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The Role of Myocardial Performance Index in Evaluating Effect of Hypothyroidism on Systolic and Diastolic Functions of Heart

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ABSTRACT

Objective: Hypothyroidism causes pathological changes in the heart. Systolic and diastolic functions of the left ventricle of the heart can be evaluated with the myocardial performance index (MPI). We compared MPI in overt hypothyroidism patients vs. healthy group.

Methods: The study included 50 healthy control subjects and 50 overt hypothyroid patients. Echocardiographic procedure was performed in all patients. The following parameters, like ejection fraction (EF), diastolic transmitral peak velocity (E and A waves), E/A ratio, and MPI, were measured.

Results: The E wave (0.79 ± 0.26 m/s) and E/A ratio (0.95 ± 0.30), which are echocardiographic parameters that reflect cardiac diastolic dysfunction, were dramatically lower in the case group ($P < .05$). Myocardial performance index (MPI) (0.42 ± 0.04), which reflects systolic and diastolic functions of the heart, was significantly higher in the case group ($P < .05$). Ejection fraction value (62.5 ± 4.0%) was not statistically different between the case and healthy subjects ($P > .05$).

Conclusion: Significant decrease in E and E/A values in the hypothyroid patients indicated the development of diastolic dysfunction. Although no difference could be detected between the groups in EF value, which reflects systolic functions of the heart, a significant increase in MPI value in the hypothyroid group indicated that systolic and diastolic functions of the heart started to deteriorate. In our study, the elevation of the MPI in hypothyroid patients without EF impairment suggests that MPI should be practiced more widely in the evaluation of cardiac functions in hypothyroid patients.

Keywords: Diastolic dysfunction, hypothyroidism, myocardial performance index, systolic dysfunction

INTRODUCTION

Hypothyroidism affects the functions of all organs and systems. Typically, there is a slowing in physical and mental activity and the functioning of many organs. Basic clinical symptoms include weakness, coarse, dry and cold skin, lethargy, slow speech, facial edema, constipation, weight gain, dyspnea, peripheral edema, hair thickening, menorrhagia, and bradycardia.[1,2]

Major cardiovascular changes due to hypothyroidism include decrements in cardiac output, myocardial contractility, and heart rate, and an increment in peripheral vascular resistance.[3,4] Because of decreased cardiac output, all values related to left ventricular performance deteriorate in overt hypothyroidism.[5] Ventricular diastolic relaxation rate is also decreased due to impairment in compliance and diastolic filling.[6]

In 1995, Tei Chuwa described the myocardial performance index (MPI).[7] It reflects the systolic and diastolic functions of the heart. It has found to be related to morbidity and mortality in cardiovascular diseases. It is easily calculated and has a narrow range in normal healthy individuals. This index can be measured by Doppler tracings obtained from mitral and aortic flows; MPI is not affected by heart rate, ventricular structure, and afterload.[8] MPI value can be determined using pulsed wave Doppler (PWD) echocardiography by dividing the sum of isovolumetric relaxation time (IVRT) and isovolumetric contraction time (IVCT) by ejection time (ET) (Figure 1).

In this study, we tried to investigate the role of MPI in the evaluation how hypothyroidism affects the systolic and diastolic functions of the heart.

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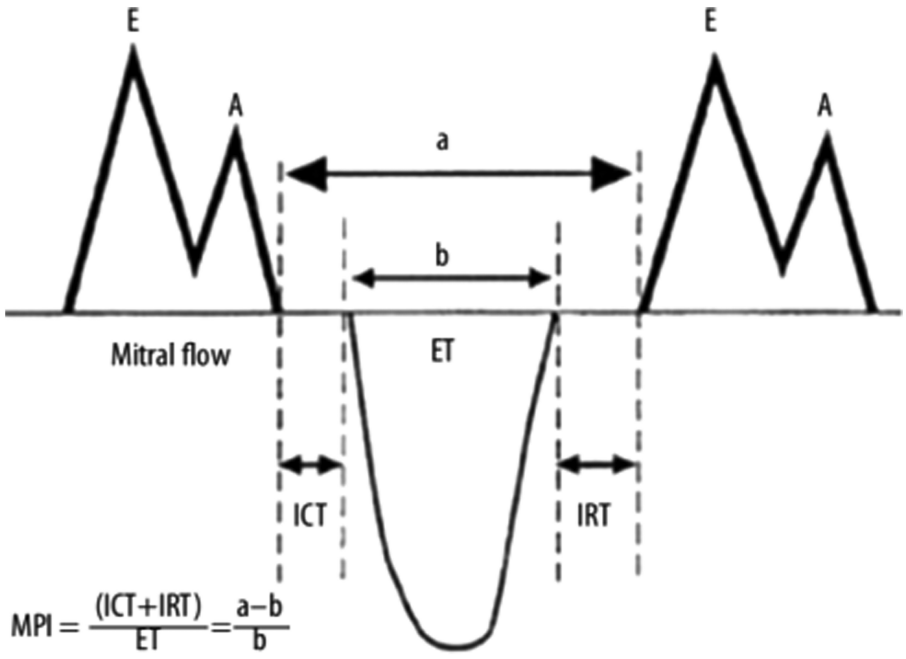

Figure 1. Schematic display of MPI calculation. a, the time between late diastolic and early diastolic waves; A, late diastolic wave; b and ET, systolic ejection time; E, early diastolic wave; ICT, isovolumetric contraction time; IRT, isovolumetric relaxation time; MPI, myocardial performance index..

METHODS

Data were obtained from 100 subjects who were admitted to our internal medicine clinic in Prof. Dr. Cemil Taşçıoğlu City Hospital. Informed consent forms from the study participants and approval from the ethics committee of our hospital were obtained. Ethics committee approval number is E-48670771-903.99-2190425 63. Subjects with diseases that may impair cardiac systolic and diastolic functions, such as chronic renal disease (creatinine > 1.4 mg/dL), patients with EF < 50, hypertension (> 140/90 mmHg), coronary heart disease, non-ischemic dilated cardiomyopathy, hypertropic cardiomyopathy, and diabetes, were excluded. Blood samples from the patient and the control groups were obtained at 08.00-08.30 AM in the morning after 10-12 hours of fasting. Creatinine, total cholesterol, triglyceride, and low-density lipoprotein values were measured from everyone participating in the study.

All echocardiographies were performed transthoracically using a 2.5 MHz transducer and Vivid 3 pro (Cingmed Technology, USA, 2006) echocardiography device. The patients were examined at left lateral decubitus position; measurements were made using two-dimensional, M-mode, continuous wave Doppler and pulsed wave Doppler in the presence of parasternal long, short, apical, and four-chamber images. In accordance with the recommendations of the American Echocardiography Association, all echocardiographies were performed by the same person at midday to eliminate the effects of circadian changes on cardiac functions. Appropriate M-mode images were attained in the parasternal long axis between the mitral valve and papillary muscle. Ultrasound beam was adjusted to be perpendicular to the interventricular septum and the posterior wall of the left ventricle. By this way, end-diastolic and end-systolic internal diameters of the left ventricle were measured from the extreme endocardial points, and the left ventricular ejection fraction was calculated using the Teichholz method. In terms of diastolic dysfunction, the E wave, which shows early diastolic peak transmitral filling rate, the A wave, which shows late diastolic peak transmitral atrial filling rate, and the E/A ratio were measured.

For MPI calculation, records were obtained with pulse wave Doppler from the sample volume placed under the aortic valve for mitral valve diastolic flow and from the sample volumes placed at mitral valve tips at the apical 4 chambers using the apical long axis image of the left ventricular outflow tract. For every cycle, typical diastolic early filling (the E wave), diastasis period, and atrial contraction (the A wave) periods were obtained. Isovolumetric contraction time (IVCT), isovolumetric relaxation time (IVRT), and ejection time were recorded. Myocardial performance index was figured out by dividing the summation of isovolumetric times by ejection time (ET). The normal value for MPI was accepted as 0.39 ± 0.05.[7]

For descriptive statistics of the data obtained in this study, mean, standard deviation ratio, and frequency were taken into consideration. The distribution of data was analyzed with the Kolmogorov–Smirnov test. Mann–Whitney *U*-test and independent samples *t*-test were applied for the evaluation of quantitative data, and the chi-square test was used for qualitative data. The Statistical Package for the Social Sciences Statistics, version 22.0, (IBM SPSS Corp., Armonk, NY, USA) program was utilized for the analyses.

RESULTS

The hypothyroidism group included a total of 50 patients, 24 females and 26 males between 30 and 70 years of age, and the control group was made up of 50 subjects, 30 females and 20 males. No statistically significant difference was found among the case and control groups in terms of age and gender distribution ($P = .904$, and $P = .229$, respectively) (Table 1).

In the hypothyroidism group, low density lipoprotein (LDL) and total cholesterol levels were higher than those in the control group ($P < .05$). And there was no significant difference in

Table 1. Demographic Parameters of Hypothyroid and Control Groups

	Hypothyroid Group		Control Group		
	Avg. ± SS/n %	Med.	Avg. ± SS/n %	Med.	*P*
Age (years)	49.4 ± 11.6	49 (30-74)	49.1 ± 8.0	48 (36-64)	.904
Gender					
Female	24 (48%)		30 (60%)		.229
Male	26 (52%)		20 (40%)		

Table 2. Biochemical Data for Hypothyroid and Control Groups

	Hypothyroid Group		Control Group		
	Avg.	Med.	Avg.	Med.	*P*
Creatinine (mg/dl)	0.77 ± 0.17	0.74 (0.51-1.18)	0.77 ± 0.14	0.74 (0.5-1.18)	.772
LDL (mg/dL)	131.8 ± 35	126 (57-205)	88.5 ± 19.4	87 (56-156)	<.001
TG (mg/dL)	146.4 ± 63.2	160 (43-325)	127.1 ± 35.1	119 (67-198)	.122
T-Cholesterol (mg/dL)	203.2 ± 35.3	205 (108-293)	155.8 ± 28.3	156 (108-210)	<.001

LDL, low density lipoprotein; T-Cholesterol, total cholesterol; TG, triglycerides.

Table 3. Echocardiographic Data for Hypothyroid and Control Groups

	Hypothyroid Group		Control Group		
	Avg.	Med.	Avg.	Med.	*P*
E'' (m/s)	0.79 ± 0.26	0.70 (0.42-1.80)	1.02 ± 0.23	1.05 (0.60-1.80)	<.001
A' (m/s)	0.87 ± 0.25	0.86 (0.49-1.80)	0.83 ± 0.25	0.80 (0.20-1.80)	.397
E''/A''	0.95 ± 0.30	0.84 (0.50-1.60)	1.35 ± 0.55	1.24 (0.60-4.0)	<.001
MPI	0.42 ± 0.04	0.41 (0.33-0.51)	0.40 ± 0.04	0.41 (0.31-0.49)	.033
EF (%)	62.5 ± 4.0	63 (52-71)	62.3 ± 4.0	62 (52-71)	0.594

A, late diastolic wave; E, early diastolic wave; EF, ejection fraction; MPI, myocardial performance index.

triglyceride (TG) and creatinine levels between hypothyroid and control subjects ($P > .05$) (Table-2).

The MPI value in the hypothyroidism group was (0.42 ± 0.04) significantly higher than the control group (0.40 ± 0.04) ($P = .033$) (Table 1). The E value (0.79 ± 0.26) and E/A ratio (0.95 ± 0.30) in the hypothyroidism group were significantly lower than the control (1.02 ± 0.23)-(1.35 ± 0.55) group ($P < .05$) (Table 1). No significant difference in A value was detected between the hypothyroid (0.87 ± 0.25) and the control groups (0.83 ± 0.25) ($P > .05$) (Table 1). No significant difference in EF value was detected between the hypothyroid (62.5 ± 4.0) and the control (62.3 ± 4.0) groups ($P > .05$) (Table 3).

DISCUSSION

It is known that the most characteristic and frequently observed symptoms and findings of thyroid diseases are caused by the impacts of the thyroid hormone on the cardiovascular system.[9] Hypothyroidism is a disease characterized by a decrease in the use of oxygen by all the major organs in the body. This reduction in oxygen demand reduces cardiac output. By the way, hypothyroidism deteriorates cardiac function by changing the expression of the myocyte-specific gene.[10] Major changes in hypothyroidism are decreased cardiac contractility and heart rate and increased peripheral vascular resistance.[11-13]

In hypothyroidism, the left ventricular performance of the heart is impaired and cardiac output is reduced. Diastolic filling and compliance are impaired due to decreased ventricular diastolic relaxation. Decreased ventricular performance is probably multifactorial.[14] Possible mechanisms include increases in heart rate and changes in the gene expression of proteins that regulate myocardial calcium. Various enzymes regulating calcium entry are controlled by thyroid hormones, and impaired activity of these enzymes due to hypothyroidism disrupts systolic performance and diastolic relaxation.[12]

Changes in cardiac gene expression in hypothyroidism lead to decreased cardiac contractility.[11] Decreased sarcoplasmic reticulum calcium adenosine triphosphatase (Ca-ATPase) expression and increased phospholamban expression (Ca-ATPase inhibitor) are the main reasons for cardiac diastolic dysfunction. All these proteins regulate the intracellular calcium cycle and diastolic function. These genomic changes explain the slowed isovolumetric relaxation phase, which is a characteristic diastolic marker of hypothyroidism.[12,15] Indeed, a study conducted in 2013[16] demonstrated significant prolongation of both the systolic pre-ejection period and the isovolumetric relaxation period in hypothyroid patients.

A study performed in 2013 in Turkey[17] included 25 patients with subclinical hypothyroidism, 21 patients with overt hypothyroidism, and 28 healthy controls and detected a decreased E/A ratio, which is among cardiac diastolic echocardiographic parameters both in subclinical and overt hypothyroidism patients when they are compared with the control subjects. Consistent with the findings of this paper, we also found a low E/A ratio in our study and detected diastolic dysfunction in hypothyroidism patients. In another study,[18] a decrease in both E and E/A values was found in hypothyroidism patients. Again, consistent with this literature, we found an important decrease in E and E/A values in our study.

In our study, we found MPI value was high, and EF value was normal between the control subjects. Several factors, like left ventricular volume and cardiac geometry, play a role in the calculation of cardiac ejection fraction.[19] We think this may be the reason that we found a high MPI and a normal EF value. A study performed in Brazil in 2004[20] demonstrated a significantly high MPI value in untreated central hypothyroidism patients. We also detected a statistically higher MPI value than the control group.
In conclusion, overt hypothyroidism causes pathological changes in the cardiovascular system and impairs both systolic and diastolic functions of the heart. Calculation of MPI values with echocardiography is a suitable method to determine these functional disturbances. It may give better information than EF measurements to predict future cardiac failure. For this reason, we think that its wider use in clinical practice would be beneficial.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Prof. Dr. Cemil Taşçıoğlu University (Number: E-48670771-903.99-219042563).

Informed Consent: Written informed consent was obtained from all patients participating in this study.

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