ORIGINAL ARTICLE

Short-term effects of sleeve gastrectomy on weight loss and diastolic function in obese patients

Obez hastalarda 'sleeve' gastrektominin kısa dönemde kilo kaybı ve diyastolik fonksiyon üzerine etkileri

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ABSTRACT

Objective: Bariatric surgery has been shown to improve cardiac structure and function in obese patients. This study was an examination of the short-term effects of sleeve gastrectomy on body measurements and diastolic function.

Methods: A total of 41 consecutive obese patients who were scheduled to undergo a sleeve gastrectomy procedure were included in the study. Baseline body and echocardiographic measurements and the follow-up counterpart data, including total and excess weight loss percentages, were recorded.

Results: The mean age of the patients was 42.85±11.47 years. Of the total, 21 (51.1%) patients were female. The mean body mass index (BMI) was 44.86±5.62 kg/m². The mean duration of follow-up was 91.24±44.48 days. The participants demonstrated statistically significant weight loss (26.64±10.95 kg), as well as a decrease in BMI (8.84±3.93 kg/m²) and body surface area (0.27±0.12 m²). A significant increase in E velocity and mitral annular e velocity were observed, as well as a significant decrease in A velocity, E/e ratio, left ventricle mass, and left atrial volume (LAV). No significant correlations between the body measurement changes and changes in echocardiographic parameters were observed, with the exception that the excessive weight loss percentage was moderately correlated with a change in LAV.

Conclusion: Sleeve gastrectomy led to a significant decrease in body weight and improved diastolic function parameters in the short-term. No significant relationship was found between the amount of weight loss and change in echocardiographic measurements.

ÖZET

Amaç: Bariatrik cerrahinin obez hastaların kalp yapısı ve fonksiyonlarını iyileştirdiği bilinmektedir. Bu çalışmada 'sleeve' gastrektominin (tüp mide ameliyatı) vücut ölçüleri ve diyastolik fonksiyon üzerinde kısa dönem etkilerini araştırdık.

Yöntemler: 'Sleeve' gastrektomi planlanan 41 ardışık obez hasta çalışmaya dahil edildi. Çalışma başlangıcında ve takipte vücut ölçümleri ve ekokardiyografik ölçümler kaydedildi. Toplam kilo kaybı yüzdesi ve fazla kilonun kayıp yüzdesi hesaplandı.

Bulgular: Hastaların ortalama yaşı 42.85±11.47 idi, bunların 21'i (%51.1) kadındı. Ortalama vücut kitle indeksi (VKİ) 44.86±5.62 kg/m² idi. Ortalama takip süresi 91.24±44.48 gündü. Katılımcılarda istatistiksel anlamlı olarak kilo kaybı (26.64±10.5 kg), VKİ'de (8.84±3.93 kg/m²) ve vücut yüzey alanında (VYA) azalma (0.27±0.12 m²) saptandı. Mitral E hızında ve mitral annüler e hızında anlamlı artış; mitral A hızında, E/e oranında, sol ventrikül kitlesinde (LVM) ve sol atriyum hacminde (LAV) anlamlı azalma saptandı. Vücut ölçülerindeki değişiklik miktarı ile ekokardiyografik ölçümlerdeki değişim miktarları arasında anlamlı bir ilişki bulunmadı. Sadece fazla kilonun kayıp yüzdesi ile LAV'deki azalma arasında orta derecede pozitif korelasyon saptandı.

Sonuç: 'Sleeve' gastrektomi ile ameliyat sonrası kısa dönemde anlamlı kilo kaybı ve diyastolik parametrelerde anlamlı iyileşme sağlanmıştır. Kilo kaybı miktarı ile ekokardiyografik parametreler arasında anlamlı ilişki saptanmamıştır.

Obesity affects more than 600 million people worldwide, and the prevalence has tripled since 1975.[1] Long-term obesity increases the risk of developing heart failure,[2] and it affects left ventricle geometry and muscle mass.[3] Obesity-related pathological changes cause hemodynamic abnormalities,

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especially diastolic dysfunction (DD) in the heart.[4] Obese patients have significantly higher levels of DD compared with patients with a normal body weight (BW).[5] Insulin resistance has been proposed as one of the mechanisms related to the relationship between obesity and DD[6] and a decrease in the hemoglobin A1c level has been shown to predict improved diastolic function.[7]

Bariatric surgery can enable significant, and more importantly, sustained weight loss in obese patients. This can improve quality of life and potentially reduce morbidity and mortality.[8] A reduction in BW after bariatric surgery improves the metabolic profile of patients, which may translate into morphological and clinical improvement in different aspects of the cardiovascular system.[9] Several studies have demonstrated improved cardiac morphology and structure after weight loss achieved with bariatric surgery.[10–12]

This study was a prospective examination of the short-term effects of laparoscopic sleeve gastrectomy on weight loss and echocardiographic diastolic function parameters in obese patients.

METHODS

Patient selection and data acquisition

A flowchart of the study parameters is shown in Figure 1. Patients who were to undergo laparoscopic sleeve gastrectomy were included in this study. Indications for sleeve gastrectomy were a body mass index (BMI) ≥40 kg/m^2 without comorbid illnesses or a BMI between 30–40 kg/m^2 with at least 1 serious accompanying disease (i.e., diabetes and/or hypertension). Patients with coronary heart disease, decompensated heart failure, systolic dysfunction (i.e., left ventricular ejection fraction <50%), moderate or severe valvular heart disease, chronic kidney disease, active malignancy, or other comorbid conditions that would jeopardize safe anesthesia (including moderate or severe obesity hypoventilation syndrome) were excluded. No patient was excluded due to low image quality. Baseline characteristics of age, gender, and cardiovascular risk factors, as well as preoperative and follow-up body measurements of BW, BMI, and body surface area (BSA) were recorded. Follow-up visits were scheduled for between 1 and 6 months after surgery. Three months of follow-up was defined as short-term. Total weight loss percentage (TWL%) was defined as the percentage of change in BW divided by the baseline BW. Excess weight loss percentage (EWL%) was defined as the percentage of achieved weight loss divided by the baseline BW less the ideal body weight. Echocardiographic examination data were obtained from the TomTec Image-Arena software (TomTec Imaging Systems GmbH, Unterschleissheim, Germany) image and examination report database. Echocardiographic measurements of mitral inflow patterns (E and A waves, E/A ratio), medial and lateral mitral annular velocity using tissue Doppler (e wave), mean E to e ratio (mean E/e; defined as the mean ratio of mitral E velocity to medial and lateral mitral annular e velocities), left atrial volume (LAV), left atrial volume index (LAVI), left ventricle mass (LVM), and left ventricle mass index (LVMI) were categorized as preoperative and postoperative (i.e., follow-up). LAV was calculated using the biplane Simpson method. LVM was calculated using the Devereux formula. The amount of change between post- and preoperative anthropometric and echocardiographic measurements was denoted with the letter delta (Δ).

Abbreviations:

BMI	*Body mass index*
BSA	*Body surface area*
BW	*Body weight*
DD	*Diastolic dysfunction*
EWL	*Excess weight loss*
LAV	*Left atrial volume*
LAVI	*Left atrial volume index*
LVM	*Left ventricle mass*
LVMI	*Left ventricle mass index*
TWL	*Total weight loss*

Informed consent was obtained from all participants and the criteria established by the Declaration of Helsinki were observed throughout the study. The

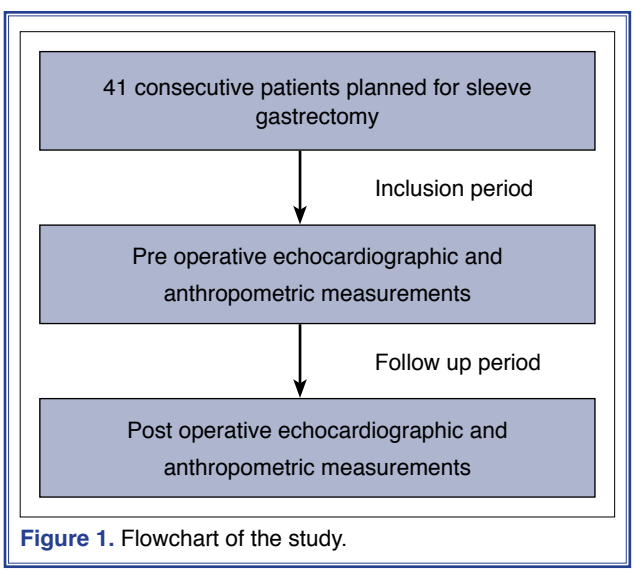

Figure 1. Flowchart of the study.

required evaluation of the study was conducted and permission was obtained from Local Ethics Committee of Yeditepe University.

Statistical analysis and outcomes

Statistical analysis

All parametrical parameters were given as mean±SD. A paired samples t-test was used to compare pre- and postoperative values, the Spearman test was used to determine correlations between the change in echocardiographic measurements and the amount of loss in BW, TWL%, and EWL%. The statistical analysis was performed using IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA).

Outcomes

The primary purpose of this study was to determine the short-term effect of sleeve gastrectomy on the body measurements and echocardiographic diastolic function parameters in the overall study population. The relationship between the amount of change in BW and change in echocardiographic parameters was also studied.

RESULTS

A total of 41 consecutive patients who were scheduled to have a laparoscopic sleeve gastrectomy were included in our study. The mean age was 42.85±11.47 years, and of the group, 21 (51.1%) patients were female. The mean BMI was 44.86±5.62 kg/m^2. The baseline characteristics of the study participants are summarized in Table 1.

The mean length of follow-up was 91.24±44.48 days. All of the study participants demonstrated consistent and statistically significant weight loss (26.64±10.95 kg) and a decrease in BMI (8.84±3.93 kg/m^2) and BSA (0.27±0.12 m^2) ($p<0.001$ for all variables). The mean TWL% was 20.05±6.71% for the overall study population and did not differ between gender groups ($p>0.05$). The mean EWL% was 48.35±21.08%. Male patients had a significantly greater EWL% than the female patients (56.35±23.45% vs 40.73±15.52%; $p=0.036$).

The E/A ratio increased in 39 patients (95%), whereas the E/e ratio decreased in 30 patients (73%), and overall changes in the E/A ratio and E/e ratio were statistically significant ($p<0.001$ for both parameters).

Table 1. Baseline characteristics and echocardiographic measurements of the study population

Baseline characteristics	
Age (years)	42.85±11.47
Gender, n (%)	
Male	20 (48.8)
Female	21 (51.2)
Hypertension, n (%)	9 (22)
Diabetes, n (%)	13 (31.7)
Cigarette smoking, n (%)	8 (19.5)
Height (cm)	170.73±6.93

The majority of patients also showed a decrease in LAV and LAVI [39 patients (95%) and 28 patients (68%), respectively]. Likewise, LWM and LWMI were reduced in the majority of patients (75% for both parameters). Changes in LAV, LAVI, and LVM were significant ($p<0.001$, 0.048, and <0.001, respectively), whereas, the change in LWMI did not reach a level of statistical significance.

The baseline and follow-up echocardiographic and anthropometric measurements are summarized in Table 2.

Correlation analysis revealed no significant relationship between a change in BW and change in E/A ratio, mean E/e ratio, LAV, or LAVI. On the other hand, the EWL% had a significant though moderate positive correlation with ΔLAV ($r=0.39$; $p=0.012$) (Fig. 2).

Post hoc analysis was performed to reveal the effects of a change in BW, TWL%, or EWL% on change in LAVI and LWMI. Patients with a high LAVI or a high LWMI did not have a significantly different change in BW, TWL%, or EWL% when compared with the patients with a lower LAVI or LWMI.

DISCUSSION

The results of this study indicated that, during short-term follow up, sleeve gastrectomy had led to significant weight loss, a significant decrease in BMI and in BSA in a small group of obese patients. Significant changes in echocardiographic diastolic function parameters were also observed. There was no significant difference in these changes between the patient subgroups. No significant relationship was

Table 2. Baseline and follow-up anthropometric and echocardiographic measurements

	Baseline	Follow-up	Amount of change (Δ)	*p*
Body weight (kg)	131.00±21.19	105.50±16.18	26.64±10.95	<0.001
Body surface area (m²)	2.48±0.25	2.21±0.20	0.27±0.10	<0.001
Body mass index (kg/m²)	44.86±5.62	36.01±5.03	8.83±3.95	<0.001
Total weight loss percentage	N/A	19.97±6.76	N/A	
Excess weight loss percentage	N/A	41.49±17.43	N/A	
Echocardiographic measurements				
Mitral E velocity (E) (cm/s)	82.54±16.71	84.37±16.80	0.28±0.22	0.045
Mitral A velocity (A) (cm/s)	78.07±19.34	66.37±14.68	11.71±15.28	<0.001
E/A	1.10±0.32	1.33±0.32	0.23±0.15	<0.001
Medial mitral annular e velocity (cm/s)	9.73±2.22	9.80±1.79	0.04±2.17	0.227
Lateral mitral annular e velocity (cm/s)	12.00±2.06	13.29±3.90	1.29±3.13	0.003
Mean E/e	8.10±1.65	7.28±1.56	1.03±0.98	<0.001
Left atrial volume (mL)	61.12±15.55	47.20±11.80	14.46±12.42	<0.001
Left atrial volume index (mL/m²)	23.94±6.30	21.87±5.79	2.07±6.50	0.048
Left ventricular mass (g)	191.44±29.83	175.07±22.07	16.36±26.09	<0.001
Left ventricular mass index (g/m²)	81.45±13.57	81.66±11.73	0.21±11.96	0.911

found between the amount of BW change and changes in individual echocardiographic diastolic function parameters. TWL% and EWL% were weakly correlated with the change in LAV.

Two studies have demonstrated effective weight loss following sleeve gastrectomy with results similar to ours. Çetinkünar et al.[13] reported a significant BMI decrease (from 46.3 to 32.8 kg/m²) and 58% EWL in 73 obese patients at the end of 9 months of follow-up. Major et. al.[14] studied 65 patients, and at the end of 12 months, they found a significant reduction in BMI (from 50.44 to 34.4 kg/m²) and 58.8 %EWL.

The impact of weight loss achieved through bariatric surgery on heart failure has inspired a number of cardiac imaging studies. One meta-analysis conducted by Aggarwal et al.[10] included the data of 1486 patients from 40 studies, 14 of which were prospective. In all, 37 of the studies used echocardiography. The mean follow-up was 18.2 months. As in our study, a significant increase in E wave and E/A ratio, as well as a significant decrease in A wave, were observed. A change in mitral annular tissue Doppler velocity or LAV was not reported. The largest study in this meta-analysis was performed by Owan et al.,[15]

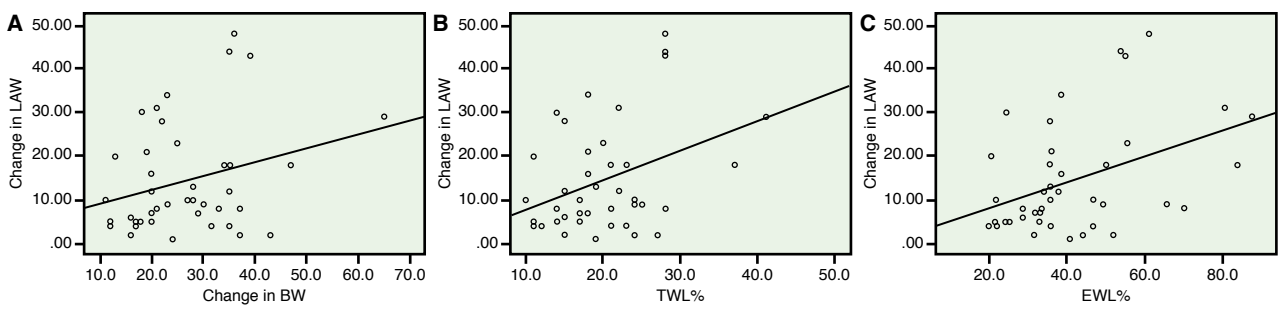

Figure 2. Scatter plots of change in BW, TWL%, and EWL% with respect to change in LAV. **(A)** Change in body weight (BW) and change in left atrial volume (LAV). The correlation is not significant (p=0.167). **(B)** Change in total weight loss percentage (TWL%) and change in left atrial volume (LAV). The correlation is not significant (p=0.072). **(C)** Change in exceessive weight loss percentage and change in left atrial volume (LAV). The correlation is moderate and significant (r=0.390, p=0.012).

BW: Body weight; EWL: Excess weight loss; LAV: Left atrial volume; TWL: Total weight loss.

who prospectively studied 423 patients treated with gastric bypass surgery and a non-surgically treated control group. In that study, echocardiographic measurements at baseline and at the end of 2 years of follow-up were compared, and a significant decrease in cardiac chamber size and a non-significant decrease in LAV were observed in the surgery group. Also, the E/e ratio decreased, and was found to have a significant negative correlation with exercise duration at the 2-year visit.

The pathophysiological mechanism underlying this beneficial effect of bariatric surgery is not clear. In obese patients, several mediators have been shown to cause left ventricular hypertrophy,[16] which is known to be associated with adverse cardiovascular outcomes.[17] The reduction of adipose tissue and LVM after bariatric surgery may be the key factor that improves diastolic function parameters. A significant reduction in LVM was found in our study.

One of the interesting results of our study is that not all of the patients experienced a decrease in LAVI or LWMI during follow-up. A total of 16 patients (39%) had increased LAVI, which is in contrast with the findings of previously published studies. One of the explanations may be the short follow-up period, which may hinder observance of the benefit of weight loss on LAV. Another explanation may be inter- and intraobserver variability between echocardiographic examinations. Lastly, the volume status of the patients was unknown, and this could affect the size of the left atrium. Our study is not sufficiently powered to establish the underlying reasons for this finding, so future studies with a large number of patients are needed to clarify any differences between short- and long-term echocardiographic measurements after sleeve gastrectomy.

The short-term results of sleeve gastrectomy in terms of echocardiographic measurements are scarce. Tuluce et al.[18] studied 32 patients with severe obesity who underwent laparoscopic severe gastrectomy and 30 healthy controls. Unlike our study, they investigated left ventricular function and left atrial structural, mechanical, and electrical functions, mainly using strain echocardiography. After 1 month, the longitudinal global strain significantly improved compared with the baseline, and similar to our study, significant reductions were found in the left atrial anteroposterior diameter, LAVI, and E/e ratio.

Maintaining the short-term success achieved for the long-term is sometimes difficult for patients. Keren et al.[19] studied 119 patients who underwent laparoscopic sleeve gastrectomy as a first procedure and found that patients with better lifestyle adaptations had higher EWL% values. This issue is important because weight regain and a sedentary lifestyle may impair diastolic function and attenuate the initial beneficial effects of the treatment. The relationship between short-term cardiac function improvement after bariatric surgery and long-term maintenance of this effect should be investigated in further studies.

Despite significant differences between preoperative and follow-up echocardiographic measurements in previous studies, to the best of our knowledge, there are no data regarding the relationship between the amount of BW change or EWL% and change in echocardiographic measurements of diastolic function. We found no correlation between BW change and echocardiographic measurements, but the TWL% and EWL% were weakly correlated with the change in LAV. The parameters affecting cardiac function after bariatric surgery require further investigation.

There are several limitations to our study. The sample size is small and non-random, which limited the power of the primary outcome statistics; second, interobserver variability between echocardiographic examinations could not be calculated because the examination data were taken from an image and examination report database program; and third, due to the lack of long-term follow-up results, a comparison between short- and long-term data could not be performed.

Conclusion

In our study, sleeve gastrectomy proved to be an effective surgical method for weight loss, and resulted in significantly improved diastolic function measurements in a small group of obese patients. Factors independently affecting these changes warrant further studies.

Ethics Committee Approval: Permission was obtained from Local Ethics Commitee of Yeditepe University (Date: 05.05.2016 Decision No: 611).

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M.A.Ş., A.T.C., O.Ö., Ö.T., S.A.; Data: M.A.Ş., A.T.C., O.Ö., Ö.T., S.A.; Literature search: M.A.Ş.; Writing: M.A.Ş.; Critical revision: M.D., O.Ö., S.A.

REFERENCES

1. Obesity and overweight. Feb 3, 2018. Available at: http://www.who.int/mediacentre/factsheets/fs311/en/. Accessed Oct 31, 2018.
2. Kenchaiah S, Evans JC, Levy D, Wilson PW, Benjamin EJ, Larson MG, et al. Obesity and the risk of heart failure. N Engl J Med 2002;347:305–13. [CrossRef]
3. Cuspidi C, Rescaldani M, Sala C, Grassi G. Left-ventricular hypertrophy and obesity: a systematic review and meta-analysis of echocardiographic studies. J Hypertens 2014;32:16–25.
4. Cuspidi C, Tadic M, Grassi G. Diastolic dysfunction, blood pressure and obesity: new insights from a general population. J Hypertens 2014;32:2359–61. [CrossRef]
5. Kossaify A, Nicolas N. Impact of overweight and obesity on left ventricular diastolic functionand value of tissue Doppler echocardiography. Clin Med Insights Cardiol 2013;7:43–50.
6. Peterson LR. Obesity and insulin resistance: effects on cardiac structure, function, and substrate metabolism. Curr Hypertens Rep 2006;8:451–6. [CrossRef]
7. Kosmala W, O'Moore-Sullivan T, Plaksej R, Przewlocka-Kosmala M, Marwick TH. Improvement of left ventricular function by lifestyle intervention in obesity: contributions of weight loss and reduced insulin resistance. Diabetologia 2009;52:2306–16. [CrossRef]
8. English WJ, Williams DB. Metabolic and Bariatric Surgery: An Effective Treatment Option for Obesity and Cardiovascular Disease. Prog Cardiovasc Dis 2018;61:253–69. [CrossRef]
9. Yu H, Chen J, Lu J, Bao Y, Tu Y, Zhang L, Decreased visceral fat area correlates with improved arterial stiffnessafter Roux-en-Y gastric bypass in Chinese obese patients with type 2diabetes mellitus: a 12-month follow-up. Surg Obes Relat Dis 2016;12:550–5. [CrossRef]
10. Aggarwal R, Harling L, Efthimiou E, Darzi A, Athanasiou T, Ashrafian H. The Effects of Bariatric Surgery on Cardiac Structure and Function: a Systematic Review of Cardiac Imaging Outcomes. Obes Surg 2016;26:1030–40. [CrossRef]
11. Kurnicka K, Domienik-Karłowicz J, Lichodziejewska B, Bielecki M, Kozłowska M, Goliszek S, et al. Improvement of left ventricular diastolic function and left heartmorphology in young women with morbid obesity six months afterbariatric surgery. Cardiol J 2018;25:97–105. [CrossRef]
12. Alpert MA, Omran J, Bostick BP. Effects of Obesity on Cardiovascular Hemodynamics, CardiacMorphology, and Ventricular Function. Curr Obes Rep 2016;5:424–34. [CrossRef]
13. Çetinkünar S, Erdem H, Aktimur R, Aziret M, Özdaş S, Yürekli B, et al. The effect of laparoscopic sleeve gastrectomy on morbid obesity and obesity-related comorbidities: A cohort study. Ulus Cerrahi Derg 2015;31:202–6.
14. Major P, Matłok M, Pędziwiatr M, Migaczewski M, Budzyński P, Stanek M, et al. Quality of Life After Bariatric Surgery. Obes Surg 2015;25:1703–10. [CrossRef]
15. Owan T, Avelar E, Morley K, Jiji R, Hall N, Krezowski J, et al. Favorable changes in cardiac geometry and function following gastricbypass surgery: 2-year follow-up in the Utah obesity study. J Am Coll Cardiol 2011;57:732–9. [CrossRef]
16. Sirbu A, Stanca I, Copaescu C, Martin S, Albu A, Barbu C, et al. Association of serum adiponectin and insulin-like growth factor I levelswith parameters of cardiac remodeling in severely obese patients. J Endocrinol Invest 2013;36:686–92.
17. Ruilope LM, Schmieder RE. Left ventricular hypertrophy and clinical outcomes in hypertensivepatients. Am J Hypertens 2008;21:500–8. [CrossRef]
18. Tuluce K, Kara C, Tuluce SY, Cetin N, Topaloglu C, Bozkaya YT, et al. Early Reverse Cardiac Remodeling Effect of Laparoscopic SleeveGastrectomy. Obes Surg 2017;27:364–75.
19. Keren D, Matter I, Lavy A. Lifestyle modification parallels to sleeve success. Obes Surg 2014;24:735–40. [CrossRef]

Keywords: Diastolic function; obesity; sleeve gastrectomy.

Anahtar sözcükler: Diyastolik fonksiyon; obezite; sleeve gastrektomi.