Original Article

AOSPINE

Global Spine Journal
2019, Vol. 9(3) 254-259

DOI: 10.1177/2192568218780355
journals.sagepub.com/home/gsj
SAGE

Impact of Obesity on Surgical Outcomes Following Laminectomy for Spinal Metastases

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Abstract

Study Design: Retrospective cohort study.

Objectives: To determine the effect of obesity (body mass index >30 kg/m^2) on perioperative morbidity and mortality after surgical decompression of spinal metastases.

Methods: The American College of Surgeons National Surgical Quality Improvement Program database is a large multicenter clinical registry that collects preoperative risk factors, intraoperative variables, and 30-day postoperative morbidity and mortality outcomes from hospitals nationwide. Current Procedural Terminology codes were used to query the database for adults who underwent decompression with laminectomy for treatment of metastatic spinal lesions between 2010 and 2014. Patients were separated into 2 cohorts based on the presence of absence of obesity. Univariate analysis and multivariate logistic regression analysis were used to analyze the effect of obesity on perioperative morbidity and mortality.

Results: There was a significantly higher rate of venous thromboembolism (VTE; obese 6.6% vs nonobese 4.2%; $P = .01$) and pulmonary complications (obese 2.6% vs nonobese 2.2%; $P = .046$) in the obese group compared with the nonobese group. The nonobese group had prolonged hospitalization (obese 62.0% vs nonobese 69.0%; $P = .001$) and a higher incidence of blood transfusions (obese 26.8% vs nonobese 34.2%; $P < .001$). On multivariate analysis, obesity was found to be an independent risk factor for VTE (odds ratio = 1.75, confidence interval = 1.17-2.63, $P = .007$).

Conclusions: Obese patients were predisposed to an elevated risk of VTE following laminectomy for spinal metastases. Early postoperative mobilization and a low threshold to evaluate for perioperative VTE are important in these patients in order to appropriately diagnose and treat these complications and minimize morbidity.

Keywords

ACS-NSQIP, spinal tumor, spinal metastases, laminectomy, decompression, complications, morbidity, mortality, obesity, body mass index, BMI

Introduction

The spine is a common location for the development of primary and metastatic tumors. Spinal metastases are the most common tumor in the spine, accounting for more than 95% of spinal tumors and more than 18 000 newly diagnosed cases in North America each year.[1] Surgical indications for spinal metastases have expanded over the past few years to address symptoms of neurological deficit and spinal instability.[2]

Currently, the effect of obesity on outcomes following surgery for spinal metastases remains largely unknown. Obesity is a national epidemic, and according to the Centers for Disease

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Control and Prevention, among 78 million American adults, 35.7% of the population is currently obese (ie, body mass index [BMI] $\geq$30 kg/m^2). Despite efforts geared toward optimizing diets and losing weight preoperatively, a subgroup of patients undergoing surgery for spinal metastases are inevitably obese. Spine surgery in the setting of obesity is challenging due to difficulties with anesthesia, intravenous access, positioning, and physical access during the surgery itself.[3] Furthermore, obesity represents a systematic inflammatory state that can affect postoperative recovery and fusion rates, which could be particularly detrimental for patients with spinal metastases who are frail and have poor physiological reserve.[3] Although several studies have demonstrated an increased risk of perioperative complications in patients with obesity, other studies have shown contradicting findings.[4]

There are currently no studies in the literature analyzing the relationship between obesity and perioperative outcomes following surgery for metastatic spinal tumors. In this study, we used the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database to investigate the effect of obesity on 30-day perioperative complications in patients undergoing decompressive laminectomy for spinal metastases.

Methods

Patient Selection and Data Collection

We included data from the ACS-NSQIP database between 2010 and 2014. The ACS-NSQIP is a nationwide database that collects data from over 600 hospitals. Based on medical chart review, data on over 150 variables is collected by a trained and certified Surgical Clinical Reviewer. The collected data includes preoperative risk factors including patient demographics and comorbidities, surgical variables, and 30-day postoperative outcomes and complications for patients undergoing surgical procedures.[5] Adult patients aged 18 years or older undergoing surgery for the treatment of metastatic spinal lesions were included. We included only those patients undergoing laminectomy for decompression of extramedullary spinal neoplasms in the cervical, thoracic, lumbar, and/or sacral spine. Patients were separated into 2 cohorts: obese (World Health Organization definition: BMI $\geq$30 kg/m^2) and nonobese (BMI <30 kg/m^2). Baseline patient characteristics and comorbidities, operative variables, and complications were identified.

Variable Definitions

Preoperative variables included obesity ($\geq$30 kg/m^2), diabetes (non–insulin-dependent diabetes mellitus or insulin-dependent diabetes mellitus), current smoking (within 1 year of surgery), dyspnea ($\leq$30 days prior to surgery), functional status prior to surgery (independent or partially/totally dependent $\leq$30 days prior to surgery), pulmonary comorbidity (ventilator dependent $\leq$48 hours prior to surgery or history of chronic obstructive pulmonary disease $\leq$30 days prior to surgery), cardiac comorbidity (use of hypertensive medication or history of chronic heart failure $\leq$30 days prior to surgery), renal comorbidity (acute renal failure $\leq$24 hours prior to surgery or dialysis treatment $\leq$2 weeks prior to surgery), steroid use for chronic condition ($\leq$30 days prior to surgery), $\geq$10% loss of body weight (in the past 6 months), bleeding disorder (chronic, active condition), preoperative transfusion of $\geq$1 unit of whole/packed red blood cells ($\leq$72 hours prior to surgery), concurrent fusion surgery (any approach), low platelet count (<150 000), American Society of Anesthesiologists classification $\geq$3, nonelective surgery (includes patients who were transferred for operative treatment from another acute care hospital, emergency department or clinic, undergoing emergent/urgent surgery, or admitted to the hospital on the day(s) prior to a scheduled procedure for any reason), thrombocytopenia (platelet count <150 000), preoperative anemia (male with hematocrit <40% or female with <36%), and prolonged operative time (operative time $\geq$95th percentile of operative times in the included cohort).

Thirty-day perioperative outcome variables included mortality, wound complication (deep surgical site infection, organ space infection, or wound dehiscence), pulmonary complication (pneumonia, unplanned reintubation, or ventilator-assisted respiration $\geq$48 hours), venous thromboembolism (VTE; pulmonary embolism or deep vein thrombosis), renal complication (progressive renal insufficiency or acute renal failure), urinary tract infection, cardiac complication (cardiac arrest requiring cardiopulmonary resuscitation or myocardial infarction), intraoperative or postoperative red blood cell transfusion, reoperation (related to initial procedure), prolonged length of stay (LOS; $\geq$10 days), non–home discharge (discharge to another acute care hospital, skilled care facility, non–skilled care facility, or rehabilitation), and unplanned readmission (related to initial procedure). Further details about each of these variables are described in the ACS-NSQIP guide.

Statistical Analysis

Baseline patient demographics, comorbidities, operative variables, and perioperative complications were analyzed. Baseline patient and operative variables were compared between the obese and nonobese groups. Categorical variables were assessed using Pearson's χ^2 test (or Fisher's exact test where appropriate). The incidence of perioperative complications was then compared between the obese and nonobese groups. Finally, multivariate logistic regression analysis was used to determine 30-day perioperative complications that were independently associated with obesity. Baseline patient and operative variables with $P < .2$ were then carried forward and controlled for in this multivariate analysis. This specific methodology was used in order to consider as many potential risk factors as possible without including confounding variables. This was important in order to avoid compromising the validity of our regression models. Statistical significance was set at the level of .05. The overall model was assessed using the *C*-statistic, which is the area under the receiver operating

Table 1. Baseline Patient and Operative Variables.

Category	Obese (N = 695), n (%)	Nonobese (N = 1507), n (%)	P
Sex			
Male	394 (56.77)	1004 (65.03)	.0001
Female	298 (42.94)	540 (34.97)	
Race			
White	538 (78.65)	1132 (74.57)	<.0001
Other	6 (0.88)	76 (5.01)	
Black	76 (11.11)	150 (9.88)	
Unknown	64 (9.36)	160 (10.54)	
Concurrent fusion	298 (42.94)	788 (51.04)	.0004
Age ≥65	228 (32.85)	616 (39.90)	.0014
Diabetes	114 (16.43)	172 (11.14)	.0007
Dyspnea	62 (8.93)	116 (7.51)	.2551
Smoker	126 (18.16)	308 (19.95)	.3189
Functional status			
Independent	616 (88.76)	1372 (88.86)	.9450
Partial or total dependence	78 (11.24)	172 (11.14)	
Pulmonary comorbidity	44 (6.34)	70 (4.53)	.0776
Cardiac comorbidity	400 (57.64)	628 (40.67)	<.0001
Renal comorbidity	2 (0.29)	10 (0.65)	.2542
Steroid use	78 (11.24)	152 (9.84)	.3184
Recent weight loss	26 (3.75)	126 (8.16)	<.0001
Bleeding disorder	40 (5.76)	72 (4.66)	.2752
Preoperative RBC transfusion	16 (2.31)	64 (4.15)	.0241
Thrombocytopenia	86 (12.39)	204 (13.21)	.5916
Nonelective surgery	288 (44.86)	702 (49.65)	.0440
Preoperative anemia	296 (42.65)	850 (55.05)	<.0001

Abbreviation: RBC, red blood cell.

characteristic curve. SAS software (Version 9.3, SAS Institute Inc, Cary, NC) was used for all statistical analyses.

Results

Study Population

A total of 2202 adult patients with metastatic spinal tumors undergoing laminectomy were identified. Within this cohort, 695 (31.6%) patients were obese. There were significant differences between the obese and nonobese groups in terms of sex, race, concurrent fusion, age, diabetes, cardiac comorbidities, recent weight loss, preoperative transfusion, nonelective surgery, and preoperative anemia (Table 1).

Univariate Analysis of the Incidence of Perioperative Outcomes

A univariate analysis was performed to compare the incidence of perioperative morbidity and mortality between the obese and nonobese groups. Results of this univariate analysis are outlined in Table 2. Obese patients had a higher incidence of pulmonary complications (obese 2.6% vs nonobese 2.2%; $P = .050$) and VTE (obese 6.6% vs nonobese 4.2%; $P = .010$), and a lower incidence of prolonged hospitalization (obese 62.0% vs nonobese 69.0%; $P = .001$) and blood transfusions (obese 26.8% vs nonobese 34.2%; $P < .001$).

Multivariate Analysis of Obesity as an Independent Risk Factor for Perioperative Complications

We performed a multivariate analysis to examine the role of obesity as an independent risk factor for 30-day perioperative morbidity and mortality. Results of the multivariate logistic regression analysis are outlined in Table 3. In order to avoid potential confounding factors that were different between the 2 groups at baseline, we included patient and operative variables that were significantly different or had $P < .2$ when compared between the obese and nonobese groups (Table 1). These baseline patient and operative variables were sex, race, age, diabetes, pulmonary comorbidity, cardiac comorbidity, recent weight loss, preoperative anemia, preoperative blood transfusion, hypoalbuminemia, nonelective surgery, and concurrent fusion. After controlling for these baseline factors, we found that obesity was an independent risk factor for VTE (odds ratio = 1.75, 95% confidence interval = 1.17-2.63, $P = .007$) and a protective factor against urinary tract infection (odds ratio = 0.38, 95% confidence interval = 0.15-0.95, $P = .038$). There was no association between obesity and the other perioperative complications included in this study.

Discussion

Despite the worsening epidemic of obesity in the United States, there remains a paucity of data about its effect on clinical outcomes following surgery for spinal metastases. Given the relatively high prevalence of both obesity and spinal metastases, careful analysis of patients who harbor both comorbidities has important clinical merit. In this study, we investigated the effect of obesity on 30-day perioperative complications following laminectomy in patients with spinal metastases.

Perioperative complication rates following surgery for spinal metastases are high.[6] Previous studies have reported an average perioperative complication rate of 26.9%, with rates ranging from 5.3% to 76.2%.[6,7] Studies have also reported on multiple risk factors for increased morbidity following surgery for metastatic spinal lesions, which include age, multilevel disease, preoperative radiation, surgeon experience, myelopathy, and preoperative Karnofsky Performance Score.[8-13] However, obesity has not yet been studied as a potential risk factor for surgical complications following operative decompression of metastatic spinal tumors.

In this ACS-NSQIP study of 2202 patients, we found obesity to be an independent predictor of VTE in patients undergoing surgery for metastatic spinal tumors, with a 1.75 times increased odds of VTE compared with nonobese patients. The magnitude of this association is consistent with results from smaller single-institution retrospective studies, which have demonstrated a 2-fold increased risk of thromboembolic events in obese patients.[14,15] Potential mechanisms underlying this

Table 2. Univariate Analysis of 30-Day Perioperative Outcomes in the Obese and Nonobese Groups.

Category	Obese (N = 695), n (%)	Nonobese (N = 1507), n (%)	*P*	Total (N = 2202), n (%)
Prolonged hospitalization (>75th%)	172 (24.7)	456 (30.3)	.021	628 (28.5)
Wound complications	18 (2.6)	34 (2.3)	.573	52 (2.5)
Pulmonary complications	18 (2.6)	33 (2.2)	.046	51 (2.3)
Venous thromboembolism	46 (6.6)	64 (4.2)	.014	110 (5.0)
Renal complications	6 (0.9)	6 (0.4)	.170	12 (0.5)
Urinary tract infection	14 (2.0)	50 (3.3)	.098	64 (2.9)
Cardiac complication	2 (0.3)	12 (0.8)	.145	14 (0.6)
Intraoperative/postoperative transfusion	186 (26.8)	528 (35.0)	<.001	714 (32.4)
Sepsis	28 (4.0)	60 (3.9)	.868	88 (4.0)
Mortality	42 (6.0)	94 (6.2)	.974	136 (6.2)
Discharge to non–home facility	264 (38.0)	548 (36.4)	.366	812 (36.9)
Unplanned readmission	10 (1.4)	38 (2.5)	.217	48 (2.2)
Reoperation related to initial procedure	34 (4.9)	70 (4.6)	.747	104 (4.7)

Table 3. Multivariate Logistic Regression Analysis of Obesity as an Independent Risk Factor for 30-Day Perioperative Morbidity and Mortality[a].

Complication	Odds Ratio	95% Confidence Interval	*P*	*C*-Statistic
Venous thromboembolism	1.75	1.17-2.63	.007	.729
Urinary tract infection	0.38	0.15-0.95	.038	.778

[a]Variables that were controlled for include the following: sex, race, age, diabetes, pulmonary comorbidity, cardiac comorbidity, recent weight loss, preoperative anemia, preoperative blood transfusion, hypoalbuminemia, nonelective surgery, and concurrent fusion.

relationship include obstruction of venous return by abdominal fat, chronically raised intra-abdominal pressure in obese patients, and decreased blood velocity in the lower extremity venous system.[16,17] Furthermore, obesity has been associated with endothelial dysfunction, oxidative stress, and increased inflammation secondary to the release of nonesterified fatty acids by excess visceral fat.[17,18]

Cancer patients are also at an increased risk of venous and arterial thrombosis. Mortality rates of cancer patients with a VTE are higher than in those patients without a VTE.[19] The increased thrombotic risk associated with cancer has long been established. Malignant disease is found in 15% to 25% of all patients with VTE.[20-22] The prevalence of cancer is higher in patients with an unprovoked thrombosis than in patients with thrombosis secondary to a transient risk factor.[23] The risk of VTE is increased by 4- to 7-fold in patients with cancer.[20,24] Our findings highlight the importance of encouraging early postoperative mobilization as well as a low threshold for evaluation of VTE in the perioperative period in obese patients with spinal metastases.

The obese group had a significantly higher incidence of pulmonary complications than the nonobese group. This is consistent with several studies that have found an association between obesity and pulmonary complications.[25-27] Obesity has multiple effects on the respiratory system, including increased work of breathing, reduced pulmonary compliance, increased airway resistance, and reduced lung volume. Studies have shown an increase in respiratory resistance related to a decrease in functional residual capacity.[28-30] Vaughan and coworkers noted that obese patients have a significant preoperative reduction in arterial partial pressure of oxygen that tends to worsen during the postoperative phase.[31] Therefore, these patients are more susceptible to respiratory complications during the perioperative period, especially with regard to respiratory weaning, prolonged mechanical ventilation, and risk of pneumonia.[32,33] Weaning mechanical ventilation is often delayed in morbidly obese patients due to increased work of breathing resulting from increased airway resistance, abnormal chest elasticity, and inefficiency of the respiratory muscles.[34] Sharp et al have shown that the mechanical work needed to passively ventilate subjects weighing 114 kg is 2 to 4 times higher than that required for lighter individuals.[28] The risk of ventilator-associated pneumonia is also increased in obese patients, likely because of higher gastric volume, lower normal pH of gastric fluids, increased intra-abdominal pressure, and a higher incidence of gastric reflux.[35-37]

Obese patients had a lower incidence of prolonged hospitalization compared with nonobese patients. This is an unexpected finding that is difficult to explain, as previous studies examining outcomes after spinal surgery have found an association between obesity and prolonged LOS.[38] Hauck and Hollingsworth examined the impact of obesity on hospital LOS across multiple medical and surgical subspecialties and found that overall, medically managed obese patients tended to have a longer LOS, while surgically treated patients had a shorter LOS.[39] One explanation they proposed to explain this trend is that a smaller proportion of obese patients are indicated for surgery in the first place, and this subgroup may represent those patients at lowest risk for complications at baseline.[39] Alternatively, they suggested that perhaps obese patients are more likely to die of complications.[39] However, their results did not provide any evidence to support either explanation for shorter LOS in obese patients. As such, we do not have a good

explanation for the observed association between obesity and a decreased incidence of prolonged LOS in our study. This should be examined further in future studies to better delineate the underlying etiology of this association.

In our multivariate analysis, we did not find an association between obesity and perioperative blood transfusions. However, in the univariate analysis, obese patients had a significantly lower rate of blood transfusions compared with their nonobese counterparts. Obese patients had a transfusion rate of 26.8%, which is consistent with previous studies that have found transfusion rates of 8% to 36% in patients undergoing spinal surgery, with a tendency toward higher transfusion rates in oncologic spinal surgery.[40-42] Obese patients have a higher estimated blood volume, and therefore, the amount of blood lost as a proportion of estimated blood volume is lower for obese patients compared with that of nonobese patients. Similar to our findings, Frisch et al found that there was a significant decrease in the rate of perioperative blood transfusions following total hip and knee arthroplasty in patients with increased BMI.[43] These findings suggest that the percentage of estimated blood loss may be more predictive of blood transfusion requirements, which may offer a plausible explanation for the lower rate of perioperative transfusions observed in our cohort of obese patients.

There are several limitations to the present study. First, the ACS-NSQIP database is subject to various biases—including selection bias and sampling bias—that are inherent in all studies that are based on data from registries. The ACS-NSQIP database classifies cases based on Current Procedural Terminology codes. However, Current Procedural Terminology codes do not provide information about primary tumor location or histology, which are both significant prognostic predictors.[44-46] The overall burden of disease and number of vertebral and visceral metastases have also been associated with poor prognosis but could not be analyzed with our data set.[47,48] Additionally, prognostic variables such as Karnofsky Performance Score or postoperative functional status (eg, paraparesis, paraplegia, etc) were not available in the ACS-NSQIP database. Chemotherapy and radiation therapy were also not accounted for in this database. Another limitation is that outcomes were limited to 30 days after surgery with no long-term follow-up. In this study, obesity was defined as a dichotomous variable only, and we did not subcategorize patients further according to the degree of obesity due to the small number of patients that would have been in each subgroup. Future studies should examine long-term outcomes of laminectomy in obese patients with spinal metastases, as well as assess the effect of increasing severity of obesity on surgical outcomes.

With these limitations in mind, the ACS-NSQIP database provides a large sample size from multiple institutions nationwide to investigate the impact of obesity on 30-day perioperative complications following laminectomy for spinal metastases. Our findings demonstrate that obesity is an independent predictive risk factor for VTE but was not a risk factor for any other major perioperative complications. Given the predisposition for VTE associated with malignancy itself, obese patients with spinal metastases are at particularly high risk for perioperative VTE following laminectomy. Surgeons should be vigilant about promoting early mobilization postoperatively as prophylaxis against VTE, as well as recognizing early signs and symptoms of VTE in the perioperative period in order to appropriately evaluate and treat these complications in a timely fashion.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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