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Understanding the Impact of Obesity on Short-term Outcomes and In-hospital Costs After Instrumented Spinal Fusion

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Abstract

Background—Obesity rates continue to rise along with the number of obese patients undergoing elective spinal fusion.

Objective—To evaluate the impact of obesity on resource utilization and early complications in patients undergoing surgery for degenerative spine disease.

Methods—A single institution retrospective analysis was conducted on degenerative spine disease patients requiring instrumentation, between 2008 and 2012. The 801 identified patients were grouped based on a body mass index (BMI) of < 30 (non-obese, n=478), ≥ 30 and < 40 (obese, n=283), and alternatively BMIs of ≥ 40 (morbidly obese, n=40). Baseline characteristics, surgical outcomes and requirements, complications, and cost were compared. Logistic and linear regression analyses were used to determine the strength of association between obesity and outcomes for categorical and continuous data, respectively.

Results—Significant differences were found in co-morbidities between cohorts. Multivariate analysis revealed significant associations between obesity and longer anesthesia times (30 min, p=.008), and surgical times (24 min, p=.02). Additionally, there was a 2.8 times higher rate of wound complications in obese patients (4.2% vs. 1.5, p=.03), and 2.5 times higher rate of major medical complications (7.8% vs. 3.1, p=.01). Morbid obesity resulted in a 10 times higher rate of wound complications (p<.001). Morbid obesity resulted in a $9,078 (p=.005) increase in overall cost of care.

Conclusion—Increased BMI is associated with longer operative times, increased complication rates, and increased cost independent of co-morbidities. These effects are more pronounced with morbidly obese patients, further supporting a role for preoperative weight loss.

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Keywords

obesity; spine; fusion; cost; outcomes; complications

Introduction

Obesity in the United States has become a major public health issue in the past few decades. There is increasing literature to suggest that obesity is associated with a number of adverse health outcomes, and further increases risk of complications and cost in surgical patients [1-8]. Yet, obese individuals are increasingly opting for elective spine surgery [9]. It is, therefore, imperative to understand the impact of obesity on these patients' operative and peri-operative course.

Recent studies aimed at addressing this question have focused on overall outcomes based on inpatient sample databases, which are limited by the accuracy and detail of coding [10-12]. As such, the extent to which obesity affects outcomes and resource utilization remains unclear due to conflicting evidence in the literature [10-13]. Given that surgeons are increasingly withholding surgery from patients with body habitus or body mass index above certain thresholds, more detailed studies examining these factors are warranted.

Herein, we present a study examining the impact of obesity and morbid obesity on resource utilization, complications, and cost following elective surgery for degenerative spine disease requiring instrumentation, at a quaternary referral center.

Methods

Data was collected using the OR Data Mart, an internal procedure database that assembles clinical and administrative data of each patient by accessing the electronic medical record to obtain the user-defined parameters [14, 15]. Operative logs of surgical cases between 2008 and 2012 at our institution were reviewed in accordance with Institutional Review Board protocols, and all patients undergoing spine surgery requiring instrumentation during the defined study period were included. The data was then abstracted, compiled, and manually reviewed for quality control. Over that period, 801 patients were identified that underwent surgery for degenerative spine disease requiring instrumentation. Patients were categorized as non-obese (body mass index, BMI < 30), obese (BMI ≥ 30 and < 40), or morbidly obese (BMI ≥ 40) for comparisons.

Complications were determined by reviewing both morbidity and mortality logs and retrospective review of all electronic medical records. Standard definitions of minor and major complications were applied to avoid reporter bias as previously suggested by Ratliff et al[16]. A minor complication was defined as any adverse event that transiently resulted in detrimental effects, which required limited or no further intervention. A major complication was defined as an adverse event that resulted in permanent detrimental effects or required significant operative or medical intervention. Complications were then further subclassified as neurologic, medical, anesthetic, and wound related (dehiscence and/or infection). The definition outlined by the Center for Disease Control was used to define superficial and deep wound infections[17]. With the exception of infections, adverse events had to occur within 30 days of the index surgery to be considered a complication. Other reasons for reoperation such as incomplete surgical decompression, instrumentation failure, pseudoarthroses, proximal junctional kyphosis, and adjacent segment disease were considered treatment failures. A durotomy was not in itself considered a complication unless it resulted in the need for further wound revision (e.g. pseudomeningocele or cerebrospinal fluid fistula) or further untoward consequences such as meningitis or remote cerebellar hemorrhage. Temporary neurologic deficits (e.g. C5 palsies) and dysphagia were deemed minor unless patients failed to demonstrate improvement of deficits at subsequent follow-up. Morbidity and mortality logs at our institution are maintained prospectively by the surgical team and are updated to include adverse events occurring 6 months after the index surgery. All electronic records were screened further for complications potentially missed in morbidity and mortality logs using the above definitions. Records of patients experiencing a reported complication were reviewed to ensure the definition of a complication was met and were then subcategorized.

Demographics of the study cohort were performed assessing baseline characteristics such as age, co-morbidities using Charlson Score, Society of Anesthesiologists (ASA) class, extent of surgery, and use of interbody spacers. Short-term outcomes (within 30 days) examined were major and minor complications following surgery, in addition to peri- and postoperative resource utilization, including anesthesia and surgical times. Data from patients undergoing two-staged procedures were combined into a single event to avoid duplication.

An internal institutional database was used to determine differences in cost between patient cohorts. This source details the institutional acquisition cost of every resource utilized throughout a patient visit, with each cost standardized to the value listed for the current fiscal year. These values were extracted for each fusion event and classified as operating room cost (all costs incurred on the day of the procedure(s) excluding the value for the hospital room required post-procedure) or hospitalization cost (the remainder of the costs incurred until discharge and the hospital room required post-procedure).

Statistical analysis was performed using JMP Pro 9.03 software with the assistance of institutional biostatisticians at the Center for Clinical and Translational Science (CCaTS). Chi-squared and t-tests were used to assess significance of categorical and continuous variables, respectively. Multivariate logistic and linear regression was then used to determine the strength of associations for statistically significant univariate categorical and continuous comparisons, respectively. The Odds Ratio was calculated for categorical variables to determine the odds of a particular outcome occurring based on BMI status. P-values of less than or equal to .05 were considered significant.

Results

Baseline Characteristics

Analysis of baseline characteristics of the cohort of 801 patients (Table 1) revealed 478 non-obese patients compared to 283 obese patients and 40 morbidly obese patients. Average ages of obese, non-obese, and morbidly obese patients were 61.1, 59.6, and 57.7 years, respectively (p=.1) (Table 1). Charlson Score distribution was significantly different between obese and non-obese patients, with a greater percentage of the former receiving higher Charlson Scores (p=.02) (Table 1). ASA class distribution also significantly differed between obese and non-obese patients (p<.001), with a greater percentage of obese patients in higher ASA classes than with non-obese patients (Table 1). The majority of non-obese and obese patient were ASA II (63.0% non-obese, 58.7% obese) (Table 1). The majority of morbidly obese patients, however, were Class III (72.5%) (Table 1). There was no difference in gender representation between the groups (p=.2) (Table 1). The majority of cases for all cohorts were thoracic and/or lumbar fusions (TLFs) (47.4% non-obese, 48.8% obese, 45.0% morbidly obese), then anterior cervical fusions (ACFs) (27.5%, 32.5%, and 37.5%, respectively), followed by posterior cervical fusions (PCFs) (Table 1). There was no significant difference in the regional distribution of spine procedures between groups (p=.2) (Table 1). Extent of surgery, as defined by number of levels of fusion, were similar among the 3 groups (p=.6) (Table 1). Also, there was no significant difference in the use of interbody spacers (43.5% non-obese, 49.8% obese, 52.5% morbidly obese, p=.8), or the mean number of spacers used per patient (p=.2) (Table 1).

Resource Utilization

When comparing the operative courses of obese and non-obese patients, a number of distinctions were observed. Both surgical times and anesthesia times were longer when comparing obese and non-obese patients (4.6 hr vs. 4.2, p=.02; 6.3 hr vs. 5.8, p=.008, respectively) (Table 2). No differences were seen in the intra-operative use of medications, including phenylephrine and epinephrine, or ICU admission rates postoperatively. Morbid obesity, on the other hand, resulted in increased ICU admission rates (40.0% vs. 22.6%, p=.03), but not ICU length of stays (1.3 days vs. 1.4, p=.7) compared to non-obese patients (Table 2).

Complications

There were similar rates of overall complications among the cohorts (20.5% non-obese, 22.3% obese, and 32.5% morbidly obese) (Table 3). Obese patients, however, had a significantly higher overall rate of wound infections (4.2% vs. 1.5%, p=.03), and in particular, deep infections (2.1% vs. .2%, p=.03), by multivariate analysis (Table 3). Major medical complications, including strokes, cardiac arrest, and acute kidney injury, were also increased in obese patients (7.8% vs. 3.1%, p=.01). Neurologic complications and durotomies did not significantly differ between groups (Table 3). There was also no significant difference in unintended events, which included occurrences such as wrong level surgeries, and retained instruments. Comparison of morbidly obese and non-morbidly obese patients demonstrated a similar pattern, with a 15% rate of both wound complications (p<.001) and major medical complications (p=.006) (Table 3).

Surgical Procedures and Complications

Thoracic/Lumbar fusion (TLFs) surgeries were associated with a significantly higher rate of complications in morbidly obese patients compared to non-obese patients, 22.2% vs. 1.3%, respectively (p<.001) (Table 4). In obese patients, TLFs were also associated with higher rates of complications, though this was not statistically significant (4.4% vs. 1.3%, p=.1) (Table 4). PCF complications were similarly increased in morbidly obese patients, approaching statistical significance (20.0% vs. .9%, respectively, p=.07).

Cost

There proved to be a significant increase in the mean operating room, hospital, and total cost differential associated with treatment of morbidly obese patients compared to non-obese patients ($6,153 p=.02; $2,925, p=.03; and $9,078 p=.005, respectively) (Table 5). Comparison of obese patients against non-morbidly obese did demonstrate an increase in cost differential, though this was not statistically significant (Table 5).

Discussion

Our results show that obesity plays a major role in the hospital course of obese patients, including increased procedure times and postoperative complications. Similarly, there is a significant increase in the cost associated with increased BMI. To our knowledge, this is the first study of this nature using an institutional electronic perioperative outcomes database with query algorithms established in prior literature[14,15]. By utilizing this methodology, inaccuracies in data collection were minimized, and we were able to reliably demonstrate the significant increase in complications and cost related to the performance of complex spine surgery on obese patients.

Prior studies have aimed at elucidating the role of obesity in spine surgery outcomes [10-12, 18-20]. Yet, its impact remains incompletely understood, in part due to the variability of the study methods and results obtained [6, 10, 12, 13, 21]. Kalanithi et al surveyed 84,607 California patients using an inpatient database and hospital codes to match procedures with morbid obesity [10, 11]. They found that morbid obesity (ICD-9-CM code 278.01) was significantly associated with higher in-hospital complication rates and lengths of stay, especially with anterior cervical fusions. In our dataset, we examined both the effects of obesity and morbid obesity on outcomes. Similarly to Kalanithi et al, an increase in complications was seen with morbid obesity. In addition, we show that even obesity increases the rate of complications. Whereas Kalanithi et al found longer lengths of stay in morbidly obese patients compared to patients of normal weight (absence of codes for greater than normal weight), interestingly, no such difference was seen in the present study. This may be due to differences in methodology of data collection, as we directly determined BMI for each patient as opposed to relying on the presence or absence of ICD-9 codes associated with weight. In addition, there may have also been differences in linear regression modeling used to account for additional co-morbidities, as we have seen that Charlson Score can independently be a strong predictor of outcomes.

We show here that both obesity and morbid obesity increased the rate of complications following surgery. Stratifying by surgical approach, we found that in morbidly obese patients, combined thoracic/lumbar fusions demonstrated the greatest risk of complications. This was possibly due to increased venous pressure leading to more bleeding and longer surgical times, increasing the risk of wound complications. In contrast, Kalanithi et al, found the strongest associations with morbidly obese patients undergoing anterior cervical and posterior lumbar fusions [10]. Similar to our study, Shamji et al demonstrated that perioperative complications following thoracolumbar fusions correlated with morbid obesity in their patient cohort [12]. A recent study by McClendon et al, analyzed outcomes in 112 patients undergoing 189 surgeries, and found that with longer-term follow-up of 1 year, there was an increase in complications in obese patients [18]. However, they limited their analyses to more extensive surgeries involving at least 5 level fusions, with a mean of 8 levels.

Prior studies analyzing resource utilization and cost associated with spine surgeries in obese patients compared to non-obese patients have demonstrated a trend of increased resource utilization in the former cohort [3, 21-24]. In the study presented here, we have, indeed, found overall costs and resources utilized were increased, as obese patients had longer operative and anesthesia times. Shamji et al in their review of over 240,000 patients found that obesity resulted in increased cost and transfusion requirements [12]. Interestingly, in our dataset, obesity did not show a significant increase in transfusion requirements of either fresh frozen plasma or platelets (data not shown). Conversely, non-fusion spine surgeries did demonstrate an increase in requirements for transfusion and vasoactive drugs (unpublished data). Buerba et al did not find a significant association between obesity and resource utilization, including operating time, length of stay, and transfusions, during anterior and posterior cervical fusions [13]. This difference may be in part due to their stratification of obesity for anterior cervical fusion cohorts, which could have decreased the power of the analyses. We found an increase in overall costs associated with morbidly obese patients compared to non-obese patients. This is likely due to the combination of increased procedure times, length of stay, and resources used to treat complications.

Comparing the hospital courses of obese and morbidly obese patients revealed significant differences that could have a substantial impact on resource utilization and costs associated with spine fusions in these populations. While both groups had longer anesthesia and surgical times, morbid obesity was associated with increased ICU admission rates. Therefore, if possible, encouragement of weight loss prior to elective surgery could potentially have a significant effect on overall complication rates and resource utilization costs, in addition to the overall health benefits associated with healthy weight. This study lends further information for preoperative counseling for obese patients undergoing elective spinal fusion, although the ultimate decision to perform surgery should remain individualized between the patient and the surgeon.

Limitations

Although these findings convincingly demonstrate significant differences in the perioperative course between obese and non-obese patients, they are limited by the retrospective design and confinement to a single institution. As such, results may be biased by patient demographics and nuances of institutional practice. Additionally, this study focused on outcomes and complications in the immediate postoperative period. Future studies employing this methodology of data collection to examine long-term outcomes would be useful. Although a relatively large population was sampled for this study, stratification of patients into subclasses occasionally resulted in groups with a small sample size. Therefore, certain statistically non-significant comparisons may possibly be due to low power rather than lack of a true difference.

Conclusion

We demonstrate that obesity and morbid obesity significantly impact the perioperative care for patients undergoing spine fusions. Specifically, obesity results in increased operative times, increased postoperative complications, and overall costs associated with the procedure, which is even greater in morbidly obese patients compared to obese patients. As such, preoperative counseling should take into account these factors when appropriate. Follow-up studies are warranted to assess the long-term outcomes of such patients in an effort to gain a better understanding of the factors that will maximize the benefit of surgery.

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Table 1

Demographics of patient cohort

	Non-obese	Obese	Morbidly Obese	p-value
Age (years)	**61.1**	**59.6**	**57.7**	**.1**
Male/Female (%)	**48.5/51.5**	**43.8/56.2**	**57.5/42.5**	**.2**
Charlson Score				.02*
0	69.9 (334)	58.0 (164)	62.5 (25)	
1	17.4 (83)	22.6 (64)	17.5 (7)	
2	8.8 (42)	10.6 (30)	10.0 (4)	
3	2.3 (11)	6.0 (17)	7.5 (3)	
≥4	1.6 (8)	2.8 (8)	2.5 (1)	
ASA[a] (%)				<.0001*
Class I	3.3 (16)	0.7 (2)	0 (0)	
Class II	63.0 (301)	58.7 (166)	27.5 (11)	
Class III	33.3 (159)	39.2 (111)	72.5 (29)	
Class IV	0.4 (2)	1.4 (4)	0 (0)	
Extent of Surgery (# of Levels)				.6
1	42.3 (202)	44.9 (127)	40.0 (16)	
2	28.5 (136)	23.0 (65)	37.5 (15)	
3	12.1 (58)	13.8 (39)	5.0 (2)	
4	7.1 (34)	7.1 (20)	7.5 (3)	
5	3.3 (16)	5.3 (15)	2.5 (1)	
≥6	6.7 (32)	6.0 (17)	7.5 (3)	
Interbody Spacers				
%Used	43.5 (208)	49.8 (141)	52.5 (21)	.8
# of Spacers				.2
1	62.5 (130)	61.4 (86)	65.0 (13)	
2	30.8 (64)	31.4 (44)	35.0 (7)	
≥3	6.7 (14)	7.1 (10)	0 (0)	
Procedure				.2
ACF	27.5 (131)	32.5 (92)	37.5 (15)	
PCF	22.4 (107)	17.3 (49)	12.5 (5)	
Combined A/P	2.7 (13)	1.4 (4)	5.0 (2)	
TLF	47.4 (226)	48.8 (138)	45.0 (18)	

[a]American Society of Anesthesiologists Classification: I= healthy patient, II= mild systemic disease, III=severe systemic disease, IV= severe systemic disease that is a constant threat to life

Table 2

A comparison of time oriented outcomes in non-obese, obese, and morbidly obese individuals using multivariate linear and logistic regression

	Non-obese	Obese	Morbidly Obese
Anesthesia time* mean, hr (95% CI) *p-value* Coefficient (95% CI)	5.8 (5.7, 6.0) Reference Reference	6.3 (6.1, 6.5) .008* .4 (.07, .8)	6.5 (5.9, 7.1) .08 .6 (-.2, 1.4)
Surgical time* mean (hr) (95% CI) *p-value* Coefficient (95% CI)	4.2 (4.1, 4.4) Reference Reference	4.6 (4.4, 4.8) .02* .4 (.03, .7)	4.6 (4.0, 5.2) .3 .3 (-.4, 1.1)
ICU[a] Admission Rate* mean (%) *p-value* Odds Ratio (95% CI)	22.6 Reference Reference	25.8 .6 1.1 (.8, 1.6)	40.0 .03* 2.2 (1.1, 4.3)
ICU[a] Length of stay mean (days) (95% CI) *p-value* Coefficient (95% CI)	1.4 (1.1, 1.7) Reference Reference	1.5 (1.2, 1.8) .7 .09 (-.4, .6)	1.3 (.5, 2.0) .7 -.1 (-1.0, .7)
Hospital Length of stay mean (days) (95% CI) *p-value* Coefficient (95% CI)	3.7 (3.4, 3.9) Reference Reference	3.9 (3.6, 4.2) .5 .1 (-.3, .6)	4.3 (3.4, 5.1) .3 .5 (-.5, 1.5)

[a]Intensive Care Unit

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Table 3

A comparison of complications in non-obese, obese, and morbidly obese individuals

	Non-obese	Obese	Morbidly Obese
Overall Complications (%) Odds Ratio (95% CI) p-value	20.5 (98) Reference	22.3 (63) 1.0 (.7, 1.5) .9	32.5 (13) 1.7 (.8, 3.5) .1
Wound Infections or Dehiscence (%)* Odds Ratio (95% CI) p-value	1.5 (7) Reference	4.2 (12) 2.8 (1.1, 7.6) .03*	15.0 (6)4) <.001*
Deep Infections (%)* Odds Ratio (95% CI) p-value	.2 (1) Reference	2.1 (6) 7.2 (1.2, 138.7) .03*	2.5 (1) 7.7 (.3, 209.7) .2
Major Medical Complications (%)* Odds Ratio (95% CI) p-value	3.1 (15) Reference	7.8 (22) 2.4 (1.2, 4.8) .01*	15.0 (6) 4.9 (1.6, 13.2) .006*
Unintended Events (%) Odds Ratio (95% CI) p-value	.6 (3) Reference	1.4 (4) 2.1 (.4, 10.7) .3	2.5 (1) 3.7 (.2, 30.2) .3
Neurologic Complications (%) Odds Ratio (95% CI) p-value	12.6 (60) Reference	9.5 (27) .7 (.4, 1.1) .1	7.5 (3) .5 (.1, 1.6) .3
Durotomy (%) Odds Ratio (95% CI) p-value	2.1 (10) Reference	2.8 (8) .7 (.4, 1.1) .1	5.0 (2) .5 (.1, 1.6) .3

Table 4

A comparison of wound complications in non-obese, obese, and morbidly obese individuals by surgical procedure

	Non-obese	Obese	Morbidly Obese
ACF[a] Complications (%, n) Odds Ratio (95% CI) p-value	2.3 (3) Reference	3.3 (3) 1.4 (.2, 7.9) .7	6.7 (1) 2.5 (.1, 22.1) .5
PCF[b] Complications (%, n) Odds Ratio (95% CI) p-value	.9 (1) Reference	4.1 (2) 4.0 (.4, 89.3) .3	20.0 (1) 19.4 (.6, 629.3) .07
TLF[c] Complications (%, n)* Odds Ratio (95% CI) p-value	1.3 (3) Reference	4.4 (6) 2.8 (.7, 13.8) .1	22.2 (4) 16.9 (3.2, 97.9) <.001*

[a]Anterior cervical fusion;

[b]Posterior cervical fusion;

[c]Thoracic and/or Lumbar spinal fusion

Table 5

A comparison of cost differences among non-obese, obese, and morbidly obese individuals

	Non-Obese	Obese	Morbidly Obese	
Operating Room Cost ($)	32,412	33,832	38,566*	
Cost Differential ($)		1,420	6,153	
p-value			.02	
Hospitalization Cost ($)	4,336	5,2.287	7,261*	
Cost Differential ($)		951	2,925	
p-value		.2	.03	
Total Cost ($)	36,748	39,119	45,827*	
Cost Differential ($)		2,370	9,078	
p-value		.1	.005	