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Research Article

Does Ramadan Fasting Improve Echocardiographically Assessed Tei Index in Patients With Coronary Artery Disease?

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Abstract

Aim: Ramadan fasting (RF) can affect the health status of patients with coronary artery disease or risk factors. The aim of this study is to evaluate echocardiographic functions and tei index according to ramadan fasting status in patients followed for clinically existing coronary artery disease.

Material and Method: This single-centre, cross-sectional study included 49 patients who were being followed up with a diagnosis of coronary artery disease. The patients were separated into 2 groups as those who were fasting during the month of Ramadan (RF (+), n=24) and those who were not (RF (-), n=25). Detailed echocardiographic evaluations were made. Analyses of the study data were performed using MedCalc software.

Results: The demographic and echocardiographic characteristics of the patients in both groups were similar at the start of the study. When the fasting and non-fasting groups were compared separately, a statistically significant decrease was determined in the tei index value in the ramadan fasting (+) group after 1 month of fasting (0.44±0.14 vs. 0.40±0.12) (p: 0.025).

Conclusion: In this study, the effects of RF on cardiac functions were investigated in patients with coronary artery disease and a previous stent procedure. The results of the echocardiographic evaluation after one month of fasting showed a statistically significant decrease in the tei index in the patient group fasting for Ramadan. This finding demonstrated positive effects of RF on cardiac functions.

Keywords: Ramadan fasting, Tei index, myocardial performance index, echocardigraphy, coronary artery disease

INTRODUCTION

The month of Ramadan is a period of intermittent fasting in which most Muslims around the world abstain from eating and drinking between sunrise and sunset each day, according to the Islamic calendar. This period lasts about 30 days every year according to the Islamic calendar. Those who fast during Ramadan make a temporary change to their lifestyle, affecting their eating patterns, sleep duration, physical activity and smoking habits (1). These lifestyle changes can affect the health status of patients with cardiovascular diseases or cardiovascular risk factors (hypertension, diabetes and dyslipidemia) (2). Many studies have been conducted in recent years to investigate the effects of Ramadan fasting (RF) on physiological and cardiac performance in the body. Previous studies have found that RF is closely associated with longer life expectancy due to its positive effects on healthy living and aging (3). In a previous study, RF was associated with numerous positive cardiac effects, including a reduction in cardiac risk factors (4). Studies conducted with patients with coronary artery disease revealed that there was no increase in cardiac morbidity and mortality after RF in patients diagnosed with chronic coronary syndrome. Moreover, an improvement in cardiac symptoms and anginal symptoms was found after RF in approximately about one of third patients (5,6). Although an echocardiography study who investigated effect of intermitant fasting on cardiac function in rats has been counducted, to the best knowledge, there is no literature in terms of non invasive asssesment of cardiac function in human population with intermitans fasting-including RF (7).

The main aim of this study was to evaluate the echocardiographic functions according to RF status in individuals followed up for clinical coronary artery disease (CAD). The effect of RF on cardiac functions in patients with CAD was examined by evaluating echocardiographic parameters before and after the month of fasting in groups fasting and not fasting for the month of Ramadan.

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MATERIAL AND METHOD

Data Collection

This single-centre, cross-sectional study included patients who presented at the Cardiology Polyclinic between February 2023 and March 2023, and had undergone coronary angiography and complete revascularization with stent placement at least one year previously because of chronic coronary syndrome. The study exclusion criteria were defined as i) a coronary intervention made again within the last year, ii) the presence of symptoms thought to be of cardiac origin (palpitations, angina, dyspnea), iii) the use of a new drug or dose titration within the last month, iv) the presence of uncontrolled diabetes or another metabolic disease, v) the presence of arrhythmia that would cause suboptimal echocardiographic evaluation, and vi) incomplete revascularization. After the implementation of the exclusion criteria, a total of 74 patients were seen to be eligible for the study. Those 74 patients were divided into two groups; those who planned to fast and those who would not fast for the month of Ramadan.

The patients were given detailed information about the study, and written informed consent was provided by all the patients included. A record was made for each patient of demographic data, clinical findings and the drugs used. In the 72-hour period before the start of Ramadan on 23 March 2023, a detailed two-dimensional (2D) transthoracic echocardiographic (TTE) evaluation was performed for all the patients. The patients who intended to fast continuously for the 30 days of Ramadan were identified. A total of 25 patients were excluded as they did not fast regularly for the 30 days, or did not attend follow-up appointments, or had recently started new drug treatment. Finally, 49 patients were included in the analyses, separated into two groups as 24 patients who were fasting (RF (+)) and 25 patients who were not fasting (RF (-)) (Figure 1).

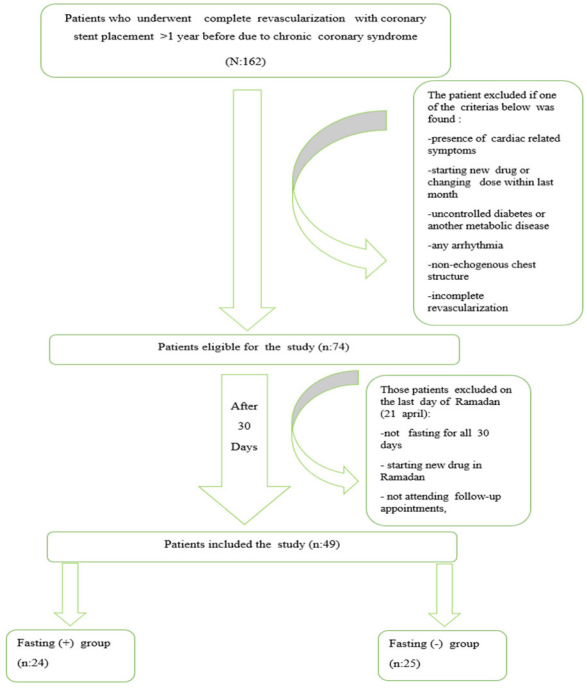

Figure 1. Flowchart of the study population

Echocardiographic Evaluation

The 2D TTE procedure was performed by an experienced echocardiography specialist who was blinded to the clinical characteristics of the patients. An Epiq 7c Ultrasound System device with a 3.5 MHz transducer (Philips Medical System, Andover, MA, USA) was used in the procedure. In the measurement of the left ventricle parameters, the recommendations of the American Society of Echocardiography Committee were taken into consideration (8). The left ventricle ejection fraction (LVEF) and left ventricle end diastolic volume (LVEDV) values were measured with the modified Simpson method. The Tei index was calculated as the total of the isovolumetric contraction time and relaxation time divided by the left ventricle (LV) ejection time (9). For the measurement of basal S', the average was taken of the S' waves measured with tissue Doppler pulse wave echocardiography in septum, lateral, anterior, and inferior wall basal segments in apical 2 chamber and apical 4 chamber windows.

For the LV global longitudinal strain (GLS) procedure, Automated Cardiac Motion Quantification (aCMQ) software was used (Qlab 10; Philips Medical System, Andover, MA, USA). The digital cineloop images were recorded on frame rate 55 from the R wave peak at the end of expirium, on the apical 2 chamber, apical 3 chamber, and apical 4 chamber window images, respectively. Care was taken that the difference in heart rate between the loop recordings was <10%. Then, reference points were placed manually first on the mitral valve leaflet insertion, left ventricle outflow tract (LVOT), and apex endocardium of the apical 3 chamber recording, then on the left and right mitral valve leaflet insertion and apex endocardium of the apical 2 chamber and apical 4 chamber loop recordings (10). After the placement of the reference points on each loop recording, the region of iterest (ROI) was formed automatically by the software drawing endocardial borders. If any regions were incompatible between the line drawn and the endocardial border, they were corrected manually. The GLS score was obtained as the average of 3 strain scores obtained automatically by the software from each ROI on the final recordings. Three measurements were taken for each patient and the average of the measurements was calculated. The same measurements of all the patients in the study were taken again by the same echocardiography specialist within 24 hours of 21 April, which was the date of the end of the month of Ramadan according to the Islamic calendar.

Statistical Analysis

Data obtained in the study were analyzed statistically using MedCalc Version 20.014 software (MedCalc Software Ltd,Ostend, Belgium). Conformity of the data to normal distribution was assessed with the Kolmogorov-Smirnov test. Continuous data were stated as mean±standard deviation values if distribution was normal and as median and interquartile range (IQR 25th-75th) values if not showing normal distribution. Categorical data were stated as number (n) and percentage (%). Comparisons between the two groups (RF+/RF-) were made using the Independent

Samples t-test for continuous variables with normal distribution and the Mann Whitney U-test when distribution was not normal, and categorical variables were compared using the Chi-square test. Comparisons of the basal and final values of the echocardiographic parameters were made using the Paired Samples t-test (normal distribution of data) or the Wilcoxon test (non-normal distribution of data). To evaluate observer agreement of the LVEF, tei index, and GLS measurements, the root mean square method was used with the Intraclass Coefficient test on 10 patients selected at random. In all the tests, a value of $p<0.05$ was accepted as statistically significant.

The minimum number of patients required for this study, with an effect size of 0.5, 95% confidence interval and 80% power, was found to be 27.

Ethical Statements

All the procedures in this study including human participants were applied in compliance with the ethical standards of the institutional research committee and the 1964 Helsinki Declaration and subsequent revisions or comparable ethical standards. No animals were used in this study. Approval for the study was granted by the Local Ethics Committee [Protocol Code: 2024-TBEK 2024/10-12].

RESULTS

Evaluation was made of 49 patients, comprising 37 (75.5%) males and 12 (24.5%) females with a mean age of 62.8±7.9 years. No statistically significant difference was determined between the fasting and non-fasting patients in respect of age, gender, body mass index (BMI), smoking status, hypertension, diabetes mellitus, drugs used, laboratory values, residual syntax scores, and basal GLS values. Comparison of fasting and non-fasting groups is shown in Table 1. Additionally, in Table 2, echocardiographic parameters are compared between the groups that fasted and did not fast during Ramadan at the beginning and end of Ramadan. A significant difference was found in echocardiographic parameters between the groups with RF (+) and RF (-) at baseline, only in inferior S' values evaluated with tissue doppler (p: 0.013). No significant difference was detected between other parameters. When echocardiographic parameters were compared at the end of Ramadan, a significant difference was detected in septal E' values (p: 0.028) evaluated with tissue Doppler. No significant difference was detected in other echocardiographic parameters at the end of Ramadan.

Table 1. The baseline characteristics and laboratory investigations of all patients

		All patient (n: 49)	RF (-) (n: 25)	RF (+) (n: 24)	P value
Demographic characteristics	Age, mean±SD	62.8±7.9	63.5 ±7.3	62.2±8.5	0.543
	Male, n (%)	37 (75.5)	16 (64.0)	21 (87.5)	0.056
	Baseline BMI, mean±SD	31.1±6.9	30.6±8.5	31.66 ±4.9	0.606
	Δ BMI, mean±SD	-0.25±1.4	-0.02±1.4	-0.5±1.5	0.279
Comorbidities	Diabetes, n (%)	17 (34.7)	11 (44.0)	6 (25.0)	0.162
	Hypertension, n (%)	33 (67.3)	17 (68.0)	16 (66.7)	0.921
	Smoking, n (%)	10 (20.4)	7 (28.0)	3 (12.5)	0.178
Medications	ASA use, n (%)	39 (79.5)	19 (76.0)	20 (83.3)	0.524
	Clopidogrel use, n (%)	17 (34.6)	11 (44.0)	6 (25.0)	0.162
	Beta Blocker use, n (%)	45 (91.8)	22 (88.0)	23 (95.8)	0.609
	ACE inh/ARB use, n (%)	40 (81.6)	20 (80.0)	20 (83.3)	0.763
	Statin use, n (%)	43 (87.7)	21 (84.0)	22 (91.7)	0.667
Laboratory assessment	Wbc, × 10^9/l, mean±SD	8.2±1.6	8.3±1.7	8.1±1.6	0.558
	Hemoglobin g/dl, mean±SD	13.9±1.5	13.9±1.6	13.8±1.3	0.793
	Creatinine mg/dL, mean±SD	0.9±0.2	0.9±0.2	0.8±0.1	0.082
	TSH mIU/L, median (25th-75th)	1.1 (0.6-1.9)	1.0 (0.5-1.9)	1.1 (0.7-1.9)	0.719
	LDL-C mg/dl, mean±SD	119.5±41.0	115.4±44.3	123.9±37.6	0.476
	Triglycerides, mg/dL, mean±SD	185.1±96.4	197.2±101.7	172.6±91.0	0.377
	HDL-C, mg/dL, mean±SD	45.9±9.7	46.5±11.1	45.2±8.1	0.656
	rSS median (25th-75th)	2 (0-4)	2 (0-5)	1.5 (0-3)	0.537
	Baseline GLS %, mean±SD	15.2±2.1	15.1±2.4	15.4±1.7	0.590

Data are presented as median (interquartile range) or number (percentage) of patients; ASA: asetilsalisilic asid, BMI: body mass index, ACE: angiotensin converting enzyme, ARB: angiotensin receptor blockers, GLS: global longitudinal strain, HDL-C: high-density lipoprotein cholesterol, LDL-C: low-density lipoprotein cholesterol, RF: ramadan fasting, rSS: residual syntax score, SD: standard deviation, TSH: thyroid stimulating hormone, Wbc: white blood cells

Table 2. Echocardiographic parameters of all patients and groups

	Baseline paramaters				Follow-up paramaters			
	All patients (n=49)	Fasting (-) (n=25)	Fasting (+) (n=24)	P value	All patients (n=49)	Fasting (-) (n=25)	Fasting (+) (n=24)	P value
LVEDD mm, mean±SD	48.5±5.1	48.5±5.2	48.4±5.0	0.979	48.0±3.9	48.1±4.4	47.9±3.2	0.884
LVEDV ml, mean±SD	111.0±26.3	111.3±30.1	110.7±22.1	0.936	107.4±23.3	109.6±28.5	105.1±16.6	0.509
LVEF %, mean±SD	61.4±5.6	61.1±6.0	61.7±5.2	0.743	61.7±5.5	60.7±5.9	62.7±5.0	0.210
RV mm, mean±SD	34.7±5.5	33.6±5.8	35.9±5.0	0.151	35.1±5.1	34.4±5.5	36.0±4.6	0.205
E/A, mean±SD	0.9±0.2	0.9±0,3	0.8±0.2	0.439	0.9±0.2	0.9±0.3	0.9±0.1	0.464
EDT ms, mean±SD	220.5±37.0	216.4±41.7	224.8±31.7	0.434	215.0±31.1	210.8±35.9	219.4±25.1	0.338
Septal E' cm/s, mean±SD	6.8±1.4	6.5±1.5	7.1±1.2	0.108	7.0±1.2	6.7±1.3	7.4±0.9	0.028
Septal S' cm/s, mean±SD	7.0±1.4	6.9±1.4	7.1± 1.2	0.484	7.1±1.1	6.9±1.3	7.2±0.9	0.432
Lateral S' cm/s, mean±SD	8.1±1.5	7.8±1.5	8.4±1.5	0.171	8.1±1.4	7.9±1.5	8.2±1.2	0.293
Inferior S' cm/s, mean±SD	7.6±1.5	7.1±1.4	8.1±1.4	0.013	7.6±1.1	7.3±1.2	7.8±0.9	0.109
Anterior S' cm/s, mean±SD	7.3±1.6	7.1±1.4	7.6±1.6	0.316	7.4±1.2	7.2±1.2	7.5±1.3	0.496
Tei index, mean±SD	0.44±0.16	0.43±0.17	0.44±0.14	0.873	0.42±0.13	0.43±0.14	0.40±0.12	0.447
GLS %, mean±SD	-15.2±2.1	-15.1±2.5	-15.4±1.7	0.590	-15.4±2.4	- 14.9±2.3	- 16.1±2.4	0.051

EDT: E wave deceleration time, GLS: global longitudinal strain, IVS: intraventricular septum, LA: left atrium, LVEDD: left ventricular end-diastolic diameter, LVEDV: left ventricular end-diastolic volume, LVEF: left ventricular ejection fraction, PW: posterior wall, RV: right ventricle

The BMI values of the RF (+) group were similar at baseline and at the end of the fasting month (31.8±4.9 vs 31.3±4.9 kg/m^2, p: 0.145). The intraobserver intraclass coefficients were calculated as 0.85 (0.43-0.96) for LVEF, 0.95 (0.78-0.98) for the tei index, and 0.94 (0.75-0.98) for GLS. No statistically significant difference was determined between the baseline values and the values at the end of Ramadan of the echocardiographic parameters of all the patients (Table 3).

Table 3. Comparison of the initial values of echocardiographic parameters of all patients and their values after ramadan fasting

Variable	Baseline	Follow up	P value
LVEDD mm, mean±SD	48.4±5.1	48.0±3.9	0.379
LVEDV ml, mean±SD	111.0±26.2	107.4±23.3	0.132
LVEF %, mean±SD	61.4±5.6	61.7±5.5	0.529
RV mm, mean±SD	34.7±5.5	35.1±5.1	0.121
E/A, mean±SD	0.9±0.2	0.9±0.2	0.826
EDT ms, mean±SD	220.5±37.0	215.0±31.1	0.071
Septal E' cm/s, mean±SD	6.8±1.4	7.0±1.1	0.097
Septal S' cm/s, mean±SD	7.0±1.3	7.1±1.1	0.390
Lateral S' cm/s, mean±SD	8.1±1.5	8.1±1.4	0.736
Inferior S' cm/s, mean±SD	7.6±1.5	7.6±1.1	0.699
Anterior S' cm/s, mean±SD	7.4±1.5	7.4±1.2	0.940
Tei index, mean±SD	0.44±0.1	0.42±0.1	0.104
GLS %, mean±SD	-15.2±2.1	-15.4±2.4	0.522

EDT: E wave deceleration time, GLS: global longitudinal strain, IVS: intraventricular septum, LA: left atrium, LVEDD: left ventricular end-diastolic diameter, LVEDV: left ventricular end-diastolic volume, LVEF: left ventricular ejection fraction, PW: posterior wall, RV: right ventricle

When all the patients were evaluated together, there were determined to be no significant changes in the echocardiographic diameter measurements, tissue Doppler evaluations, tei index values, and GLS values throughout the fasting month. When the fasting and non-fasting groups were compared separately, no significant change in the echocardiographic parameters was determined in the RF (-) group. In the RF (+) group, a statistically significant decrease was determined in the tei index value after 1 month of fasting (0.44±0.14 vs. 0.40±0.12, p: 0.025). No significant change was determined in the other echocardiographic parameters in this group (Table 4).

Table 4. Separate comparison of the patients' echocardiographic parameters with their baseline values and values after the ramadan fasting month

	Ramadan fasting (-) group			Ramadan fasting (+) group		
Variable	**Baseline**	**Follow up**	**P value**	**Baseline**	**Follow up**	**P value**
LVEDD mm, mean±SD	48.5±5.2	48.1±4.4	0.603	48.4±5.0	47.9±3.2	0.474
LVEDV ml, mean±SD	111.3±30.1	109.6±28.5	0.592	110.7±22.1	105.1±16.6	0.126
LVEF %, mean±SD	61.1±6.0	60.7±5.9	0.438	61.7±5.2	62.7±5.0	0.154
RV mm, mean±SD	33.6±5.8	34.4±5.5	0.119	35.9±5.0	36.0±4.6	0.597
E/A, mean±SD	0.9±0,3	0.9±0.3	0.990	0.8±0.2	0.9±0.1	0.748
EDT ms, mean±SD	216.4±41.7	210.8±35.9	0.143	224.8±31.7	219.4±25.1	0.271
Septal E' cm/s, mean±SD	6.5±1.5	6.7±1.3	0.359	7.1±1.2	7.4±0.9	0.145
Septal S' cm/s, mean±SD	6.9±1.4	6.9±1.3	0.484	7.1±1.2	7.2±0.9	0.615
Lateral S' cm/s, mean±SD	7.8±1.5	7.9±1.5	0.851	8.4±1.5	8.2±1.2	0.565
Inferior S' cm/s, mean±SD	7.1±1.4	7.3±1.2	0.253	8.1±1.4	7.8±0.9	0.068
Anterior S' cm/s, mean±SD	7.1±1,4	7.2±1.2	0.602	7.6±1.6	7.5±1.3	0.580
Tei index, mean± SD	0.43±0.17	0.43±0.14	0.960	0.44±0.14	0.40±0.12	0.025
GLS %, mean±SD	-15.1±2.5	-14.7±2.3	0.276	-15.4±1.7	-16.1±2.4	0.083

Data are presented as median (interquartile range) or number (percentage) of patients; EDT: E wave deceleration time, GLS: global longitudinal strain, IVS: intraventricular septum, LA: left atrium, LVEDD: left ventricular end-diastolic diameter, LVEDV: left ventricular end-diastolic volume, LVEF: left ventricular ejection fraction, PW: posterior wall, RV: right ventricle

DISCUSSION

The aim of this study was to investigate the effects of fasting during the month of Ramadan on cardiac functions in patients with coronary artery disease who had previously undergone complete revascularization with stent procedure. Although there is sufficient evidence on the safety of RF in patients after percutaneous coronary intervention (PCI), there is no study showing that cardiac functions are positively affected noninvasively in this population (11). Due to the lack of data in this area, we prefer only the PCI patient population. We excluded patients with CAD and incomplete/non revascularization because ongoing ischemia might be a co-founded factor which could affect echocardiographic parameters. Another limitation of the study was that no functional non-invasive test was implemented following PCI in order to determine residual ischemia.

The results of the echocardiographic evaluation after the fasting period showed a significant decrease in the tei index in the patients who fasted for the month of Ramadan. This shows that Ramadan fasting could have positive effects on cardiac functions. To the best of our knowledge, this is the first study in literature to have investigated the effect of Ramadan fasting on cardiac functions.

When all the patients were evaluated at the end of the study, there was observed to be no significant change in the BMI values in both groups. There was expected to be a decrease in BMI in the RF (+) group as they had no food or water intake for the whole day. In previous studies on this subject, decreases in BMI values have been observed after RF (12). However, in other studies it has been shown that patients could gain weight after RF (13). That these values remained stable in the current study was thought to be due to weight gain being triggered by the wish to eat more because of the high level of hunger and thirst when breaking the fast and going to sleep after eating in the early hours at the start of the fast.

The Tei index (Myocardial Performance Index - MPI), which includes both systolic and diastolic time intervals in the cardiac cycle, was first used to evaluate global cardiac dysfunction by Tei et al. in 1995 (14). Tei index can be measured using continuous wave Doppler in routine echocardiographic evaluation, and repeated measurements can be easily performed in patients. This index can be easily used to evaluate right and left heart function and provides easy estimation of combined systolic and diastolic functions of the heart. It has been documented in many studies that the Tei index, which can be measured in routine echocardiographic evaluation in patients in the supine position, is independent of arterial pressure, heart rate, ventricular geometry, valve pathologies, afterload and preload, and therefore standardization of this value is not necessary and is reproducible (14-17). In previous studies on the Tei index, significant relationships were detected between the prolongation of the time measured by this index and the long-term adverse cardiac outcomes. Especially in a study by Kishore et al., the probability of end-stage heart failure and death occurring in a 2-year follow-up period was determined to be 5-fold greater in patients with Tei index >1.4, independently of all other causes (18).

When the two groups in the current study who were fasting and not fasting during Ramadan were compared, the echocardiographic parameters were determined to be similar. A significant difference was determined only in the tei index between the patients. In the patients who

were fasting during Ramadan, a significant decrease was determined in the tei index after 1 month of fasting. A previous study conducted with a drug that had an effect on energy metabolism, showed that the tei index values were significantly decreased during the follow up of patients who were taking the drug (19). This drug made changes in the energy metabolism by affecting fatty acid oxidation within the cell. Therefore, the changes in enegy metabolism occurring in the fasting group, the decrease in body fat ratio and the positive changes occurring in body composition (20) are thought to be responsible for the decrease in the tei index in this group.

There is no study in the literature evaluating the effect of RF on noninvasive echocardiographic parameters in patients with coronary heart disease and coronary stents. According to the results of this study, it was determined that there was a significant decrease in the Tei index of the patients after RF. Therefore, with this study, it can be thought that improvement in cardiac functions was observed in patients after RF and that it will shed light on future studies aiming to reduce the risk of side effects.

CONCLUSION

In this study, the effects of RF on cardiac functions were investigated in patients with coronary artery disease and a previous complet revascularization with stent procedure. The results of the echocardiograph evaluation after one month of fasting showed a statistically significant decrease in the tei index in the patient group fasting for Ramadan. This finding demonstrated that RF could have positive effects on cardiac functions. To the best of our knowledge, this is the first study to have evaluated the effect of RF on cardiac functions.

Study Limitations

As the study had to be conducted within the short period of the month of Ramadan, a greater number of patients could not be included. Despite the low number of patients, the study can be considered to make a very important mark. It was shown that the cardiac functions of patients improved with RF, which is a religious obligation undertaken by a significant proportion of Muslims. Additionally, echocardiographic parameters of the patients could not be monitored after Ramadan. For this reason, the stability of the results found and whether the effects achieved were reversible could not be evaluated. However, it is stated in the literature that after intermittent feeding is stopped, the effects at the cellular level will continue for a few weeks (21). It is also stated that stopping intermittent feeding does not increase metabolic risks (21). However, this study was conducted on mice and human studies are needed on this subject. This study can be of guidance for further larger scale studies on this subject. In addition, right ventricular functions, which have previously been shown to be affected by volume overload, were not evaluated in this study. The reason for this is that the devices in our hospital do not have the features required for right ventricular strain measurement.

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Ethical approval: *All the procedures in this study including human participants were applied in compliance with the ethical standards of the institutional research committee and the 1964 Helsinki Declaration and subsequent revisions or comparable ethical standards. No animals were used in this study. Approval for the study was granted by the Local Ethics Committee [Protocol Code: 2024-TBEK 2024/10-12].*

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