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Original Article

Effect of laparoscopic sleeve gastrectomy on heart remodeling and right ventricular function

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Abstract

Background: Weight loss following bariatric surgery reduces cardiovascular workload and may improve cardiac structure and function. This study aimed to assess changes in right heart echocardiographic parameters and cardiac remodeling six months after laparoscopic sleeve gastrectomy (LSG).

Methods: In this cross-sectional study, patients who underwent LSG between 2022 and 2024 were evaluated before surgery and at six-month follow-up. Demographic data, clinical variables, and comprehensive echocardiographic indices of cardiac function were recorded and compared.

Results: Twenty-two patients (mean age 38.09±9.47 years) were included. Significant postoperative improvements were observed in left ventricular ejection fraction (55.84±6.49% to 62.86 ± 4.41%, p<0.001), right ventricular peak systolic myocardial velocity (12.22±2.59 to 14.24±2.38 cm/s, p<0.001), tricuspid annular plane systolic excursion (22.95±3.03 to 24.18±2.82 mm, p=0.04), E wave velocity (7.35±2.01 to 9.54±1.98 cm/s, p<0.001), and left ventricular global longitudinal strain (15.42±3.86 to 18.24±2.93, p<0.001). Significant reductions were noted in right ventricular diameter, left ventricular end-diastolic and end-systolic volumes, and pulmonary artery pressure (all p<0.01). The prevalence of diastolic dysfunction decreased markedly from 63.6% preoperatively to 13.6% postoperatively (p<0.001).

Conclusion: Laparoscopic sleeve gastrectomy is associated with significant improvement in cardiac remodeling and both left and right ventricular function, with notable enhancement of right heart echocardiographic parameters.

Keywords: Sleeve gastrectomy, Echocardiography, Cardiac function.

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Obesity, as a global problem, has a negative impact on the health of societies and is known as the main risk factor for serious diseases such as diabetes, non-alcoholic liver disease, cardiovascular diseases, hypertension, stroke and some cancers (1). Over the past four decades, the prevalence of overweight and obesity has continuously increased worldwide (2). Despite extensive efforts to raise awareness, obesity continues to rise at an alarming rate. If effective measures are not taken to prevent and treat obesity, it is predicted that by 2035, more than half of the world's population will be overweight and obese (3, 4). According to studies, a five-point increase in body mass index increases the risk of cardiovascular disease by 92% (5). Therefore, the adverse effects of excess weight can account for about 45% of the increase in the risk of cardiovascular disease (6). Bariatric surgery is an effective and sustainable treatment for obesity, which can help to improve diseases associated with obesity. Laparoscopic sleeve gastrectomy (LSG) and gastric bypass (RYGB) are among the most popular bariatric surgeries around the world. Both LSG and RYGB procedures are effective in reducing weight, improving diseases associated with obesity, and increasing quality of life (7).

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However, since LSG is associated with fewer complications and nutritional deficiencies, it can be considered as a valid treatment for obesity and its associated diseases in eligible patients (8). The right ventricle, anatomically and functionally, is significantly different from the left ventricle. The left ventricle, which pumps blood with high pressure to the whole body, the right ventricle directs blood with low pressure to the lungs (9). This difference causes a thinner structure and less contraction power of the right ventricle. However, the role of the right ventricle in cardiovascular function is very important and recent evidence shows that the right ventricle has an increasing role in determining the symptoms and clinical outcomes of heart diseases. Adaptation of the right ventricle to the disease is influenced by three main factors: pressure overload, volume overload, and disorders in intrinsic contractility. Chronic volume overload in the right ventricle that occurs in obesity can lead to systolic dysfunction and heart failure and increase mortality (10, 11). Based on this, there is evidence that therapeutic interventions aimed at improving obesity can lead to improved cardiac function, especially the right ventricle (12); however, the effectiveness of gastrectomy surgeries on improving the function of ventricular parameters has not been well studied. As a result, the current study investigated the effects of LSG on echocardiographic parameters with a special focus on the right heart and cardiac remodeling.

Methods

Study population: This cross-sectional study was performed on consecutive patients undergoing LSG in a referral hospital in Istanbul, Turkey between 2022 and 2024. After receiving the necessary permits, patients aged 18 to 65 years with a body mass index (BMI) over 40 kg/m^2 or over 35 kg/m^2 along with underlying diseases were selected to participate in this study. In this research, patients who have previously undergone any surgery or intervention in the heart, those with left ventricular ejection fraction less than 50%, patients with valvular heart failure, history of coronary artery disease, non-sinusoidal heart rhythm, and patients with unfavorable echocardiography imaging quality were excluded from participating in the study.

Study measurements: In general, people's demographic information, including history of smoking, history of diabetes or hypertension, or family history of heart disease, was collected through interviews with the patient and the patient's medical record. Among the variables recorded for people, the variables of age, sex, blood pressure, body mass index, diabetes, waist circumference index and echocardiographic indices of heart function were evaluated. In the present study, the definition of various evaluated indicators was as follows: 1) BMI index was calculated as weight (kilograms) divided by the square of height (square meters). In BMI classification, values less than 18.5 kg/m^2 were considered underweight, 18.5 kg/m^2 to less than 25 kg/m^2 as normal weight, 25 to less than 29.9 kg/m^2 as overweight, and values 30 kg/m^2 and above as obesity (13).

Obesity itself was divided into three categories: class 1 included a BMI between 30 and less than 35 kg/m^2, class 2 included a BMI between 35 and less than 40 kg/m^2, and class 3 included a BMI equal to or greater than 40 kg/m^2 (13), 2) Normal blood pressure included systolic pressure less than 120 mm Hg and diastolic pressure less than 80 mm Hg, high blood pressure (first stage) included systolic pressure between 120 and 129 mm Hg and diastolic pressure less than 80 mm Hg, high blood pressure (second stage) was considered as systolic pressure between 130 and 139 mm Hg or diastolic pressure between 80 and 89 mm Hg, high blood pressure (third stage) included systolic pressure 140 mm Hg or more or diastolic pressure 90 mm Hg or more, blood pressure crisis included systolic pressure above 180 mm Hg and/or diastolic pressure above 120 mm Hg, which required immediate consultation with a doctor (14), 3) right ventricular ejection fraction was defined as the amount of blood that the right ventricle of the heart pumps during each contraction (15), 4) Right ventricular area changes in echocardiogram was calculated as the difference between end-systolic and end-diastolic area divided by end-diastolic area (16); 5) Right ventricular diameter or RVD referred to the measurement of the width of the right ventricle of the heart. This measurement was usually done using imaging methods such as echocardiography and helps to evaluate the health and function of the right ventricle (17), 6) Right ventricular function or RVF expressed right ventricular function. This parameter evaluated the overall performance of the right ventricle in pumping blood to the lungs (17), 7) Tricuspid Annular Plane Systolic Excursion Index or TAPSE that was used in echocardiography to evaluate the longitudinal function of the right ventricle and indicated the displacement of the annular plane of the tricuspid valve during heart contraction (18), 8) Pulmonary Artery Pressure or PAP that measured the amount of pressure that the blood creates in the pulmonary arteries and is used to evaluate the function of the heart and lungs and diagnose cardiovascular and pulmonary diseases (19), 9) Right ventricular longitudinal global strain index or RV GLS that is one of the important indices in echocardiography, which is used to evaluate the systolic function of the right ventricle of the heart. This index was measured using the 2D speckle-

tracking imaging technique and showed the longitudinal changes of the right ventricular wall during the cardiac cycle (20), 10) Right ventricular fractional area change index or RV FAC that is one of the important indices in echocardiography that is used to evaluate the systolic function of the right ventricle of the heart. This index measures the percentage of right ventricular area changes between diastole and systole. The normal value for RV FAC is more than 35%, and lower values indicate poor right ventricular function (21).

Statistical analyses: In this study, the data were analyzed using SPSS computer software (Version 23.0). First, the assumption of normality of data distribution in all groups was investigated using the Kolmogorov-Smirnov test. The results of this study were reported as mean±standard deviation. Paired t-test was used to compare echocardiographic parameters before and after gastrectomy. The level of significance in this study was considered significant with $p \leq 0.05$.

Ethical considerations: In this research, all necessary efforts were made to comply with ethical principles. Before starting the research, specific agreements were signed with the patients. These agreements included full information to the participants about the purpose of the research, risks and their rights, and the method of its implementation was approved by the institutional ethics committee (ethical code: TR.OK.REC.2025.129). In this research, there was no intervention on the patients and patients who were candidates for sleeve surgery were used to participate in this research. This study was observational and the echocardiography parameters before and 6 months after the sleeve surgery of these patients were investigated. All procedures and echocardiography were performed under the supervision of a doctor with appropriate skills and knowledge. Supervision included taking care of the participants during the research stages. The participants were fully informed about the purpose of the research, methods and risks. The personal information of the participants was protected. Injuring people was avoided, which included physical, psychological, and social injuries.

Results

The changes in anthropometric parameters: In the present study, 22 patients were evaluated. The average age of the patients was 38.09±9.47 years in the age range of 21 to 58 years, and in terms of gender distribution, 5 (22.7%) cases were males and 17 (77.3%) cases were females. In terms of anthropometric changes after surgery compared to before (table 1), firstly, the average weight of people decreased from 122.13±22.17 kg to 90.59±17.38 kg, which was completely significant ($p < 0.001$). Similarly, the average BMI of the patients decreased from 45.03±5.32 kg/m^2 before surgery to 33.39±4.30 kg/m^2 after surgery, which was statistically significant again ($p<0.001$). Accordingly, before surgery, all patients were classified as obese, while after surgery, 6 (27.3%) cases were classified as overweight. Also, in the classification of obesity, before surgery, 2 (9.1%)cases were in class two obesity and 20 (90.9%) cases were in class three obesity, while after surgery, 9(40.9) %)cases in class one, 7 (31.8%) cases in class two and only 1 (4.5%)case in class three obesity.

Table 1. The changes in anthropometric parameters

Index	Before surgery	After surgery	P-value
Weight, kg	122.13±22.17	90.59±17.38	<0.001
Body mass index, kg/m^2	45.03±5.32	33.39±4.30	<0.001
Classification of obesity, %			<0.001
Overweight	0 (0.0)	5 (22.7)	
Obesity class I	0 (0.0)	9 (40.9)	
Obesity class II	2 (9.1)	7 (31.8)	
Obesity class III	20 (90.9)	1 (4.5)	

The changes in echocardiographic parameters: Majority of cardiac parameters showed significant changes after sleeve surgery (table 2). In this regard, a significant increase in left ventricular ejection fraction (LVEF), right ventricular peak systolic myocardial velocity (RVSM), TAPSE, RV FAC, E wave velocity as well as global GLS and RV GLS was clearly evident (figure 1). In contrast, a significant decrease in RV diameter, Left Ventricle End-diastolic

Volume (LVEDV), Left Ventricle End-systolic Volume (LVEDV) and PAP was evident after surgery (figure 1). Regarding the frequency of diastolic dysfunction, the frequency before and after surgery was 63.6% and 13.6%, respectively, which showed a significant difference (p<0.001).

Table 2. The changes in echocardiography parameters

Index	Before surgery	After surgery	P-value
LVEF, %	55.84±6.49	62.86±4.41	<0.001
PAP, mmHg	26.63±4.46	23.45±4.51	<0.001
RVSM	12.22±2.59	14.24±2.38	<0.001
RV diameter	28.40±2.73	26.72±2.74	0.002
TAPSE	22.95±3.03	24.18±2.82	0.04
LVEDV	106.86±34.62	89.59±19.21	<0.001
LVESV	49.17±21.31	32.73±7.86	<0.001
LVDD	48.18±4.46	46.63±4.18	0.002
LVSD	27.77±4.45	24.95±3.42	<0.001
RV FAC	0.39±0.07	0.52±0.07	<0.001
AO	29.27±4.27	28.50±4.16	0.23
LA diameter	33.36±3.64	32.68±3.07	0.17
E wave velocity	7.35±2.01	9.54±1.98	<0.001
A2 ch	16.12±4.56	18.61±3.43	<0.001
A3 ch	14.49±4.60	17.96±3.64	<0.001
A4 ch	16.70±4.13	18.80±3.58	0.007
Global GLS	15.42±3.86	18.24±2.93	<0.001
RV GLS	10.90±5.91	14.25±14.34	<0.001
LVH			<0.001
No LVH	6 (27.3)	18 (81.8)	
Moderate LVH	12 (54.5)	4 (18.2)	
Severe LVH	4 (18.2)	0 (0.0)	
Diastolic dysfunction	14 (63.6)	3 (13.6)	<0.001

LVEF: left ventricular ejection fraction, PAP: pulmonary artery pressure, RVSM: right ventricular peak systolic myocardial velocity, RV: right ventricle, TAPSE: tricuspid annular plane systolic excursion, LVEDV: left ventricular end-diastolic volume, LVESV: left ventricular end-systolic volume, LVDD: left ventricular diastolic diameter, LVSD: left ventricular systolic diameter, RV FAC: right ventricular fractional area change, AO: Aortic diameter, LA: left atrium, A2 ch: apical two-chamber, A3 ch: apical three-chamber, A4 ch, apical four-chamber, GLS: global longitudinal strain, LVH: left ventricular hypertrophy

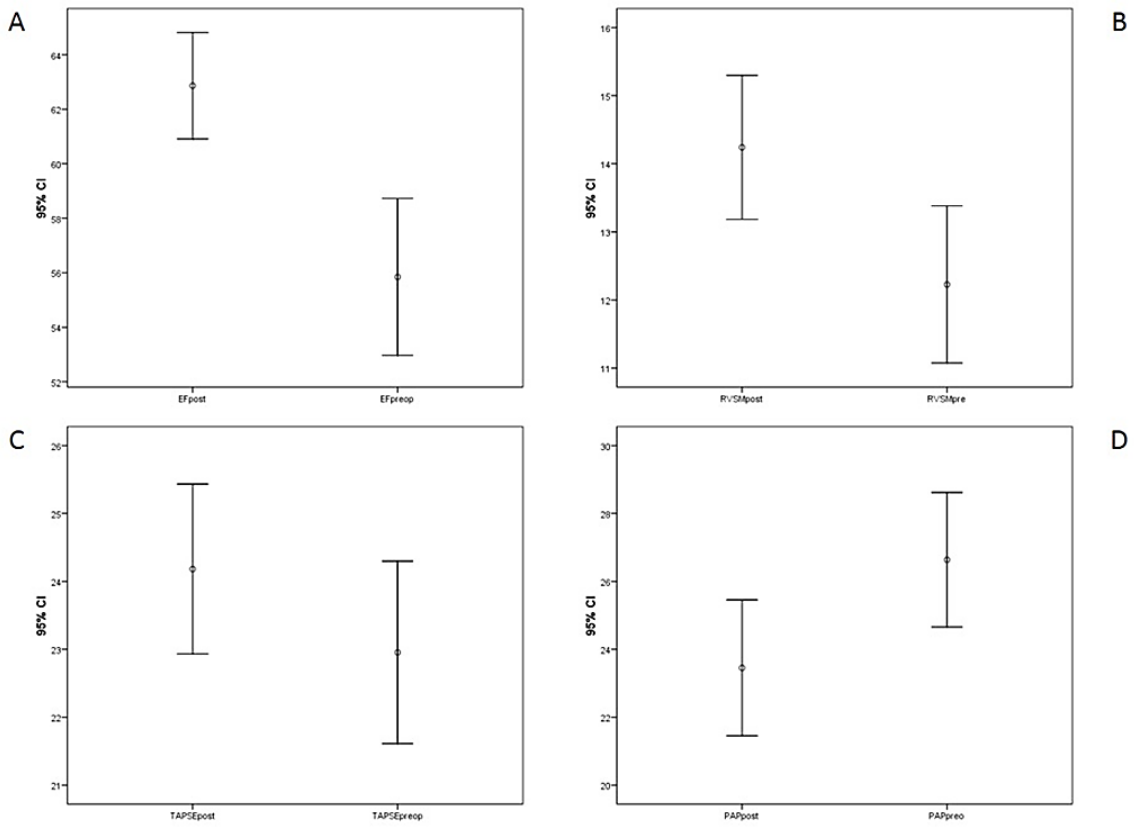

Figure 1. The changes in the parameters of left ventricular ejection fraction (A), right ventricular peak systolic myocardial velocity (B), tricuspid annular plane systolic excursion (C), and pulmonary artery pressure (D) following sleeve surgery

Discussion

In patients with morbid obesity, the reduction of fat mass following gastrectomy surgeries is definitely associated with a reduction in the workload on the cardiovascular system, which is accompanied by compensation in volume and pressure parameters in the heart ventricles, and therefore improvement in the systolic and diastolic function of the heart is expected after this surgery. What was emphasized in this present study was the evaluation of echocardiographic parameters of the right heart as well as heart remodeling six months after sleeve gastrectomy compared to before. These results were anticipated, the results of the present study indicated that there was a significant improvement in many diametric and functional parameters of the left and right heart after sleeve gastrectomy. In this regard, what was clearly evident within six months after this surgery was a significant increase in LVEF, RVSM, TAPSE, RV FAC, E wave velocity, as well as Global GLS and RV GLS, and in contrast to a significant decrease in RV diameter, LVEDV, LVESV and PAP followed by surgery. Accordingly, not only the frequency of left ventricular hypertrophy (LVH) was reduced after sleeve gastrectomy, but diastolic dysfunction was also significantly improved. Also, as it was evident about the improvement of the parameters related to the right heart function, the improvement in TAPSE and RV FAC parameters as the most important functional parameters of the right heart indicated the significant effect of the mentioned surgery in improving the right heart function. Various studies evaluated the changes in heart function in obese patients undergoing sleeve gastrectomy, although few of these studies evaluated the improvement of right heart function and heart muscle remodeling following the said surgery. In the study of Esparham et al. (22), although most structural indices of the left side of the heart improved significantly after bariatric surgery, however, the structural indices of the right side did not change significantly. Left ventricular ejection fraction and many indices of diastolic function improved significantly after bariatric surgery. Their analysis also showed that the left ventricular mass index showed a further decrease in the long-term follow-up. In Abdallah Salman et al.'s study (23), during a 15-month

follow-up after sleeve surgery, improvement in right ventricular (RV) size, significant improvement in pulmonary artery pressure, and improvement in RVSP parameter were all observed following gastrectomy. In Kaier et al.'s (24) study, there was a significant increase in LVEF as well as RVEF following gastrectomy surgery. In the study of Sargsyan et al. (25), bariatric surgery was associated with a statistically significant changes in cardiac geometry and function, including a 12.2% decrease in left ventricular (LV) mass index with a 0.155 unit increase in the E/A ratio, a decrease of 0.1 2.2 mm in left atrial diameter, 1.16 mm decrease in left ventricular diastolic dimension and 1.63% increase in LVEF after surgery. In the study of Cuspidi et al. (26), obesity methods reduced the mass of the left ventricle and the relative thickness of the ventricular wall. The improvement of left ventricular diastolic function was accompanied by an increase in E/A ratio and also a decrease in left atrial diameter, but no change in LVEF was observed. Finally, in Avner et al.'s (27) study, most cardiac indices changed 3 to 6 months after bariatric surgery. Improvement in cardiac geometry was demonstrated by reduction in left ventricular mass. Left ventricular diastolic function was improved, as was associated with a decrease in the E/e' ratio. Although left ventricular ejection fraction (LVEF) did not show an obvious change, left ventricular longitudinal strain (LV LS) was significantly increased. What can be concluded is that at least six months after sleeve gastrectomy surgery, there is an improvement in the majority of diametric and functional indicators of both the left and right heart. Despite the significant results regarding the effects of sleeve surgery on cardiac function parameters, the project had some potential limitations. First, the small sample size of the study could have affected the power of the assessments, and therefore, to achieve more reliable results, it would be necessary to repeat the assessments on a larger sample size. Second, all assessments were performed by a single echocardiologist, who could be subject to observer bias, and therefore, it is recommended that two cardiologists with high agreement be employed in subsequent assessments. Also, the assessments were performed in the short term, and therefore, it would be very useful to examine the long-term effects of surgery on cardiac parameters. As a final conclusion, sleeve gastrectomy surgery in obese patients is associated with improvement in the majority of diametric and functional parameters of the heart. In this regard, improvement in the performance of echocardiographic parameters of the right heart in the form of improvement in TAPSE, right ventricular GLS and RV FAC indicators is clearly evident after this surgery.

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Ethics approval: Ethics approval: The study protocol was ethically approved by the Ethics Committee of Okan University (ethical code: TR.OK.REC.2025.129).

Conflict of interests: The authors have no conflicts of interest.

Authors' contribution: HD supervised the study protocol, MAT and MS performed the project and collected the data, MAT performed all echocardiography procedures, and MS drafted the paper and analyzed the data.

Availability of data: All study data will be available to editorial board and readers upon request.

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