



Reduced Impact of Obesity on Short-Term Surgical Outcomes, Patient-Reported Pain Scores, and 30-Day Readmission Rates After Complex Spinal Fusion (≥ 7 Levels) for Adult Deformity Correction

Aladine A. Elsamadicy¹, Joaquin Camara-Quintana¹, Adam J. Kundishora¹, Megan Lee¹, Isaac G. Freedman¹, Aaron Long¹, Tariq Qureshi¹, Maxwell Laurans¹, Patrick Tomak¹, Isaac O. Karikari²

OBJECTIVE: In the past decade, prevalence of obesity in the United States have been soaring at a disarming rate. Previous spine studies have associated obesity with inferior surgical outcomes, increased complication and 30-day readmission rates, and worsening patient-reported outcomes. However, there is a paucity of data identifying whether the impact of obesity is sustained in patients undergoing complex deformity correction involving 7 levels or greater. The aim of this study was to determine whether obesity impacts surgical outcomes, patient-reported pain scores, and 30-day readmission rates after complex spinal fusions ≥ 7 levels.

METHODS: The medical records of 112 adult patients (≥ 18 years old) with spine deformity undergoing elective, primary complex spinal fusion (≥ 7 levels) for deformity correction at a major academic institution from 2010 to 2015 were reviewed. Preoperative body mass index greater than or equal to 30 kg/m^2 was classified as obese. Patient demographics, comorbidities, and intraoperative and postoperative complication rates were collected for each patient. Inpatient patient-reported pain scores and ambulatory status also were collected. The primary outcomes of this study were surgical outcomes, patient-reported pain scores, and 30-day readmission rates.

RESULTS: Of the 112 patients, 33 (29.5%) were obese (obese: $n = 33$ vs. non-obese: $n = 79$). Patient

demographics and comorbidities were similar between both cohorts, including age, sex, diabetes, hypertension, and home narcotic use. The median number of fusion levels operated, length of surgery, estimated blood loss, transfusion, and complication rates were similar between both cohorts. Moreover, the postoperative complication profiles between the cohorts also were similar, with a comparable length of hospital stay (obese: 6.5 ± 4.6 days vs. non-obese: 7.0 ± 3.9 days, $P = 0.5833$) and 30-day readmission rates (obese: 12.1% vs. non-obese: 13.9%, $P = 0.7984$). Baseline ($P = 0.6826$), first ($P = 0.9691$), and last ($P = 0.9583$) postoperative patient-reported pain scores were similar between cohorts. Analogously, ambulatory status was similar between the cohorts, including days from operating room to ambulation ($P = 0.3471$) and number of steps on first ($P = 0.9173$) and last ($P = 0.1634$) ambulatory day before discharge.

CONCLUSIONS: Our study suggests that obesity does not significantly affect surgical outcomes, patient-reported pain scores, and 30-day readmission rates after complex spinal surgery requiring ≥ 7 levels of fusion. Further studies are necessary to corroborate our findings.

Key words

- 30-day readmission rates
- Adult deformity correction
- Complex spine fusion
- Obesity
- Patient-reported pain scores
- Postoperative complications
- Postoperative pain

Abbreviations and Acronyms

- ASD:** Adult spinal deformity
- BMI:** Body mass index
- DVT:** Deep vein thrombosis
- EBL:** Estimated blood loss
- HTN:** Hypertension
- PE:** Pulmonary embolism

PRO: Patient-reported outcome

SSI: Surgical-site infection

UTI: Urinary tract infection

From the ¹Department of Neurosurgery, Yale University School of Medicine, New Haven, Connecticut; and ²Department of Neurosurgery, Duke University Medical Center, Durham, North Carolina, USA

To whom correspondence should be addressed: Aladine A. Elsamadicy, M.D.
[E-mail: aladine.elsamadicy@yale.edu]

Citation: *World Neurosurg.* (2019) 127:e108-e113.

<https://doi.org/10.1016/j.wneu.2019.02.165>

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

1878-8750/\$ - see front matter © 2019 Published by Elsevier Inc.

INTRODUCTION

In the past decade, the prevalence of obesity has continued to grow at a disparaging rate, currently affecting more than one third of adults in the United States.¹ Obesity is a modifiable risk factor that has been associated increased health care resource use and morbidity across all surgical fields.²⁻⁶ Specifically in spine surgery, obesity has been associated with increased infection rates,^{3,7} estimated blood loss,^{3,8} length of hospital stay,^{3,7,8} and 30-day readmission rates.^{2,3,8-10} Moreover, the estimated health care cost increase associated with obesity after spine surgery is approximately \$8000–\$9000 per patient.^{11,12}

With an aging population, there is a growing population of patients presenting with adult spine deformity (ASD), with approximately 5 million adults disabled with a spine disorder in the United States.^{13,14} As a result, there has been an associated increase of spinal fusion performed annually, with the rate of primary spinal fusion increasing by 46.6% from 2002 to 2009, and by 62.3% from 2004 to 2015 for elective lumbar fusion.^{15,16} Therefore, there is a national emphasis to reduce morbidities associated with spinal fusions while also increasing quality of care and patient-reported outcomes (PROs). Previous studies have generally looked at less than 3 levels of spinal fusion,^{3,7,8} whereas little remains known about the impact of obesity on complex spinal fusions involving 7 levels or more. Thus, the aim of this study was to determine whether obesity impacts surgical outcomes, patient-reported pain scores, and 30-day readmission rates after complex spinal fusions ≥ 7 levels.

METHODS

The medical records of 112 patients (≥ 18 years old) with ASD undergoing elective complex spinal fusion (≥ 7 levels) for deformity correction at a major academic institution from 2010 to 2015 were reviewed. Institutional review board approval was obtained before study initiation. Inclusion criteria included adult patients (18 years or older) with 1) available demographics and treatment 2) who underwent an elective, primary complex spinal fusion (≥ 7 levels) for deformity correction; and 3) who had baseline and postoperative patient-reported pain scores. Patients were excluded if they had 1) previous back surgery or 2) severe coexisting pathology (i.e., neoplastic etiologies). Follow-up was 30 days after indexed surgery, and the surgeries were performed by multiple deformity surgeons at the single academic institution. Patients were categorized based on body mass index (BMI), with obese classified as BMI of 30 kg/m² or greater and nonobese as < 30 kg/m². The primary outcomes of this study were surgical outcomes, patient-reported pain scores, and 30-day readmission rates.

Baseline characteristics and demographic variables evaluated included patient age, sex, percent white, and BMI. Comorbidities included depression, anxiety, chronic obstructive pulmonary disease, diabetes, congestive heart failure, coronary artery disease, atrial fibrillation, hypertension (HTN), and hyperlipidemia. Other preoperative variables collected included alcohol use, smoking status, and home narcotic use. Intraoperative variables included number of fusion levels, operative time, estimated blood loss (EBL), administration of packed red blood cell or cell-saver transfusions, and whether a laminectomy and/or osteotomy was performed. Other operative variables assessed included use of somatosensory

Table 1. Demographic and Comorbidities

Variables	Obese (n = 33)	Nonobese (n = 79)	P Value
Female, %	72.7	72.2	0.9505
Age, years	51.8 \pm 18.2	52.7 \pm 21.4	0.8335
White, %	87.9	80.8	0.3703
BMI, kg/m ²	35.1 \pm 4.5	23.9 \pm 3.8	<0.0001*
Depression, %	27.3	30.4	0.7423
Anxiety, %	18.2	26.6	0.3434
COPD, %	9.1	6.3	0.6049
Diabetes, %	21.2	8.9	0.0716
CHF, %	0.0	3.8	0.2565
CAD, %	12.1	7.6	0.4438
A-Fib, %	3.0	2.5	0.8815
HTN, %	51.5	44.3	0.4854
HLD, %	36.4	31.7	0.6284
Alcohol use, %	41.9	27.9	0.1535
Current smoker, %	22.6	16.5	0.4537
Home narcotic-use, %	45.5	56.0	0.3119

BMI, body mass index; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; CAD, coronary artery disease; A-Fib, atrial fibrillation; HTN, hypertension; HLD, hyperlipidemia.

stimulus-evoked potentials, transcranial motor-evoked potentials, electromyography, and fluoroscopy. In addition, whether patients received bone graft and intraoperative drain placement also was collected. Intraoperative complications collected included spinal cord injury, nerve root injury, and incidental durotomy.

Postoperative complications included length of stay in hospital, delirium, urinary tract infection (UTI), fever, ileus, deep and superficial surgical-site infection (SSI), draining wounds, pneumonia, HTN, hypotension, hematoma, anemia, myocardial infarction, pulmonary embolism (PE), deep vein thrombosis (DVT), stroke, weakness, and sensory deficit. Rate of unplanned 30-day readmissions also was collected for every patient. Baseline and postoperative inpatient patient-reported pain scores and ambulatory status also were collected. Pain scores were recorded on a scale from 0 to 10 first postoperative day and before discharge. Ambulatory status included the number of days from the operating room to ambulation, the number of steps of first ambulatory steps, and the number of steps of last ambulatory steps.

Parametric data were expressed as means \pm standard deviation and compared using the Student *t* test. Nonparametric data were expressed as median [interquartile range] and compared via the Mann–Whitney *U* test. Nominal data were compared with the χ^2 test. All tests were 2-sided and were statistically significant if the *P* value was less than 0.05. Statistical analysis was performed using JMP, Version 13 (SAS Institute Inc., Cary, North Carolina, USA).

Table 2. Intraoperative Variables and Complications

Variables	Obese (n = 33)	Nonobese (n = 79)	P Value
Median no. levels [IQR]	9 [8.5–13]	10 [9–13]	0.1593
Laminectomy, %	56.3	48.1	0.4356
Osteotomy, %	21.9	20.8	0.8984
SSEP, %	41.4	47.2	0.5937
TcMEP, %	32.1	22.2	0.3036
EMG, %	25.0	23.6	0.8839
Fluoroscopy, %	67.9	58.3	0.3806
Bone graft, %	93.9	96.0	0.6387
Operative time, minutes	331.4 ± 129.6	323.6 ± 115.2	0.7657
EBL, mL	1375.0 ± 1070.5	1485.3 ± 1388.3	0.6513
PRBC transfusions, %	42.4	62.0	0.0566
Cell saver transfusions, %	78.8	72.2	0.4649
Drain placement, %	97.0	92.3	0.3557
Nerve/spinal cord damage, %	0.0	0.0	1.000
Durotomy, %	6.1	6.4	0.9448

IQR, interquartile range; SSEP, sensory stimulus-evoked potentials; TcMEP, transcranial motor-evoked potentials; EMG: electromyography; EBL, estimated blood loss; PRBC, packed red blood cells.

RESULTS

Patient Demographics and Preoperative Variables

There were 112 adults (≥ 18 years old) who met the inclusion criteria of this study, with 29.5% of patients classified as obese (nonobese: n = 79; obese: n = 33; **Table 1**). The mean BMIs for nonobese and obese cohorts were 23.9 ± 3.8 kg/m² and 35.1 ± 4.5 kg/m², respectively (**Table 1**). There were no significant differences in mean age (nonobese: 52.7 ± 21.4 years vs. obese: 51.8 ± 18.2 years; $P = 0.8335$), proportion of female patients (nonobese: 72.2% vs. obese: 72.7%; $P = 0.9505$), and white (nonobese: 80.8% vs. obese: 87.9%; $P = 0.3703$), **Table 1**. The prevalence of comorbidities between the cohorts were similar, including depression ($P = 0.7423$), anxiety ($P = 0.3434$), chronic obstructive pulmonary disease ($P = 0.6049$), diabetes ($P = 0.0716$), congestive heart failure ($P = 0.2565$), coronary artery disease ($P = 0.4438$), atrial fibrillation ($P = 0.8815$), HTN ($P = 0.4854$), hyperlipidemia ($P = 0.6284$), alcohol use ($P = 0.1535$), or current smoker ($P = 0.4537$). The proportion of patients who took home narcotics before surgery was similar between the cohorts (nonobese: 45.5% vs. obese: 56.0%; $P = 0.3119$), **Table 1**.

Intraoperative Variable and Complications

The median [interquartile range] number of fusion levels (nonobese: 10 [9–13] vs. obese: 9 [8.5–13], $P = 0.1593$) and operative time (nonobese: 323.6 ± 115.2 minutes vs. obese: 331.4 ± 129.6

Table 3. Postoperative Complications

Variables	Obese (n = 33)	Nonobese (n = 79)	P Value
LOS, days	6.5 ± 4.6	7.0 ± 3.9	0.5833
Delirium, %	9.1	11.5	0.7043
UTI, %	6.3	7.6	0.8040
Fever, %	6.7	8.9	0.7101
Deep SSI, %	6.5	3.9	0.5675
Draining wound, %	6.3	1.3	0.1462
Superficial SSI, %	0.0	2.6	0.3651
Pneumonia, %	0.0	1.3	0.5226
Hypertension, %	3.1	7.6	0.3802
Hypotension, %	15.6	12.7	0.6788
Hematoma, %	0.0	3.8	0.2638
Anemia, %	37.5	34.2	0.7398
PE, %	3.1	1.3	0.5048
DVT, %	3.1	2.5	0.8614
Stroke, %	3.1	1.3	0.5048
Weakness, %	9.4	7.6	0.7556
Sensory deficit, %	3.1	0.0	0.1145
30-day readmission, %	12.1	13.9	0.7984

LOS, length of stay; UTI, urinary tract infection; SSI, surgical-site infection; PE, pulmonary embolism; DVT, deep vein thrombosis.

minutes, $P = 0.7657$) were similar between cohorts (**Table 2**). There were no significant differences in the other surgical variables, including the performance of laminectomy (nonobese: 48.1% vs. obese: 56.3%, $P = 0.4356$) or osteotomy (nonobese: 20.8% vs. obese: 21.9%, $P = 0.8984$) between the cohorts (**Table 2**). Both groups had similar intraoperative EBL (nonobese: 1485.3 ± 1388.3 mL vs. obese: 1375.0 ± 1070.5 mL, $P = 0.6513$), packed red blood cell transfusions (nonobese: 62.0% vs. obese: 42.4%, $P = 0.0566$), and cell-saver transfusions (nonobese: 72.2% vs. obese: 78.8%, $P = 0.4649$), **Table 2**. The use of intraoperative monitoring and imaging were similar between the cohorts, including somatosensory stimulus-evoked potentials ($P = 0.5937$), transcranial motor-evoked potentials ($P = 0.3036$), electromyography ($P = 0.8839$), and fluoroscopy ($P = 0.3806$), **Table 2**. There were no significant differences in intraoperative incidental durotomy (nonobese: 6.4% vs. obese: 6.1%, $P = 0.9448$), with no patient experiencing nerve root or spinal cord injury (**Table 2**). The proportion of patients having a drain placement ($P = 0.3557$) also was similar between the cohorts (**Table 2**).

Postoperative Complications

There were no significant differences in overall length of stay between the cohorts (nonobese: 7.0 ± 3.9 days vs. obese: 6.5 ± 4.6 days, $P = 0.5833$), **Table 3**. There were no significant

Table 4. Pre- and Postoperative Patient-Reported Pain Scores

Variables	Obese (n = 33)	Nonobese (n = 79)	P Value
Pain scores			
Baseline pain score	5.6 \pm 3.0	5.3 \pm 3.1	0.6826
First pain score	5.9 \pm 3.0	6.0 \pm 2.7	0.9691
Last pain score	3.9 \pm 3.4	3.9 \pm 3.2	0.9583
Δ Baseline – first pain score	+0.48 \pm 2.4	+0.55 \pm 3.7	0.9168
Δ Baseline – last pain score	1.7 \pm 3.9	1.5 \pm 4.4	0.8689
Ambulatory status			
Days from OR to ambulation, days	2.3 \pm 1.9	2.0 \pm 1.2	0.3471
No. steps of first ambulatory steps, ft	79.3 \pm 101.5	77.0 \pm 103.8	0.9173
No. steps of last ambulatory steps, ft	195.5 \pm 143.0	251.4 \pm 256.0	0.1634

OR, operating room.

differences in the incidence of other postoperative complications including delirium ($P = 0.7043$), fever ($P = 0.7101$), UTI ($P = 0.8040$), deep SSI (0.5672), draining wounds ($P = 0.1462$), superficial SSI ($P = 0.3651$), pneumonia ($P = 0.5226$), HTN ($P = 0.3802$), hypotension ($P = 0.6788$), hematoma ($P = 0.2638$), anemia ($P = 0.7398$), PE ($P = 0.5048$), DVT ($P = 0.8614$), stroke ($P = 0.5048$), weakness ($P = 0.7556$), and sensory deficits ($P = 0.1145$). Also, 30-day readmission rates were similar between then cohorts (nonobese: 13.9% vs. 12.1%, $P = 0.7984$), **Table 3**.

Pre- and Postoperative Patient-Reported Pain Scores

There were no significant differences in baseline pain scores (nonobese: 5.3 \pm 3.1 vs. obese: 5.6 \pm 3.0, $P = 0.6826$) as well as the first pain score (nonobese: 6.0 \pm 2.7 vs. obese: 5.9 \pm 3.0, $P = 0.9691$) and the last pain score (nonobese: 3.9 \pm 3.2 vs. obese: 3.9 \pm 3.4, $P = 0.9583$) between both cohorts, **Table 4**. The change from baseline to first pain score (nonobese: +0.55 \pm 3.7 vs. obese: +0.48 \pm 2.4, $P = 0.9168$) and from baseline to the last pain score (nonobese: 1.5 \pm 4.4 vs. obese: 1.7 \pm 3.9, $P = 0.8689$) were also similar, **Table 4**. In addition, there were no significant differences in the number of days from the operating room to ambulation (nonobese: 2.0 \pm 1.2 vs. obese: 2.3 \pm 1.9, $P = 0.3471$), the number of first ambulatory steps (nonobese: 77.0 \pm 103.8 vs. obese: 79.3 \pm 101.5, $P = 0.9173$), or the number of last ambulatory steps (nonobese: 251.4 \pm 256.0 vs. obese: 195.5 \pm 143.0, $P = 0.1634$), **Table 4**.

DISCUSSION

In this retrospective cohort study assessing the impact obesity has in patients undergoing complex elective primary spinal fusion involving ≥ 7 levels for deformity correction, we demonstrated

similar surgical outcomes, pain scores, and 30-day readmission rates between obese and nonobese patients.

Although there is a paucity of studies examining the impact that obesity has on in patients undergoing complex spinal fusion for deformity correction, there have been other spine studies that have demonstrated an association between obesity and intraoperative complications. In a retrospective study of 732 patients who underwent 1- to 3-level posterolateral fusion for degenerative spine disease, De la Garza-Ramos et al.³ demonstrated that patients with a BMI >30 kg/m² had an increased EBL. Similarly, in another a retrospective study of 2447 patients who underwent decompression alone or decompression plus fusion for lumbar spinal stenosis, Onyekwelu et al.⁸ found that both EBL and operative time were greater in obese patients undergoing spinal fusion. Analogously, in a retrospective analysis of 801 patients with degenerative spine disease requiring spinal fusion with instrumentation, Higgins et al.¹¹ demonstrated that surgical time in obese patients was increased relative to nonobese patients.

Contrary to the aforementioned studies, in a retrospective study of 63 patients undergoing lumbar spinal fusion, Vaidya et al.¹⁷ found that the number of levels fused and not the BMI correlated with increase operative time. Analogously, our study did not demonstrate a significant difference in operative time, EBL, or intraoperative complications between obese and nonobese patients undergoing complex spinal fusions involving ≥ 7 levels.

Obesity also has been associated with increased postoperative complications and length of hospital stay. In a retrospective study of 64,813 patients who underwent primary 1- to 2-level posterolateral lumbar fusion for degenerative pathology, Puvanesarajah et al.¹² reported that UTIs, wound infection, and wound dehiscence rates increased with over 2-fold odds in obese patients. Similarly, in another retrospective cross-sectional study of 84,607 patients who underwent a spinal fusion, Kalanithi et al.⁹ reported a greater complication rate in nearly all categories examined, including DVT/PE and infection rates. Moreover, the authors reported a longer length of stay among obese patients. Similarly, in a retrospective study of 3270 undergoing elective noninstrumented decompressive surgeries for degenerative spine disease, Planchard et al.¹⁸ found a significant association between obesity and length of hospital stay. The difficulties encountered in operating in obese patients are mostly due to the comorbidities associated with obesity, such as inadequate glucose control or hypercoagulability and stasis that impact wound healing and increase risk for DVT/PE. Identifying these increased risks may assist in operative planning to reduce EBL, length of operating time, extra attention to wound closure in efforts to better patient care and limit postoperative complications.

However, there also have been studies that did not find an association between obesity and postoperative complications. In a retrospective study of 118 patients undergoing surgery for degenerative lumbar spine disease, Pereira et al.¹⁹ found that BMI did not correlate with increased rates of complications. Similarly, in a retrospective study of 244 patients with ASD involving ≥ 5 level arthrodesis, Amin et al.²⁰ reported similar inpatient complication rates between obese and nonobese cohorts. In a propensity-matched case control study of 3601 patients who

underwent a posterior instrumented lumbar spinal fusion, Owens et al.²¹ showed no difference in complication rates, including infections, hematomas, or UTIs, between cohorts, whereas in a retrospective study of 244,170 patients who underwent thoracolumbar or lumbar spine fusion for degenerative disease, Shamji et al.²² found that there was no clinically relevant difference in length of stay between obese and nonobese patients. Analogous to the aforementioned studies, our study demonstrated similar postoperative complications and length of hospital stay between obese and nonobese patients undergoing complex spinal fusions involving ≥ 7 levels.

In an era of reducing hospital readmission rates, there are several studies that have found associations between obesity and 30-day readmission rates after spinal fusion. In the retrospective study by Puvanesarajah et al.¹² of 64,813 patients, the authors found that obese patients had significantly greater 30-day readmission rates compared with nonobese patients. In another retrospective study of 500 patients undergoing elective spine surgery, Elsamadicy et al. showed that obese patients had over a 2-fold increased 30-day readmission rate compared with nonobese patients.² Similarly, using the National Readmission Database of 144,123 patients undergoing elective lumbar surgery, Elsamadicy et al.¹⁰ demonstrated that obesity was an independent predictor for 30-day readmission rates. In contrast, in Onyekwelu et al.'s retrospective study⁸ of 2447 patients, the authors did not find a significant difference in 30-day readmission rates between obese and nonobese patients. Analogously, our study demonstrated no significant difference in 30-day readmission rates between obese and nonobese patients undergoing complex spinal fusions involving ≥ 7 levels.

There have only been a few studies that have linked obesity with postoperative PROs. In a prospective study of 88 patients undergoing cervical spine surgery, Auffinger et al.²³ showed that obesity was associated with inferior postoperative PROs and overall patient-rated improvement. Interestingly, the authors found that surgeons reported lower outcomes after operating on patients with BMI > 25 kg/m²,²³ whereas in a study of 191 patients undergoing thoracolumbar fusion for ASD correction, Sharma et al.²⁴ demonstrated that obese men had greater odds of reporting better follow-up PRO compared with nonobese men.

Similarly, in another retrospective study of 500 consecutive patients undergoing thoracolumbar spine surgery, Manson et al.²⁵ showed no significant difference between BMI groups' patient-reported pain scores, disability, and mental questionnaires. Analogously, our study demonstrated no significant difference in patient-reported pain scores at baseline, immediately after surgery, and before discharge. Overall, our study suggests that due to the complexity and invasiveness of spinal fusions involving ≥ 7 levels, that obesity may not have as significant of an impact as it has been shown for less-involved spine surgeries. There needs to be a particular emphasis in caring for obese patients postoperatively to reduce preventable complications and better quality of care. These interventions include early ambulation, preventative measures for pressure ulcers, and increase respiratory management.²⁶ Our study showed no difference between ambulation

between obese and nonobese patients, illustrating similar debilitating impact that complex spinal fusions have on patients. Although we found no clinical differences between obese and nonobese patients, there should still be an emphasis on reducing preventable complications associated with complex spinal fusions for adult deformity.

Previous studies also have associated obesity with increased health care costs in spine surgery. In the Higgins et al.¹¹ study of 801 patients undergoing spinal fusion for degenerative disease, the authors showed that morbidly obese patients cost \$9078 greater in total cost than normal-weight patients. Similarly, in the Puvanesarajah et al.¹² study of 64,813 lumbar fusion patients, the authors found that morbidly obese patients had in-patient hospital costs of nearly \$8000 more in comparison with the nonobese control group. Analogously, in the Shamji et al.²² study of 244,170, the authors demonstrated that morbidly obese patients cost 16% more for anterior fusions, 31% more for lateral fusions, and 15% more for posterior fusions. In the Kalanithi et al.⁹ study of 84,607 patients who underwent spinal fusion, the authors found that patients with morbid obesity cost at total of \$108,604 per hospital admission, in comparison with \$84,861 for normal-weight patients. Analogously, in a retrospective analysis of 816 patients who underwent spine surgery, Walid et al.²⁷ suggested that obese patients had a greater rate of comorbidities, which significantly increased costs. Overall, identifying the physiological impact that obesity has on short-term complications and expenditures is important to better patient quality of care and decrease the soaring health care costs. More studies are necessary to determine the impact that obesity has on patients undergoing complex spinal deformity, as although the morbidity associated with these surgeries may outweigh the negative implications in the short term, long-term differences may ensue.

This study has limitations with potential implications for study interpretation. Although all variables were recorded pre-, peri-, and postoperatively, they were reviewed retrospectively and, as such, are limited by the weaknesses inherent to retrospective analyses. Furthermore, a relatively small patient sample size from only one academic center was used, making broad conclusions difficult and potentially biasing our results for particular patient population or treatment paradigms. Furthermore, a low sample size subjects the analysis to a Type II error, not having enough power to identify a true difference between our cohorts. In addition, due to sample size, we are not able to perform subanalyses identifying the impact of morbid obesity. Despite these limitations, this study has demonstrated obesity does not impact surgical outcomes, patient-reported pain scores, and 30-day readmission rates after complex spinal fusions ≥ 7 levels.

CONCLUSIONS

Our study suggests that obesity does not significantly affect surgical outcomes, patient-reported pain scores, and 30-day readmission rates after complex spinal surgery requiring ≥ 7 levels of fusion. Further studies are necessary to corroborate our findings.

REFERENCES

- Hales CM, Fryar CD, Carroll MD, Freedman DS, Ogden CL. Trends in obesity and severe obesity prevalence in US youth and adults by sex and age, 2007–2008 to 2015–2016. *JAMA*. 2018;319:1723–1725.
- Elsamadicy AA, Adogwa O, Vuong VD, et al. Patient body mass index is an independent predictor of 30-day hospital readmission after elective spine surgery. *World Neurosurg*. 2016;96:148–151.
- De la Garza-Ramos R, Bydon M, Abt NB, et al. The impact of obesity on short- and long-term outcomes after lumbar fusion. *Spine (Phila Pa 1976)*. 2015;40:56–61.
- Sood A, Abdollah F, Sammon JD, et al. The effect of body mass index on perioperative outcomes after major surgery: results from the National Surgical Quality Improvement Program (ACS-NSQIP) 2005–2011. *World J Surg*. 2015;39:2376–2385.
- Hannan EL, Zhong Y, Lahey SJ, et al. 30-day readmissions after coronary artery bypass graft surgery in New York State. *JACC Cardiovasc Interv*. 2011;4:569–576.
- Biener AI, Decker SL, Agency for Healthcare Research and Quality. Medical care use and expenditures associated with adult obesity in the United States. *JAMA*. 2018;319:218.
- Lim S, Edelstein AI, Patel AA, Kim BD, Kim JYS. Risk factors for postoperative infections after single-level lumbar fusion surgery. *Spine (Phila Pa 1976)*. 2018;43:215–222.
- Onyekwelu I, Glassman SD, Asher AL, Shaffrey CI, Mummaneni PV, Carreon LY. Impact of obesity on complications and outcomes: a comparison of fusion and nonfusion lumbar spine surgery. *J Neurosurg Spine*. 2017;26:158–162.
- Kalanithi PA, Arrigo R, Boakye M. Morbid obesity increases cost and complication rates in spinal arthrodesis. *Spine (Phila Pa 1976)*. 2012;37:982–988.
- Elsamadicy AA, Ren X, Kemeny H, et al. Independent associations with 30- and 90-day unplanned readmissions after elective lumbar spine surgery: a national trend analysis of 144 123 patients. *Neurosurgery*. 2019;84:758–767.
- Higgins DM, Mallory GW, Planchard RF, et al. Understanding the impact of obesity on short-term outcomes and in-hospital costs after instrumented spinal fusion. *Neurosurgery*. 2016;78:127–132.
- Puvanesarajah V, Werner BC, Cancienne JM, et al. Morbid obesity and lumbar fusion in patients older than 65 years: complications, readmissions, costs, and length of stay. *Spine (Phila Pa 1976)*. 2017;42:122–127.
- Di Capua J, Lugo-Fagundo N, Somani S, et al. Diabetes mellitus as a risk factor for acute postoperative complications following elective adult spinal deformity surgery. *Global Spine J*. 2018;8:615–621.
- Cowan JA Jr, Dimick JB, Wainess R, Upchurch GR Jr, Chandler WF, La Marca F. Changes in the utilization of spinal fusion in the United States. *Neurosurgery*. 2006;59:15–20 [discussion: 15–20].
- Rajae SS, Kanim LE, Bae HW. National trends in revision spinal fusion in the USA: patient characteristics and complications. *Bone Joint J*. 2014;96-b:807–816.
- Martin B, Mirza SK, Spina N, Spiker WR, Lawrence B, Brodke DS. Trends in lumbar fusion procedure rates and associated hospital costs for degenerative spinal diseases in the United States, 2004–2015. *Spine (Phila Pa 1976)*. 2019;44:369–376.
- Vaidya R, Carp J, Bartol S, Ouellette N, Lee S, Sethi A. Lumbar spine fusion in obese and morbidly obese patients. *Spine (Phila Pa 1976)*. 2009;34:495–500.
- Planchard RF, Higgins DM, Mallory GW, et al. The impact of obesity on perioperative resource utilization after elective spine surgery for degenerative disease. *Global Spine J*. 2015;5:287–293.
- Pereira BJ, de Holanda CV, Ribeiro CA, et al. Impact of body mass index in spinal surgery for degenerative lumbar spine disease. *Clin Neurol Neurosurg*. 2014;127:112–115.
- Amin RM, Raad M, Jain A, Sandhu KP, Frank SM, Kebaish KM. Increasing body mass index is associated with worse perioperative outcomes and higher costs in adult spinal deformity surgery. *Spine (Phila Pa 1976)*. 2018;43:693–698.
- Owens RK 2nd, Djurasovic M, Onyekwelu I, Bratcher KR, McGraw KE, Carreon LY. Outcomes and revision rates in normal, overweight, and obese patients 5 years after lumbar fusion. *Spine J*. 2016;16:1178–1183.
- Shamji MF, Parker S, Cook C, Pietrobon R, Brown C, Isaacs RE. Impact of body habitus on perioperative morbidity associated with fusion of the thoracolumbar and lumbar spine. *Neurosurgery*. 2009;65:490–498 [discussion: 498].
- Auffinger B, Lam S, Kraninger J, Shen J, Roitberg BZ. The impact of obesity on surgeon ratings and patient-reported outcome measures after degenerative cervical spine disease surgery. *World Neurosurg*. 2014;82:e345–e352.
- Sharma A, Tanenbaum JE, Hogue O, et al. Predicting clinical outcomes following surgical correction of adult spinal deformity. *Neurosurgery*. 2019;84:733–740.
- Manson NA, Green AJ, Abraham EP. Elevated patient body mass index does not negatively affect self-reported outcomes of thoracolumbar surgery: results of a comparative observational study with minimum 1-year follow-up. *Global Spine J*. 2016;6:108–117.
- Kaffarik M, Utzolino S. Postoperative management of patients with BMI > 40 kg/m². *Zentralbl Chir*. 2009;134:43–49 [in German].
- Walid MS, Robinson JS Jr. Economic impact of comorbidities in spine surgery. *J Neurosurg Spine*. 2011;14:318–321.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 30 October 2018; accepted 18 February 2019

Citation: *World Neurosurg*. (2019) 127:e108–e113.
<https://doi.org/10.1016/j.wneu.2019.02.165>

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

1878-8750/\$ - see front matter © 2019 Published by Elsevier Inc.