSION

In the present study demonstrated that the LV Tei index was measurable in dogs and the elevation of the LV Tei index in dogs with symptomatic mitral regurgitation due to shortening of ejection time may suggest LV systolic dysfunction and the decrement of forward stroke volume. Tei index appeared to be correlate with severity of disease and can be used for early diagnosis of DCM. In moderate to severe Mitral Regurgitation (MR), isovolumic contraction and relaxation times can be extremely short or non-existent due to the presence of an opening in the mitral valve area. Therefore, in such cases, the TEI index seems to be inaccurate for assessing myocardial function.

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