Original Article

The Effect of Bariatric Surgery on Left Atrium Mechanical Activity, Left Atrial Strain, and Diastolic Function

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Abstract

Background: As a widespread global health concern, obesity frequently results in cardiovascular complications. Bariatric surgery has emerged as an effective intervention for managing severe obesity in cases where conventional weight-loss methods have proven unsuccessful. This investigation aimed to evaluate alterations in left atrial (LA) mechanical activity, atrial strain parameters, and diastolic function following bariatric surgery.

Materials and Methods: In this quasi-experimental longitudinal study, patients scheduled for bariatric procedures at Imam Hossein Hospital (Tehran, Iran) between March 2021 and March 2022 were enrolled. Comprehensive echocardiographic assessments were performed pre- and post-operatively, followed by detailed statistical evaluation.

Results: The study cohort comprised 22 individuals with a mean age of 40.27 ± 9.79 years, predominantly female (72.2%). A substantial reduction in mean body mass index was documented, decreasing from 43.68 ± 5.17 kg/m² to 36.09 ± 4.94 kg/m² ($p < 0.001$). Among comorbidities, diabetes mellitus was most prevalent (31.8%). Postoperative assessments revealed significant reductions in multiple cardiac parameters ($p < 0.05$), including left ventricular end-diastolic and end-systolic dimensions, right ventricular diastolic diameter, LA dimensions, atrial volume, and pericardial adipose tissue. Concurrently, significant improvements were observed in septal and lateral É values, alongside enhanced LA reservoir and conduit functions ($p < 0.05$).

Conclusion: The results demonstrate that bariatric surgery produces favorable modifications in diastolic performance and left atrial dynamics. Additionally, the procedure positively influences functional parameters of both ventricular chambers.

Keywords: Metabolic surgery, Atrial mechanics, Cardiac diastolic function, Morbid obesity

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Introduction

Obesity represents one of the most widespread health challenges worldwide. Substantial evidence links this condition to numerous adverse cardiovascular outcomes, particularly elevated risks of atrial arrhythmias such as atrial fibrillation (AF) and heart failure with preserved ejection fraction (HFpEF)[1, 2]. The pathogenesis of these arrhythmias is often attributed to underlying structural and functional alterations in the left atrium. Moreover, impaired left atrial (LA) mechanical function has been identified as a significant contributor to compromised left ventricular (LV) filling dynamics, thereby promoting the development of HFpEF[3, 4].

Concurrently, obesity is a well-established risk factor for coronary artery disease (CAD). The fundamental pathophysiology of CAD involves atherosclerosis, a process accelerated by obesity. Although atherosclerotic changes can initiate early in life, their progression is markedly influenced by obesity in younger adult populations. These vascular lesions impair myocardial perfusion, ultimately leading to cardiomyocyte loss. Studies indicate a direct correlation between body weight and the rate of this pathological progression[5, 6].

Weight gain and obesity-related comorbidities, particularly arterial hypertension, have been shown to adversely impact LA architecture and performance. These changes create a substrate conducive to atrial arrhythmogenesis and diastolic impairment[7, 8].

Traditional echocardiographic assessment of the LA initially relied on anterior-posterior diameter measurements, later evolving to include area and volume quantification. More recently, left atrial longitudinal strain—representing deformation of atrial walls throughout the cardiac cycle—has emerged as a superior indicator of LA mechanical function[9, 10].

Multiple investigations have established that LA strain provides independent and enhanced predictive value compared to conventional LA morphological parameters for detecting paroxysmal AF across various clinical contexts, including ischemic stroke, hypertrophic cardiomyopathy, chemotherapy-related cardiotoxicity, and HFpEF post-coronary artery bypass grafting[11-14]. Furthermore, LA strain independently predicts HFpEF occurrence and improves stratification of diastolic dysfunction severity[15, 16].

Research confirms that obesity-associated risks for atrial fibrillation and HFpEF coincide with demonstrable left atrial mechanical dysfunction. Importantly, surgical weight loss interventions have proven effective in mitigating these cardiovascular risks[17-19]. This study therefore aimed to evaluate the effects of bariatric surgery on LA mechanical activity, atrial strain parameters, and diastolic function in severely obese patients.

Methods

Study Design and Participants: This quasi-experimental investigation employed a pre-post design involving patients referred for bariatric surgery at Imam Hossein Hospital (Tehran, Iran) between March 2021 and March 2022. Inclusion criteria required participants to be ≥18 years with either: 1) BMI 35-39.9 kg/m², or 2) BMI ≥35 kg/m² with at least one comorbidity including obesity hypoventilation syndrome, diabetes mellitus, hypertension, or dyslipidemia.

Exclusion criteria encompassed: documented coronary artery disease, ejection fraction <50%, moderate-or-severe valvular heart disease (including mitral, aortic, or tricuspid disorders), prior cardiac surgery, atrial fibrillation rhythm, and inadequate echocardiographic windows. All participants provided written informed consent, and the study protocol received approval from the Ethics Committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.RETECH.REC.1401.485).

Data Collection and Variables: Patient medical histories were obtained through clinical examinations and direct interviews. Baseline characteristics included demographic information (gender, age) and cardiovascular risk factors (hypertension, diabetes, hyperlipidemia, smoking history, cardiac and renal disease history). Anthropometric measurements (height, weight, BMI) were recorded. Epicardial adipose tissue thickness was quantified by an experienced cardiologist using echocardiography, with measurements obtained once preoperatively and again three months postoperatively.

Echocardiographic Protocol: Comprehensive transthoracic echocardiography was performed using a PHILIPS EPIQ 7 system by an echocardiography specialist. Parameters were indexed to body surface area using the Du Bois formula when appropriate. The protocol included:

1. Interventricular septal thickness measurement in parasternal long-axis view
2. LV end-diastolic dimension assessment via M-mode in parasternal long-axis view
3. LV end-systolic dimension measurement using M-mode technique
4. LV ejection fraction calculation using Teichholz

formula from M-mode measurements

5. Mitral inflow Doppler analysis including early (E) and late (A) diastolic velocities with E/A ratio computation
6. Septal E/e' ratio measurement for diastolic function evaluation
7. Comprehensive diastolic assessment using pulsed-wave Doppler transmitral inflow patterns
8. LA volume quantification using biplane method (apical 4- and 2-chamber views) at end-systole
9. Right ventricular diastolic dimension measurement in apical 4-chamber view
10. LA strain analysis via 2D speckle tracking echocardiography
11. Epicardial fat pad measurement in parasternal long-axis view during end-diastole
12. Tricuspid annular plane systolic excursion (TAPSE) assessment using M-mode

Statistical Analysis: Continuous variables were summarized as mean ± standard deviation, while categorical data were presented as frequencies and percentages. Pre- and postoperative comparisons utilized paired t-tests or Wilcoxon signed-rank tests based on data distribution normality. All analyses were conducted using SPSS version 26, with statistical significance defined as $p < 0.05$.

Results

The study enrolled 22 patients with mean age 40.27 ± 9.79 years, predominantly female (72.2%). A significant reduction in mean BMI was observed following bariatric surgery, decreasing from 43.68 ± 5.17 kg/m² to 36.09 ± 4.94 kg/m². Detailed patient characteristics are presented in Table 1.

The most prevalent underlying disease among patients was diabetes, accounting for 31.8% of cases. Table 2 presents a comprehensive overview of the patient's medical history, including details regarding the underlying disease, habitual history, drug history, vital signs, and electrocardiogram results.

Echocardiography was performed on all patients both before and after bariatric surgery. Postoperative reductions were observed in LVEDD, LVESD, RVDD, LA area, pericardial fat pad size, LA volume, and septal thickness. The mean É septal, É lateral, LA reservoir function, and LA conduit function increased significantly after the intervention. The relevant data are presented in Table 3.

Discussion

This quasi-experimental investigation sought to evaluate the effects of bariatric surgery on left atrial dynamics and diastolic performance through pre- and postoperative comparisons. Our cohort of 22 patients demonstrated significant improvements in both diastolic function and LA mechanical properties following surgical intervention. Additionally, the procedure positively influenced echocardiographic

Table 1. Basic data of the patients.

Variables		N	%
Sex	Male	6	27.3
	Female	16	72.7
Education	Lower than diploma	4	18.2
	Diploma	11	50.0
	Bachelor of Science	6	27.3
	Master of Science	1	4.5
Physical Activity (times in a week)	0-1	13	59.1
	2-3	6	27.3
	4-5	1	4.5
	>5	2	9.1
		Mean ± SD	**Mean difference ± SD difference**
Age (years)	-	40.27 ± 9.79	-
Height (cm)	-	165.91 ± 8.56	-
Weight (kg)	Pre	120.59 ± 19.52	-
Weight	Post	104 ± 20.95	-
P-value	-	0.0007	-16.59 ± 24.51
BMI (kg/m^2)	Pre	43.68 ± 5.17	-
BMI	Post	36.09 ± 4.94	-
P-value	-	<0.001	-7.58 ± 2.22

P-value based on paired t-test or Wilcoxon rank-sum test. Mean difference = after value – before value parameters related to both left and right ventricular performance.

Left atrial strain has emerged as a robust marker for detecting diastolic impairment. Multiple investigations have established its superior diagnostic accuracy compared to conventional LA volumetric assessments[21-23]. Notably, one study reported 91% accuracy in distinguishing grade 3 diastolic dysfunction from milder grades using LA strain analysis[24].

Consistent with existing literature, Cuspidi et al. documented enhanced right ventricular systolic and diastolic function following bariatric surgery in patients with RV hypertrophy, attributing these benefits primarily to BMI reduction and amelioration of obstructive sleep apnea[25]. Our findings align with this consensus, demonstrating significant reduction in RV diastolic dimensions among morbidly obese patients' post-surgery.

Vest et al. evaluated bariatric surgery outcomes in

Table 2. Historical, vital signs, and electrocardiogram data of the patients.

Variables	N	%
Diabetes (DM)	7	31.8
Hypertension (HTN)	5	22.7
Dyslipidemia (DLP)	1	4.5
Hypothyroidism	1	4.5
Hyperthyroidism	1	4.5
Smoker	4	18.2
Ex-smoker	3	13.6
Alcohol	1	4.5
Aspirin	1	4.5
Beta-blocker	5	22.7
Statin	3	13.6
ACEI.ARB	3	13.6
Oral anti-diabetic agents	7	31.8
EKG (NSR)	22	100
	Mean ± SD	
Systolic blood pressure	114.94 ± 42.28	
Diastolic blood pressure	70.28 ± 24.33	
Heart Rate	80.36 ± 19.36	
PR interval	0.11 ± 0.04	
QRS duration	0.08 ± 0.02	

Table 3. Echocardiographic findings pre-bariatric surgery and post-bariatric surgery.

Echocardiography factors		Mean ± SD	P-value
LVEF (%)	Pre	54.55 ± 1.47	—
	Post	54.55 ± 1.47	
LVEDD (cm)	Pre	4.67 ± 0.34	**<0.001**
	Post	4.38 ± 0.43	
LVESD (cm)	Pre	3.15 ± 0.34	**0.001**
	Post	2.96 ± 0.4	
E-velocity (m/s)	Pre	0.73 ± 0.24	0.547
	Post	0.89 ± 0.79	
E/A	Pre	1.14 ± 0.35	0.079
	Post	1.32 ± 0.51	
É septal (cm/s)	Pre	8.17 ± 1.97	**0.013**
	Post	9.1 ± 2.24	
É lateral (cm/s)	Pre	11.11 ± 2.68	**0.004**
	Post	12.93 ± 2.96	
LA reservoir function (%)	Pre	14.68 ± 5.09	**0.0001**
	Post	20.65 ± 5.41	
LA contraction function(%)	Pre	5.07 ± 2.46	0.139
	Post	6.25 ± 3.51	
LA conduit function (%)	Pre	9.55 ± 3.41	**<0.001**
	Post	14.4 ± 3.98	
RVDD (cm)	Pre	3.1 ± 0.23	**0.019**
	Post	2.93 ± 0.37	
TAPSE (cm)	Pre	2.09 ± 0.26	0.499
	Post	2.06 ± 0.13	
SM (cm/s)	Pre	11.09 ± 1.11	0.318
	Post	10.51 ± 2.01	
LA area cm2	Pre	19.27 ± 3.47	**0.018**
	Post	18.19 ± 3.51	
RA area (cm2)	Pre	15.95 ± 2.67	0.089
	Post	15.20 ± 2.28	
E/é	Pre	9.08 ± 2.73	0.055
	Post	7.45 ± 2.83	
pericardial fat pad size (mm)	Pre	5.42 ± 2.2	**0.0001**
	Post	3.67 ± 2.13	
TRG (mmHG)	Pre	20.27 ± 5.25	0.419
	Post	19.08 ± 6.57	
PAP (mmHG)	Pre	25.27 ± 5.25	0.181
	Post	24.5 ± 5.54	
A-velocity (m/s)	Pre	0.67 ± 0.22	0.375
	Post	1.47 ± 4.14	
LA volume (cm2)	Pre	50.85 ± 11.07	**0.0003**
	Post	43.89 ± 9.49	
Septal thickness (cm)	Pre	0.92 ± 0.16	0.025
	Post	0.89 ± 0.14	

obese patients with left ventricular systolic dysfunction (LVSD), concluding the procedure is safe and effective in this population, with associated improvements in LV ejection fraction[26]. While our study similarly observed postoperative enhancements in LV end-systolic and end-diastolic dimensions, we noted stable LVEF values pre- and post-intervention—a finding that merits further investigation.

The investigation by Heydar et al. examining sleeve gastrectomy outcomes reported reductions in multiple cardiac parameters including IVS thickness, LV posterior wall thickness, LV mass, and pericardial fat thickness, though they observed increased LA volume index and deceleration time[20]. Our results partially converge with these findings, demonstrating significant decreases in LV dimensions, RV diameter, LA area, septal thickness, pericardial fat, and LA volume, alongside improvements in septal and lateral É values and LA reservoir and conduit functions.

Davarpasand et al. utilized speckle-tracking echocardiography to demonstrate impaired LA strain and strain rate patterns in obese patients with myocardial infarction[27]. Our observations similarly indicate obesity-related alterations in multiple LA parameters that showed favorable postoperative improvement, reinforcing the association between obesity and LA dysfunction.

Hamo et al.'s comprehensive assessment of 98 surgical patients revealed weight-reduction-associated improvements in echocardiographic parameters and high-sensitivity cardiac troponin T levels, thereby correlating myocardial injury markers with cardiac structural and functional changes 28. While our study confirmed BMI reduction and general cardiac improvements, we did not observe significant changes in wall thickness or E/e' ratio—discrepancies potentially attributable to sample size differences that warrant larger-scale validation.

Strzelczyk et al. specifically investigated LA strain modifications following surgical weight loss, documenting enhanced reservoir and conduit strain components alongside reduced contraction strain[29]. Our results partially align, demonstrating significantly improved reservoir and conduit functions without notable changes in contraction strain—another divergence potentially explained by cohort size variations.

Hosseinsabet et al. identified associations between poor diabetic control and impaired LA mechanics in coronary artery disease patients using speckle-tracking echocardiography[30]. Although their study focused on diabetic populations, the metabolic parallels with obesity suggest both conditions significantly impact LA function. Our application of similar echocardiographic methodology confirms that obesity-related subclinical dysfunction can manifest as impaired LA strain patterns.

Study Limitations and Conclusion: The primary limitation of this investigation is its modest sample size, highlighting the need for larger prospective studies. Nonetheless, our findings consistently indicate that bariatric surgery induces favorable modifications in diastolic function and LA mechanics. The observed LA strain improvements substantiate that surgical weight loss enhances atrial and diastolic performance. Furthermore, our echocardiographic data confirm that this intervention has a beneficial impact on multiple cardiac structures in severely obese patients.

Conclusion

Our findings indicate that bariatric surgery leads to meaningful improvements in left ventricular diastolic function and left atrial mechanical performance. In addition, it improves the functional performance of both ventricles, highlighting its overall benefit for cardiac function in patients with obesity.

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None.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

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