

Normal Values of Left and Right Ventricular Tissue Doppler Imaging Myocardial Performance Index by Age and Gender

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Summary

The Myocardial Performance Index (MPI) is a validated modality for LV and RV assessment.

Objective: This study evaluates the normal values of MPI by PWD and TDI in males and females across a wide age range.

Methods: MPI was measured for LV and RV using PWD and TDI in 99 healthy adults, of which 49 were women.

Results: The sample was divided by age into: GI 17-44 years, GII 45-60 years, GIII 61-75 years and GIV >75 years. Mean LV PWD-MPI was 0.5 and LV TDI-MPI for septal/lateral walls 0.384/0.386. Mean LV PWD-MPI for males is [GI 0.53±0.18, GII 0.59±0.13, GIII 0.49±0.23, GIV 0.48±0.27] and females [GI 0.49±0.16, GII 0.54±0.17, GIII 0.45±0.10, GIV 0.47±0.08]. Mean LV TDI-MPI for septal and lateral in males are [GI 0.37/0.31, GII 0.36/0.36, GIII 0.46/0.39, GIV 0.36/0.36] and females [GI 0.37/0.36, GII 0.37/0.42, GIII 0.41/0.42, GIV 0.33/0.45].

There was an excellent correlation between LV TDI-MPI septal and lateral (0.38 ± 0.13 and 0.39 ± 0.13 ; $R = 0.337$; $p = 0.001$). There were no significant differences in LV TDI-MPI between males and females for the septal MPI (0.39 ± 0.15 vs. 0.37 ± 0.10 ; $P = 0.46$) and lower in males than females for the lateral MPI (0.36 ± 0.12 vs. 0.41 ± 0.13 ; $p = 0.04$). However, the reference value was higher for LV TDI-MPI septal/lateral in GIII 0.46/0.39. The correlation was not significant between LV PWD-MPI and LV TDI-MPI septal = 0.18; p value = 0.078, and between the LV PWD-MPI and LV TDI-MPI lateral = 0.13; p value = 0.22. The Mean RV PWD-MPI was 0.4 ± 0.28 . The RV PWD-MPI showed significant variation by age and gender for male/female [GI $0.35 \pm 0.23/0.27 \pm 0.22$, GII $0.26 \pm 0.19/0.49 \pm 0.28$, GIII $0.51 \pm 0.27/0.63 \pm 0.45$, GVI $0.47 \pm 0.35/0.35 \pm 0.17$]. The normal RV TDI-MPI was 0.39 ± 0.12 with no significant differences between males and females (0.40 ± 0.28 and 0.40 ± 0.26 ; $p = 0.99$).

Conclusion: The septal and lateral LV TDI-MPI is well correlated for all the groups in both genders. However, in GIII there is an increase in the LV TDI-MPI. There is significant variation in RV PWD-MPI by gender especially in the in GIII. This variation is not seen by TDI-MPI for the RV.

Introduction

The Left ventricular (LV) systolic function has been reported to be a strong predictor of long-term survival in patients affected by a wide spectrum of cardiac diseases [1-4]. The use of myocardial performance index MPI in evaluation of LV systolic function showed excellent correlated with Simpson's method for LV ejection fraction (EF) [5]. The MPI is a Doppler derived time interval index that combines both systolic and diastolic cardiac performances [6]. The MPI is a sum of isovolemic relaxation time (IVR), isovolemic contraction time (IVC) and ejection time (ET). Tei and colleagues described using pulse wave Doppler (PWD) to evaluate MPI [6]. Many studies documented that MPI is simple, noninvasive, easy to estimate and reproducible [7-9]. It is independent of arterial pressure, heart rate, ventricular geometry, atrioventricular valve regurgitation, afterload, and preload [7-9]. The role of MPI in evaluating RV

function in pulmonary hypertension is well documented [10,11]. Using PWD-MPI is limited because both the mitral inflow or tricuspid inflow and the ejection time are not acquired in the same cycle. Using tissue Doppler imaging (TDI) overcomes this limitation since all the parameters are acquired simultaneously [5,12,13]. TDI-MPI for the RV is shown to be superior to PWD-MPI [11]. The previous studies did not define the LV PWD-MPI in MPI by gender [5,14,15]. The normal value for LV PWD-MPI is defined as 0.39 ± 0.05 and for the RV PWD-MPI is 0.26 ± 0.08 [6,16,17]. This study hypothesizes that the normal value may vary with age and gender.

Methods

Study Population: a cohort study included 99 healthy individuals who were referred for routine transthoracic echocardiography (ECHO). The selection criteria were: age ≥ 17 years, no history

of cardiovascular or lung disease, absence of cardiovascular risk factors such as hypertension, smoking, diabetes and dyslipidemia.

Dimensional Echocardiography: a complete 2D ECHO examination was performed in the left lateral recumbent position using a commercial ultrasound equipped with a 2.5 MHz transducer connected to Philips IE33 echo machine. For the LV, PWD was used at the mitral valve inflow in apical 4-chamber view and the aortic valve outflow in apical 5-chamber views. The MPI was calculated for the LV by using the formula [(MV closure time - AVET)/AVET] [4]. The TDI for the LV was obtained by placing the sample volume at the mitral annulus level of the anterolateral and inferoseptal walls in apical 4-chamber view. The MPI for the LV was calculated using the formula [(IVRT + IVCT)/ET] [4].

For the RV, PWD were used at the tricuspid valve inflow apical 4-chamber views and the pulmonary valve outflow in parasternal short axis view. The MPI was calculated for the RV by using the formula [(TV closure time - PVET)/PVET]. The TDI for the RV was obtained by placing the sample volume at the tricuspid annulus level of the RV free wall in the apical 4-chamber view. The MPI for the RV was Calculated using the formula [(IVRT + IVCT)/ET] [4].

Statistical Analysis

Statistical analysis was performed using the software Minitab Express version 1.5.0. All data obtained were presented as mean ± standard

deviation (SD). Paired sample t-test was performed to determine the Difference in MPI values obtained by PWD and TDI. The level of significance was set to P<0.05. Enrolled participants were stratified according to age groups. Comparison of MPI values between males and females among different age groups were performed by analysis of variance (ANOVA), as appropriate. Correlation between the two modalities was obtained by Pearson correlation.

Results

Baseline Criteria: Total of 99 healthy subjects: 50 males and 49 females were enrolled in the study with mean age of 57y ± 9y. The mean values were: LV diastolic volume ± 111ml, LV systolic volume ± 40ml and LVEF ± 62%. The patients were classified into 4 groups according to age:

Group I: included 26 patients whom age between 17 and 45 years.

Group II: included 27 patients whom age range between 45 to 60 years.

Group III: included 26 patients whom age range between 61 to 75 years.

Group IV: included 20 patients whom age is above 75 years. The characteristics of LV geometry and function are shown in (Table 1). There was no significant difference in LV function and geometry among the all groups.

Table 1: Baseline LV characteristics of all patients with comparison with each age group

	No. (%) Mean ± SD	G I 26 (26.2%)	G II 27 (27.2%)	G III 26 (26.2%)	G IV 20 (20.2%)
Male	50 (50.5%)	12 (13.2%)	10 (10.2%)	16 (16.2%)	12 (12.1%)
Female	49 (49.4%)	14 (14.2%)	17 (17.2%)	10 (10.1%)	8 (8.08%)
BSA (m2)	1.86 ± 0.22	1.94 ± 0.24	1.85 ± 0.21	1.89 ± 0.15	1.73 ± 0.24
LVEF (%)	62 ± 0.54	61.4 ± 4.8	62.4 ± 7.5	60.8 ± 6.2	61.3 ± 5.9
LVDV (mL)	111 ± 23.7	109.7 ± 21.6	109 ± 23.8	117 ± 25.5	107.7 ± 24.2
LVSV (mL)	40.3 ± 14.7	44.4 ± 5.7	34.7 ± 9.9	44.3 ± 16	41.1 ± 22.5
LVDD (mm)	4.77 ± 0.54	4.8 ± 0.4	4.6 ± 0.6	4.86 ± 0.58	4.77 ± 0.46
LVSD (mm)	3.1 ± 0.41	3.3 ± 0.17	2.9 ± 0.34	3.26 ± 0.52	3.32 ± 0.44
LV mass (g)	146.9 ± 44.6	138.2 ± 39	155 ± 43	145.5 ± 54.5	150.5 ± 48
LV-FS (%)	33.9 ± 4.9	34.5 ± 1.4	35.6 ± 6.6	32.9 ± 3.2	32.3 ± 5.4

SD standard deviation, BSA body surface area, LVEF left ventricle ejection fraction, LVDV left ventricle diastolic volume, LVSV left ventricle systolic volume, LVDD left ventricle diastolic diameter, LVSD left ventricle systolic diameter, LV-FS left ventricle fractional shortening.

The LV MPI values by PWD and TDI

The time required for acquisition and complete analysis of MPI for the LV by PWD was 34 seconds while it was 28 seconds using TDI. The values of LV septal and lateral MPI by TDI were nearly equal with a significant correlation (r= 0.34; p value= 0.001). There was significant difference between PWD-MPI and both septal and lateral TDI-MPI for the LV (0.50 ± 0.18 vs. 0.38 ± 0.13; p <0.0001). The correlation between PWD-MPI and septal TDI-MPI for the LV was fair (r = 0.18 with p value= 0.08) while between the PWD-MPI and lateral TDI-MPI for the LV was poor (r= 0.13; p value= 0.22).

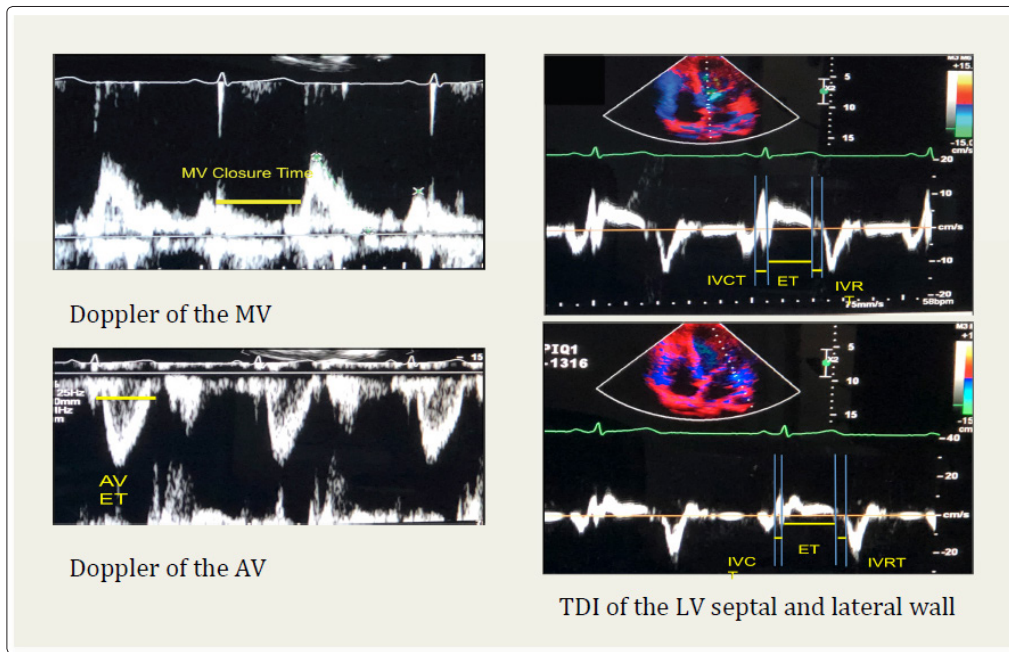


Figure 1: LV MPI by PWD and TDI

The LV MPI by age and gender distribution

The values of MPI for the LV by both TDI and PWD among the groups are displayed in (Table 2). The MPI for the LV for each group by PWD in males were [GI 0.53±0.18, GII 0.59±0.13, GIII 0.49±0.23, GIV 0.48±0.27] and in females [GI 0.49±0.16, GII 0.54±0.17, GIII 0.45±0.10, GIV 0.47±0.08]. In males, the septal TDI-MPI is [GI 0.37±0.10, GII 0.36±0.095, GIII 0.46±0.2, GIV 0.36±0.11] and the lateral is [GI 0.31±0.13, GII 0.36±0.096, GIII 0.39±0.13, GIV 0.36±0.12]. In females, the septal TDI-MPI for each age group is [GI 0.37±0.11, GII 0.37±0.08, GIII 0.41±0.15, GIV 0.33±0.08] and the lateral is [GI 0.36±0.08, GII 0.42±0.08, GIII 0.42±0.19, GIV 0.45±0.18]. There is no significant difference in the MPI values for male and females either by PWD or TDI.

Table 2: The Left Ventricle MPI by Age and Gender

Groups	Gender	LV-MPI PWD	LV-MPI TDI Septal	LV-MPI TDI Lateral
Group I (17-44y)	Male	0.53 ± 0.18	0.37 ± 0.10	0.31 ± 0.13
	Female	0.49 ± 0.16	0.37 ± 0.11	0.36 ± 0.08
Group II (45-60y)	Male	0.59 ± 0.13	0.36 ± 0.095	0.36 ± 0.096
	Female	0.54 ± 0.17	0.37 ± 0.08	0.42 ± 0.08
Group III (61-75y)	Male	0.49 ± 0.23	0.46 ± 0.2	0.39 ± 0.13
	Female	0.45 ± 0.10	0.41 ± 0.15	0.42 ± 0.19
Group IV (>75y)	Male	0.48 ± 0.27	0.36 ± 0.11	0.36 ± 0.12
	Female	0.47 ± 0.08	0.33 ± 0.08	0.45 ± 0.18

The RV MPI values by PWD and TDI

The time required for image acquisition and analysis of MPI for the RV was 43 seconds using PWD and 26 seconds using TDI. There is poor correlation between PWD-MPI and TDI-MPI for the RV (r= 0.1; P-Value = 0.5). The Mean PWD-MPI for the RV for all groups was [0.4± 0.28] while by TDI was [0.39± 0.12].

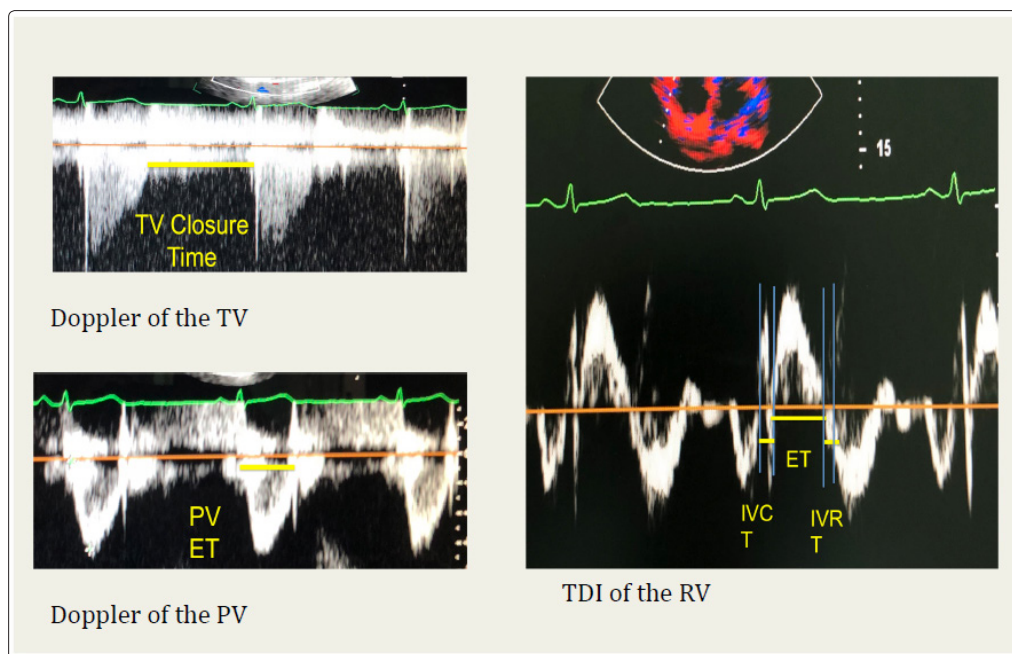


Figure 2: RV MPI by PWD and TDI

The RV MPI by age and gender distribution

The PWD-MPI for the RV for each group in males were [GI 0.35±0.23, GII 0.26±0.19, GIII 0.51±0.27, GIV 0.47±0.35] and in females [GI 0.27±0.22, GII 0.49±0.28, GIII 0.63±0.45, GIV 0.35±0.17]. There was no significant difference in the mean PWD-MPI between males and females ($0.4 \pm 0.28, 0.4 \pm 0.26; p=0.99$). The TDI-MPI in males for each age group was [GI 0.38±0.14, GII 0.3±0.16, GIII 0.45±0.35, GIV 0.43±0.26] and in females [GI 0.39±0.09, GII 0.43±0.12, GIII 0.38±0.14, GIV 0.45±0.15]. There is no significant difference in the MPI values for male and females either by PWD or TDI for the RV (Table 3).

Table 3: The Right Ventricle MPI by Age and Gender

	Mean RV-MPI PWD		Mean RV-MPI TDI	
	Males	Females	Males	Females
Group I (17-44y)	0.35 ± 0.23	0.27 ± 0.22	0.38 ± 0.14	0.39 ± .09
Group II (45-60y)	0.26 ± 0.19	0.49 ± 0.28	0.30 ± 0.16	0.43 ± 0.12
Group III (61-75y)	0.51 ± 0.27	0.63 ± 0.45	0.45 ± 0.35	0.38 ± 0.14
Group IV (>75y)	0.47 ± 0.35	0.35 ± 0.17	0.43 ± 0.26	0.45 ± 0.15

Discussion

This study evaluated the reference values of MPI by PWD and TDI for both LV and RV in normal population with a wide age range in both genders. The study showed a good correlation in LV MPI measurements by TDI for both lateral and septal walls. The values of PWD-MPI are similar across all age groups as well as the value of TDI-MPI. However, Group III age 60 -75y had shown a slightly difference values in TDI-MPI calculation but not statistically significant. In addition, there is high degree of similarity between MPI by TDI in both lateral and septal walls, which is similar to what was reported previously for the TDI-MPI values in all the walls (lateral, Septal, Anterior, Inferior) [7,18,19].

Thus, the septal TDI can be considered equivalent and feasible for MPI calculation. The overall mean MPI in our population by PWD for the LV was is 0.5. It is higher than was set as a reference range 0.32 ± 0.12 [17, 20]. This may be due to the variation in the values by the age groups. In GIII (age 61-75y) the TDI-MPI for the LV had shown deviation from the other groups at a value of 0.46 ± 0.2

and 0.41 ± 0.15 in males and females. The overall mean MPI in this population by PWD-MPI for the RV was 0.4 ± 0.28 . Our reference for the RV PWD-MPI is higher than the guidelines normal values 0.26 ± 0.0817 . This variation was not seen in the RV TDI-MPI as the mean value is 0.32 ± 0.12 in this population and it is similar to 0.38 ± 0.08 in the guidelines.¹⁷ The RV MPI in our study showed that the mean for PWD is significantly variable when divided by age. This variation is not observed in TDI especially for the RV. There was no significant difference between males and females by either modality.

Study limitation

The small number of cases in each group limits the generalizability of our findings.

Conclusion

This study is a comprehensive assessment of the normal reference value of MPI for TDI-MPI across a wide age range in males and females. The Septal and Lateral LV TD-MPI are well correlated for

all the groups in both genders. However, in GIII there is an increase in the MPI value by TDI. There is significant variation in PWD-MPI for the RV by age especially in the in GIII. This variation is not seen by TDI-MPI for the RV. Using TDI-MPI measurement for both ventricles is more reliable than PWD.

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