ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

Evaluation of Right Ventricular Functions Using Noninvasive Methods in Patients Followed in the Cardiology Clinic with Inferior Myocardial Infarction

Kardiyoloji Kliniğinde Takip Edilen İnferior Miyokard İnfarktüsü Olan Hastalarda Sağ Ventrikül Fonksiyonlarının Noninvaziv Yöntemlerle Değerlendirilmesi

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ABSTRACT

Aim: *Coronary artery disease (CAD) continues to be one of the leading causes of morbidity and mortality in developed and developing countries. In this study, the right ventricular functions of patients with inferior myocardial infarction (inferior MI) were investigated.*

Material and Method: *In this prospective study, patients who were followed up with inferior MI between January 2023 and June 2023, along with a healthy control group, were included. Transthoracic echocardiography was performed on all patients under appropriate conditions and recorded.*

Results: *A total of 103 patients (68 males, average age: 51±12 years) were included in the study. The patients were divided into two groups: patients (n=50) and healthy controls (n=53). In single and multiple regression analyses between groups, age, glucose, tricuspid annular plane systolic excursion (TAPSE), and TAPSE/pulmonary arterial systolic pressure (SPAP) were shown to be independent risk factors for inferior myocardial infarction.*

Conclusion: *TAPSE and TAPSE/SPAP are independent risk factors for inferior myocardial infarction.*

Key words: *inferior myocardial infarction; tricuspid annular plane systolic movement; echocardiography*

ÖZET

Amaç: *Koroner arter hastalığı (KAH) gelişmiş ve gelişmekte olan ülkelerde morbidite ve mortalitenin en önde gelen nedenlerinden biri olmaya devam etmektedir. Bu çalışmada inferior miyokart infarktüsü (İnferior MI) ile takip edilen hastaların sağ ventrikül fonksiyonlarının araştırılması gerçekleştirilmiştir.*

Gereç ve Yöntem: *İleriye yönelik olarak yapılan çalışmada, Ocak 2023 ile Haziran 2023 tarihleri arasında İnferior MI ile takip edilen ve sağlıklı kontrol grubundan oluşan hastalar dâhil edilmiştir. Bütün hastalara uygun koşullarda transtorasik ekokardiyografi yapılıp kayıt altına alınmıştır.*

Bulgular: *Çalışmaya toplam 103 hasta (68 erkek, ortalama yaş: 51±12) alındı. Hastalar (n=50) ve sağlıklı kontrol grubu (n=53) olmak üzere ikiye ayrıldı. Gruplar arasında tekli ve çoklu regresyon analizlerinde yaş, glukoz, triküspit anüler düzlem sistolik hareketi (TAPSE), TAPSE/SPAP, inferior miyokart infarktüsü açısından bağımsız risk faktörü olarak gösterilmiştir.*

Sonuç: *TAPSE, TAPSE/SPAP inferior miyokart infarktüsü için bağımsız risk faktörü olarak gösterilmiştir.*

Anahtar Kelimeler: *inferior miyokart infarktüsü; triküspit anüler düzlem sistolik hareketi; ekokardiyografi*

Introduction

Coronary artery disease (CAD) is frequently seen in developed and developing countries. It is one of the most important causes of mortality and morbidity. It is stated that approximately 16 million people in the United States (USA) have CAD, and the majority of them are asymptomatic[1,2]. According to the data of the World Health Organization, it is predicted that deaths due to CAD will increase by 120% in women and 137% in men in the next twenty years[3]. Coronary artery disease poses both a severe economic burden and a social problem with its adverse effects on the quality of life. According to US data, one-fourth of all inpatient treatment expenses are caused by CAD with 71.2 billion dollars[4].

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The term acute coronary syndrome describes clinical conditions that occur as a result of impaired myocardial blood flow and are usually accompanied by acute chest pain or other symptoms of myocardial ischemia and electrocardiographic changes due to myocardial ischemia. Unstable angina pectoris (USAP) refers to a series of events that occur due to thrombotic coronary artery disease, including non-ST-segment elevation myocardial infarction (NSTEMI), ST-segment elevation myocardial infarction (STEMI), and sudden cardiac death[5]. It also occurs in patients with STEMI or NSTEMI. Mortality is extremely high, with in-hospital mortality of 7% in NSTEMI and 6.5–7% in STEMI[6]. Survivors of acute myocardial infarction (AMI) suffer from chronic heart failure due to heart failure, angina pectoris, and functional limitations due to myocardial damage. It faces the risk of morbidity[7]. The pathogenesis of acute coronary syndromes is common. Almost all of them have an underlying atherosclerotic plaque, which does not necessarily narrow the coronary artery to a critical level, but can be easily complicated[8]. Acute myocardial infarction is often caused by an unstable atherosclerotic plaque, which can be caused by high-intensity physical activity, emotional stress, sexual activity, cocaine/amphetamine use, extreme cold, and acute infections. It occurs due to damage to the vascular endothelial wall as a result of rupture or erosion due to triggers, intracoronary thrombus formation and ultimately coronary blood flow occlusion[9]. Many parameters in acute myocardial infarction have been investigated for use in defining the prognosis of the patient. Some of these parameters can also be detected with the help of echocardiography. Echocardiography is widely used in clinical practice as a noninvasive and easily applicable imaging method that can be performed at the bedside. Determination of cardiac functions in AMI patients will provide important information about the patient's mortality and morbidity, and can be easily determined by echocardiography[10].

The right ventricle (RV) is difficult to evaluate on echocardiography due to the irregularity of the endocardial surface, its unusual shape, and its complex contraction mechanism. Right ventricle has a complex geometry and physiology that differs from the left ventricle[11]. Advances in invasive and noninvasive assessments, combined with epidemiological analyses, have contributed to understanding RV pathophysiology across the spectrum of health and disease[12]. In addition to these factors, the fact that the RV is anatomically directly behind the sternum makes echocardiography even more difficult[13]. Right ventricle functions in STEMI patients have been examined in some studies. However, in these studies, the evaluation of RV functions was made using only routine parameters of echocardiography.

Our aim in this study is to examine the effects of inferior myocardial infarction on right ventricular functions in STEMI patients using advanced echocardiographic methods, compared to the control group, and to conduct more intensive follow-up and treatment for patients visiting the cardiology outpatient clinic.

Materials and Methods

Patient Selection

The flow diagram of the study is displayed in Fig. 1. Patients aged 18–90 years who had inferior myocardial infarction in the cardiology clinic were included in this single-center, case-controlled study. This study was conducted on 50 patients followed in the cardiology unit of our hospital. Echocardiographic examination was done on all patients within the first 24 to 72 hours. In addition to routine echocardiographic measurements, right ventricular tissue Doppler, right ventricular ejection fraction (RVEF), myocardial performance index (MPI) and tricuspid annular plane systolic excursion (TAPSE) measurements were taken. The diagnosis of Inferior MI is: According to the 4th Universal Myocardial infarction definition published by the European Society of Cardiology, acute myocardial infarction is defined as an increase and/or decrease in troponin and at least one troponin value >99. is above the perisantile URL and is accompanied by

- Myocardial ischemia symptoms;
- Novel ischemic ECG changes;
- Formation of pathological Q wave;
- New wall motion abnormality or new myocardial loss compatible with ischemic etiology in imaging methods;
- Angiography, intracoronary imaging or autopsy.

It was defined as being accompanied by at least one of the following conditions: intracoronary thrombus[14].

Fifty healthy individuals were taken as the control group. Participants were knowledgeable about the study protocol, and their written consent was received. Transthoracic echocardiography was performed by a single physician on the patient and the healthy control group. Biochemical parameters recorded in the system

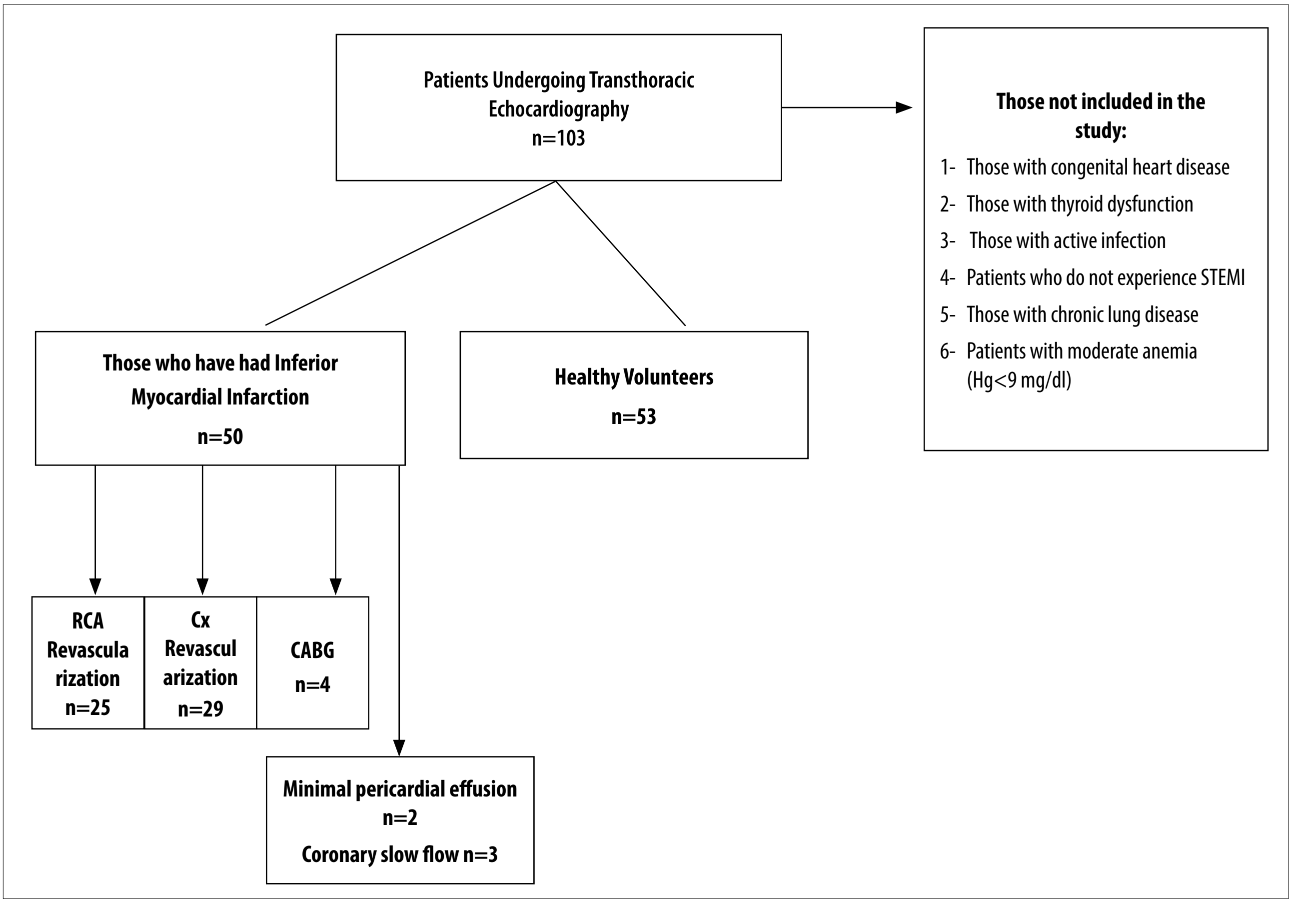

Figure 1. *Flow diagram (RCA: right coronary artery; Cx: circumflex artery; CABG: coronary artery bypass grafting; Hg: hemoglobin).*

were taken. Patients who were not registered in the system and did not have laboratory parameters were excluded from the study. Patients with thyroid dysfunction, active infection, without STEMI, with chronic lung disease, or with moderate anemia (Hgb <9 mg/dL) were not included. Transthoracic echocardiography was performed on all participants, and their measurements were recorded.

Echocardiographic examination: Echocardiographic measurements were performed on all patients and healthy volunteers who applied to the cardiology outpatient clinic within the first 24–72 hours using a Philips Epic 7 echocardiography device with a 2.5 mHz transducer. All Doppler measurements were saved at the end of expiration, while the patient was prevented from breathing. This ensured that the flow samples were not impacted by respiration and were more stable. The average of three consecutive measurements was then taken. Pulsed wave tissue Doppler velocities were measured with the echocardiography device's gain and filter settings at their lowest, compression and rejection settings at their highest, speed setting generally between -30 and +30 cm/sec, and a sampling volume width of 5 mm. All measurements were made in accordance with the recommendations of the American Heart Association[15]. As an indicator of RV systolic function; for right ventricular ejection fraction (RVEF), TAPSE and tricuspid Sm, diastolic function; premature and late diastolic velocities of tricuspid flow and their ratio (E/A) and tricuspid annular diastolic pulsed wave tissue doppler velocities and their ratio (Em/Am), also for global function; RV myocardial performance index (MPI) was taken. End-diastolic and end-systolic volumes calculated according to the 'ellipsoidal shell' model were used to measure RVEF. [EF=(Vdiast-Vsist) × 100/ Vdias]. Tricuspid annular plane systolic excursion was measured by M-mode echocardiographic measurement by placing the cursor lateral to the tricuspid annulus, and the movement of the lateral tricuspid valve annulus from the apical four chambers to the apex during the systole of the right ventricle was measured in mm[16]. By using pulsed wave Doppler sample volume in apical four-chamber

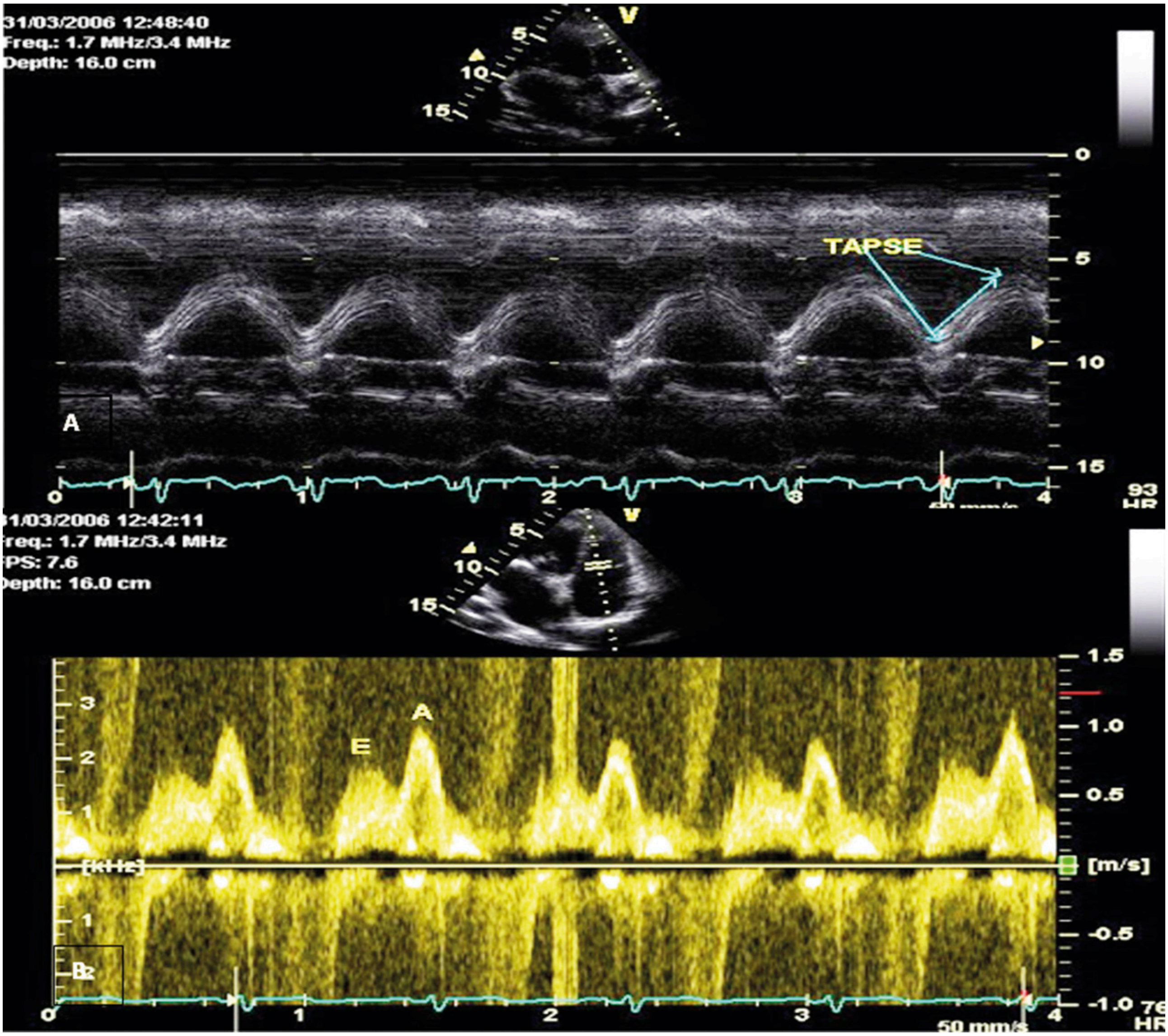

Figure 2. *a, b. Measurement of tricuspid annular plane systolic movements (TAPSE) (a). Tricuspid annular pulsed wave (PW) filling parameters (b).*

images, as previously described, the Early diastolic flow rate (E), the late diastolic flow rate (A), and the E/A ratio of the right ventricle were measured. In apical four-chamber images, pulsed wave tissue Doppler sample volume was placed at the right ventricular free wall-tricuspid annulus junction, and early diastolic (Em), late diastolic (Am), isovolumetric contraction time (IVCZ), and systolic wave (Sm) velocities were obtained (Fig. 2).

The tricuspid inflow velocity pattern was saved by placing a pulsed wave Doppler sample volume between the tricuspid valve tips from the apical-4 space. A pulsed wave Doppler was placed below the pulmonary valve to assess the right ventricular outflow pattern and was enrolled from the parasternal short axis. Doppler measurements were calculated as the average of three successive cardiac cycles. Doppler time intervals were measured from tricuspid inflow and right ventricular outflow velocity time intervals. The “a” interval is the time from the end to the start of tricuspid inflow, and the “a” interval is equal to the sum of isovolumetric contraction time, ejection time and isovolumetric relaxation time. Right ventricular ejection time “b” is the right ventricular outflow velocity profile time. The combined index of right ventricular systolic and diastolic functions (right ventricular MPI) (the sum of isovolumetric contraction time and isovolumetric relaxation time divided by ejection time) was calculated as “ab / b” (Fig. 2)

Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki. Informed consent forms were obtained from patients and healthy volunteers, and an ethics committee application was received from the local ethics committee (2022/17-167) along with written informed consent acknowledgment from the patients.

Statistical Analysis

Those with normal distribution were expressed as mean ± standard deviation, and those without normal distribution were expressed as median (25%-75%). Mann-Whitney U and Student's t tests were used to compare continuous variables. Categorical variables were shown as numbers and percentages and analyzed with the chi-square test. Independent variables were determined to predict the presence of inferior MI by performing multiple regression analysis on the data, with only significant changes observed in the study. Statistical analysis was performed using IBM Statistical Package for Social Sciences (SPSS) program version 27.0 for Windows. A p-value of <0.05 was considered statistically significant.

Results

A total of 103 patients (68 male, mean age: 51±12) were involved in the study. They were divided into patients (n=50) and control groups (n=53). The basic characteristics of patients and healthy volunteers are displayed in Table 1. The mean age of the patients was higher than that of the healthy ones. Considering the laboratory characteristics of the patients, hemoglobin (Hb), albumin, and platelet (PLT) values were lower, and C-Reactive Protein (CRP), glucose, and low density lipoprotein (LDL) values were higher in the patient group.

The comparison of echocardiographic right ventricular functions between the groups is shown in Table 2. While Right VEF, TAPSE, and TAPSE/SPAP were lower in the patient group (p<0.05), the Pmax value measured over the tricuspid was higher in the patients (p<0.05). While right ventricular early diastolic flow rate (E) did not create a statistical difference between the groups (p>0.05), late diastolic flow rate (A) (p=0.015) and their ratio (E/A) (p=0.005) did show a statistical difference between the groups. Made a difference.

Table 1. *The relationship between demographic characteristics of the groups and laboratory parameters*

	Patients (n=50)	Control group (n=53)	p
Age, years	49±10	44±10	<0.001
Male n (%)	41 (82)	27(50.9)	<0.001
HT n (%)	38 (76)	0	<0.001
DM n (%)	16 (32)	0	<0.001
Cigarette n (%)	32 (64)	0	<0.001
Hg (g/L)	14.1±2.5	14.7±1.9	0.129
PLT (10^9/L)	258±76	292±72	0.025
CRP (mg/L)	20.1±5	4.2±4	0.011
Glucose (mg/dL)	138 ±69	90±16	<0.001
Creatinine (mg/dL)	0.9± 0.5	0.7±0.1	0.020
Albumin (g/L)	42±4	44±3.3	0.004
Uric Acid (mg/dL)	5.4±1.6	4.8±1.2	0.052
LDL (mg/dL)	140±53	120±33	0.023
HDL (mg/dL)	33±10	42±13	<0.001

HT: hypertension; DM: diabetes mellitus; Hb: hemoglobin; PLT: platelet; CRP: C-reactive protein; LDL: low density lipoprotein; HDL: high density lipoprotein.

Table 2. *Comparison of echocardiographic parameters of the groups*

	Patients (n=50)	Control group (n=53)	p
RVEF (%)	46±7	55±7	<0.001
LA mm	3.6±0.1	3.7 ±0.1	0.450
RA mm	3.7±0.2	3.6±0.2	0.540
Tricuspid E, cm/s	75.1±16.7	80.6±13.6	0.065
Tricuspid A, cm/s	75.2±23.4	65.2±12.1	0.015
Y/N	1.07±0.3	1.2 ±0.1	0.005
Pmax mmHG	27.7±12	18.5±1.8	0.009
Right ventricle free wall			
Sm,cm/s	12±3	17±5	<0.001
Em, cm/s	14±3	14±4	0.780
Am, cm/s	25±7	21±4	0.990
Em/Am	0.6±0.2	0.6±0.3	0.580
RightVDD, cm	3.7±0.4	3.6±0.3	0.450
RightVSD, cm	2.8±0.5	2.6±0.4	0.050
Right ventricular MPI	0.76±0.14	0.52±0.1	0.010
TAPSE cm	2.2±0.4	2.8±0.3	<0.001
TAPSE/SPAP	0.09±0.04	0.18±0.02	<0.001

RVEF: right ventricular ejection fraction; LA: left atrium; RA: right atrium; Tricuspid E: early diastolic velocity of tricuspid flow; Tricuspid A: late diastolic velocities of tricuspid flow; Sm: systolic wave; Em: early diastolic; Am: late diastolic; IVKZ: Isovolumetric contraction time; RVDD: right ventricular end-diastolic diameter; RVSD: Right ventricular end-systolic diameter; MPI: myocardial performance index; TAPSE: tricuspid annular plane systolic movements.

Table 3. *Effects of different variables on myocardial infarction in univariate and multivariate logistic regression analyses*

	Univariate			Multivariate		
	R.O.	95% CI	p	R.O.	95% CI	p
Age	1,131	(1.077-1.188)	<0.001	1,111	(1.033-1.194)	0.004
CRP	1,117	(1.023-1.218)	0.013	0.984	(0.899-1.077)	0.720
glucose	1,046	(1.022-1.070)	<0.001	1,048	(1.015-1.081)	0.004
Albumin	0.848	(0.754-0.954)	0.006	0.825	(0.623-1.090)	0.170
LDL	1,011	(1.001-1.021)	0.029	1,025	(0.994-1.056)	0.110
RVEF (%)	0.808	(0.691-0.944)	0.007	0.663	(0.384-1.145)	0.140
E/A	0.061	0.01-0.389	0.003	0.020	(0.01-1.795)	0.070
TAPSE	0.009	0.001-0.052	<0.001	0.011	(0.001-0.103)	<0.001
TAPSE/SPAP	1.12	(1.001-1.34)	<0.001	0.030	(0.01-0.059)	0.040

RR: risk ratio; CI: safe interval; CRP: C-reactive protein; LDL: low density lipoprotein; RVEF: right ventricular ejection fraction; E/A: right ventricular early diastolic flow rate/late diastolic flow rate, TAPSE: tricuspid annular plane systolic movements.

In the patient group, Sm was lower (p<0.05) and IVKT was higher (p=0.04). No significant difference was observed between Em, Am and Em/Am groups (p>0.05). Right ventricular MPI was observed to be higher in patients (p=0.01).

In single and multiple regression analysis, age (RR=1.111 95%, CI=1.033–1.194, p=0.004), glucose (RR=1.048 95%, CI=1.015–1.081, p=0.004), TAPSE (RR=0.011 95%), CI=0.001–0.103, <0.001), TAPSE/SPAP (RR=0.03 95%, CI=0.01–0.059, p=0.04) have been indicated to be independent risk factors for inferior myocardial infarction (Table– 3).

Discussion

In our study, significant statistical differences were observed in systolic and diastolic functions in transthoracic echocardiography performed in patients with inferior myocardial infarction compared to the control group.

A study has shown that TAPSE can be used to evaluate right ventricular systolic function[17]. In another study, it has been reported that TAPSE can be a physiological indicator of RV systolic function, as determined by M-mode echocardiography based on RVEF using the thermodilution method[18]. In another study, tricuspid annular motion (TAPSE and tricuspid annular Sm) has been observed to be strongly associated with radionuclide RVEF. It is a good indicator in distinguishing those with normal and impaired right ventricular functions[19]. Tricuspid annular motion is easy to use, reproducible, and inexpensive compared to the radionuclide technique. It has been shown that its sensitivity (80% and 80%, respectively) and specificity (75% and 85%, respectively) are recommended for clinical use[19]. In another study, TAPSE was associated with irritable bowel syndrome[20]. Our study also supports similar studies. Tricuspid annular plane systolic excursion was observed to be meaningfully lower than the control group. A study found that the Sm and Em peak rates from the RV free wall of patients with inferior myocardial infarction involving the RV were significantly lower than those without RV involvement and control patients. Additionally, the Em/Am ratio was similar[21]. In our study, the Sm peak rate was meaningfully lower than that of the control group. We observed that the Em/Am ratio was very low, the Em/Am ratio was similar to previous studies, and the Em peak velocity was not significantly different. In another study, they found that the tricuspid annulus Sm peak velocity, which indicates systolic function, measured in the first two days after the onset of symptoms, was lower in cases with RV involvement and inferior MI compared to those without right ventricular involvement. It has been reported that this decrease in the tricuspid annulus Sm peak velocity can be used in the diagnosis of MI with RV involvement[22]. In our study, it was shown that the tricuspid annulus Sm peak velocity of the patients in the inferior MI group was meaningfully lower than that of the control group.

In RV MI, right ventricular functions are impaired, although hemodynamic deterioration is not always present[23]. Myocardial performance index is a method that evaluates systolic and diastolic functions together[24]. It has been reported that right ventricular MPI increases in those with primary pulmonary hypertension, right ventricular failure and Ebstein anomaly, and those who have had AMI[25]. In our study, MPI risen significantly in the patient group. In another study, it was reported that right ventricular MPI improved until the third month after acute MI and reached the values in healthy individuals at the end of the third month[26]. Although it has been reported that the right ventricular diastolic function, which was impaired on the first day of acute myocardial infarction, improved in the third month, it is not known when this improvement started and how it progressed[27].

Limitations of the study

The fact that the study was conducted in a single center and the number of patients was small may be considered a limitation. The fact that the patients were evaluated in a single visit may have relatively limited our study data.

Conclusion

As a result of this study, the use of advanced echocardiographic methods together with routine echocardiographic evaluation may provide more accurate information about RV functions in terms of directing STEMI treatment. A more intensive treatment can be performed using echocardiographic parameters on patients who come to the outpatient clinic for control.

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