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Authors
Hu, Qingwei
Shi, Lu
Chen, Liwei
et al.

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Original article

Seasonality in the adverse outcomes in weight loss surgeries

Qingwei Hu, M.D., Ph.D.[a], Lu Shi, Ph.D.[a,*], Liwei Chen, M.D., Ph.D.[a], Lu Zhang, M.P.H., Ph.D.[a], Khoa Truong, Ph.D.[a], Alex Ewing, M.S.[b], Jiande Wu, Ph.D.[a], John Scott, M.D.[b]

[a]*Department of Public Health Sciences, 525 Edwards Hall, Clemson University, Clemson, South Carolina*

[b]*Greenville Health System, Greenville, South Carolina*

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Abstract

Background: Weight loss surgery is a common procedure in the United States.

Objective: As weight loss surgery is largely an elective procedure for which patients and physicians can choose the timing, it could be helpful to explore the seasonality pattern of its perioperative adverse outcomes to help decide the timing of this surgery.

Setting: United States.

Methods: We used an obese adult sample (age ≥20 yr) of patients who underwent weight loss surgeries from the Premier Healthcare Database from 2011 to 2014. The International Classification of Diseases, Ninth Revision Clinical Modification procedure codes were used to identify weight loss surgery cases. Binary variables are used for 4 adverse outcomes, including hospital mortality, sepsis, deep vein thrombosis (DVT), and pulmonary embolism. The associations between the adverse outcomes and season of surgery were examined using logistic regressions, adjusting for age, sex, race, marital status, surgery types, body mass index, the Charlson co-morbidity index, and region.

Results: A total of 69,365 weight loss surgeries were identified for the analytic sample. The overall rate was .27% for hospital mortality, .16% for DVT, .10% for pulmonary embolism, and .20% for sepsis. For DVT, adjusted odds ratio for the fall was 2.68 (95% confidence interval: 1.39–5.19) and the odds ratio for the winter was 2.26 (95% confidence interval: 1.09–4.27) compared with the summer. For sepsis, adjusted odds ratio for the spring was 1.83 (95% confidence interval: 1.07–3.12) compared with that of the summer. The seasonality pattern was not statistically significant for hospital mortality and pulmonary embolism.

Conclusion: DVT and sepsis are more likely to occur in colder seasons compared with the summer season, although the crude rates of these adverse events were low. (Surg Obes Relat Dis 2018;14:291–296.) © 2018 Published by Elsevier Inc. on behalf of American Society for Metabolic and Bariatric Surgery.

One third of the U.S. adult population was obese in 2010, and 6.6% of Americans are estimated to be morbidly obese [1]. Many approaches are suggested to control or reduce excess weight, such as lifestyle changes, including education, dietary modification, regular physical activity, and regular staff contacts with participants. However, these approaches can produce modest long-term weight loss of approximately 5% to 10% of starting weight [2]. Many patients select bariatric surgery as an effective option for treatment of substantial weight loss and improvement of obesity-related complications [3]. In 2013, an estimated 179,000 bariatric surgeries were performed in the United States, and the potential benefits of bariatric surgery are

*Correspondence: Lu Shi, Ph.D., 525 Edwards Hall, Clemson University, College of Behavioral, Social and Health Sciences, Department of Public Health Sciences, Clemson, SC 29634-0745.

E-mail: lus@clemson.edu

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substantial [4]. Bariatric surgeries have been shown to be safe, with a low possibility of perioperational adverse outcomes [5]. For example, the 30-day postoperative mortality rate of bariatric surgery was .8 per 1000 based on a meta-analysis of randomized clinical trials published in 2014 [5]. Deep vein thrombosis (DVT) and pulmonary embolism (PE) are 2 common causes of morbidity and mortality during and after bariatric surgery [6,7]. The reported postoperative rate of DVT varies widely from 2 to 13 per 1000 at 30 days among different subtypes of bariatric surgeries [6,8]. Factors that have been identified as increasing these adverse outcomes include certain surgery types, older age, and postoperative anastomotic leak [8].

As bariatric surgeries for weight loss are largely an elective procedure in which patients and physicians choose the time for surgery, it could be helpful to explore whether there is a temporal pattern of these perioperative adverse outcomes. Such a pattern, if found, could reduce the risk of complications, especially for those patients with existing conditions for adverse outcomes. Previous studies have shown seasonal pattern for the occurrence of PE and DVT among the general population [9,10]. In this study, we aimed to examine the seasonality pattern of the incidence of adverse outcomes among primary bariatric surgeries within the initial hospitalization, including hospital mortality, sepsis, DVT, and PE.

Methods

The Premier Database prospectively collected standard hospital discharge data (both outpatient and inpatient hospital visits) from more than 600 hospitals in the United States [11]. The Premier database included detailed information about procedures and medicine usage [11]. Using a subset of this database containing adult obese patients aged ≥20 years, we performed a retrospective study for those who underwent bariatric surgery from July 1, 2011 through June 3, 2014.

For our analysis, we included patients with body mass index (BMI) ≥30 kg/m^2 [12]. Participants were divided into 3 groups based on BMI categories: 30 to 34.9, 35 to 39.9, and ≥40 kg/m^2. Dependent variables were binary outcomes for each of the 4 adverse outcomes, and independent variables included age, race/ethnicity, sex, BMI categories, bariatric surgery subtypes, marital status, region, and seasons. Race/ethnicity was defined according to medical-record reporting; for simplicity, this variable was categorized as non-Hispanic white, non-Hispanic black, and others. Four seasons in a year were defined as spring (March–May), summer (June–August), fall (September–November), and winter (December–February), and summer was used as the reference level.

We used the International Classification of Diseases, Ninth Revision Clinical Modification procedure codes to identify bariatric surgery cases: 44.31 (high gastric bypass), 44.38 (laparoscopic gastroenterostomy), 44.39 (other gastroenterostomy), 44.68 (laparoscopic gastroplasty), 44.69 (other repair of stomach), 43.89 (open and other partial gastrectomy), 45.51 (isolation of segment of small intestine), 45.91 (small-to-small intestinal anastomosis), 43.7 (partial gastrectomy with anastomosis to jejunum), 44.38 (laparoscopic gastric bypass), 44.95 (laparoscopic gastric banding), and 43.82 (laparoscopic sleeve gastrectomy) to identify bariatric surgery patients [13–15]. Hospital death was identified by discharge status labeled as “expired” for the index surgery. Sepsis (995.91) [16], PE (415.1, 415.11, 415.12, 415.13, and 415.19) [17,18], and DVT (451.11, 451.19, 451.2, 451.81, 451.9, 453.40, 453.41, 453.42, 453.8, and 453.9) [19,20] were identified by the International Classification of Diseases, Ninth Revision diagnosis codes, respectively.

Four multivariate logistic regressions were used to examine the association between the seasons and the occurrence of hospital mortality, DVT, PE, and sepsis during the inpatient visits for bariatric surgery. We used Firth’s penalized likelihood method [21] for estimation given the sparse nature of these adverse events. We adjusted for patient age, sex, marital status, race/ethnicity, BMI categories before surgery (30–34.9, 35–39.9, and ≥40 kg/m^2), type of bariatric surgery (open versus laparoscopic bariatric surgeries), and the Charlson co-morbidity index [22]. We used the 4 regions of the United States as the geographic covariates (northeast, midwest, south, and west). Statistical analyses were performed with SAS software (version 9.4; SAS Institute, Cary, NC, USA). To address the possible issue of multiple inferences, we use the Dunnett’s multiplicity-adjusted confidence interval to determine the statistical significance in logistic regressions [23].

Results

We identified 69,365 bariatric operations in the Premier data set from 2011 to 2014. The median age of bariatric surgery recipients was 45 years (range, 20–89 yr), and approximately 95.00% aged from 20 to 65 years. Among them, 78.38% were female, 65.59% were non-Hispanic whites, 48.30% were married, and 79.32% had BMI ≥40 before the surgery (Table 1). In bariatric surgery patients, 90.04% surgeries were conducted under the assistance of laparoscope, and the most common bariatric surgery subtype was laparoscopic sleeve gastrectomy (41.56%), followed by laparoscopic gastric bypass (37.48%), and laparoscopic gastric banding (10.22%). Among the bariatric procedures, 27.85% were in spring, 27.30% were in summer, 21.50% were in fall, and 23.09% were in winter. There were statistically significant differences between the 4 seasons for the following variables: DVT, number of bariatric surgery patient, types of surgery, median age, marital status, and BMI. In particular, open surgery accounted for 13.34% in summer (the highest), while only

Table 1
Characteristics of bariatric surgery in PREMIER data from 2011–2014

	Total	Spring	Summer	Fall	Winter	*P* value
Total # of procedures	69,365	19,369	18,988	14,951	16,057	
% of procedures	100.00	27.85	27.30	21.50	23.09	<.0001
Adverse outcomes, %						
Hospital mortality	.27	.29	.30	.25	.22	.4219
Deep vein thrombosis	.16	.15	.09	.25	.19	.0034
Pulmonary embolism	.10	.11	.09	.09	.09	.9308
Sepsis	.20	.26	.16	.21	.18	.1881
Type of surgery, %						<.0001
Laparoscopic surgery	90.04	92.32	86.66	89.12	92.16	
Open surgery	9.96	7.68	13.34	10.88	7.84	
Characteristics						
Age, yr, median (range)	45 (20–89)	44 (20–89)	44 (20–89)	45 (20–89)	45 (20–89)	<.0001
20–65 yr	95.00	95.44	94.71	94.97	95.00	.09
>65 yr	5.00	4.56	5.29	5.03	5.00	
Female, %	78.38	78.26	78.92	78.40	77.86	.11
Race/ethnicity, %						.09
Non-Hispanic White	65.59	65.54	66.13	65.25	65.51	
Non-Hispanic Black	14.49	14.78	13.92	14.28	14.82	
Other	19.92	19.68	19.94	20.47	19.68	
Marital status, %						.0007
Married	48.30	48.65	47.83	48.03	48.69	
Unmarried	35.92	36.36	35.87	35.41	35.94	
Others	15.78	14.99	16.30	16.57	15.37	
BMI, kg/m^2 , %						.0023
30–34.9	2.76	2.85	2.43	2.74	3.06	
35–39.9	17.92	18.05	18.09	18.14	17.35	
≥40	79.32	79.10	79.49	79.11	79.59	
CCI mean ± SD	.42 ± .87	.43 ± .90	.41 ± .83	.42 ± .86	.43 ± .89	.07

BMI = body mass index; CCI = Charlson co-morbidity index; SD = standard deviation.

covering approximately 7.68% in spring (the lowest). The differences for hospital mortality, PE, sepsis, sex, race, co-morbidities (indexed by the Charlson co-morbidity index), and age group (20–65 years versus >65 years) between the 4 seasons were not statistically significant.

The overall rate was .27% for hospital mortality, .16% for DVT, .10% for PE, and .20% for sepsis (Table 1). For DVT, the highest rate was found in the fall (.25%), followed by winter (.19%), spring (.15%), and summer (.09%). Compared with surgeries performed during the summer, surgeries performed during the other 3 seasons are all positively associated with having DVT (fall, odds ratio [OR] = 2.68 with Dunnett-adjusted 95% confidence interval [CI] 1.39–5.19, $P = .0015$; spring, OR = 1.80 with Dunnett-adjusted 95% CI .88–3.49, $P = .13$; winter, OR = 2.26, with Dunnett-adjusted 95% CI 1.09–4.27, $P = .024$) although the adjusted difference between spring and summer was not statistically significant (Table 2). For sepsis, the highest rate was observed in spring (.26%), followed by fall (.21%), winter (.18%), and summer (.16%). After adjusting for other factors, the OR of sepsis was 1.83 (Dunnett-adjusted 95% CI: 1.07–3.12, $P = .02$) for spring compared with that of summer. For sepsis, the OR was 1.31 (Dunnett-adjusted 95% CI .73–2.35, $P = .055$) for fall; the OR was 1.27 (Dunnett-adjusted 95% CI .70–2.31, $P = .67$) for winter compared with summer. The seasonal difference was not statistically significant for hospital mortality or PE in both crude rate and adjusted ORs.

Discussion

In this study of large sample size, we found that DVT and sepsis are more likely to occur in colder seasons compared with the warmer seasons among the 4 adverse outcomes, while the seasonal pattern was not significant for hospital mortality and PE. The seasonality pattern has been consistently identified in many health outcomes (especially cardiovascular outcomes), with the higher rates of adverse events occurring in colder months of the year [24,25]. Although the mechanism for these differences needs further investigation, our study is among the first to find the significant seasonal differences in certain perioperational adverse outcomes after bariatric surgery, independent of individual's demographic characteristics, surgery type, and co-morbidity before surgery.

DVT is a severe condition in which a blood clot forms in one or more of the deep veins and is closely associated with increased morbidity and mortality [26,27]. Among previous studies investigating the association between seasons and the occurrence of DVT, the majority found a higher

Table 2
Adjusted odds ratios (OR) of hospital mortality, deep vein thrombosis, pulmonary embolism, and sepsis by seasons (N = 69,365)

	Hospital mortality		Deep venous thrombosis		Pulmonary embolism		Sepsis	
	Adjusted rate (per 1000)	Adjusted OR (95% CI)	Adjusted rate (per 1000)	Adjusted OR (95% CI)	Adjusted rate (per 1000)	Adjusted OR (95% CI)	Adjusted rate (per 1000)	Adjusted OR (95% CI)
Four seasons								
Fall	1.48 (.95–2.33)	0.82 (.54–1.25)	2.64 (1.66–4.19)	2.68* (1.39–5.19)	1.60 (.86–2.95)	0.99 (.51–1.93)	3.46 (2.25–5.30)	1.31 (.80–2.14)
Summer	1.81 (1.20–2.73)	1.00 (reference)	.98 (.56–1.74)	1.00 (reference)	1.61 (0.91–2.84)	1.00 (reference)	2.63 (1.71–4.06)	1.00 (reference)
Spring	1.96 (1.30–2.96)	1.09 (.74–1.59)	2.12 (1.29–3.47)	1.80 (.88–3.49)	2.06 (1.19–3.58)	1.29 (.70–2.36)	4.82 (3.31–7.02)	1.83† (1.17–2.86)
Winter	1.40 (.88–2.23)	0.77 (.50–1.19)	1.73 (1.06–2.82)	2.26† (1.09–4.27)	1.67 (.90–3.10)	1.04 (0.54–2.03)	3.33 (2.14–5.20)	1.27 (.77–2.09)

CI = confidence interval.
ORs are adjusted by age, sex, race, marital status, bariatric surgery types, BMI, geographic regions, and Charlson Co-morbidity Index.
*Adjusted $P < 0.01$ (the P values were adjusted with Dunnett-Hsu correction for multiple comparisons).
†Adjusted $P < 0.05$ (the P values were adjusted with Dunnett-Hsu correction for multiple comparisons).

occurrence of DVT in the colder seasons [28]. For example, a retrospective study conducted by Boulay et al. [29] in France that included 65,081 patients with a diagnosed DVT between 1995 and 1998 showed that the number of patients is far larger in the winter than in the summer. The possible explanations for this observation include atmospheric temperature, air pressure, and air pollution [28].

The seasonality pattern of sepsis in our study was consistent with a retrospective cohort study in the United States conducted by Danai et al. [30] that investigated seasonal variation in sepsis using patients hospitalized between 1979 and 2003, using data from the National Hospital Discharge Survey. The higher occurrence rate in colder seasons may come from higher risk of infectious disease outbreaks in those seasons, as the influenza season and respiratory syncytial virus outbreak often overlap [31,32]. The lower level of vitamin D in patients during colder months [33–35] may also result in a higher risk of infection [36–38], including sepsis, as sepsis severity has been found to be positively associated with vitamin D deficiency among emergency department patients [39].

Conclusions

Our study reveals the significance of seasonality in predicting adverse postoperative outcomes in bariatric surgeries and thus provides evidence to help the decision making about the timing for these elective surgeries. For patients with elevated risks for DVT complications (e.g., chronic heart failure, long hours of physical inactivity, history of multiple pregnancies, or rheumatoid arthritis [27,40]) and sepsis (e.g., older age, immune system impairment, chronic or serious illness [41,42]), such precautionary awareness of the possible seasonality factor could be particularly important. On the other hand, because the crude rate for DVT was only .16%, the clinical implication of those statistically significant ORs we estimated might be limited.

One seemingly paradoxical result is that the summer season saw the highest crude mortality even though its difference from other seasons is not statistically significant after adjusting for other factors. As our results show, the summer season has by far the highest ratio of open surgeries (13.34% as compared with the 9.96% rate in all seasons), which could account for the statistically insignificant difference between the summer surgeries' crude mortality rate and other seasons' crude mortality rate. The reason for the occurrence of more open surgeries in the summer warrants further investigation.

Our study has its strength in that we used a large sample size covering 4 years of data from many hospitals across different regions of the United States. This large sample size compensates for weaknesses typically associated with a convenience sample (e.g., insufficient external validity). One limit of this study is that our analysis was based on a hospital discharge database and thus is subject to the hospital system's potential reporting bias. For instance, hospitals might choose not to charge for events such as sepsis because the provider could consider it as a medical error, as underreporting adverse events is not uncommon in the U.S. health systems [43]. However, our estimation of the seasonality pattern is unlikely to be substantially affected by this possible mechanism of underreporting adverse events as long as the underreporting does not vary across different seasons significantly.

Disclosure

The authors have no commercial associations that might be a conflict of interest in relation to this article.

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