

New Onset Cardiac Arrhythmias after Metabolic and Bariatric Surgery

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ABSTRACT

Background: Metabolic and bariatric surgery (MBS) has been shown to improve medical problems; however, there are known arrhythmias that can occur after MBS (i.e., sick sinus syndrome [SSS] and sinus bradyarrhythmias). While the literature in this area contains case reports, there is a lack of published data on a state or national level. We used a large state administrative database to evaluate the occurrence of cardiac arrhythmias after MBS.

Methods: We studied the years 2016 to 2018 using the Texas Inpatient Public Use Data File. Inclusion criteria were patients who had a pacemaker installed and were ≥ 18 years. Quantitative variables were described using mean and standard deviation. Categorical variables were described using frequency and proportion. The student's t-test and chi-squared test were used to assess the differences across pacemaker installation.

Results: There were a total of 79,807 (10.2%) who had a history of MBS and 31,072 (4%) patients who underwent pacemaker insertion, respectively. After excluding all patients < 18 years, the prevalence of pacemakers installed in patients with prior bariatric surgery was 0.8% ($n = 257/30,823$) or about 8 in every 1000 patients. Of note, bariatric patients who had a pacemaker placed were younger than non-bariatric patients ($P < 0.001$). The most common reason for pacemaker placement was SSS (51.5%), followed by atrioventricular block (13.1%),

and then bradycardia at 8.5%. The most common arrhythmia overall was bradycardia.

Conclusions: Eight out of every 1000 patients with a pacemaker installed in the study period had a history of MBS. The most common arrhythmia was bradycardia and the most common reason for pacemaker placement was sick sinus syndrome. These results do not indicate causality but may demonstrate an association between MBS and arrhythmias. Bariatric patients undergo pacemaker placement at a younger age. The relationship between bariatric surgery and cardiac arrhythmias warrants further study.

Key Words: Cardiac arrhythmias, Metabolic and bariatric surgery, Pacemakers, Sick sinus syndrome, Bariatric surgery.

INTRODUCTION

Metabolic and bariatric surgery (MBS) has been shown to improve medical problems, including cardiac dysfunction. Morbidly obese patients have a higher rate of arrhythmias secondary to obesity. After MBS there is an improvement in left heart function, congestive heart failure, and hypertension with the massive weight loss associated with MBS.¹ However, there are known arrhythmias that can occur after MBS. These are usually bradyarrhythmias and there is scant literature on the arrhythmogenic impacts of MBS, such as sick sinus syndrome (SSS) or sinus bradyarrhythmias. The short- and long-term heart rate variability that diminish with obesity tend to normalize after substantial weight loss, a representation of increased vagal and reduced sympathetic input.² Studies also show increased incidence of sinus bradycardia following bariatric surgery that can be seen in patients several months postoperatively.^{3,4} A compounding problem with these patients is often the presence of obstructive sleep apnea (OSA). OSA is associated with atrial tachyarrhythmias and sudden death syndrome.⁵

Most of the literature on new onset arrhythmias requiring pacemaker placement after MBS is in the form of case reports. There is otherwise a lack of published data and none that use data from a state or national level. We proposed using a large state administrative database to

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evaluate the incidence of cardiac arrhythmias requiring pacemaker placement after MBS.

METHODS

We used data from January 2016 to December 2018 from the Texas Inpatient Public Use Data File (PUDF).⁶ Inclusion criteria were patients ≥ 18 years who had a history of bariatric surgery or underwent pacemaker insertion. To select these patients, we initially identified all patients who had a pacemaker installed and assessed if they also had undergone a bariatric procedure identified by the International Classification of Disease Version 10 (ICD-10) of Z98.84. (Figure 1). For the inpatient PUDF, the ICD-10 procedure codes used were 0JH606Z (insertion of pacemaker, dual chamber into chest subcutaneous tissue and fascia, open approach), 0JH636Z (insertion of pacemaker, dual chamber into chest subcutaneous tissue and fascia, percutaneous approach), 02H63JZ (insertion of pacemaker lead into right atrium, percutaneous approach), 02HK3JZ (insertion of pacemaker lead into right ventricle, percutaneous approach), 02HK4JZ (insertion of pacemaker lead into right ventricle, percutaneous endoscopic approach), 0JH605Z (insertion of pacemaker, single chamber rate responsive into chest subcutaneous tissue and fascia, open approach), 0JH635Z (insertion of pacemaker, single chamber rate responsive into chest subcutaneous tissue and fascia, percutaneous approach), 0JH805Z (insertion of pacemaker, single chamber rate responsive into abdomen subcutaneous tissue and fascia, open approach), and 0JH835Z (insertion of pacemaker, single chamber rate responsive into abdomen subcutaneous tissue and fascia, percutaneous approach). The principal ICD-10 diagnosis codes were Z95.0 (presence of cardiac pacemaker), Z95.810 (presence of automatic

[implantable] cardiac defibrillator), and Z98.84 (previous bariatric surgery). The codes for the cardiac arrhythmias are included in Table 1. The Texas PUDF also uses Diagnosis-Related Groups (DRGs) which are a classification system relating categories of patients treated based on clinical features and diagnosis to the cost incurred by the hospital due to resources used by patients within these categories. DRGs are the “principal means of reimbursing hospitals for acute inpatient care”.⁷

Quantitative variables were described using mean and standard deviation (SD). For skewed data, the median and interquartile range (IQR) were reported. Categorical variables were also described using frequency and proportion. The student’s t – test and chi – squared test were used to assess the differences across bariatric surgery status. In the case of a violation of normality for quantitative variables, the Wilcoxon sum rank test was used. These skewed variables were log – transformed and used in the regression models.

To further assess the unadjusted and adjusted associations between our outcomes of interest (length of stay [LOS], total cost, and death) and selected cofactors, the linear regression models and logistic regression models, accounting for clustering of the hospitals were used. These model estimates were reported as regression coefficients (RC) and odds ratios (OR) together with their 95% confidence intervals. A sensitivity analysis on the effect of obstructive sleep apnea (OSA) was further conducted. *P* values less than 5% were considered statistically significant. All analyses were carried out using STATA V.15. Our institutional review board approved this study. We signed and complied with the Department of State Health Statistics Hospital Discharge Data Use Agreement prior to analyzing this data.

RESULTS

Our study focused on patients who had a pacemaker installed and had a history of MBS. There were a total of 79,807 (10.2%) who underwent bariatric surgery and 31,072 (4%) patients who underwent pacemaker insertion, respectively. After excluding patients < 18 years of age, there were a total of 30,823 patients in the data set. Of that, 257 (0.83%) patients had prior bariatric surgery; approximately 8 in every 1000 patients with a pacemaker in our study had undergone prior bariatric surgery. Table 2 shows the summary descriptive of the entire cohort of patients who received pacemakers only, and by bariatric surgery status. Of note, bariatric patients who had a pacemaker placed were younger than non-bariatric patients ($P < 0.001$). When compared to the very elderly non-

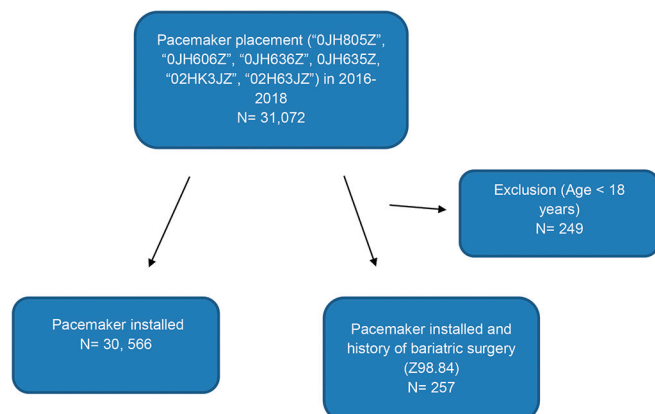


Figure 1. Flowchart of Patient Selection.

Table 1.
Diagnosis on Admission

History of Bariatric Surgery						
Yes			No			
CODES		n	%	CODES	n	%
Admitting diagnosis						
R001	Bradycardia, Unspecified	41	16.0	R001	3,884	13.0
R55	Syncope and Collapse	28	10.9	R55	3,377	11.0
I495	Sick Sinus Syndrome	21	8.17	I442	2,741	8.90
I442	Atrioventricular Block, Complete	12	4.67	I495	2,113	6.90
R0602	Shortness Of Breath	12	4.67	R0602	1,737	5.64
R079	Chest Pain, Unspecified	11	4.28	R079	1,582	5.13
I480	Paroxysmal Atrial Fibrillation	8	3.11	R42	1,000	3.30
I350	Nonrheumatic Aortic (Valve) Stenosis	7	2.72	I350	949	3.08
I441	Atrioventricular Block, Second Degree	7	2.72	I4891	902	2.93
R42	Dizziness and Giddiness	7	2.72	R531	878	2.90
Principal diagnosis						
I495	Sick Sinus Syndrome	81	31.3	I495	8,019	26.0
I442	Atrioventricular Block, Complete	34	13.1	I442	6,072	19.3
R001	Bradycardia, Unspecified	22	8.50	I441	2,011	6.40
I441	Atrioventricular Block, Second Degree	14	5.41	R001	1,411	4.50
I480	Paroxysmal Atrial Fibrillation	13	5.02	I480	993	3.20
A419	Sepsis	6	2.32	I350	964	3.10
I350	Nonrheumatic Aortic (Valve) Stenosis	6	2.32	I214	666	2.12
I481	Persistent Atrial Fibrillation	6	2.32	I130	489	1.60
I25110	Atherosclerotic Heart Disease of Native Coronary Artery with Unstable Angina Pectoris	4	1.54	A419	469	1.50
T82110A	Breakdown (Mechanical) of Cardiac Electrode, Initial Encounter	4	1.54	I4891	460	1.50

bariatric patients (≥ 75 years), bariatric patients in the 18 – 44 age group had an increased OR of 17.6 ($P < 0.001$) of having a pacemaker placed. In the 45 – 64 age group, the OR dropped to 11.8 ($P < 0.001$). Conversely, patients who were 65 – 74 years of age with a pacemaker had a lower risk (OR 6.4, $P < 0.001$) of being bariatric patients compared to older non-bariatric patients (≥ 75 years). There was a larger percentage of females in the bariatric pacemaker group at 70.4% of the total. There were no statistically significant differences by race, but non-Hispanics had increased odds of undergoing bariatric surgery and pacemaker placement (OR 1.34, $P = 0.048$). There were no statistical differences between the years 2016 to 2018 in pacemaker rates in patients with a history

of bariatric surgery. Most patients in both cohorts had emergency admissions to the hospital (59.5% bariatric vs 65.9% non-bariatric) with bariatric patients having urgent admission in 21.8% of cases vs 14.7% in non-bariatric patients.

The most common diagnosis for pacemaker placement was SSS in both groups followed by atrioventricular (AV) block. The third most common diagnosis for bariatric patients was bradycardia and second degree AV block for non-bariatric patients. **Table 1** lists the most common admitting diagnosis codes and the most common procedural diagnosis codes. **Table 3** shows unadjusted association of LOS, cost, and death. LOS was less for bariatric

Table 2.
Patient Characteristics by Cohort

Factor	Pacemaker Cohort	History of Bariatric Surgery Status		OR (95% CI)	P-Value
		No	Yes		
N	30,823	30,566	257		
Age (years)					
18 – 44	650 (2.1%)	628 (2.1%)	22 (8.6%)	17.6 (9.24, 33.5)	< 0.001
45 – 64	4,570 (14.8%)	4,470 (14.6%)	100 (38.9%)	11.2 (7.48, 16.9)	< 0.001
65 – 74	8,005 (26.0%)	7,905 (25.9%)	100 (38.9%)	6.35 (4.25, 9.47)	< 0.001
75+	17,598 (57.1%)	17,563 (57.5%)	35 (13.6%)		
Ethnicity					
Hispanic	7,671 (24.9%)	7,620 (24.9%)	51 (19.8%)		
Non-Hispanic	23,065 (74.8%)	22,860 (74.8%)	205 (79.8%)	1.34 (1, 1.79)	0.048
Unknown/missing	87 (0.3%)	86 (0.3%)	1 (0.4%)	1.74 (0.24, 12.82)	0.59
Race					
Black	2,441 (7.9%)	2,417 (7.9%)	24 (9.3%)		
White	23,802 (77.2%)	23,588 (77.2%)	214 (83.3%)	0.91 (0.62, 1.36)	0.65
Others (Other, Indian, Asian)	4,575 (14.8%)	4,556 (14.9%)	19 (7.4%)	0.42 (0.21, 0.83)	0.01
Invalid	5 (< 1%)	5 (< 1%)	0 (0.0%)		
Gender					
Female	15,075 (48.9%)	14,894 (48.7%)	181 (70.4%)		
Male	14,809 (48.0%)	14,738 (48.2%)	71 (27.6%)	0.4 (0.29, 0.54)	< 0.001
Unknown	939 (3.0%)	934 (3.1%)	5 (1.9%)	0.44 (0.18, 1.08)	0.07
Risk mortality*					
Minor	5,937 (19.3%)	5,864 (19.2%)	73 (28.4%)		
Moderate	9,655 (31.3%)	9,568 (31.3%)	87 (33.9%)	2.01 (1.31, 3.1)	0.001
Major	10,676 (34.6%)	10,607 (34.7%)	69 (26.8%)	1.47 (0.94, 2.3)	0.09
Extreme	4,555 (14.8%)	4,527 (14.8%)	28 (10.9%)	1.05 (0.69, 1.6)	0.82
Source of admission					
Clinic or physician's office	4,834 (15.7%)	4,787 (15.7%)	47 (18.3%)		
Non-healthcare facility	22,503 (73.0%)	22,325 (73.0%)	178 (69.3%)	0.81 (0.59, 1.11)	0.2
Others	101 (0.3%)	98 (0.3%)	3 (1.2%)	3.12 (1.06, 9.17)	0.04
Transfer from a hospital	2,684 (8.7%)	2,661 (8.7%)	23 (8.9%)	0.88 (0.56, 1.38)	0.58
Transfer from a skilled nursing facility	130 (0.4%)	130 (0.4%)	0 (0.0%)		
Transfer from another health care facility	518 (1.7%)	513 (1.7%)	5 (1.9%)	0.99 (0.49, 2.02)	0.98
Unknown	53 (0.2%)	52 (0.2%)	1 (0.4%)	1.96 (0.37, 10.4)	0.43
Type of admission					
Emergency	20,305 (65.9%)	20,152 (65.9%)	153 (59.5%)		
Urgent	4,536 (14.7%)	4,480 (14.7%)	56 (21.8%)	1.65 (1.23, 2.21)	0.001
Elective	5,606 (18.2%)	5,559 (18.2%)	47 (18.3%)	1.11 (0.82, 1.51)	0.49
Trauma	237 (0.8%)	236 (0.8%)	1 (0.4%)	0.56 (0.09, 3.66)	0.54
Information not available	139 (0.5%)	139 (0.5%)	0 (0.0%)		

Table 2.
Continued

Factor	Pacemaker Cohort	History of Bariatric Surgery Status		OR (95% CI)	P-Value
		No	Yes		
Sleep apnea					
No	27,381 (88.8%)	30,039 (98.3%)	237 (92.2%)		
Yes	3,442 (11.2%)	527 (1.7%)	20 (7.8%)	4.08 (3.16, 5.26)	< 0.001
Year PUDF					
2016	10,161 (33.0%)	10,087 (33.0%)	74 (28.8%)		
2017	10,370 (33.6%)	10,277 (33.6%)	93 (36.2%)	1.23 (0.88, 1.72)	0.22
2018	10,292 (33.4%)	10,202 (33.4%)	90 (35.0%)	1.2 (0.9, 1.61)	0.22

P-value from log transformed value

OR, odds ratio; CI, confidence interval; PUDF, Texas Inpatient Public Use Data File.

*Risk Mortality: Likelihood of dying based on 3M™ APR DRG Classification.

patients at 5.3 vs. 6.2 days, $P = 0.014$. Cost was also less for bariatric patients. There was no difference in mortality rates with 0.8% for bariatric patients and 1.3% for non-bariatric patients ($P = 0.43$). **Table 4** shows the outcomes of patients adjusted for OSA. Patients with a pacemaker placed with OSA had a higher risk of death (RC 1.87), but this was not statistically significant.

We performed an additional analysis for patients who had a pacemaker placed and who also had a diagnosis of OSA. **Table 5** also shows the adjusted association of pacemaker placement and bariatric surgery by stratifying patients into OSA and no OSA. Of the 257 MBS patients who had a pacemaker placed, 20 (7.8%) also had a diagnosis of OSA. Patients with prior bariatric surgery and OSA were more likely to die (adjusted OR 1.87, $P = 0.51$) and had a shorter LOS (RC -1.08, $P = 0.013$). On the other hand, patients with prior bariatric surgery and no OSA were less likely to die (OR 0.56, $P = 0.58$) and also had shorter LOS (RC -1.12, $P = 0.12$). Patients with a history of bariatric surgery also had significantly lower hospital charges.

DISCUSSION

Our findings indicate that there may be an association between rapid weight loss induced by bariatric surgery and arrhythmias. We have previously evaluated the numbers of MBS performed in Texas for the years 2013 to 2017.⁸ When we consider that there was an average of about 20,000 bariatric surgeries a year, and for the years of 2016 to 2018 found that 257 bariatric patients had a pacemaker placed, this gives us a yearly incidence rate of

0.8%. We are not able to use the PUDF to track patients over time, but we can estimate the rate of pacemaker placement in the overall population of bariatric patients. Nationwide, in 2016, there were 200,000 pacemakers placed. Given the population of the United States at that time, that is an unadjusted rate of 0.06%, substantially less than our control group.⁹ The nationwide data includes all patients, not just MBS or obese patients, but gives a frame of reference of baseline pacemaker placement in the general population.

One other important finding of our paper was the age at which bariatric patients had pacemakers placed. In the bariatric group, 78% of patients with pacemakers had them placed between the ages of 45 – 74, whereas in the non-bariatric group, the majority of patients (58%) who had a pacemaker placed were ≥ 75 . We cannot draw a causative association from this, but this was a statistically significant finding and may indicate that bariatric patients develop a condition requiring a pacemaker at an earlier age because of their bariatric surgery status. Conversely, the pathologic changes incurred by their prior obesity may have predisposed these patients to arrhythmias and they may have developed the same arrhythmia without MBS. This is certainly an area for future investigation as this question is not answered by the current study.

The most common arrhythmia in our study group was SSS, which is characterized by abnormalities of the sinus node leading to bradycardia. Beyond the obesity-associated electro-structural changes that are noted at the level

Table 3.
Unadjusted Association of Selected Outcomes and History of Bariatric Surgery

Factor	Pacemaker Cohort	History of Bariatric Surgery		RC (95% CI)	P-Value
		No	Yes		
N	30,823	30,566	257		
LOS (in days), mean (SD)	6.2 (7.3)	6.2 (7.3)	5.3 (5.3)	-0.94 (-1.55, -0.32)	0.014*
LOS (in days), median (IQR)	4.0 (2.0, 7.0)	4.0 (2.0, 7.0)	4.0 (2.0, 7.0)		
Charges (\$), mean (SD)	145,803.4 (150,128.7)	145,943.4 (150,232.8)	129,151.9 (136,429.7)	-16,791.55 (-33,073.97, -509.14)	0.009*
Charges (\$), median (IQR)	105,772.8 (68,881.7, 167,778.2)	105,878.0 (68,909.7, 167,962.0)	99,159.4 (67,535.1, 142,737.1)		
Death, OR (95% CI)	409 (1.3%)	407 (1.3%)	2 (0.8%)	0.58 (0.15, 2.25)	0.432

*P-value from log transformed value

SD, standard deviation; IQ, inter-quartile range; RC, regression coefficient; OR, odds ratio; CI, confidence interval; LOS, length of stay.

of cardiac tissue, obesity has also been associated with dysfunction of the autonomic nervous system that manifests with increased sympathetic activity and reduced vagal tone.² This may be why SSS was the most common arrhythmia found in the Texas PUDF. The causes of arrhythmias are multifactorial given the high incidence of comorbid conditions that are independent risk factors for cardiac disease, but obesity alone is thought to lead to functional, anatomical, and electrical remodeling of the atria.¹⁰⁻¹² SSS is accountable for 30 – 50% of pacemakers placed nationwide. One large study (the Cardiac Health Study) found an incidence of SSS of 0.8 per 1000 person years. One of the major risk factors was obesity, along with diabetes.¹³ There is an association of obesity with atrial fibrillation, which was also seen in our population.¹⁴

The elevated incidence of pacemaker placement in post-MBS patients is curious since multiple studies over the past 20 years have shown that weight loss, and specifically weight loss after MBS, is associated with increase in heart rate variability and improved autonomic nervous system control, which are both positive markers of improved neuro-cardiac health. It is unclear from the present study if the autonomic and cardiac dysfunction leading to pacemaker placement in the post-MBS group is actually due to the long-term consequences of obesity, rather than due to the bariatric surgical procedure and subsequent weight loss. Obesity is associated with increased sympathetic and suppressed parasympathetic tone. Weight loss, including that from bariatric surgery, is associated with increased vagal control of the sinus node and improved

Table 4.
Adjusted* Association and Stratified Analysis of Selected Outcomes and History of Bariatric Surgery

	Overall		Sleep Apnea		No Sleep Apnea	
	RC (95% CI)	P-Value	RC (95% CI)	P-Value	RC (95% CI)	P-Value
LOS (in days)	-1.15 (-1.68, -0.62)	0.015	-1.08 (-2.2, 0.05)	0.013	-1.12 (-1.72, -0.53)	0.12
Charges (\$)	-24,321.35 (-38,875.43, -9,767.27)	0.002	-5,998.26 (-40,426.31, 28,429.79)	0.056	-32,009.84 (-45,455.72, -18,563.95)	0.005
Death, OR (95% CI)	0.78 (0.2, 2.99)	0.72	1.87 (0.29, 12.12)	0.51	0.56 (0.07, 4.47)	0.58

*Adjusted for: age, ethnicity, race, gender, insurance status, risk mortality, and type of admission.

RC, regression coefficient; OR, odds ratio; CI, confidence interval; LOS, length of stay.

Table 5.
Association of Selected Covariates and History of Bariatric Surgery, Stratified by Obstructive Sleep Apnea

Factor	Obstructive Sleep Apnea			No Obstructive sleep Apnea		
	History of Bariatric Surgery		P-Value	History of Bariatric Surgery		P-Value
	No	Yes		No	Yes	
N	3,356	86		27,210	171	
LOS, mean (SD)	6.4 (6.2)	5.4 (6.7)	0.026*	6.2 (7.5)	5.2 (4.5)	0.076*
Charges, mean (SD)	156,146.1 (133,737.8)	152,088.8 (206,075.7)	0.099*	144,685.1 (152,098.2)	117,616.4 (79,971.7)	0.008*
Age (years)			< 0.001			< 0.001
18 - 44	52 (1.5%)	3 (3.5%)		576 (2.1%)	19 (11.1%)	
45 - 64	698 (20.8%)	32 (37.2%)		3,772 (13.9%)	68 (39.8%)	
65 - 74	1,233 (36.7%)	41 (47.7%)		6,672 (24.5%)	59 (34.5%)	
75+	1,373 (40.9%)	10 (11.6%)		16,190 (59.5%)	25 (14.6%)	
Ethnicity			0.34			0.37
Hispanic	677 (20.2%)	14 (16.3%)		6,943 (25.5%)	37 (21.6%)	
Non-Hispanic	2,669 (79.5%)	72 (83.7%)		20,191 (74.2%)	133 (77.8%)	
Unknown/missing	10 (0.3%)	0 (0.0%)		76 (0.3%)	1 (0.6%)	
Race			0.30			0.094
Black	266 (7.9%)	7 (8.1%)		2,151 (7.9%)	17 (9.9%)	
White	2,729 (81.3%)	74 (86.0%)		2,0859 (76.7%)	140 (81.9%)	
Others (other, Indian, Asian)	360 (10.7%)	5 (5.8%)		4,196 (15.4%)	14 (8.2%)	
Invalid	1 (< 1%)	0 (0.0%)		4 (< 1%)	0 (0.0%)	
Gender			< 0.001			<0.001
Female	1,218 (36.3%)	49 (57.0%)		13,676 (50.3%)	132 (77.2%)	
Male	2,030 (60.5%)	36 (41.9%)		12,708 (46.7%)	35 (20.5%)	
Unknown	108 (3.2%)	1 (1.2%)		826 (3.0%)	4 (2.3%)	
Risk mortality**			0.46			<0.001
Minor	519 (15.5%)	17 (19.8%)		5,345 (19.6%)	56 (32.7%)	
Moderate	1,005 (29.9%)	28 (32.6%)		8,563 (31.5%)	59 (34.5%)	
Major	1,252 (37.3%)	30 (34.9%)		9,355 (34.4%)	39 (22.8%)	
Extreme	580 (17.3%)	11 (12.8%)		3,947 (14.5%)	17 (9.9%)	
Source of admission			0.23			0.20
Clinic or Physician's Office	617 (18.4%)	19 (22.1%)		4,170 (15.3%)	28 (16.4%)	
Non-Healthcare Facility	2,402 (71.6%)	55 (64.0%)		19,923 (73.2%)	123 (71.9%)	
Others	8 (0.2%)	1 (1.2%)		90 (0.3%)	2 (1.2%)	
Transfer from a hospital	274 (8.2%)	10 (11.6%)		2,387 (8.8%)	13 (7.6%)	
Transfer from a skilled nursing facility	7 (0.2%)	0 (0.0%)		123 (0.5%)	0 (0.0%)	

Table 5.
Continued

Factor	Obstructive Sleep Apnea			No Obstructive sleep Apnea		
	History of Bariatric Surgery			History of Bariatric Surgery		
	No	Yes	<i>P</i> -Value	No	Yes	<i>P</i> -Value
Transfer from another health care facility	44 (1.3%)	1 (1.2%)		469 (1.7%)	4 (2.3%)	
Unknown	4 (0.1%)	0 (0.0%)		48 (0.2%)	1 (0.6%)	
Type of Admission			0.03			0.22
Emergency	2,104 (62.7%)	45 (52.3%)		18,048 (66.3%)	108 (63.2%)	
Urgent	485 (14.5%)	21 (24.4%)		3,995 (14.7%)	35 (20.5%)	
Elective	733 (21.8%)	20 (23.3%)		4,826 (17.7%)	27 (15.8%)	
Trauma	14 (0.4%)	0 (0.0%)		222 (0.8%)	1 (0.6%)	
Information unavailable	20 (0.6%)	0 (0.0%)		119 (0.4%)	0 (0.0%)	
Year PUDF			0.66			0.36
2016	1,023 (30.5%)	26 (30.2%)		9,064 (33.3%)	48 (28.1%)	
2017	1,115 (33.2%)	32 (37.2%)		9,162 (33.7%)	61 (35.7%)	
2018	1,218 (36.3%)	28 (32.6%)		8,984 (33.0%)	62 (36.3%)	

P*-value from log transformed valueMortality risk: likelihood of dying based on 3M™ APR DRG Classification
LOS, length of Stay; PUDF, Texas Inpatient Public Use Data File.

sympathetic-parasympathetic balance.² However, the increased incidence of pacemaker placement in post-MBS patients seems to indicate that the neuro-cardiac changes associated with MBS may not always be positive. It may be possible that the increased vagal tone seen in patients with significant weight loss may be too extreme leading to bradyarrhythmias and pacemaker placement. Increased vagal tone is also more significant in younger patients which may help to explain the lower average age for pacemaker placement seen in the post-MBS cohort.¹⁵

Although OSA was not listed as one of the top 10 diagnoses in either group, there is a well-known association, as half of patients undergoing MBS have OSA.¹⁶ Similar to obesity-driven cardiac changes, OSA-related arrhythmogenesis is also thought to be a consequence of both autonomic imbalance in favor of chronic excessive sympathetic stimulation and cardiac remodeling in the setting of oxidative stressors and comorbid conditions.^{17,18} There is a growing body of literature that also suggests an association with sleep-associated bradyarrhythmias and alternating tachy- and brady-arrhythmias (e.g., SSS), aberrations not seen with obesity alone.¹⁹

Unnecessary pacemaker placement may occur if OSA is left untreated. As early as 2001, a case report was published describing 3 patients ages 38 – 59 with body mass indices (BMI) over 40 mg/kg² who had undergone duodenal switch and had episodes of bradyarrhythmias (prolonged arrests and 2nd degree block) caught on telemetry during original admission.²⁰ The arrhythmias and OSA resolved and improved as the patients underwent significant weight loss within the first year after surgery. The author noted that without adequate investigation into and treatment of OSA these patients could have had pacemakers unnecessarily placed. There have been other reports in the literature that have demonstrated unnecessary pacemaker placement in patients with undiagnosed or untreated OSA.^{21,22}

It is also noteworthy that heart block, one of the arrhythmias associated with OSA and discussed by Block and others, represents two of the three most common diagnoses for pacemaker placement in the post-MBA cohort. Multiple studies have shown evidence of impaired autonomic functioning and increased rates of arrhythmias to

be associated with OSA.^{5,23} Is the significantly increased rate of pacemaker placement in the post-MBS cohort, particularly in the younger patients, partially explained by this phenomenon? There may be a subset of the population in which cardiac conduction changes from long-standing obesity, in the context of increased vagal tone, with recent weight loss leads to the emergence of tachy-/brady-arrhythmias, similar to the patterns we see in OSA.

The catchall term of obesity cardiomyopathy defines the cardiac dysfunction and electro-structural abnormalities that occur secondary to the metabolic effects on cardiac hemodynamics, structure, and function, which include left ventricular hypertrophy, left atrial enlargement and ultimately, diastolic and systolic dysfunction. Progression and severity of obesity cardiomyopathy is time-dependent with a complex pathogenesis.¹¹ While the clearly positive cardiac implications of bariatric surgery and its propensity to provide sustained weight reduction are well documented, we know less about the emergence of new cardiac conditions following bariatric surgery. Our data on the occurrence of cardiac arrhythmias following bariatric surgery serves to expand on this lesser known cardiac phenomenon. More studies are needed to elucidate the relationship between MBS and arrhythmias.

In summary, the findings reported in this paper cannot be construed to show causation, but there seems to be an association of bariatric surgery with cardiac arrhythmias. The database does not account for any underlying pre-existing cardiac pathology secondary to the effects of obesity in this population. The patients undergoing pacemaker placement may have already had cardiac dysfunction secondary to obesity that was not apparent pre-operatively. This large administrative database study demonstrates a high rate of pacemaker placement in a post-bariatric surgery population when compared to the rate in the general population. These findings will hopefully result in well controlled studies in the future that will further explore the relationship, if any, between cardiac arrhythmias and a history of bariatric surgery status.

LIMITATIONS

Our analysis of this large administrative database has severe limitations, foremost being that we do not have the ability in this database to follow these patients over time. We can only observe that a defined number of patients with the ICD-10 code for 'bariatric surgery status' had a

pacemaker placed. Thus, we can only give the prevalence of disease for a given time period, but these patients could have had surgery within the study period or even many years before. The development of these arrhythmias may be completely unrelated to obesity or bariatric surgery and we cannot show causality. They may also be BMI dependent, and we were unable to parse patients by BMI in this study. A comparison of the percentage of subjects receiving cardiac pacemakers based on BMI may reveal that increasing BMI is a greater risk factor for pacemaker placement, or vice versa.

We also have to be careful drawing an associative relationship of bariatric surgery with arrhythmias. But there is a growing number of reported cases of patients developing arrhythmias after MBS and there may prove to be an association in a subset of MBS patients. Therefore, we feel that these findings should be reported and hopefully will prompt surgeon researchers to start prospective studies to evaluate the relationship between MBS and arrhythmias.

CONCLUSIONS

Eight out of every 1000 patients with a pacemaker installed in the study period had a history of bariatric surgery. The most common arrhythmia was atrial fibrillation and the most common reason for pacemaker placement was SSS. These results do not indicate causality, but may demonstrate an association between MBS and arrhythmias. The relationship between bariatric surgery and cardiac arrhythmias warrants further study.

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