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Complications following Surgery for Lumbar Stenosis in a Veteran Population

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Abstract

Study Design—Secondary analysis of the prospectively collected Veterans Affairs National Surgical Quality Improvement Program (VASQIP) database.

Objective—Determine rates of major medical complications, wound complications, and mortality among patients undergoing surgery for lumbar stenosis; and examine risk factors for these complications.

Summary of Background Data—Surgery for spinal stenosis is concentrated among older adults, for whom complications are more frequent than among middle-aged patients. Many studies have focused on infections or device complications, but fewer have focused on major cardiopulmonary complications, using prospectively collected data.

Methods—We identified patients who underwent surgery for a primary diagnosis of lumbar stenosis between 1998 and 2009 from the VASQIP database. We created a composite of major medical complications, including acute myocardial infarction, stroke, pulmonary embolism, pneumonia, systemic sepsis, coma, and cardiac arrest.

Results—Among 12,154 eligible patients, major medical complications occurred in 2.1% ; wound complications in 3.2%; and 90-day mortality in 0.6%. Major medical complications, but not wound complications, were strongly associated with age. American Society of Anesthesiologists (ASA) class was a strong predictor of complications. Insulin use, chronic corticosteroid use, and preoperative functional status were also significant predictors. Fusion procedures were associated with higher complication rates than decompression alone. In logistic regressions, ASA class and age were the strongest predictors of major medical complications (OR for ASA class 4 vs. classes 1 or 2: 2.97, 95% CI 1.68, 5.25, p=0.0002). After adjustment for comorbidity, age, and functional status, fusion procedures remained associated with higher medical complication rates than decompression alone (OR 2.85, 95% CI 2.14, 3.78, p<0.0001).

Conclusion—ASA class, age, type of surgery, insulin or corticosteroid use, and functional status were independent risk factors for major medical complications. These factors may help in selecting patients and planning procedures, improving patient safety.

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Keywords

spinal stenosis; lumbar stenosis; lumbar fusion; Complications; surgical complications; postoperative mortality; prediction rule; patient safety; risk prediction; receiver operating characteristic (ROC)

INTRODUCTION

With growing attention to patient safety, complications of spinal surgery have come under closer examination. This concern is especially important among older patients, for whom complications are more common than in younger adults. Spinal stenosis is the most common diagnosis prompting spine surgery in older adults, and surgical rates have increased in this population.[1] Other studies of spine surgery complications have often focused on general populations, all diagnoses, or other single conditions rather than on older adults with lumbar stenosis.[2–6] Many studies have focused only on complications during the surgical hospitalization, or on specific types of complications, such as device complications or infections.[4–12] Relatively few have focused on the major medical complications that are more common in older adults. Further, these studies have generally not reported how accurately a risk factor, or combination of risk factors can distinguish between those who will have a complication, and those who will not.

One group previously reported on surgical complications for lumbar stenosis in the Medicare population,[13] but Medicare claims data have limited or no information on some important predictors of complications, such as patient functional status, smoking, and obesity. Furthermore, collection of complication data is not a specific aim of that database, is not performed proactively, and does not include adverse events identified outside the hospital.

The Veterans Health Administration (VA) initiated its National Surgical Quality Improvement Program in 1994, with the aim of prospectively collecting data on specific postoperative complications for all major surgery, along with detailed information on pre-operative health status. This database allowed us to examine complications identified within 30 days after surgery for spinal stenosis, and mortality within 90 days.

Our goals were:

1. To quantify rates of specific complications following surgery for lumbar stenosis
2. To examine how surgical complications varied with patient demographic characteristics, specific co-morbid conditions, and pre-operative functional status
3. To determine if complications varied by the nature of the index operation, independent of patient characteristics
4. To estimate the ability of a combination of preoperative risk factors to predict who will have major complications.

METHODS

Data Source

We obtained data from the VA Surgical Quality Improvement Program (VASQIP) for the years 1998–2009. To create VASQIP, research nurses at over 120 VA medical centers record a specific list of 21 possible complications, along with all ICD-9 complication codes. These are typically identified in the hospital and at follow-up visits. In addition, all patients

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assessed by VASQIP are sent a questionnaire that might identify adverse events cared for outside the VA system. Our data request included no individually identifiable information or actual dates of services. The project was approved by the Portland VA Medical Center IRB.

Patient Selection

We initially selected all patients in the VASQIP database with a primary diagnosis of lumbar stenosis (n=12,842), and identified those with Current Procedural Terminology (CPT) codes indicating lumbar discectomy, laminectomy, or fusion. We then excluded patients who had concurrent diagnoses of cancer, spinal infections, pregnancy, fractures, vertebral dislocations, vehicular trauma, cervical or thoracic spine surgery, or emergency cases. This resulted in an analytic dataset of 12,154 cases. We were unable to identify patients with co-existing operative diagnoses of spondylolisthesis or scoliosis to examine those in a stratified fashion.

American Society of Anesthesiologists (ASA) Physical Status classification

ASA class was that recorded in the clinical record. Definitions of the classes are: *Status 1* - A normal healthy patient; *Status 2* - A patient with mild systemic disease; *Status 3* - A patient with severe systemic disease; *Status 4* - A patient with severe systemic disease that is a constant threat to life; *Status 5* - A moribund patient who is not expected to survive without the operation; *Status 6* - A declared brain-dead patient whose organs are being removed for donor purposes

Complications

We tabulated many complications as they were recorded, using ICD-9-CM diagnosis codes. In addition, we created a composite variable for major medical complications that included VASQIP codes for cardiac arrest requiring cardiopulmonary resuscitation or repeat postoperative endotracheal intubation and mechanical ventilation, along with codes for myocardial infarction, respiratory failure, pulmonary embolism, pneumonia, systemic sepsis, coma, and stroke. We also created a composite variable for wound complications that included wound disruption, superficial infection, or deep wound infection. In VASQIP, postoperative deaths are verified against the VA's Beneficiary Identification and Records Locator System (BIRLS). A final composite variable for "life-threatening complications" included both major medical complications as listed above (within 30 days postoperative) *and* 90-day mortality.

Procedure characteristics

We used CPT codes to separately define cases with anterior fusion, posterior fusion, combined anterior and posterior fusion, multilevel fusions, instrumented fusions, decompression, and removal of hardware. In addition, we grouped procedures into larger categories of decompression alone, "simple fusion" (single level, anterior or posterior) or "complex fusion" (multilevel, or combined anterior and posterior).

Analysis

Categorical data were compared using chi-square tests, and continuous data using t-tests or Analysis of Variance. Logistic Regression was used to adjust data for multiple variables. The primary analysis used forward selection of variables, but the models were repeated using backward selection to determine if the same variables were selected. In addition to examining odds ratios for various risk factors, we examined the c-statistics that describe the ability of a set of variables to discriminate between those who will develop a complication and those who will not. The c-statistic represents the area under a receiver operating characteristic (ROC) curve.

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RESULTS

Patient Characteristics

Overall, 12,154 cases met our inclusion criteria. In this older veteran's population, 96% were men, and modal age was in the 60's. With regard to race, 66% were white, 11% Black, 13% were recorded as other race, and 9% were missing.

Overall complication rates

Our combined variable for major medical complications occurred in 2.1% of cases and wound complications occurred in 3.2% of cases (Table 1). Ninety-day mortality was 0.6%. Among major medical complications, pneumonia was the most common, followed by reintubation for respiratory or cardiac failure and systemic sepsis (Table 1).

Complications according to demographic features, functional health, and health habits

As expected, major medical complication rates rose substantially with age, from 0.7% among those under age 50 to 4.0% among those over age 80 (Table 2). Similarly, 90-day postoperative mortality increased substantially with age, from approximately 0.5% among those under age 50 to 1.7% among those aged 80 and over. Wound complications, in contrast, showed little trend with increasing age (Table 2). Variations in complications by race were relatively modest. However, functional dependence – even partial – was a major risk factor for major medical complications, wound complications, and mortality (Table 2). Smoking was only modestly associated with complications (Table 2). Men accounted for 96% of patients in this VA population and there were no statistically significant differences in complication rates between sexes. Alcohol use was also evaluated and no differences in complication rates were found between those who reported more than 2 drinks per day and those who did not.

Complications according to comorbid conditions

The ASA classification was a powerful predictor of complications (Table 3). There were relatively few patients in ASA class 1, so we combined classes 1 and 2 for purposes of multivariate analysis, and in this selection of patients having elective surgery, there were none in classes 5 or 6. Patients in class 1 had no reported major medical complications or mortality, whereas among those in class 4, 6.0% had major medical complications, and 90-day mortality was 3.8%. (Table 3).

Important specific comorbid medical conditions were diabetes, dyspnea with minimal exertion (or at rest), history of severe chronic obstructive pulmonary disease (COPD), and use of steroids for chronic disease. Among patients with diabetes, complication risk was only modestly increased among those receiving oral hypoglycemic medications, but more substantially increased among those using insulin. Patients using insulin had more than double the rate of major medical complications or mortality as compared to patients without diabetes or with diet-controlled diabetes (Table 3). Body Mass Index (BMI) greater or less than 30 was not a statistically significant predictor of major medical complications, wound complications or 90-day mortality. However, we note that BMI was not collected in VASQIP prior to 2005, so we had incomplete data for this analysis.

The risk of major medical complications nearly doubled for patients with dyspnea with minimal exertion or history of severe COPD, although risk of wound complications and death within 90 days were not substantially greater. The groups with dyspnea on minimal exertion and severe COPD are likely substantially overlapping. Compared to those not receiving corticosteroids, patients using steroids for a chronic condition had more than three times the rate of major medical complications and more than double the mortality rate.

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Complications according to features of the index operation

By our definitions, 10,291 (85.6%) operations were decompressions alone, and 1,728 (14.2%) involved a fusion procedure. Of the fusions, 1,020 (59.0%) were instrumented, and 695 (40.2%) were defined as complex fusions, meaning multi-level or combined anterior and posterior approaches (Table 4). We do not know what proportion of patients undergoing fusions may have had coexisting scoliosis or spondylolisthesis as secondary diagnoses. Fusion procedures as a group were associated with more major medical complications, wound complications, and 90-day mortality than decompressions alone. Complex fusions were associated with more major medical complications than simple fusions, but wound complications and mortality occurred at slightly lower rates.

Multivariate analyses

For logistic regression models, we considered those demographic, comorbid, and procedural variables that appeared most strongly associated with complications. We then allowed stepwise forward selection of variables. The strongest single predictor of major medical complications was age, followed by ASA class (Table 5). ASA class 4 (compared to combined classes 1 and 2) had an odds ratio of 2.97 (95% CI 1.68,5.25, p=0.0002). Other predictors of major medical complications included steroid use for a chronic condition, any fusion procedure, functional status, and insulin-dependent diabetes. In backward selection models, the selected variables and odds ratios were very similar, except that history of COPD was removed from the models.

The strongest predictor of mortality within 90 days was ASA Class followed by steroid use for a chronic condition, any fusion procedure, insulin-dependent diabetes, and functional status. When 90-day mortality rate and major medical complications were combined (life-threatening complications) the strongest predictors were again ASA Class, age, and steroid use for chronic condition.

Accuracy of prediction of complications

The multivariate models showed moderate ability to predict those who did and did not have complications by incorporating preoperative and operative (procedure choice) data. This was assessed by examining the area under the curve for receiver operating characteristic (ROC) curves predicting the occurrence of complications. An ROC curve is a plot of sensitivity (the proportion of patients with complications predicted by the model) versus 1-specificity (the proportion without complications that are incorrectly predicted to have complications). The area under this curve is a measure of the model's ability to discriminate patients with and without disease (or in this case, with or without complications).

The area under the curve (AUC) for major medical complications was 0.71, for 90-day mortality it was 0.76, and for the combination (life-threatening complications), it was 0.71. The ability of these variables to distinguish patients with and without wound complications was considerably weaker (AUC = 0.58). For context, a perfect AUC is 1.0, and a model with no discriminatory ability is 0.5. As a comparator, our AUC results of 0.71 to 0.76 for complications and 90-day mortality are similar to the discriminatory power of history-taking plus *H. Pylori* serology for predicting a peptic ulcer on endoscopy, [14] or the history and physical examination for identifying obstructive lung disease.[15]

DISCUSSION

In this older, largely male patient population, more than 2% had major medical complications or 90-day mortality. This emphasizes the importance of studying major

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medical complications of lumbar stenosis surgery, in addition to wound complications and device complications.

The best predictors of major medical complications after surgery for lumbar stenosis (highest odds ratios) were age, clinical judgment about the severity and impact of overall comorbidity (ASA class), use of steroids for a chronic condition, and use of a fusion procedure. Functional status was a significant but less powerful predictor of complication rates. A useful finding in this study was the significance of insulin-requiring diabetes as a predictor of complications, as compared to diabetes controlled with diet or oral agents alone. This confirms a trend reported elsewhere towards greater serious complications (but not minor complications) among insulin-using diabetics compared to non-insulin using diabetics.[16] As in reports from the National Surgical Quality Improvement Program (NSQIP) for non-VA hospitals, smoking status, chronic alcohol use, and BMI were relatively less important predictors of complications.[2] However, we note that data on BMI were incomplete.

As earlier studies have suggested,[3,13,17,18] the complexity of the surgical procedure was a significant predictor of major medical complications. The odds ratio for any fusion in this study compared to decompression (OR 2.85) was very close to that observed in a separate (Medicare) population (OR 2.64 for simple fusion and 2.98 for complex fusion).[2] Other predictors of major medical complications were similar to those in the Medicare population, with age, comorbidity, COPD, and surgical complexity proving important in both samples. Further, rates of specific key complications such as stroke, pulmonary embolism, postoperative sepsis, and cardiopulmonary complications were very similar to those observed in the non-VA NSQIP data.[2] As in that study, corticosteroid use was an important risk factor. We were not able to identify previous lumbar surgery in the VASQIP database, but this was another important predictor of both medical complications and wound complications in Medicare claims.[13]

Our data on wound complications in stenosis surgery are comparable to those reported for all spine operations using VASQIP data.[8] In that study, 3.04% of patients had a postoperative wound infection, comparable to our 3.6% rate of overall wound complications (including “wound disruption”). This rate is higher than reported in Medicare claims data (1.2%), but this may be a result of closer surveillance and proactive reporting in VASQIP, as well as a population with greater comorbidity. Other studies have reported very similar rates: from 2.0% to 3.8%.[9–12]

This study had the advantages of including many centers and surgeons, a large patient sample, and prospective collection of complication data by a dedicated nurse at each center.

However, there were also important imitations. This was a largely male population, and one with substantial comorbidity. Though the results may generalize to a large fraction of stenosis patients, it remains uncertain how well they generalize to a female population. Although 30-day follow-up was an advantage over examining in-hospital complications alone, it was too short to capture some complications such as instrumentation failures or iatrogenic instability. However, for the systemic complications that are a focus of VASQIP, this may be an appropriate follow-up interval. Capture of adverse events cared for outside the VA system may be less complete than for those treated within the VA system. Diagnoses and procedures may be miscoded, but this may be less likely in a database focused on surgical quality improvement than in an insurance claims database. Substantial missing data for some preoperative characteristics, such as body mass index or cardiac symptoms, precluded an examination of some specific comorbid conditions. We did not have data on previous spinal operations, or on patient outcomes other than complications. We were not

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able to identify possible secondary diagnoses that may have prompted fusion procedures, such as spondylolisthesis or scoliosis. Though we report treatment complications, we had no data on treatment efficacy, in terms of pain relief or functional recovery. Finally, patients of individual medical centers may resemble each other in their demographic features, clinical characteristics, and surgical outcomes. Such potential "clustering" effects were not considered in this analysis.

These results highlight the need for reporting major medical complications as well as device and wound complications when studying surgery for spinal stenosis. They also help to identify key risk factors, some of which (such as insulin use and corticosteroid use) are relatively novel risk factors. The results also support previous findings of risk factors for wound complications. The ROC prediction models, by combining easily acquired data such as patient age, medications, ASA class, functional dependence, comorbidity, and type of planned procedure, suggest that it may be possible to develop reasonable predictions for an individual likelihood of surgical complications. Such prediction rules might improve surgical planning, the patient consent process, and strategies for reducing risk.

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References

1. Rajaee SS, Bae HW, Kanim LEA, Delamarter RB. Spinal fusion in the United States. Analysis of trends from 1998 to 2008. Spine. 2012; 37:67–76. [PubMed: 21311399]
2. Schoenfeld AJ, Ochoa LM, Bader JO, Belmont PJ. Risk factors for immediate postoperative complications and mortality following spine surgery: a study of 3475 patients from the National Surgical Quality Improvement Program. J Bone Joint Surg Am. 2011; 93:1577–82. [PubMed: 21915571]
3. Lee MJ, Hacquebord J, Varshney A, et al. Risk factors for medical complication after lumbar spine surgery: a multivariate analysis of 767 patients.
4. Tormenti MJ, Maserati MB, Bonfield CM, et al. Perioperative surgical complications of transforaminal lumbar interbody fusion: a single-center experience. J Neurosurg Spine. 2012; 16:44–50. [PubMed: 21999389]
5. Shen Y, Silverstein JC, Roth S. In-hospital complications and mortality after elective spinal fusion surgery in the United States: a study of the nationwide inpatient sample from 2001–2005. J Neurosurg Anesthesiol. 2009; 21:21–30. [PubMed: 19098620]
6. Kalanithi PS, Patil CG, Boakye M. National complication rates and disposition after posterior lumbar fusion for acquired spondylolisthesis. Spine. 2009; 34:1963–69. [PubMed: 19652635]
7. Li G, Patil CG, Lad SP, Ho C, Tian W, Boakye M. Effects of age and comorbidities on complication rates and adverse outcomes after lumbar laminectomy in elderly patients. Spine. 2008; 33:1250–5. [PubMed: 18469700]
8. Veeravagu A, Patil CG, Lad SP, Boakye M. Risk factors for postoperative spinal wound infections after spinal decompression and fusion surgeries. Spine. 2009; 34:1869–1872. [PubMed: 19644339]

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9. Wimmer C, Gluch H, Franzreb M, Ogon M. Predisposing factors for infection in spine surgery: a survey of 850 spinal procedures. J Spinal Disord. 1998; 11:124–8. [PubMed: 9588468]
10. Olsen MA, Nepple JJ, Riew KD, Lenke LG, Bridwell KH, Mayfield J, Fraser VJ. Risk factors for surgical site infection following orthopaedic spinal operations. J Bone Joint Surg Am. 2008; 90:62–69. [PubMed: 18171958]
11. Abbey DM, Turner DM, Warson JS, Wirt TC, Scalley RD. Treatment of postoperative wound infections following spinal fusion with instrumentation. J Spinal Disord. 1995; 8:278–83. [PubMed: 8547767]
12. Levi AD, Dickman CA, Sonntag VK. Management of postoperative infections after spinal instrumentation. J Neurosurg. 1997; 86:975–980. [PubMed: 9171176]
13. Deyo RA, Mirza SK, Martin BI, Kreuter W, Goodman DC, Jarvik JG. Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults. JAMA. 2010; 303:1259–1265. [PubMed: 20371784]
14. Weijnen CF, Numand ME, de Wit NJ, Smout AJPM, Moons KGM, Verheij TJM, Hoes AW. Testing for *Helicobacter pylori* in dyspeptic patients suspected of peptic ulcer disease in primary care: cross sectional study. Br Med J. 2001; 323:71–5. [PubMed: 11451780]
15. Holleman DR, Simel DL. Quantitative assessments from the clinical examiniation. How should clinicians integrate the numerous results? J Gen Intern Med. 1997; 12:165–171. [PubMed: 9100141]
16. Glassman SD, Alegre G, Carreon L, Dimar JR, Johnson JR. Perioperative complications of lumbar instrumentation and fusion in patients with diabetes mellitus. Spine J. 2003; 3:496–501. [PubMed: 14609695]
17. Fritzell P, Hagg O, Nordwall A. Swedish Lumbar Spine Study Group. Complications in lumbar fusion surgery for chronic low back pain: comparison of three surgical techniques used in a prospective randomized study. Eur Spine J. 2003; 12:178–189. [PubMed: 12709856]
18. Mirza SK, Deyo RA, Heagerty PJ, et al. Development of an index to characterize the "invasiveness" of spine surgery: validation by comparison to blood loss and operative time. Spine. 2008; 33:2651–2661. [PubMed: 18981957]

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KEY POINTS

1. Relatively few studies have focused on the major systemic postoperative complications (as opposed to wound or device complications) that are more common in older adults, for whom spinal stenosis is the most common surgical indication.
2. We used prospectively collected data from the VA Surgical Quality Improvement Program (VASQIP) for the years 1998–2009 to study major medical complications, wound complications, and 90-day mortality in 12,154 adults having surgery for spinal stenosis.
3. Major medical complications occurred in 2.1% ; wound complications in 3.2%; and 90-day mortality in 0.6%. ASA class, age, type of surgery, insulin or corticosteroid use, and functional status were independent risk factors for major medical complications.
4. Receiver operating characteristic (ROC) curves were used to test the ability of combining patient age, medications, ASA class, functional dependence, comorbidity, and type of procedure performed to predict the occurrence of complications. The area under the curve (AUC) was over 0.7 for major medical complications and for 90-day mortality. Such prediction rules might improve surgical planning, the patient consent process, and strategies for reducing risk.

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Table 1

Overall complication rates, veterans having surgery for a primary diagnosis of spinal stenosis, 1998–2009, n=12,154.

Complication	Number with complication (%)
Return to OR	403 (3.3)
Urinary tract infection	202 (1.7)
Death within 90 days	79 (0.6)
Congestive heart failure in 1 month after surgery	73 (0.6)
Progressive renal insufficiency	23 (0.2)
Acute renal failure	11 (0.1)
Peripheral nerve injury	12 (0.1)
Bleeding requiring >4 units RBCs	7 (0.1)
Included in "major medical complication" composite	**253 (2.1)***
Pneumonia	81 (0.7)
Systemic sepsis	78 (0.6)
Reintubation for respiratory or cardiac failure	71 (0.6)
Myocardial infarction	40 (0.3)
Failure to wean >48 hours	38 (0.3)
Cardiac arrest requiring CPR	36 (0.3)
DVT/thrombophlebitis	27 (0.2)
Pulmonary embolism	19 (0.2)
Cerebrovascular accident/stroke	9 (0.1)
Coma >24 hours	4 (0.0)
Included in "wound complication" composite	**391 (3.2)***
Superficial infection	225 (1.9)
Deep wound infection	147 (1.2)
Wound disruption	41 (0.3)

* Total number of patients in these composites is not the sum of individual complications as some patients had more than one complication.

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Table 2

Major medical complications, wound complications, and mortality following surgery for lumbar stenosis, by patient demographic characteristics, functional status, and health habits.

Characteristic	Values	n	Major Medical Complications, n (%)	Wound Complications, n (%)	90-day mortality, n (%)	Life - Threatening Complications, n (%)†
Overall sample		12154	253 (2.1)	391 (3.2)	79 (0.6)	286 (2.4)
Age category	<50	1487	**11 (0.7)‡**	**60 (4.0)‡**	**7 (0.5)‡**	**16 (1.1)‡**
	50–59	3580	**53 (1.5)**	**113 (3.2)**	**11 (0.3)**	**60 (1.7)**
	60–69	3752	**79 (2.1)**	**108 (2.9)**	**19 (0.5)**	**83 (2.2)**
	70–79	2734	**86 (3.2)**	**90 (3.3)**	**32 (1.2)**	**99 (3.6)**
	≥80	601	**24 (4.0)**	**20 (3.3)**	**10 (1.7)**	**28 (4.7)**
Race/ethnicity*	White	8050	177 (2.2)	264 (3.3)	51 (0.6)	197 (2.5)
	Black	1346	28 (2.1)	45 (3.3)	13 (1.0)	33 (2.5)
	Other	1639	24 (1.5)	52 (3.2)	8 (0.5)	30 (1.8)
Functional Health status	Independent	11670	**228 (2.0)‡**	369 (3.4)	**70 (0.6)‡**	**257 (2.2)‡**
	At least partially dependent	484	**25 (5.2)**	22 (4.5)	**9 (1.9)**	**29 (6.0)**
Smoker within past year**	No	7872	171(2.2)	**231 (2.9) ‡**	55 (0.7)	191(2.4)
	Yes	4248	81(1.9)	**157 (3.7)**	24 (0.6)	94(2.2)

*1119 cases (9.2%) missing

**34 cases (0.3%) missing

†Life-threatening complications included the category of major medical complications within 30 days or death within 90 days (often co-existing)

‡Differences among categories are statisfically significant (p<0.05)

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Table 3

Major medical complications, wound complications, and mortality following surgery for lumbar stenosis, by patient comorbid conditions

Characteristic	Values	n	Major Medical Complications, n (%)	Wound Complications, n (%)	90-day mortality, n (%)	Life - Threatening Complications, n (%)†
ASA Class	1	124	**0 (0)‡**	**2 (1.6)‡**	**0 (0)‡**	**0 (0)‡**
	2	4168	**52 (1.3)**	**111 (2.7)**	**17 (0.4)**	**59 (1.4)**
	3	7546	**182 (2.4)**	**265 (3.5)**	**50 (0.7)**	**204 (2.7)**
	4	316	**19 (6.0)**	**13 (4.1)**	**12 (3.8)**	**23 (7.3)**
Diabetes*	None or diet only	9807	**188 (1.9)‡**	305 (3.1)	**52 (0.5)‡**	**210 (2.1)‡**
	Oral agents	1551	**33 (2.1)**	50 (3.2)	**16 (1.0)**	**41 (2.6)**
	insulin	762	**31 (4.1)**	33 (4.3)	**11 (1.4)**	**34 (4.5)**
Steroid use for chronic condition	No	11922	**239 (2.0)‡**	381 (3.2)	**74 (0.6)‡**	**270 (2.3)‡**
	Yes	232	**14 (6.0)**	10 (4.3)	**5 (2.1)**	**16 (6.9)**
Dyspnea with minimal exertion**	No	10852	**208 (1.9)‡**	339 (3.1)	**68 (0.6)‡**	**237 (2.2)‡**
	Yes	1256	**42 (3.3)**	52 (4.1)	**11 (0.9)**	**46 (3.7)**
History of severe COPD	No	10886	**210 (1.9)‡**	342 (3.1)	73 (0.7)	**241 (2.2)‡**
	Yes	1268	**43 (3.4)**	49 (3.9)	6 (0.5)	**45 (3.6)**

*34 cases (0.3%) missing

**46 cases (0.4%) missing

†Major medical complications within 30 days or death within 90 days (often coexisting)

‡Differences among categories are statistically significant ($p<0.05$)

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Table 4

Major medical complications, wound complications, and mortality following surgery for lumbar stenosis, by characteristics of the index operation

Surgical Characteristic	n*	% of all operations	% of all fusions	Major Medical Complications n (%)	Wound Complications n (%)	90-day mortality n (%)	Life - Threatening Complications† n (%)
Decompression alone‡	10291	85.6	---	178 (1.7)	309 (3.0)	58 (0.6)	202 (2.0)
Simple fusion	1033	8.6	59.8	38 (3.7)	46 (4.5)	14 (1.4)	44 (4.3)
Complex fusion	695	5.8	40.2	34 (4.9)	28 (4.0)	5 (0.7)	36 (5.2)
Instrumented fusion	1020	8.4	59.0	47 (4.6)	42 (4.1)	12 (1.2)	52 (5.1)
Non-instrumented fusion	708	5.9	41.0	25 (3.5)	32 (4.5)	7 (1.0)	28 (4.0)
Any fusion procedure	1728	14.2	100	72 (4.2)	74 (4.3)	19 (1.1)	80 (4.6)

*135 cases (1.1%) missing

†Major medical complications within 30 days or death within 90 days (often coexisting)

‡Differences between decompression alone and any type of fusion were statistically significant ($p < 0.05$), but differences between types of fusion were not.

Simple fusion is defined as single level, anterior or posterior approach.

Complex fusion is defined as multilevel fusion or combined anterior and posterior approach.

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Table 5

Logistic regression results for major medical complications, death within 90 days, and life-threatening complications (n=11987)* Odds Ratios in bold differ significantly from 1.0 ($p < 0.05$).

Variable	Values	Medical complications, OR (95% CI)	Death within 90 days, OR (95% CI)	Life -Threatening Complications OR (95% CI)
ASA Class	1 or 2	1.0	1.0	1.0
	3	**1.41 (1.01, 1.96)**	1.20 (0.66, 2.18)	**1.43 (1.05, 1.96)**
	4	**2.97 (1.68,5.25)**	**6.01 (2.65, 13.6)**	**3.35 (1.98, 5.67)**
Age category	<50 years	1.0	1.0	1.0
	50–59	1.79 (0.92, 3.48)	0.57 (0.21, 1.51)	1.36 (0.77, 2.40)
	60–69	**2.31 (1.20, 4.44)**	0.82 (0.33, 2.05)	1.62 (0.92, 2.83)
	70–79	**3.67 (1.90, 7.08)**	1.90 (0.78, 4.62)	**2.81 (1.61, 4.91)**
	≥80	**4.58 (2.17, 9.67)**	2.32 (0.80, 6.71)	**3.40 (1.80, 6.55)**
Functional status	Independent	1.0	1.0	1.0
	At least partially dependent	**1.96 (1.26, 3.06)**	**2.18 (1.06, 4.52)**	**2.06 (1.36, 3.11)**
History of severe COPD	No	1.0	1.0	1.0
	Yes	1.37 (0.97, 1.94)	0.53 (0.23, 1.24)	1.25 (0.90, 1.76)
Diabetes	None or diet only	1.0	1.0	1.0
	Oral agent	0.94 (0.64, 1.38)	1.60 (0.88, 2.90)	1.07 (0.75, 1.51)
	Insulin	**1.80 (1.21, 2.69)**	**2.25 (1.14, 4.47)**	**1.78 (1.22, 2.62)**
Surgery class	Decompression	1.0	1.0	1.0
	Any fusion	**2.85 (2.14, 3.78)**	**2.32 (1.36, 3.95)**	**2.81 (2.14, 3.68)**
Steroid use for chronic condition	No	1.0	1.0	1.0
	Yes	**2.77 (1.57, 4.90)**	**3.55 (1.39, 9.05)**	**2.91 (1.70, 4.98)**

*167 cases (1.4%) deleted due to missing values for 1 or more variables