



Assessing the differences in outcomes between general and non-general anesthesia in spine surgery: Results from a national registry



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ABSTRACT

Objectives: Endotracheal/general anesthesia is one of the most commonly used anesthetic techniques when performing thoracic and lumbar surgeries. However, spinal and epidural (non-general) anesthesia have been increasingly employed for lumbar decompressions (LD) and lumbar fusion recently. The objective of this study was to investigate the outcomes of general and non-general anesthesia in patients undergoing posterior lumbar fusion (PLF) and LD using a national registry.

Patients and Methods: ACS-NSQIP database was queried to identify patients who underwent LD or PLF with general or non-general anesthesia between 2011–2015. Patient characteristics and postoperative variables were compared. Multivariable regression was used to identify predictors of thirty-day readmission, any complication and length of stay (LOS). Three-to-one propensity-score matching and conditional logistic regression were used to adjust for potential bias.

Results: A total of 60,222 patients who underwent LD were identified; 59,876 (99.4%) received general anesthesia and 342 (0.6%) were given non-general anesthesia. On multivariable conditional regression, type of anesthesia was found to have no significant effect on any of the outcomes analyzed (Readmission: OR:0.90, $p = 0.79$; Any Complication: OR:0.75, $p = 0.75$; LOS: Coef.:0.18, $p = 0.35$). A total of 31,419 patients who underwent PLF were identified; 31,377 (99.9%) were given general anesthesia and 42 (0.1%) were given non-general anesthesia. Anesthesia type had no significant effect on any of the outcomes analyzed (Readmission: OR:0.78, $p = 0.83$; Any Complication: OR:0.50, $p = 0.40$; LOS: Coef.:0.17, $p = 0.68$).

Conclusion: Our analysis showed that non-general anesthesia had equivalent outcomes with respect to readmission, LOS and complications compared to general anesthesia in patients undergoing LD or PLF. While the choice of anesthesia type remains a matter of preference, our results show that non-general anesthesia may be practiced safely and is associated with equivalent outcomes.

1. Introduction

Thoracic and lumbar spine surgeries can be performed under different anesthetic techniques, with general endotracheal anesthesia being the most commonly used [1]. Some of the benefits of general anesthesia include the ability to maintain the anesthetic throughout long surgical procedures, the safety of a secure airway, and patient tolerance [2,3]. However, neuraxial (non-general) anesthesia has become more commonly used for laminectomies and discectomies and

includes either spinal or epidural anesthesia. Benefits of neuraxial anesthesia include reduction in intraoperative hypertension and tachycardia, reduced hospital length of stay, reduced PACU pain scores, and reduced nausea and vomiting ultimately resulting in improved cost of care [4,5]. There is a paucity of literature comparing non-general and general anesthesia in spine surgery. Previous studies have compared the outcomes between the two techniques for lumbar laminectomies and discectomy using single institutional data and have shown that non-general anesthesia is associated with equivalent or superior outcomes,

Abbreviations: ACS-NSQIP, American College of Surgeons - National Surgical Quality Improvement Program; ASA, American Society of Anesthesiologists; BMI, Body Mass Index; COPD, chronic obstructive pulmonary disease; CPT, Current Procedural Terminology; LD, Lumbar Decompression; OR, Odds Ratio; PLF, Posterior Lumbar Fusion; PUF, Participant Use Data File; SMD, Standardized Mean Difference; Std. Diff., Standardized Difference

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such as lower blood loss and better perioperative hemodynamic stability [6–8].

The objective of the present study is to compare clinical and surgical outcomes between general and non-general (spinal and epidural) anesthesia for patients undergoing posterior lumbar fusion and lumbar decompression using a national registry. We hypothesized that there are no difference in any complications or readmissions between patients undergoing the two anesthetic techniques, but non-general anesthesia will result in shorter length of stay (LOS)

2. Patients and methods

2.1. Data source

For this study, we queried the American College of Surgeons - National Surgical Quality Improvement Program (ACS-NSQIP). ACS-NSQIP receives data from more than 200 hospitals in the United States and keeps track of patients' demographics, comorbidities, as well as 30-day postoperative complications [9]. To ensure reliable data, ACS randomly samples cases from each hospital and continues to inspect their data [9,10].

2.2. Patient cohort

Using Current Procedural Terminology (CPT) codes, patients who underwent lumbar decompression, lumbo-sacral decompression, posterior lumbar fusion or lumbosacral fusion with general anesthesia, spinal anesthesia, or epidural anesthesia between 2011 and 2015 were included in this study. All included CPT codes are presented in the supplementary material table (Supplemental Digital Content 1). Patients diagnosed with vertebral fractures, cysts, or tumors have been excluded from this study. To correctly exclude these cases, the PODIAG and PODIAGTX variables were used [11].

2.3. Patient characteristics

Patient demographics included sex, age and race. Recorded preoperative comorbidities included body mass index (BMI), functional status, inpatient/outpatient procedure, smoker, weight loss (greater than 10% within the last 6 months), diabetes, dyspnea, chronic obstructive pulmonary disease (COPD), currently on dialysis, bleeding disorder, open or infected wound, and preoperative blood transfusion. Operative variables include American Society of Anesthesiologists (ASA) class, wound class, and operative time.

2.4. Primary predictor

Anesthesia type was assessed based on the ANESTHES variable, which codes for principal anesthesia technique, from NSQIP Participant Use Data File (PUF) [9]. Entries containing "General" were included in general anesthesia group, while entries containing "Spinal" or "Epidural" were included in non-general anesthesia.

2.5. Outcomes

Thirty-day postoperative complications included bleeding, transfusions, superficial wound infection, deep wound infection, organ space infection, wound dehiscence, pneumonia, unplanned intubation, deep-vein thrombosis, failure to wean from ventilator, pulmonary embolism, renal insufficiency, acute renal failure, urinary tract infection, stroke, coma, peripheral nerve injury, cardiac arrest, myocardial infarction, graft/implant failure, sepsis, septic shock, reoperation, mortality, and readmission. In addition, operative time, length of stay, discharge destination, and reason for readmission were recorded.

2.6. Statistical analysis

Preoperative patient characteristics, comorbidities and postoperative complications were compared between general and non-general anesthesia groups stratified by procedure type, i.e., decompression and posterior fusion. To account for confounding and to attenuate selection bias [12], three-to-one propensity score calculation was performed. Cases were matched based on age, sex, BMI, outpatient procedure and ASA class [13]. As per Rubin's recommendations, matching was considered sufficient if the standardized differences in the means of propensity scores were found to be less than 0.25 [14]. Demographic and operative variables were compared between the two anesthesia techniques after matching by calculating standardized means differences (SMDs) for continuous variables and standardized difference (std. diff.) in proportions for categorical variables. T-tests could not be used due to the violation of the assumption of independence between the compared groups [15].

For the unmatched cohort, multivariable logistic regression was used to assess the odds of 30-day complications with variables available in NSQIP for each procedure type separately. These outcomes included: readmission and any complication. Any complication is defined if the patient had any of the following: blood transfusion during or within 72 h of surgery, superficial wound infection, deep wound infection, organ space infection, wound dehiscence, pneumonia, unplanned intubation, deep vein thrombosis, failure to wean from ventilator, pulmonary embolism, renal insufficiency, acute renal failure, urinary tract infection, stroke, coma (more than twenty four hours), peripheral nerve injury, cardiac arrest, myocardial infarction, graft/implant failure, sepsis, septic shock, reoperation within thirty days, and mortality [11]. Multivariable linear regression was used for the outcome length of stay. For the matched cohort, conditional logistic and linear regressions were used [16]. Statistical analysis was performed using STATA 15 (StataCorp. 2017. *Stata Statistical Software: Release 15*. College Station, TX: StataCorp LP). P-values < 0.05 are considered to be statistically significant, and standardized differences > 0.10 are considered to be statistically different.

3. Results

3.1. Lumbar decompression

A total of 60,222 patients were identified who underwent lumbar decompression; 59,876 (99.4%) were given general anesthesia and 342 (0.6%) were given non-general anesthesia. Fourteen of the 35 preoperative and operative variables were significantly different. Therefore, propensity score matching was used to reduce selection bias. After adjustment, none of the variables used for matching (age, sex, BMI, outpatient procedure and ASA class) was statistically significant. Additionally, median operative time was longer for patients who were given general anesthesia (91 vs 72 min, SMD = 0.37). Patient characteristics of the unmatched and matched cohorts are contained in [Table 1](#). Postoperative complications of the cohorts are contained in [supplementary table \(Supplementary Digital Content 2\)](#).

Anesthesia type was not found to have a statistically significant effect on any of the outcomes (readmission: OR: 0.70, 95% CI: 0.34–1.41, $p = 0.32$; any complication: OR: 0.48, 95% CI: 0.20–1.16, $p = 0.10$; LOS: Coef.: -0.20, 95% CI: -0.68 to 0.25, $p = 0.36$, respectively). Male patients had a lower risk of readmission (OR: 0.92, $p = 0.039$), of any complication (OR: 0.82, $p < 0.001$), and a shorter length of stay (Coef.: -0.27, $p < 0.001$) than female patients. Older patients had a higher risk of readmission (OR: 1.02, $p < 0.001$), of any complication (OR: 1.02, $p < 0.001$), and a longer hospital stay (Coef.: 0.02, $p < 0.001$); this is the same for patients with higher BMI (OR: 1.02, $p < 0.001$; OR: 1.04, $p < 0.001$; Coef.: 0.02, $p < 0.001$, respectively). Other independent variables and their results from regression are shown in [Table 2](#).

Table 1
Patient Demographics, Preoperative and operative variables for those who underwent Lumbar Decompression.

Variables	Unmatched			Matched		
	General Anesthesia (n = 59,876)	Non-general Anesthesia (n = 346)	SMD	General Anesthesia (n = 1000)	Non-general Anesthesia (n = 341)	SMD
Age, mean (SD)	56.5 (15.9)	50.2 (15.3)	0.396	49.58 (16.2)	50.23 (15.1)	0.041
Female sex, n(%)	25,477 (42.6)	149 (43.1)	0.012	445 (44.5)	147 (43.1)	0.028
Race, n(%)						
White	49307 (82.4)	302 (87.3)	0.129	827 (82.7)	298 (87.4)	0.128
African American	3750 (6.2)	16 (4.62)	0.066	62 (6.2)	16 (4.7)	0.064
Other	1733 (2.9)	2 (0.58)	0.139	22 (2.2)	2 (0.6)	0.121
Unknown	5086 (10.5)	26 (7.5)	0.076	89 (8.9)	25 (7.3)	0.057
BMI, mean (SD)	30.3 (6.42)	29.0 (5.54)	0.203	28.95 (5.96)	29 (5.52)	0.009
BMI, median (range)	29.4 (10.5–137.3)	28.2 (17.9–50.7)	N/A	28.4 (10.6–64.2)	28.2 (17.9–50.7)	N/A
Functional Status (dependent) (%)	928 (1.55)	1 (0.29)	0.102	6 (0.60)	1 (0.30)	0.046
Outpatient (%)	29,680 (49.6)	233 (67.3)	0.354	664 (66.4)	230 (67.4)	0.022
Smoker within 1 year (%)	2659 (21.1)	59 (17.1)	0.098	217 (21.7)	58 (17.0)	0.119
Alcohol use (%)	141 (0.24)	1 (0.29)	0.01	1 (0.10)	1 (0.30)	0.084
Steroid use (%)	2163 (3.61)	8 (2.31)	0.07	33 (3.30)	8 (2.30)	0.058
Weight loss (%)	112 (0.19)	2 (0.58)	0.089	1 (0.10)	2 (0.60)	0.083
Diabetes (%)	9563 (16.0)	25 (7.22)	0.24	100 (10.0)	25 (7.30)	0.095
Dyspnea (%)	2490 (4.16)	10 (2.89)	0.064	27 (2.70)	10 (2.90)	0.014
COPD (%)	2037 (3.40)	8 (2.31)	0.06	16 (1.60)	7 (2.10)	0.034
Dialysis (%)	105 (0.18)	2 (0.58)	0.094	0 (0)	1 (0.30)	0.077
Bleeding disorder (%)	866 (1.45)	2 (0.58)	0.073	10 (1.00)	2 (0.60)	0.047
Open wound/wound infection (%)	183 (0.31)	1 (0.29)	0.004	2 (0.20)	1 (0.30)	0.019
Preoperative blood transfusion (%)	30 (0.05)	0 (0)	0.022	1 (0.10)	0 (0)	0.045
Operative Variables						
ASA Class (%)						
1	4478 (7.48)	65 (18.8)	0.429	204 (20.4)	63 (18.5)	0.048
2	32644 (54.5)	221 (63.9)	0.189	603 (60.3)	221 (64.8)	0.093
3	21627 (36.1)	58 (16.8)	0.402	189 (18.9)	56 (16.4)	0.065
4	1056 (1.76)	1 (0.29)	0.112	4 (0.40)	1 (0.30)	0.016
5	1 (0.002)	1 (0.29)	0.477	0 (0)	0 (0)	.
Not assigned	70 (0.12)	0 (0)	0.035	0 (0)	0 (0)	.
Wound class 1 or 2 (%)	59,747 (99.8)	345 (99.7)	0.022	2 (0.20)	1 (0.30)	0.019
Mean operative time (min, SD)	102.2 (62.4)	72.3 (47.1)	0.48	90.9 (56.7)	72.0 (46.1)	0.365
Median operative time (median, range)	87 (0–1111)	62 (22–607)	N/A	80 (15–759)	62 (22–607)	N/A
Emergency (%)	942 (1.57)	3 (0.87)	0.056	13 (1.30)	3 (0.90)	0.04

After running conditional regression, anesthesia was found to have no significant effect on any of the outcomes analyzed (readmission rate: OR: 0.90, 95% CI: 0.40–2.00, $p = 0.79$; any complication OR: 0.75, 95% CI: 0.28–2.04, $p = 0.75$; Coef.: LOS 0.18; 95% CI: -0.20 to 0.57, $p = 0.35$, respectively). Results from propensity score matching are shown in supplementary table and figure (Supplementary Digital Content 3 and Supplementary Digital Content 4, respectively).

3.2. Posterior lumbar fusion

A total of 31,419 patients were identified who underwent posterior lumbar fusion; 31,377 (99.9%) were given general anesthesia and 42 (0.1%) were given non-general anesthesia. Eighteen of the 35 preoperative and operative variables were significantly different. Therefore, propensity score matching was used to reduce selection bias. After adjustment, none of the variables used for matching (age, sex, BMI, outpatient procedure and ASA class) was statistically significant. Additionally, median operative time was longer for patients who were given general anesthesia (208 vs 181 min, SMD = 0.30). Patient characteristics of the unmatched and matched cohorts are contained in Table 3. Postoperative complications of the cohorts are contained in supplementary table (Supplementary Digital Content 5).

Anesthesia technique was not found to have a statistically significant effect on any of the outcomes (readmission: OR: 0.42, 95% CI: 0.006 to 3.07, $p = 0.39$; any complication: OR: 0.76, 95% CI: 0.18–3.19, $p = 0.71$; length of stay: Coef.: 0.06, 95% CI: -1.30 to 1.43, $p = 0.93$, respectively). Male patients had a lower risk of readmission (OR: 0.92, $p = 0.039$), of any complication (OR: 0.82, $p < 0.001$), and a shorter length of stay (Coef.: -0.27, $p < 0.001$) than female patients.

Older patients had a higher risk of readmission (OR: 1.02, $p < 0.001$), of any complication (OR: 1.02, $p < 0.001$), and a longer hospital stay (Coef.: 0.02, $p < 0.001$); this is the same for patients with higher BMI (OR: 1.02, $p < 0.001$; OR: 1.04, $p < 0.001$; Coef.: 0.02, $p < 0.001$, respectively). More results are shown in Table 4.

After running conditional regression, anesthesia still had no significant effect on any of the outcomes analyzed (OR: 0.78, 95% CI: 0.08–7.34, $p = 0.83$; OR: 0.50, 95% CI: 0.11–2.38, $p = 0.40$; Coef.: 0.17; 95% CI: -0.65 to 0.99, $p = 0.68$, respectively). Results from propensity score matching are shown in supplementary table and figure (Supplementary Digital Content 6 and Supplementary Digital Content 7, respectively).

4. Discussion

Although general anesthesia is the technique used in most lumbar surgeries, recent studies have generated evidence that non-general anesthesia can be safely used for shorter lumbar surgeries [1,5]. Non-general anesthesia has been shown to have several benefits over general anesthesia. Pierce et al compared efficiency of general and non-general anesthesia for patients undergoing lumbar decompression [8]. Results indicate a shorter mean length of stay in the non-general anesthesia group (1.5 days versus 3.1 days, $p < 0.001$), which agrees with our analysis of the unmatched cohort (1.2 days vs 1.8 days, SMD = 0.10). However, our results indicated that anesthesia technique had no significant effect on length of stay after controlling for comorbidities before and after matching for patients who underwent lumbar decompression (Coef.: -0.20, 95% CI: -0.68 to 0.25, $p = 0.36$; Coef.: 0.18; 95% CI: -0.20 to 0.57, $p = 0.35$, respectively). Other benefits mentioned by

Table 2
Univariate and Multivariable regression for (a) readmission, (b) any complication and (c) length of stay of lumbar decompression patients.

2(a)								
Variable	Univariate				Multivariable			
	Odds Ratio	P-Value	Lower 95%	Upper 95%	Odds Ratio	P-Value	Lower 95%	Upper 95%
male (vs female)	0.91	0.021	0.84	0.99	0.92	0.039	0.84	1.00
Age	1.02	< 0.001	1.02	1.02	1.02	< 0.001	1.01	1.02
Non-General Anesthesia (vs General)	0.58	0.13	0.29	1.17	0.70	0.32	0.34	1.41
BMI	1.02	< 0.001	1.01	1.03	1.02	< 0.001	1.01	1.03
Diabetes								
No	(base)				(base)			
Insulin	1.90	< 0.001	1.63	2.20	1.38	< 0.001	1.18	1.61
Non-insulin	1.44	< 0.001	1.28	1.62	1.14	0.04	1.01	1.29
Smoker	1.00	0.97	0.90	1.10	Not significant in Univariate			
Functional Status								
Independent	(base)				(base)			
Partially Dependent	2.83	< 0.001	2.26	3.54	2.02	< 0.001	1.60	2.55
Totally Dependent	3.86	0.001	1.74	8.55	2.59	0.024	1.14	5.89
Unknown	1.38	0.16	0.88	2.18	1.28	0.29	0.81	2.02
Ventilator Dependent	(omitted)				Collinear in Univariate			
History of Severe COPD	2.23	< 0.001	1.89	2.63	1.63	< 0.001	1.36	1.94
Ascites	4.92	0.15	0.57	42.15	Not significant in Univariate			
History of CHF	3.53	< 0.001	2.12	5.88	1.75	0.039	1.03	2.97
History of MI	4.26	0.18	0.51	35.55	Not significant in Univariate			
Hypertension requiring medication	1.58	< 0.001	1.46	1.72	1.08	0.11	0.98	1.20
Acute Renal Failure (pre-op)	1.12	0.91	0.15	8.30	Not significant in Univariate			
Currently on dialysis (pre-op)	6.05	< 0.001	3.75	9.77	3.94	< 0.001	2.38	6.52
Disseminated cancer	5.06	< 0.001	3.04	8.42	3.87	< 0.001	2.29	6.52
Steroid use for Chronic Condition	2.10	< 0.001	1.78	2.48	1.76	< 0.001	1.49	2.08
Bleeding Disorder	2.12	< 0.001	1.65	2.73	1.53	0.001	1.18	1.97
Pre-op Transfusion	2.74	0.10	0.83	9.03	Not significant in Univariate			
2(b)								
Variable	Univariate				Multivariable			
	Odds Ratio	P-Value	Lower 95%	Upper 95%	Odds Ratio	P-Value	Lower 95%	Upper 95%
Male (vs female)	0.80	< 0.001	0.74	0.87	0.82	< 0.001	0.76	0.90
Age	1.02	< 0.001	1.02	1.02	1.02	< 0.001	1.01	1.02
Non-General Anesthesia (vs General)	0.38	0.031	0.16	0.92	0.48	0.10	0.20	1.16
BMI	1.04	< 0.001	1.03	1.05	1.04	< 0.001	1.03	1.05
Diabetes								
No	(base)				(base)			
Insulin	2.08	< 0.001	1.79	2.42	1.42	< 0.001	1.21	1.66
Non-insulin	1.59	< 0.001	1.42	1.80	1.21	0.004	1.06	1.37
Smoker	1.05	0.34	0.95	1.16	Not significant in Univariate			
Functional Status								
Independent	(base)				(base)			
Partially Dependent	3.31	< 0.001	2.67	4.11	2.38	< 0.001	1.90	2.98
Totally Dependent	5.50	< 0.001	2.68	11.28	3.08	0.006	1.39	6.83
Unknown	1.70	0.014	1.12	2.60	1.50	0.07	0.97	2.32
Ventilator Dependent	12.95	0.003	2.37	70.76	6.41	< 0.001	0.86	47.71
History of Severe COPD	2.26	< 0.001	1.91	2.67	1.61	< 0.001	1.34	1.94
Ascites	5.18	0.13	0.60	44.35	Not significant in Univariate			
History of CHF	3.22	< 0.001	1.88	5.52	1.53	0.14	0.87	2.68
History of MI	4.16	0.19	0.50	34.74	Not significant in Univariate			
Hypertension requiring medication	1.62	< 0.001	1.48	1.76	1.05	0.37	0.95	1.16
Acute Renal Failure (pre-op)	3.89	0.028	1.15	13.09	1.98	0.30	0.55	7.19
Currently on dialysis (pre-op)	4.58	< 0.001	2.69	7.80	2.47	0.003	1.35	4.52
Disseminated cancer	4.63	< 0.001	2.71	7.89	3.54	< 0.001	2.04	6.17
Steroid use for Chronic Condition	2.00	< 0.001	1.69	2.38	1.65	< 0.001	1.38	1.97
Bleeding Disorder	2.31	< 0.001	1.80	2.96	1.64	< 0.001	1.27	2.12
Pre-op Transfusion	6.49	< 0.001	2.65	15.88	3.43	0.013	1.30	9.08
2(c)								
Variable	Univariate				Multivariable			
	Coef.	P-Value	Lower 95%	Upper 95%	Coef.	P-Value	Lower 95%	Upper 95%
Male (vs female)	-0.28	< 0.001	-0.35	-0.21	-0.27	< 0.001	-0.34	-0.19
Age	0.03	< 0.001	0.03	0.03	0.02	< 0.001	0.02	0.03
Non-General Anesthesia (vs General)	-0.50	0.04	-0.97	-0.03	-0.22	0.36	-0.68	0.25
BMI	0.03	< 0.001	0.02	0.03	0.02	< 0.001	0.02	0.03

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Table 2 (continued)

Variable	Univariate				Multivariable			
	Coef.	P-Value	Lower 95%	Upper 95%	Coef.	P-Value	Lower 95%	Upper 95%
2(c)								
Diabetes								
No	(base)				(base)			
Insulin	1.09	< 0.001	0.93	1.25	0.61	< 0.001	0.44	0.77
Non-insulin	0.53	< 0.001	0.41	0.64	0.13	0.036	0.01	0.24
Smoker	-0.24	< 0.001	-0.33	-0.15	0.03	0.58	-0.06	0.11
Functional Status								
Independent	(base)				(base)			
Partially Dependent	2.48	< 0.001	2.18	2.77	1.99	< 0.001	1.70	2.29
Totally Dependent	3.79	< 0.001	2.60	4.99	2.95	< 0.001	1.75	4.14
Unknown	0.07	0.76	-0.37	0.51	-0.02	0.92	-0.46	0.42
Ventilator Dependent	5.43	0.00	1.88	8.98	3.33	0.06	-0.19	6.84
History of Severe COPD	0.69	< 0.001	0.49	0.89	0.20	0.06	-0.01	0.40
Ascites	2.26	0.21	-1.28	5.81	Not significant in Univariate			
History of CHF	2.20	< 0.001	1.46	2.95	1.16	0.002	0.41	1.90
History of MI	0.66	0.77	-3.78	5.10	Not significant in Univariate			
Hypertension requiring medication	0.71	< 0.001	0.64	0.78	0.16	< 0.001	0.08	0.25
Acute Renal Failure (pre-op)	6.79	< 0.001	4.98	8.60	5.00	< 0.001	3.17	6.83
Currently on dialysis (pre-op)	3.43	< 0.001	2.59	4.27	1.99	< 0.001	1.13	2.86
Disseminated cancer	3.33	< 0.001	2.48	4.17	2.51	< 0.001	1.67	3.36
Steroid use for Chronic Condition	0.83	< 0.001	0.64	1.02	0.57	< 0.001	0.38	0.76
Bleeding Disorder	1.32	< 0.001	1.02	1.62	0.79	< 0.001	0.49	1.08
Pre-op Transfusion	10.04	< 0.001	8.45	11.62	8.97	< 0.001	7.40	10.55

Table 3

Patient Demographics, Preoperative and operative variables for those who underwent Posterior Lumbar Fusion.

Variables	Unmatched			Matched		
	General Anesthesia (n = 31,377)	Non-general Anesthesia (n = 42)	SMD	General Anesthesia (n = 126)	Non-general Anesthesia (n = 42)	SMD
Age, mean (SD)	60.5 (13.2)	62.6 (13.0)	0.159	63.2 (13.6)	62.6 (13)	0.046
Female sex, n(%)	17,287 (55.1)	26 (61.9)	0.137	67 (53.2)	26 (61.9)	0.177
Race, n(%)						
White	26469 (84.4)	34 (81.0)	0.094	106 (84.1)	34 (81.0)	0.083
African American	2358 (7.5)	2 (4.76)	0.104	7 (5.60)	2 (4.80)	0.035
Other	823 (2.6)	1 (2.38)	0.014	3 (2.40)	1 (2.40)	0
Unknown	1727 (5.5)	5 (11.9)	0.281	10 (7.90)	5 (11.9)	0.091
BMI, mean (SD)	30.8 (6.39)	29.2 (5.53)	0.25	29.2 (6.19)	29.2 (5.53)	0.005
BMI, median (range)	30.0 (10.9-86.1)	29.0 (17.3-40.3)	N/A	28.2 (17.5-52.9)	29.0 (17.3-40.3)	N/A
Functional Status (dependent) (%)	727 (2.16)	0 (0)	0.149	1 (0.80)	0 (0)	0.126
Outpatient (%)	717 (2.29)	2 (4.76)	0.165	4 (3.20)	2 (4.80)	0.081
Smoker within 1 year (%)	6576 (21.0)	7 (16.7)	0.106	18 (14.3)	7 (16.7)	0.066
Alcohol use (%)	83 (0.26)	0 (0)	0.051	0 (0)	0 (0)	.
Steroid use (%)	1225 (3.90)	3 (7.14)	0.167	5 (4.00)	3 (7.14)	0.139
Weight loss (%)	61 (0.19)	0 (0)	0.044	0 (0)	0 (0)	.
Diabetes (%)	5706 (18.2)	7 (16.7)	0.039	14 (11.1)	7 (16.7)	0.161
Dyspnea (%)	2020 (6.43)	1 (2.38)	0.165	10 (7.90)	1 (2.40)	0.253
COPD (%)	1522 (4.85)	2 (4.76)	0.004	7 (5.60)	2 (4.80)	0.036
Dialysis (%)	56 (0.18)	0 (0)	0.043	0 (0)	0 (0)	.
Bleeding disorder (%)	473 (1.51)	0 (0)	0.124	1 (0.80)	0 (0)	0.104
Open wound/wound infection (%)	140 (0.45)	0 (0)	0.067	1 (0.80)	0 (0)	0.104
Preoperative blood transfusion (%)	49 (0.16)	0 (0)	0.04	1 (0.80)	0 (0)	0.104
Operative Variables						
ASA Class (%)						
1	847 (2.70)	3 (7.14)	0.274	12 (9.50)	3 (7.14)	0.083
2	15239 (48.6)	21 (50.0)	0.028	60 (47.6)	21 (50.0)	0.048
3	14550 (46.4)	18 (42.9)	0.07	54 (42.9)	18 (42.9)	0
4	700 (2.23)	0 (0)	0.154	0 (0)	0 (0)	.
5	2 (0.01)	0 (0)	0.01	0 (0)	0 (0)	.
Not assigned	39 (0.12)	0 (0)	0.035	0 (0)	0 (0)	.
Wound class 1 or 2 (%)	31,317 (99.8)	42 (100)	0.045	125 (99.2)	42 (100)	0.126
Mean operative time (min, SD)	200.6 (94.1)	181.3 (78.7)	0.205	208.1 (99.5)	181.3 (78.7)	0.299
Median operative time (median, range)	184 (0-1130)	169 (0-339)	N/A	181 (61-558)	169 (0-339)	N/A
Emergency (%)	157 (0.50)	0 (0)	0.071	2 (1.60)	0 (0)	0.18

Table 4
Univariate and Multivariable regression for (a) readmission, (b) any complication and (c) length of stay of posterior lumbar fusion patients.

4(a)								
Variable	Univariate				Multivariable			
	Odds Ratio	P-Value	Lower 95%	Upper 95%	Odds Ratio	P-Value	Lower 95%	Upper 95%
Male (vs female)	0.89	0.026	0.81	0.99	0.93	0.15	0.84	1.03
Age	1.02	< 0.001	1.01	1.02	1.01	< 0.001	1.01	1.02
Non-General Anesthesia (vs General)	0.43	0.40	0.06	3.10	0.42	0.39	0.06	3.07
BMI	1.02	< 0.001	1.02	1.03	1.02	< 0.001	1.01	1.03
Diabetes								
No	(base)				(base)			
Insulin	2.01	< 0.001	1.71	2.37	1.60	< 0.001	1.34	1.90
Non-insulin	1.31	< 0.001	1.14	1.50	1.11	0.18	0.96	1.28
Smoker	1.00	0.96	0.88	1.12	Not significant in Univariate			
Functional Status								
Independent	(base)				(base)			
Partially Dependent	1.97	< 0.001	1.51	2.56	1.57	0.001	1.20	2.05
Totally Dependent	5.15	< 0.001	2.07	12.77	4.16	0.003	1.64	10.57
Unknown	1.90	0.003	1.25	2.91	1.70	0.017	1.10	2.63
Ventilator Dependent	2.50	0.39	0.31	20.34	Not significant in Univariate			
History of Severe COPD	1.67	< 0.001	1.38	2.01	1.38	0.001	1.13	1.68
Ascites	8.76	0.08	0.79	96.62	Not significant in Univariate			
History of CHF	1.51	0.29	0.70	3.28	Not significant in Univariate			
History of MI	(omitted)				Collinear in Univariate			
Hypertension requiring medication	1.44	< 0.001	1.30	1.60	1.09	0.17	0.97	1.22
Acute Renal Failure (pre-op)	2.69	0.19	0.61	11.95	Not significant in Univariate			
Currently on dialysis (pre-op)	3.36	0.001	1.65	6.88	2.37	0.022	1.13	4.97
Disseminated cancer	2.73	0.014	1.23	6.06	2.52	0.025	1.12	5.65
Steroid use for Chronic Condition	1.98	< 0.001	1.63	2.41	1.73	< 0.001	1.42	2.11
Bleeding Disorder	1.45	0.033	1.03	2.05	1.14	0.47	0.80	1.61
Pre-op Transfusion	1.14	0.82	0.35	3.67	Not significant in Univariate			

4(b)								
Variable	Univariate				Multivariable			
	Odds Ratio	P-Value	Lower 95%	Upper 95%	Odds Ratio	P-Value	Lower 95%	Upper 95%
Male (vs female)	0.79	< 0.001	0.72	0.86	0.82	< 0.001	0.74	0.90
Age	1.02	< 0.001	1.02	1.03	1.02	< 0.001	1.02	1.02
Non-General Anesthesia (vs General)	0.75	0.69	0.18	3.10	0.76	0.71	0.18	3.19
BMI	1.04	< 0.001	1.03	1.04	1.03	< 0.001	1.03	1.04
Diabetes								
No	(base)				(base)			
Insulin	2.38	< 0.001	2.06	2.76	1.76	< 0.001	1.51	2.06
Non-insulin	1.48	< 0.001	1.30	1.68	1.19	0.012	1.04	1.36
Smoker	0.89	0.05	0.79	1.00	Not significant in Univariate			
Functional Status								
Independent	(base)				(base)			
Partially Dependent	3.06	< 0.001	2.47	3.78	2.37	< 0.001	1.90	2.96
Totally Dependent	2.73	0.06	0.94	7.90	1.88	0.26	0.62	5.69
Unknown	2.13	< 0.001	1.45	3.13	1.91	0.001	1.29	2.84
Ventilator Dependent	9.00	0.003	2.15	37.67	8.63	0.004	1.99	37.45
History of Severe COPD	1.53	< 0.001	1.27	1.83	1.26	0.019	1.04	1.53
Ascites	(omitted)				Collinear in Univariate			
History of CHF	2.61	0.001	1.44	4.70	1.46	0.24	0.78	2.72
History of MI	(omitted)				Collinear in Univariate			
Hypertension requiring medication	1.62	< 0.001	1.47	1.78	1.11	0.07	0.99	1.24
Acute Renal Failure (pre-op)	7.50	< 0.001	2.56	21.97	3.53	0.038	1.07	11.64
Currently on dialysis (pre-op)	4.10	< 0.001	2.16	7.78	2.59	0.007	1.30	5.14
Disseminated cancer	3.14	0.002	1.53	6.46	2.81	0.006	1.34	5.88
Steroid use for Chronic Condition	1.88	< 0.001	1.56	2.26	1.57	< 0.001	1.30	1.91
Bleeding Disorder	2.26	< 0.001	1.72	2.96	1.74	< 0.001	1.31	2.30
Pre-op Transfusion	2.09	0.09	0.89	4.92	Not significant in Univariate			

4(c)								
Variable	Univariate				Multivariable			
	Coef.	P-Value	Lower 95%	Upper 95%	Coef.	P-Value	Lower 95%	Upper 95%
Male (vs female)	-0.25	< 0.001	-0.35	-0.14	-0.19	< 0.001	-0.29	-0.09
Age	0.03	< 0.001	0.02	0.03	0.02	< 0.001	0.01	0.02
Non-General Anesthesia (vs General)	0.002	1.00	-1.40	1.40	0.06	0.93	-1.30	1.43
BMI	0.03	< 0.001	0.02	0.03	0.02	< 0.001	0.02	0.03

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Table 4 (continued)

Variable	Univariate				Multivariable			
	Coef.	P-Value	Lower 95%	Upper 95%	Coef.	P-Value	Lower 95%	Upper 95%
4(c)								
Diabetes								
No	(base)				(base)			
Insulin	0.92	< 0.001	0.70	1.14	0.55	< 0.001	0.33	0.76
Non-insulin	0.43	< 0.001	0.27	0.59	0.20	0.012	0.05	0.36
Smoker	-0.37	< 0.001	-0.49	-0.24	-0.11	0.09	-0.24	0.02
Functional Status								
Independent	(base)				(base)			
Partially Dependent	2.18	< 0.001	1.82	2.53	1.76	< 0.001	1.40	2.11
Totally Dependent	5.42	< 0.001	3.68	7.17	4.90	< 0.001	3.19	6.61
Unknown	-0.09	0.77	-0.66	0.49	-0.17	0.56	-0.73	0.40
Ventilator Dependent	5.27	0.001	2.06	8.48	4.35	0.007	1.21	7.50
History of Severe COPD	0.65	< 0.001	0.42	0.89	0.49	< 0.001	0.25	0.74
Ascites	-0.40	0.88	-5.64	4.84	Not significant in Univariate			
History of CHF	2.17	< 0.001	1.20	3.14	1.50	0.002	0.55	2.46
History of MI	-1.60	0.51	-6.35	3.15	Not significant in Univariate			
Hypertension requiring medication	0.46	< 0.001	0.35	0.56	0.07	0.23	-0.04	0.19
Acute Renal Failure (pre-op)	3.00	0.012	0.65	5.34	1.51	0.20	-0.79	3.81
Currently on dialysis (pre-op)	4.43	< 0.001	3.22	5.65	3.87	< 0.001	2.67	5.06
Disseminated cancer	12.13	< 0.001	10.88	13.38	11.99	< 0.001	10.75	13.24
Steroid use for Chronic Condition	0.65	< 0.001	0.38	0.91	0.36	0.006	0.10	0.62
Bleeding Disorder	0.87	< 0.001	0.45	1.29	0.45	0.034	0.03	0.86
Pre-op Transfusion	4.52	< 0.001	3.22	5.81	3.41	< 0.001	2.14	4.69

the study by Pierce et al included shorter operative time, less operative blood loss, shorter anesthesia time and shorter time from entering the OR until incision. Finsterwald et al conducted a similar comparison of patient outcomes between those undergoing non-general anesthesia and those undergoing general anesthesia among high risk patients. They found a lower rate of hypotensive episodes, significantly shorter duration of surgery and lower pain in the post anesthesia care unit (PACU) among non-general anesthesia patients compared to general anesthesia patients [7]. Attari et al conducted a randomized controlled trial and compared outcomes between non-general and general anesthesia among patients undergoing elective spinal surgery and found that non-general anesthesia patients had lower blood loss, less post-operative analgesic use and better pain relief, in addition to higher surgeon overall satisfaction [6]. Meng et al published a meta-analysis comparing the outcomes between the two techniques and found that mean length of stay was shorter in the non-general anesthesia group (SMD: -1.15, 95% CI: -1.98 to -0.31, heterogeneity $I^2 = 89\%$, $p = 0.007$) [5]. However, they included studies of many other types of lumbar surgeries, such as laminectomy and discectomy.

Literature on complication rates between non-general anesthesia and general anesthesia patients has been conflicted with some studies suggesting benefit with non-general anesthesia while others have found no difference. For example, Sadrolsadat et al found no difference in effect between the two techniques in terms of postoperative complications, such as nausea and vomiting and analgesia requirement after 24 h [17]. Finsterwald also found complication rates to be the same between non-general anesthesia and general anesthesia among high-risk patients undergoing elective lumbar surgery [7]. McInain et al conducted a case control analysis of non-general anesthesia and general anesthesia among 400 patients undergoing lumbar laminectomy surgery and found that overall complication rates, urinary retention and spinal headaches were significantly less in non-general anesthesia patients compared to general anesthesia patients [18]. Our analysis revealed that anesthesia type had no significant effect on any postoperative complication for patients undergoing lumbar decompression ($p = 0.58$) or posterior lumbar fusion ($p = 0.39$), after propensity score matching.

There were some limitations in our study inherent to the nature of the NSQIP database. First, important outcomes such as total PACU time and perioperative hemodynamic changes that have been shown to be

important considerations when choosing a specific anesthetic technique could not be studied. Finally, we acknowledge the limitation associated with the discrepancy in sample sizes of the two groups; spinal anesthesia is relatively much rare compared to general anesthesia and this was reflected in the difference between the original sizes of the two cohorts. Thus, propensity scoring was utilized to minimize the heterogeneity between the two groups. However, given the discrepancy, the generalizability of these results may be limited [12].

5. Conclusion

Overall, our analysis showed that non-general (epidural and spinal) anesthesia had no significant effect on either readmission, length of stay, or any complication, compared to general anesthesia from lumbar decompression or posterior lumbar fusion. Nevertheless, selection of an appropriate anesthetic requires close collaboration between the anesthesiologist, surgeon, and patient. The expertise and comfort level of the entire team and patient factors may lead to a preference of one technique over another. This study demonstrates that patients undergoing lumbar or lumbo-sacral decompression or posterior lumbar fusion can be safely cared for using either general or regional anesthesia.

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Appendix A. Supplementary data

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