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Effect of Bariatric Surgery on Emergency Department Visits and Hospitalizations for Atrial Fibrillation

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Abstract

Atrial fibrillation (AF) and obesity are major health problems in the United States. However, little is known about whether bariatric surgery affects AF-related morbidities. This study investigated whether bariatric surgery is associated with short-term and long-term changes in the risk of emergency department (ED) visits or hospitalizations for AF. We performed a self-controlled case series study of obese adults with AF who underwent bariatric surgery by using population-based ED and inpatient databases in California, Florida, and Nebraska from 2005 to 2011. The primary outcome was ED visit or hospitalization for AF. We used conditional logistic regression to compare each patient's risk of the outcome event during sequential 12-month periods, using presurgery months 13 to 24 as a reference period. Our sample consisted of 523 obese adults with AF who underwent bariatric surgery. The median age was 57 years (interquartile range 48 to 64 years), 59% were female, and 84% were non-Hispanic white. During the reference period, 15.9% (95% confidence interval [CI] 12.7% to 19.0%) of patients had an ED visit or hospitalization for AF. The risk remained similar in the subsequent 12-month presurgery period (adjusted OR [aOR] 1.29 [95% CI, 0.94 to 1.76] p = 0.11). In contrast, the risk significantly increased within 12 months after bariatric surgery (aOR 1.53 [95% CI 1.13 to 2.07] p = 0.006). The risk remained elevated during 13–24 months after bariatric surgery (aOR 1.41 [95% CI, 1.03 to 1.91] p = 0.03). In conclusion, this population-based study demonstrated that bariatric surgery was associated with an increased risk of AF episodes requiring an ED visit or hospitalization for at least 2 years after surgery among obese patients with AF.

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Atrial fibrillation (AF) affects 3 to 6 million US adults.[1,2] Health care utilizations for AF contribute to the public health burden, accounting for 479,000 hospitalizations and $6 billion direct costs annually.[3] The United States has also experienced an obesity epidemic, with 35% to 40% of adults being obese.[4] Although there are potential pathophysiologic mechanisms that link obesity to increased morbidity in patients with AF, data are scarce on the role of weight reduction in AF-related morbidities. Within the limited literature, nonsurgical weight management has been shown to result in improved AF symptoms and less frequent AF episodes.[5] Bariatric surgery is known to be the most effective method to achieve substantial and sustained weight loss, and has been associated with a lower risk of incident AF.[6,7] However, bariatric surgery also leads to enhanced sympathetic tone, electrolyte disturbances, and anemia.[8] These factors may have a negative impact on AF-related morbidities. In this context, we aimed to determine whether, in obese patients with AF, bariatric surgery affects the risk of ED visits or hospitalizations for AF.

Methods

This study was a self-controlled case series study of obese patients with AF using the data from the Healthcare Cost and Utilization Project (HCUP) State Emergency Department Databases (SEDD) and State Inpatient Databases (SID).[9,10] The study design allows each patient to function as his or her own control. This study performed intraperson comparisons in patients who experienced both the exposure (bariatric surgery) and the outcome (ED visit or hospitalization for AF), and therefore control group was not necessary.[11] All time-invariant covariates (e.g., patient characteristics and genetics) are implicitly controlled, thereby minimizing confounding by unmeasured variables.[11] The present study meets the requirements of the self-controlled case series design as the exposure is transient and discrete and the outcome is an acute event.[11]

We analyzed the data from HCUP SEDD and SID in 3 states (California, Florida, and Nebraska) from 2005 to 2011. HCUP is the largest longitudinal hospital care data warehouse available in the United States and provides all-payer, encounter-level information.[9,10] The SEDD records all ED visits (including treat-and-release encounters and transfers) from short-term, acute-care, nonfederal hospitals in participating states.[9] The SID captures all inpatient discharges from short-term, acute-care, nonfederal, general, and other specialty hospitals, including data of hospitalizations through the ED.[10] Taking the data together, we were able to identify all ED visits regardless of disposition and all hospitalizations regardless of the source of hospitalization.[9,10] We chose these 3 states because data from these states have unique patient identifiers. This allowed us to perform longitudinal patient follow-up across the study years in geographically disperse populations. Details of the study design, databases, and statistical analysis methods have been published elsewhere.[9,10,12-14] The institutional review board of Massachusetts General Hospital approved this study.

We took the following steps to identify all obese adult patients who underwent bariatric surgery and had an ED visit or hospitalization for AF in the databases from the 3 states. First, we identified adult patients (age ≥18 years) with a diagnosis code for obesity and hospitalized for bariatric surgery, by using the *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* procedure codes for bariatric surgery (43.89, 44.31, 44.38, 44.39, 44.50, 44.68, 44.69, 44.93, 44.95, 44.99, 45.51, and 45.90),[12-15] and the *ICD-9-CM* diagnosis codes for obesity (278.0 to 278.1, V77.8, V85.3x, and V85.4).[12-15] Patients with gastrointestinal cancer (diagnosis codes 150.0 to 159.9) were excluded.[12-14] Patients who underwent bariatric surgery between January 1, 2007, and December 31, 2009, were included to accommodate the 2-year periods before and after the surgery. Second, among these obese patients who underwent bariatric surgery, we further identified those with at least 1 ED visit or hospitalization for AF between January 1, 2005, and December 31, 2011, by using the *ICD-9-CM* diagnosis code for AF (427.31) in the primary diagnosis field.[16] The exclusion criteria were as follows: patients who lived outside the 3 states, died during hospitalization for bariatric surgery, died in-hospital during the 2-year postsurgery period, or had multiple bariatric surgeries during the study period.

Baseline patient characteristics were recorded during the index hospitalization for bariatric surgery. Data of demographics such as age, sex, and race or ethnicity, primary insurance type, quartiles for estimated household income, season of bariatric surgery, state (California, Florida, and Nebraska), *ICD-9-CM* diagnosis, ED disposition, and procedures were obtained from the databases.

The primary outcome measure was a composite of ED visit or hospitalization for AF during a 4-year period (i.e., 2-year period before and 2-year period after bariatric surgery). The secondary outcome measures were (1) ED visit for AF and (2) hospitalization for AF, assessed separately. To compare each patient's risk of outcome event during sequential 12-month periods, adjusted odds ratios (aORs) were calculated using a conditional logistic regression model—with presurgery period 13 to 24 months as a reference—for presurgery months 1 to 12, postsurgery months 0 to 12, and postsurgery months 13 to 24. Each patient was matched to his or her own reference period.

To examine the robustness of our findings, we performed several sensitivity analyses. First, we repeated the analysis stratified by age group (18 to 56 vs ≥57 years based on the median age) and sex. Second, we performed the primary analysis model in a subgroup of patients who had at least 1 health care utilization for any reason during postsurgery 25 to 36 months. This sensitivity analysis addressed the possibility of loss to follow-up (e.g., out-of-hospital deaths, moving out of the study states). This subgroup analysis ensured that these patients were both alive and living within the study states at least until 2 years after surgery and would have been recorded in the databases if they had the primary end point during the study period. Lastly, to identify transient postoperative changes in the outcomes, we also calculated the proportion of an outcome event for the 2 years before and after bariatric surgery in 3-month intervals. Presurgery months 22 to 24 was used as a reference period for this analysis. A 2-sided p-value <0.05 was considered statistically significant in the present study, and results are presented with a 95% confidence interval (CI). Statistical analyses were performed with SAS version 9.4 (SAS Institute, Cary, NC).

Results

We identified 543 obese patients who underwent bariatric surgery between January 1, 2007, and December 31, 2009, and also had at least 1 ED visit or hospitalization for AF between January 1, 2005, and December 31, 2011. We excluded patients who had multiple bariatric surgeries (10 patients) and who died in-hospital within 2 years after the surgery (10 patients). Thus, the analytic cohort comprised a total of 523 patients. The characteristics at the time of bariatric surgery are summarized in Table 1.

As shown in Table 2, 15.9% (95% CI, 12.7% to 19.0%) of patients had an ED visit or hospitalization for AF during the reference period (13 to 24 months prior to bariatric surgery). The risk did not change in the subsequent 12-month presurgery period (19.7%; 95%CI, 16.3% to 23.1%), corresponding to an aOR of 1.29 (95% CI, 0.94 to 1.76; p = 0.11). During the first 12 months after bariatric surgery, there was an increased risk of ED visits or hospitalizations for AF (22.8%; 95% CI, 19.1% to 26.4%) with an aOR of 1.53 (95% CI, 1.13 to 2.07; p = 0.006). Likewise, the risk remained elevated in the subsequent period of 13 to 24 months after bariatric surgery (21.2%; 95% CI, 17.7% to 24.7%), corresponding to an aOR of 1.41 (95% CI, 1.03 to 1.91; p = 0.03).

The analysis of secondary outcomes showed similar changes in the event risk of AF after bariatric surgery for the 2 component events (ED visit and hospitalization) when examined individually (Table 2). Particularly, there was a significant increase in the risk of hospitalization for AF after surgery.

In the sensitivity analysis, we further examined the change in the risk of primary outcome during the 4-year study period. Although statistical power was limited, the stratified analyses also showed statistically significantly or nonsignificantly increased risk of outcome event in the postsurgery periods across the age (Supplemental Table S1) and sex. (Supplemental Table S2) strata. Similarly, in the subgroup analysis of patients who had any health care utilization during 25 to 36 months after bariatric surgery (n = 179), the temporal pattern was essentially unchanged (Supplemental Table 3).

To further delineate the changes in AF-related outcomes, particularly during the first 12-month postoperative period, we depicted the risk of ED visits or hospitalizations for AF by 3-month intervals (Figure 1). Despite the limited statistical power due to the lower number of outcome events within the narrower time intervals (i.e., 3-month intervals compared with 12-month intervals), this analysis demonstrated a transient, large increase in the risk of ED visits or hospitalizations for AF during the first 3-month period after bariatric surgery (aOR 2.90; 95% CI 1.77 to 4.76; p <0.0001; Supplemental Table S4). Additionally, the point estimates for the aOR remained elevated in most of 3-month intervals during the 2-year postsurgery period.

Discussion

In this self-controlled case series study using population-based data from 3 US states, we found that, among obese adult patients with AF, the risk of ED visits or hospitalizations for AF was elevated for at least 2 years after bariatric surgery. The observed increase in the risk was particularly large during the first 3-month postsurgery period.

There are plausible pathophysiologic mechanisms linking obesity to AF-related morbidity. Previous research has linked obesity to left atrial enlargement,[17,18] left ventricular hypertrophy and diastolic dysfunction,[17,18] sleep apnea,[19] activation of the renin-angiotensin-aldosterone axis and sympathetic nervous system, and systemic inflammation[20] in obese patients. Physiologic studies have also suggested that a substantial weight loss may reverse some of these obesity-AF links.[21-25] However, the clinical evidence on the effects of weight reduction on AF-related symptoms and health care utilization is scarce. The best evidence comes from a small randomized controlled trial (RCT) (n = 81) that examined the efficacy of weight management with diet and exercise modifications compared with general lifestyle advice with a median follow-up period of 15 months.[5] In this RCT, the weight management group had a greater reduction in body mass index (BMI) with a reduced AF symptom burden and AF events—measured by ambulatory rhythm recordings. In contrast, our observations suggest that bariatric surgery is associated with an increase in health care utilizations for AF, especially during the early postoperative period.

The reasons for the apparent discrepancies between the RCT and the present study are likely multifactorial. First, the study populations are different. The average BMI before weight reduction in the RCT population was 33, which was likely lower than that of our study population because our population consisted of morbidly obese patients who underwent bariatric surgery. Adverse remodeling and fibrotic changes of the left atrium in such morbidly obese patients may be advanced and irreversible even with significant weight reduction by bariatric surgery. Second, these 2 studies used different weight reduction methods with different physiologic consequences (e.g., metabolic and anatomical changes). Third, the outcome measures were different between the 2 studies. Lastly, patients enrolled in RCTs may be different from the general population and may behave differently in the strictly controlled settings.[26,27] In contrast, our population-based data with the sample size 6 to 7 times larger than that of the RCT reflect the effects of weight reduction through bariatric surgery in the real world and current clinical practice, and therefore enhance the generalizability of our inferences.

Our novel finding—the association between bariatric surgery and increased risk of AF-related morbidities—suggests potentially unfavorable effects unique to bariatric surgery that may counteract the benefits of weight reduction on AF-related morbidities. However, the mechanism underlying this association warrants clarification. Bariatric surgery is unique compared with other noninvasive weight interventions in that bariatric surgery leads to transient systemic inflammation, higher sympathetic tone, and increased catecholamine concentration in postoperative periods.[28] Additionally, the common complications of bariatric surgery include anemia due to intra- and postoperative blood loss as well as postsurgical infection.[29] Furthermore, bariatric surgery is also associated with chronically impaired absorption of nutrients and resultant anemia,[29] which may lead to increased frequency of AF episodes and more severe symptoms in the long term. Any combinations of these factors can explain, at least in part, the observed increase in the AF morbidity after bariatric surgery in obese populations. Notwithstanding the complexity, our observations indicate that obese patients with AF who undergo bariatric surgery may warrant more intensive AF management (e.g., increased dose of rate control agents, frequent Holter monitoring) during postsurgery periods.

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A matched cohort study of 4,021 obese individuals in Sweden reported that bariatric surgery was associated with a lower incidence of new-onset AF,[7] which may appear to contradict with the inferences derived from the present study. However, these studies examined different populations (patients without a history of AF vs patients who have AF as a chronic condition) and outcomes (incident AF vs health care utilization for AF) to test different hypotheses. Furthermore, traditional cohort studies are prone to confounding by indication. In contrast, the internal validity of our inferences is supported by the self-controlled case series design as it eliminates time-invariant confounders.[11]

Our study has several potential limitations. First, as the present study utilized administrative data, misclassification of the outcomes is possible. However, the HCUP database has been widely used and the quality has been extensively tested.[12-15,30] Moreover, it would be difficult to postulate that other conditions were more likely to be classified as AF preferentially after bariatric surgery (i.e., differential misclassification). Second, our study did not have the detailed information on longitudinal changes in patients' body weight or BMI. Finally, patients might have been lost to follow-up after bariatric surgery. However, this would have downwardly biased our estimates in the postsurgery period. Moreover, the sensitivity analysis limiting to patients who were confirmed to be alive and living within the study states for at least 2 years after surgery showed consistent findings.

The present study suggests that bariatric surgery is associated with an increased AF burden both in the short and long terms, underscoring the value of carefully discussing the risk and benefit when offering bariatric surgery for morbidly obese patients with AF. Our findings also stress the importance of optimizing the AF management at the time of bariatric surgery to decrease postsurgical AF morbidities.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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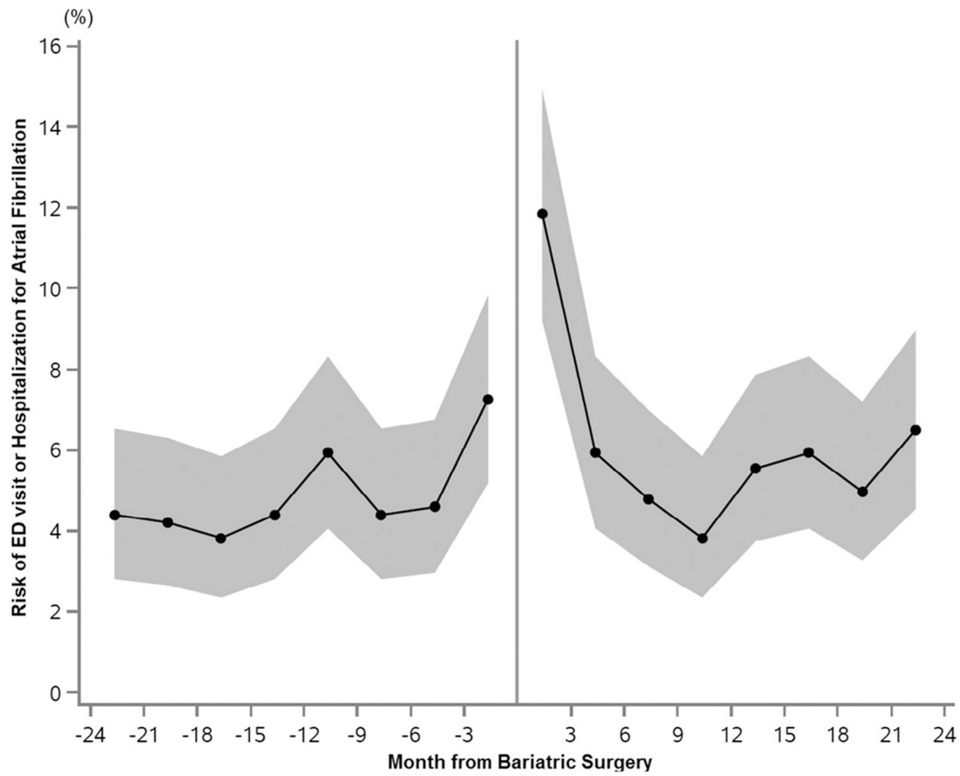

Figure 1.

Risk of emergency department visit or hospitalization for atrial fibrillation before and after bariatric surgery in a 3-month interval. Shown is the proportion of patients with a composite primary outcome of an ED visit or hospitalization for AF with the 95% CIs for the 2 years before and after surgery in 3-month intervals. The periods were centered on the date of bariatric surgery of each patient. Note the transient large increase in the risk at 3 months after surgery. AF = atrial fibrillation; CI = confidence interval; ED = emergency department.

Table 1

Baseline characteristics of obese patients with atrial fibrillation who underwent bariatric surgery

Characteristics	n = 523
Age (yr), median (IQR)	57 (48–64)
Female sex	306 (59.0%)
Race/ethnicity*	
Non-Hispanic white	409 (83.6%)
Non-Hispanic black	24 (4.9%)
Hispanic	42 (8.6%)
Other	14 (2.9%)
Primary insurance	
Medicare	163 (31.2%)
Medicaid	18 (3.4%)
Private	292 (55.8%)
Other	50 (9.6%)
Quartiles for median household income of patient’s ZIP code	
1 (lowest)	98 (19.1%)
2	153 (29.8%)
3	142 (27.7%)
4 (highest)	120 (23.4%)
Season of bariatric surgery	
January–March	118 (22.6%)
April–June	129 (24.7%)
July–September	148 (28.3%)
October–December	128 (24.5%)
State	
California	319 (61.0%)
Florida	191 (36.5%)
Nebraska	13 (2.5%)

Data were expressed as numbers (percentages), unless otherwise indicated. IQR = interquartile range.

*Analyzed for 489 (93.5%) patients with race/ethnicity data. Race/ethnicity data were not available in Nebraska.

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Table 2

Number and risk of patients with an emergency department visit and hospitalization for atrial fibrillation, according to 12-month periods

Time interval and outcome	Number of patients (n = 523)	Risk, % (95% CI)	aOR (95% CI)*	p Value
13–24 months before bariatric surgery				
ED visit or hospitalization†	83	15.9 (12.7–19.0)	reference	-
ED visit‡	29	5.5 (3.6–7.5)	reference	-
Hospitalization§	56	10.7 (8.0–13.4)	reference	-
1–12 months before bariatric surgery				
ED visit or hospitalization†	103	19.7 (16.3–23.1)	1.29 (0.94–1.76)	0.11
ED visit‡	33	6.3 (4.2–8.4)	1.16 (0.68–1.97)	0.59
Hospitalization§	78	14.9 (11.9–18.0)	1.44 (1.01–2.07)	0.05
0–12 months after bariatric surgery				
ED visit or hospitalization†	119	22.8 (19.1–26.4)	1.53 (1.13–2.07)	0.006
ED visit‡	41	7.8 (5.5–10.2)	1.48 (0.89–2.46)	0.13
Hospitalization§	90	17.2 (14.0–20.5)	1.70 (1.19–2.42)	0.003
13–24 months after bariatric surgery				
ED visit or hospitalization†	111	21.2 (17.7–24.7)	1.41 (1.03–1.91)	0.03
ED visit‡	32	6.1 (4.1–8.2)	1.12 (0.66–1.91)	0.68
Hospitalization§	86	16.4 (13.3–19.6)	1.61 (1.13–2.30)	0.008

aOR = adjusted odds ratio; CI = confidence interval; ED = emergency department.

* Adjusted odds ratios are for each 12-month period versus the reference period (i.e., 13–24 months before the index bariatric surgery), as calculated with conditional logistic regression.

† Composite of at least 1 ED visit or hospitalization for AF.

‡ At least 1 ED visit for AF, not resulting in hospitalization.

§ At least 1 hospitalization for AF.