Spine

SPINE Volume 37, Number 11, pp 982–988

HEALTH SERVICES RESEARCH

Morbid Obesity Increases Cost and Complication Rates in Spinal Arthrodesis

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Study Design. A retrospective cross-sectional study of all spinal fusions in California from 2003 to 2007.

Objective. This study analyzes whether morbid obesity alters rates of complications and charges in patients undergoing spinal fusion.

Summary of Background Data. Prior studies of obesity have focused on lumbar fusion; some identified increases in wound complications. However, these studies typically do not account for comorbidities, do not examine nonlumbar fusions, and usually are small single institution series.

Methods. Our study used the Healthcare Cost and Utilization Project's California State Inpatient Databases (CA-SID) to identify normal weight and morbidly obese patients admitted in California between 2003 and 2007 for 4 types of spinal fusion: anterior cervical fusion (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] procedure code 810.2), posterior cervical fusion (810.3), anterior lumbar fusion (810.6), and posterior lumbar fusion (810.8). Demographic, comorbidity, and complications data were collected. Primary outcome was in-hospital complication; secondary outcomes were total cost, length of stay, and in-hospital mortality. Multivariate logistic regression was performed.

Results. In total 84,607 admissions were identified, of which 1455 were morbidly obese. Morbid obesity was associated with 97% higher in-hospital complication rates (13.6% *vs.* 6.9%), sustained across nearly all complication types (cardiac, renal, pulmonary, wound complications, among others). Mortality among the morbidly obese was slightly higher (0.41 *vs.* 0.13, $P < 0.01$) as were average hospital costs ($108,604 *vs.* $84,861, $P < 0.0001$). Length of stay was longer as well (4.8 d *vs.* 3.5 d, $P < 0.0001$). All effects were less pronounced in posterior cervical fusions. On multivariate analysis, morbid obesity was the most significant predictor of complications in the anterior cervical and posterior lumbar fusion groups (more than age, demography, and other comorbidity).

Conclusion. Morbid obesity seems to increase the risk of multiple complication types in spinal fusion surgery, most particularly in anterior cervical and posterior lumbar approaches.

Key words: obesity, spinal fusion, complications, database, charges, outcomes. **Spine 2012;37:982–988**

Morbid obesity has been increasing worldwide, with the World Health Organization declaring a global epidemic in 1997. Morbid obesity, or World Health Organization Class III obesity, is defined as body mass index ≥40. In the United States and other developed countries, morbid obesity has been particularly rapid in its increase.[1] Among its many ill effects, it has been linked to increased incidence of back pain and spinal degeneration. Obesity may be correlated with spine degeneration, particularly lumbar.[2,3] In addition, several studies on the effect of obesity on general and cardiac surgery outcomes have found higher complication rates, particularly in wound infections.[4,5]

As obesity prevalence increases, obese patients may present to spine surgeons in increasing numbers, and specific questions regarding treatment cost and complication risk in this population require answers. The current literature contains studies that suggest that obesity may increase complications, particularly wound infections, in lumbar fusions.[6–9] Importantly, obesity does not seem to limit the benefit of surgical interventions.[9,10] However, several areas remain incompletely explored.

First, in an increasingly cost-conscious climate, documentation of health care resource utilization is necessary. One small study of 43 patients undergoing lumbar interbody fusions suggested a 70% higher cost for obese patients.[11] Only 1 large database study examined this issue in spine surgery and was limited to lumbar fusion only, without accounting for other comorbidities.[7] Second, although benefits may not be reduced by obesity, risks may be increased. Patients need to be advised of increased risk of complications; because most spine surgical procedures are elective, risks must be carefully studied and discussed with patients. No substantial data seem to exist outside of lumbar fusions; no studies on the impact of obesity on cervical fusion seem to exist. Finally, because morbidly obese patients represent a different body habitus than a normal-weight patient, different surgical approaches (*e.g.*, anterior *vs.* posterior) may be differentially affected by obesity.

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Acknowledgment date: December 21, 2010. First revision date: July 19, 2011. Acceptance date: September 28, 2011.

The manuscript submitted does not contain information about medical device(s)/drug(s).

No funds were received in support of this work.

No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

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DOI: 10.1097/BRS.0b013e31823bbeef

TABLE 1. Patient and Procedure Characteristics and Univariate Analysis on the Presence of 1 or More In-Hospital Complications After Spinal Fusion Surgery

	Patients	(%)	*P*
Demographic			
Age			<0.0001*
<65 yr	63,770	(75.37)	
65 yr or older	20,837	(24.63)	
County of residence			<0.0001*
Large metropolitan (>1 million)	58,527	(69.36)	
Small metropolitan (<1 million)	22,137	(26.24)	
Micropolitan	2590	(3.07)	
Other	1122	(1.33)	
Expected payer			<0.0001*
Medicare	23,243	(27.48)	
MediCal	3118	(3.69)	
Private insurance	39,293	(46.45)	
Self-pay	396	(0.47)	
Other	18,537	(21.91)	
Race			<0.0001*
White	62,229	(77.95)	
Black	3576	(4.48)	
Asian or Pacific Islander	10,326	(12.94)	
Native American	37	(0.05)	
Other	1189	(1.49)	
Sex			0.0006*
Male	38,729	(46.41)	
Female	44,723	(53.59)	
Weight			<0.0001*
Normal weight	83,152	(98.28)	
Morbidly obese	1455	(1.72)	
Procedure			<0.0001*
Anterior cervical fusion	40,109	(47.41)	
Posterior cervical fusion	3410	(4.03)	
Anterior lumbar fusion	5470	(6.47)	
Posterior lumbar fusion	35,618	(42.10)	
Health factors			
Elixhauser Comorbidity Score			<0.0001*
0	36,659	(43.33)	
1	24,842	(29.36)	
2	14,127	(16.70)	
3	5873	(6.94)	
4 or more	3106	(3.67)	

**P < 0.05 is significant.*

This study presents a broad survey of cost and complications in multiple types of spinal fusion: anterior cervical, posterior cervical, anterior lumbar, and posterior lumbar. The goals of this study are to clarify the comparative risk of complication of different approaches, including cervical, which have not yet been studied.

MATERIALS AND METHODS

Data Source and Inclusion Criteria

Our study used the Healthcare Cost and Utilization Project's California State Inpatient Databases (CA-SID) to identify normal weight and morbidly obese patients admitted for spinal fusion surgery in California between 2003 and 2007. The CA-SID contains hospital discharge data from more than 90% of California community and noncommunity (*e.g.*, federal) hospitals; its reliability has been demonstrated in several studies.[12–14] The primary procedure field was used to identify 4 types of spinal fusion, as follows: anterior cervical fusion (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] procedure code 810.2), posterior cervical fusion (810.3), anterior lumbar fusion (810.6), and posterior lumbar fusion (810.8). All nondegenerative diagnoses were excluded: congenital deformity (740.0–759.9); infection (730.00–730.99, 324.1); inflammatory spine disease (720.0–720.9); pregnancy (630–676); neoplasia (140.0–239.9); trauma (800–899.9), and postlaminectomy syndrome (722.8). In addition, occipital and C1–C2, thoracic, and any re-do fusions were not included. Patients were included only if they were diagnosed as morbidly obese (*ICD-9-CM* diagnosis code 278.01) or were determined to be of normal weight as imputed by the absence of a diagnosis of underweight, overweight, or obesity (*i.e.*, the absence of diagnosis codes 783.22, 278.0, 278.00, 278.01, and 278.02).

Recorded Data

Age, race, sex, weight group, procedure level, surgical approach, urban-rural designation of patient's county of residence, expected payer, in-hospital mortality, in-hospital postoperative complications, total hospital charges, and length

TABLE 2. Mean Total Charges and Length of Stay in Days, Overall, and for Each Fusion Cohort

Procedure	Overall	Normal Weight	Morbidly Obese	Difference	*P*
Mean total charges					
Anterior cervical fusion	$59,652	$59,450	$73,967	$14,517	<0.0001*
Posterior cervical fusion	$101,387	$100,716	$146,219	$45,503	0.0108*
Anterior lumbar fusion	$110,200	$109,699	$139,922	$30,223	<0.0001*
Posterior lumbar fusion	$108,985	$108,569	$128,661	$20,092	<0.0001*
Overall	$85,265	$84,861	$108,604	$23,743	<0.0001*
Length of stay in days					
Anterior cervical fusion	2.26	2.25	3.34	1.09	<0.0001*
Posterior cervical Fusion	5.10	5.07	7.24	2.17	0.0032*
Anterior lumbar fusion	4.29	4.27	5.41	1.14	<0.0001*
Posterior lumbar fusion	4.70	4.68	5.75	1.07	<0.0001*
All	3.53	3.51	4.85	1.34	<0.0001*

**P < 0.05 is significant.*

of stay were recorded. Comorbidity was assessed using the Elixhauser method, a well-established technique for identifying comorbidities from administrative databases such as CASID.[15] We excluded morbid obesity as a comorbidity. Total comorbidity score was determined for each case by adding 1 point per comorbidity (maximum possible, 28). Postoperative complications were identified by *ICD-9-CM* diagnosis codes as follows: renal (584, 584.9, 997.5), cardiac (997.1, 410–410.91), neurological (997.00–997.09), deep vein thrombosis or pulmonary embolism (415.1, 415.11, 415.19, 451.1, 451.11, 451.19, 451.2, 451.81, 451.9, 453.40–453.42 453.8, 453.9), pulmonary (507.0, 518.4, 518.5, 518.81, 518.82, 997.3–997.39), wound complications (998.1–998.7, 998.9), and infection (038, 320, 510–510.9, 513.1, 519.2, 590.1, 590.80, 683). To calculate complication rates, total numbers of complications were divided by total number of patients. During multivariate analysis, the race variable was reclassified; Native Americans were grouped with "Other" because of small numbers in the former. Primary outcome was in-hospital complication; secondary outcomes were total cost, length of stay, and in-hospital mortality.

Statistical Analysis

Select covariates were tested for significance in predicting the presence of 1 or more in-hospital complications by the χ^2 test or Fisher exact test, as appropriate. A multivariate logistic regression model was fit for each of the 4 spinal fusion procedure types to see whether morbid obesity remained a significant predictor of in-hospital complications. Variables were included in the multivariate analysis if their *P* value on univariate analysis was less than 0.15. A *P* value of less than 0.05 was considered significant. All calculations were performed using SAS software (version 9.2; SAS Institute, Inc., Cary, NC) running on Windows XP Pro.

RESULTS

Demography

A total of 84,607 hospitalizations were considered in the study. This includes patients identified as only morbidly obese or patients without a weight diagnosis, presumed to be normal weight. Ninety-eight percent of patients were of normal weight, with 2% morbidly obese (n = 1455). Large numbers

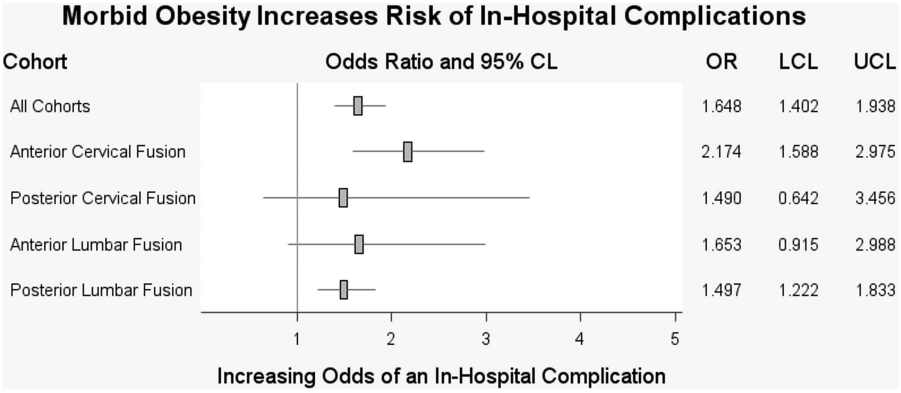

Figure 1. Morbid obesity is associated with higher rates of in-hospital complications for all spinal fusions in California, 2003–2007. CL indicates confidence limit; OR, odds ratio; LCL, lower confidence limit; UCL, upper confidence limit. Confidence limits set to 95%.

TABLE 3. Multivariate Logistic Regression of Predictors of In-Hospital Complications After Spinal Fusion

	Odds Ratio	95% CI
All fusion cohorts		
Age	1.021	1.019–1.024*
Morbidly obese *vs.* normal weight	1.648	1.402–1.938*
Elixhauser comorbidity score	1.389	1.359–1.419*
Anterior cervical fusion		
Age	1.029	1.024–1.034*
Morbidly obese *vs.* normal weight	2.174	1.588–2.975*
Elixhauser comorbidity score	1.648	1.579–1.721*
Posterior cervical fusion		
Age	1.012	1.001–1.022*
Morbidly obese *vs.* normal weight	1.490	0.642–3.456
Elixhauser comorbidity score	1.469	1.350–1.600*
Anterior lumbar fusion		
Age	1.019	1.011–1.027*
Morbidly obese *vs.* normal weight	1.653	0.915–2.988
Elixhauser Comorbidity Score	1.524	1.405–1.652*
Posterior lumbar fusion		
Age	1.020	1.017–1.022*
Morbidly obese *vs.* normal weight	1.497	1.222–1.833*
Elixhauser comorbidity score	1.277	1.243–1.312*

**Statistically significant.*

of patients had each surgical procedure (minimum: 3410 for posterior cervical fusion; maximum: 40,109 for anterior cervical fusion.) Most patients were younger than 65 years (75%), and the plurality had no comorbidities (43%). Female patients were slightly predominant (54%). On univariate analysis, all demographic factors seemed to significantly impact complication rates. See Table 1 for full data.

Hospital Charges and Length of Stay

Morbid obesity was associated with higher hospital charges, on average 28% per admission, at an increased cost of $23,743. All procedures showed markedly higher charges in morbidly obese patients. Morbid obesity, similarly, was associated with increased length of stay. The average stay was 3.5 days in normal-weight patients but 4.8 days in morbidly obese patients. This disparity was consistent across all procedure types (Table 2).

Comorbidities and Mortality

Morbidly obese patients had approximately 1 more comorbidity than normal-weight patients (1.93% *vs.* 1.05%, $P < 0.001$). This analysis excluded morbid obesity in the comorbidity count. Mortality in morbidly obese patients was slightly higher than in normal-weight patients (0.8% *vs.* 0.3%, $P = 0.0002$). In subgroup analysis by procedure type, no statistical difference was noted in mortality, with the exception of posterior lumbar fusions (0.56% *vs.* 0.16%, $P = 0.0169$).

Complications

Morbid obesity was associated with a higher complication rate than being of normal weight (13.6% *vs.* 6.9%, see Table 4). When procedure cohorts were analyzed separately, the effect persisted in both anterior cervical and posterior lumbar fusions. The higher complication rate was not statistically significant in anterior lumbar or posterior cervical fusion (Figure 1). The effect sizes of obesity in anterior cervical and posterior lumbar fusions were as large, if not larger, as any other factor, including age or comorbidity score (Table 3). Both age and comorbidity score are well-established predictors of complications; these data suggest that, in this population, morbid obesity may play an important role. Furthermore, morbid obesity was analyzed as a separate variable, suggesting that its impact may not be simply due to increased comorbidities associated with obesity.

When divided into types of complications by organ system, statistically significant higher rates of complications were seen in nearly all subtypes in morbidly obese patients. The most common complication type in normal-weight patients was wound complications (3.4%); the most common complication type in morbidly obese patients was wound complications (6.0%), with pulmonary complication second (5.8%). These effects were similar in both anterior cervical and posterior lumbar fusions (Table 4).

DISCUSSION

Morbid obesity and obesity, generally, are rapidly increasing throughout the world. Morbid obesity likely will be seen with increasing frequency by spine surgeons. Data regarding this patient population will be necessary to understand both the risks that the individual patient may experience and the overall costs to the health care system.

Our data present a broad survey of the impact of obesity on spinal fusion surgery. Hospital charges are significantly higher for morbidly obese patients than normal-weight patients, on average 27% higher. A portion of the increase in charges results from longer hospital stays (~2 d longer) as well as higher rates of complications. These data support the notion that morbidly obese patients, for the same treatment, use significantly greater amounts of health care resources; in addition, these data provide a magnitude for this increase.

Beyond the cost to the system, however, morbid obesity seems to be associated with a higher surgical risk to the patient. Two studies have demonstrated increased general complication rates in obese patients in the setting of lumbar

TABLE 4. Percentage of Patients With Specific In-Hospital Complications, Overall and by Weight Group After All Spinal Fusions, Anterior Cervical Fusion, and Posterior Lumbar Fusion

Complication	Overall	Weight Group		Odds Ratio (95% CI)
		Normal	Morbidly Obese	
Cohort: All				
Any	7.05	6.94	13.61	2.1129 (1.8145–2.4603)*
Cardiac	0.78	0.77	1.17	1.8065 (1.2865–2.5368)*
DVT/PE	0.35	0.33	1.10	3.3387 (2.0115–5.5415)*
Infection	0.15	0.14	0.27	1.9235 (0.7093–5.2165)
Neurological	0.58	0.57	1.24	2.1756 (1.3550–3.4932)*
Pulmonary	2.02	1.95	5.84	3.1167 (2.4899–3.9012)*
Renal	0.91	0.89	2.20	2.4976 (1.7465–3.5717)*
Wound complication	3.41	3.36	5.98	1.8284 (1.4674–2.2783)*
Cohort: Anterior cervical fusion				
Any	3.32	3.24	9.29	3.0579 (2.2864–4.0898)*
Cardiac	0.41	0.40	0.89	2.2460 (0.9185–5.4925)
DVT/PE	0.17	0.16	0.89	5.5581 (2.2284–13.8631)*
Infection	0.12	0.12	0.18	1.5362 (0.2115–11.1591)
Neurological	0.25	0.24	0.89	3.7024 (1.5009–9.1334)*
Pulmonary	1.44	1.39	4.64	3.4524 (2.3084–5.1634)*
Renal	0.43	0.42	1.07	2.5387 (1.1197–5.7563)*
Wound complication	1.09	1.07	3.04	2.9028 (1.7744–4.7486)*
Cohort: Posterior lumbar fusion				
Any	10.76	10.63	16.42	1.6516 (1.3583–2.0083)*
Cardiac	1.15	1.16	1.06	0.9158 (0.4531–1.8506)
DVT/PE	0.46	0.45	1.19	2.6841 (1.3655–5.2759)*
Infection	0.16	0.16	0.13	0.8394 (0.1160–6.0733)
Neurological	1.01	0.99	1.59	1.6112 (0.9020–2.8779)
Pulmonary	2.33	2.25	5.96	2.7478 (2.0165–3.7445)*
Renal	1.42	1.39	2.91	2.1364 (1.3849–3.2957)*
Wound complication	5.86	5.81	7.95	1.3985 (1.0702–1.8274)*

**Statistically significant (nonoverlapping 95% confidence intervals).*

DVT/PE indicates deep vein thrombosis/pulmonary embolism.

or thoracic fusions, with complications rates of 36% and 67%.[6,8,16] Multiple studies have demonstrated higher wound complication rates among obese patients in spine surgery, generally, and thoracolumbar fusions in spinal deformity.[17,18] A national database study of lumbar and thoracolumbar fusions demonstrated similar findings, with increased risk of certain complications in obese and morbidly obese patients, particularly in posterior approaches; this is despite not controlling for other comorbidities.[7] In this study, a moderately higher risk of complication was noted with morbid obesity, even after controlling for comorbidities (odds ratio [OR] = 1.5). The absolute increase in complication rate was 6.7%, largely accounted for by increases in pulmonary (3.9% absolute increase, OR = 3.1) and wound complications (2.6% absolute increase, OR = 1.8).

However, several studies of minimally invasive techniques in the lumbar spine, including minimally invasive extreme lateral fusion, have found no association.[19–21] This study is not able to distinguish between minimally invasive and open approaches. The possibility remains that minimally invasive

approaches may reduce risk to morbidly obese patients. Further studies are needed to clarify.

One study of the impact of obesity on anterior lumbar fusions, a single institution retrospective case review of 74 patients, found no correlation between obesity and complications.[22] This study is similarly unable to find a statistically significant correlation between morbid obesity and anterior lumbar fusion. Further prospective data are needed to clarify whether this is due to inadequate sample, surgeon selection bias, or true absence of increased risk.

In contrast, morbid obesity was highly correlated with complication rate in anterior cervical fusion (OR = 2.2). This seemed to be as or more significant than all other comorbidities combined (OR = 1.6), or any demographic factor. Within the complication subanalysis, similar to the posterior lumbar fusion cohort, morbid obesity has an absolute higher risk of complication of 6.0%, the majority of which is increases in pulmonary (absolute increase of 3.2%, OR = 3.5) and wound complications (increase of 2.0%, OR = 2.9).

Although the size and breadth of our sample provide a reasonable estimation of the impact of morbid obesity in spinal fusions, multiple caveats are necessary. The data's precision depends on *ICD-9* coding. However, inaccurate or absent coding of morbid obesity would result in morbidly obese patients being included in the normal-weight category, which would dampen the effects noted here. One study of *ICD 9* codes in spine surgery demonstrated similar overall rates of complications compared with a prospective method, even demonstrating superiority with respect to cardiac complications.[23] However, *ICD-9* codes were also prone to greater error regarding surgical complications. In addition, *ICD-9* codes cannot take into account additional factors that may impact complication rates and outcomes (disease severity, type of interbody graft or instrumentation, number of levels fused, *etc.*). These data include only in-hospital events, so late complications, such as wound infections, are likely under-represented. Similarly, it does not account for fusion procedures occurring in an ambulatory setting, which may exclude some patients undergoing anterior cervical fusions. Although a large study, there may be variations in complication rates in different portions of the country. Finally, this was not a randomized study and cannot control for decisions made by individual surgeons and individual patients. Because of this, it cannot be used to effectively compare the merits of different approaches to the spine. Because *ICD-9* codes give only broad categorizations, these data provide a broad perspective, and caution should be used to avoid overinterpretation.

Despite demonstrating increased risk of complication, morbid obesity does not seem to represent a contraindication to surgical intervention. Indeed, in-hospital mortality in morbidly obese patients in this study was less than 1%, and in-hospital complication rates, even when defined broadly, were under 15%. Reduction of risk to these patients remains an important goal, and further studies are needed to identify the best methods. The currently available literature suggests that minimally invasive approaches may hold promise.

These limitations notwithstanding, this study provides valuable data on the impact of obesity and complications in spinal fusion. First, it provides an overview of the impact of morbid obesity on complications in spinal fusions for a large population, which may better represent routine clinical practice than studies limited to academic centers. Second, it confirms prior studies assessing the impact of obesity on posterior lumbar fusion, confirming an increase in wound complications, as well as identifying risks of other complications. Third, it identifies, for the first time, the impact of morbid obesity on anterior cervical fusions, which had the strongest effects of any subgroup. Further work on anterior cervical fusions and obesity may be fruitful to pursue, as might direct comparisons between open and minimally invasive approaches in obese patients. In addition, this study broadly identifies areas of increased health care resource utilization and areas for risk reduction. Taken together, this will, along with future studies, allow a more informed public policy debate, enhance informed consent, improve patient selection, and eventually, result in greater patient safety.

➢ Key Points

- ❑ Morbid obesity is associated with increases in many types of complications in spinal fusion, particularly pulmonary and wound problems.
- ❑ In posterior lumbar and anterior cervical approaches, morbid obesity was associated with significant increases in complication rates, which was as or more predictive than age or all other comorbidities combined.
- ❑ Hospital charges, length of stay, and mortality were all increased in morbidly obese patients.

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