


Chronic Obstructive Pulmonary Disease Is an Independent Predictor for 30-Day Complications and Readmissions Following I- to 2-Level Anterior Cervical Discectomy and Fusion

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Abstract

Study Design: Retrospective cohort.

Objectives: To study evidence to assess the impact of chronic obstructive pulmonary disease (COPD) on 30-day outcomes following I- to 2-level anterior cervical discectomy and fusion (ACDF).

Methods: The 2015-2016 American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP) database was queried using Current Procedural Terminology (CPT) codes 22551 (single-level) and 22552 (additional level). Patients undergoing disc arthroplasty, multilevel (>2) fusion, posterior cervical spine surgery, and patients with fracture, tumor, and/or infection were excluded.

Results: Out of 14835 patients undergoing an elective I- to 2-level ACDF, 649 (4.4%) had a diagnosis of COPD at the time of the surgery. Following adjusted logistic regression analysis, prior history of COPD was significantly associated with a longer length of stay (odds ratio [OR] 1.25 [95% confidence interval (CI) 1.04-1.52]; $P = .019$), superficial surgical site infection (OR 2.68 [95% CI 1.06-6.80]; $P = .038$), discharge destination other than home (OR 1.49 [95% CI 1.05-2.12]; $P = .026$), pneumonia (OR 4.37 [95% CI 2.42-7.88]; $P < .001$), ventilator use >48 hours (OR 5.34 [95% CI 1.88-15.15]; $P = .002$), unplanned reintubation (OR 3.36 [1.48-7.62]; $P = .004$), and 30-day readmissions (OR 1.69 [95% CI 1.20-2.38]; $P = .003$).

Conclusions: The findings of this study show that COPD patients are more likely to have postoperative complications and 30-day readmissions, despite elective ACDF itself being a low-risk surgery in general. Results show that majority of the complications were pulmonary in nature, further stressing the need for accurate medical optimization following surgery in these patients.

Keywords

ACDF, anterior cervical discectomy and fusion, COPD, chronic obstructive pulmonary disease, cervical fusion, complications, readmissions, length of stay, non-home discharge destination, pulmonary complications

Introduction

Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality resulting in a significant health care and economic burden. In the United States alone, it is the third leading cause of death after heart disease and cancer,^{1,2} with studies estimating the global mortality to be approximately 3 million deaths annually.³ COPD has a multifactorial etiology with important factors such as cigarette smoking,⁴ age,⁵ gender,^{6,7} genetics,^{8,9} infections,¹⁰ underlying chronic bronchitis,¹¹ and occupational exposure to harmful gases.¹²

With an increase in longevity and the higher odds of being exposed to the aforementioned risk factors, the prevalence of patients presenting to hospitals with COPD as a comorbid

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diagnosis is gradually increasing.¹³ With an increasing trend in surgeries such as cervical fusions being done for degenerative pathologies in the elderly,¹⁴ COPD may complicate the postoperative course significantly. Though few studies have identified COPD as a surgical risk factor, no study has comprehensively investigated the independent impact of COPD on postoperative outcomes following anterior cervical discectomy and fusion (ACDF).

Using a large national surgical database, we aimed to determine whether COPD is associated with a higher odds of 30-day complications following ACDF and whether the presence of COPD as a comorbidity independently affects 30-day readmissions and reoperations following ACDF.

Materials and Methods

Database

This was a retrospective study done using the 2015-2016 American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database. The ACS-NSQIP database collects surgical information from more than 500 hospitals across the United States. Data is recorded for more than 150 preoperative, intraoperative, and postoperative variables up to 30 days following the operation. The data is collated by trained surgical and clinical reviewers with audit reports showing an interreviewer disagreement rate of below 2%.¹⁵ Since the ACS-NSQIP database is a de-identified public database available to participating hospitals, it was exempt from the institutional review board approval.

Study Population

Current Procedural Terminology (CPT) codes for ACDF (CPT 22551) were used to retrieve records from the database. Two-level ACDFs were queried using CPT 22552 to identify each additional level. Patients undergoing additional posterior cervical spine procedures (instrumentation, laminectomy, foraminotomy, etc) were excluded from the analysis. In addition, patients undergoing >2-level fusion, fracture fixation, and fusion for malignancy were excluded. Data was filtered to remove for missing variables to prevent confounding in analysis later on. Only elective 1- to 2-level ACDFs being done for degenerative pathologies of the spine were included in the study.

Definition of Variables Studied

For baseline clinical characteristics and demographics of the study population, the following variables were collected: age (dichotomized into <65 years and ≥65 years of age), gender, body mass index (BMI), comorbidities, type of anesthesia used (general, regional, and other), admission status (inpatient vs outpatient), American Society of Anesthesiologists (ASA) class, quarter of admission (January-March, April-June, July-September, and October-December), number of levels fused

(1-level vs 2-level), total operative time (minutes), and length of stay (≤1 day vs >1 day).

The ACS-NSQIP defines the presence of COPD based on review of medical records as well as the fulfillment of the following criteria: (1) functional disability due to COPD, (2) use of chronic bronchodilator therapy, (3) prior history of exacerbation requiring hospitalization, or (4) pulmonary function test showing a forced expiratory volume in 1 second less than 75% of the expected. Our study population of patients undergoing 1- to 2-level ACDF was divided into cohorts. The first cohort included patients with history of COPD, and the second cohort included patients without history of COPD. Thirty-day complications as defined by ACS-NSQIP were recorded. They included surgical site infection (SSI; which was divided into superficial, deep, and organ/space infections), wound dehiscence, myocardial infarction (MI), cardiac arrest, deep venous thrombosis, pneumonia, pulmonary embolism, urinary tract infection, postoperative ventilator use >48 hours, unplanned reintubation, bleeding requiring transfusion, acute renal failure, cerebrovascular/stroke, sepsis, septic shock, return to operating room within 30 days of surgery, 30-day readmissions, and 30-day unplanned reoperations.

We assessed discharge destination. The variable was dichotomized into non-home versus home cohorts. The non-home cohort included discharge to skilled care facilities, unskilled facilities, rehabilitation facilities, assisted living/elderly home facilities, separate acute care units, and death as discharge disposition.

Statistical Analysis

To identify significant predictors, Pearson χ^2 test for categorical variables and Mann-Whitney *U* test for continuous variables were used to assess for preoperative and postoperative variables that were significantly different in the 2 groups. A backward elimination logistic regression analysis was performed to estimate the risk of COPD on 30-day complications, while adjusting for all baseline demographic and clinical variables to ensure outcome of multivariate logistic regression was reflective of the independent impact of COPD alone.

For all statistical tests, a *P* value of less than .05 was considered significant. Statistical analysis was carried out using SPSSv23 (IBM, Armonk, NY).

Results

A total of 14835 patients were included in the study. Six hundred and forty-nine (4.4%) patients had a prior diagnosis of COPD at the time of the surgery. Baseline clinical characteristics are shown in Table 1. Bivariate analysis showed that the groups were significantly different in terms of age, gender, BMI, comorbidities, ASA class, and admission status.

Bivariate analysis showed postoperatively patients with COPD were significantly associated with a longer length of stay >1 day (*P* < .001), superficial SSI (*P* = .031), myocardial infarction (*P* = .034), pneumonia (*P* < .001), postoperative mechanical

Table 1. Baseline Clinical Characteristics Between COPD and Control (Non-COPD) Groups.^a

Variable	With COPD	Without COPD	P
Age (years)			<.001
<65	433 (66.7%)	11 544 (81.4%)	
≥65	216 (33.3%)	2642 (18.6%)	
Gender			.014
Male	291 (44.8%)	7059 (49.8%)	
Female	358 (55.2%)	7127 (50.2%)	
Body mass index (kg/m ²)			<.001
<25.0	143 (22.0%)	2720 (19.2%)	
25.0-29.9	182 (28.0%)	4679 (33.0%)	
30.0-35.0	152 (23.4%)	3783 (26.7%)	
>35.0	172 (26.5%)	3004 (21.2%)	
Comorbid			<.001
Diabetes			
IDDM	70 (10.8%)	772 (5.4%)	
NIDDM	77 (11.9%)	1449 (10.2%)	
No	502 (77.3%)	11 965 (84.3%)	
Smoker within past year	355 (54.7%)	3655 (25.7%)	<.001
Dyspnea			<.001
At rest	20 (3.1%)	22 (0.2%)	
At moderate exertion	165 (25.4%)	521 (3.7%)	
No	464 (71.5%)	13 643 (96.2%)	
Functional status prior to surgery			<.001
Totally dependent	1 (0.2%)	8 (0.1%)	
Partially dependent	21 (3.2%)	153 (1.1%)	
Unknown	5 (0.8%)	60 (0.4%)	
Independent	622 (95.8%)	13 965 (98.4%)	
Ventilator dependent	1 (0.2%)	0	<.001
Ascites	0	2 (~0%)	.762
Congestive heart failure in 30 days before surgery	2 (0.3%)	20 (0.1%)	.279
Hypertension requiring medication	429 (66.1%)	6253 (44.1%)	<.001
Acute renal failure	0	2 (~0%)	.762
Preoperative dialysis	6 (0.9%)	12 (0.1%)	<.001
Chronic steroid use	41 (6.3%)	460 (3.2%)	<.001
Bleeding disorders	15 (2.3%)	140 (1.0%)	0.001
Transfusion of at least 1 unit of packed RBCs within 72 hours before surgery	0	1 (~0.0%)	.831
Prior sepsis	0	1 (~0%)	.066
Prior SIRS	4 (0.6%)	27 (0.2%)	
No systemic signs of sepsis	645 (99.4%)	14 158 (99.8%)	
>10% weight loss in last 6 months	1 (0.2%)	11 (0.1%)	.502
ASA class			<.001
I	0	553 (3.9%)	
II	116 (17.9%)	7954 (56.1%)	
III	487 (75.0%)	5499 (38.8%)	
IV	46 (7.1%)	179 (1.3%)	
V	0	1 (~0%)	
Admission status			<.001
Inpatient	510 (78.6%)	9335 (70.0%)	
Outpatient	139 (21.4%)	4251 (30.0%)	
Total operative time (minutes)	121.1 ± 57.7	118.9 ± 59.7	.388

(continued)

Table 1. (continued)

Variable	With COPD	Without COPD	P
Length of stay (days)	1.0 [1.0-2.0]	1.0 [1.0-1.0]	<.001
0-1 days	430 (66.3%)	10 785 (76.0%)	<.001
>1 days	219 (33.7%)	3401 (24.0%)	
Anesthesia type			.107
General	649 (100%)	14 089 (99.3%)	
Regional	0	31 (0.2%)	
Other	0	66 (0.5%)	

Abbreviations: COPD, chronic obstructive pulmonary disease; IDDM, insulin-dependent diabetes mellitus; NIDDM, non-insulin-dependent diabetes mellitus; RBC, red blood cell; SIRS, systemic inflammatory response syndrome; ASA, American Society of Anesthesiologists.

^aValues in bold are statistically significant.

Table 2. Univariate Regression Analysis for Significant Complications Associated With Prior Existence of COPD.^a

Variable	30-Day Complications		P
	With COPD	Without COPD	
Superficial SSI	5 (0.8%)	41 (0.3%)	.031
Deep SSI	0	21 (0.1%)	.327
Organ/space SSI	0	9 (0.1%)	.521
Wound dehiscence	0	2 (~0%)	.762
Myocardial infarction	3 (0.5%)	19 (0.1%)	.034
Cardiac arrest	1 (0.2%)	15 (0.1%)	.714
Deep venous thrombosis	2 (0.3%)	31 (0.2%)	.635
Pneumonia	16 (2.5%)	65 (0.5%)	<.001
Pulmonary embolism	0	25 (0.2%)	.284
Urinary tract infection	5 (0.8%)	67 (0.5%)	.285
Postoperative ventilator use >48 hours	5 (0.8%)	25 (0.2%)	.001
Unplanned reintubation	8 (1.2%)	45 (0.3%)	<.001
Bleeding requiring transfusion	2 (0.3%)	9 (0.1%)	.025
Acute renal failure	2 (0.3%)	5 (0.0%)	.002
Cerebrovascular/stroke	0	10 (0.1%)	.499
Sepsis	2 (0.3%)	17 (0.1%)	.190
Septic shock	1 (0.2%)	5 (0%)	.141
Return to operating room within 30 days of surgery	9 (1.4%)	178 (1.3%)	.768
30-Day readmission	42 (6.5%)	395 (2.8%)	<.001
30-Day unplanned reoperations	9 (1.4%)	178 (1.3%)	.768
Discharge destination			<.001
Non-home	50 (7.7%)	477 (3.4%)	
Home	599 (92.3%)	13 709 (96.6%)	

Abbreviations: COPD, chronic obstructive pulmonary disease; SSI, surgical site infection.

^aValues in bold are statistically significant.

ventilation for more than 48 hours ($P = .001$), unplanned reintubation ($P < .001$), bleeding requiring transfusion ($P = .025$), acute renal failure ($P = .002$), having any complication within 30 days ($P < .001$), 30-day readmissions ($P < .001$), and a non-home discharge destination ($P < .001$; Table 2).

On adjusted analysis, prior history of COPD was significantly associated with a longer length of stay (odds ratio

Table 3. Adjusted Analysis of Significant Postoperative Complications in COPD Patients Undergoing 1- to 2-Level ACDF.^a

Dependent Variables	OR [95% CI]	P
Length of stay (days) >1 day	1.25 [1.04-1.52]	.019
Superficial SSI	2.68 [1.06-6.80]	.038
Discharge destination		
Non-home	1.49 [1.05-2.12]	.026
Pneumonia	4.37 [2.42-7.88]	<.001
Ventilator use >48 hours	5.34 [1.88-15.15]	.002
Unplanned reintubation	3.36 [1.48-7.62]	.004
30-Day readmission	1.69 [1.20-2.38]	.003

Abbreviations: COPD, chronic obstructive pulmonary disease; ACDF, anterior cervical discectomy and fusion; OR, odds ratio; CI, confidence interval; SSI, surgical site infection; BMI, body mass index; SIRS, systemic inflammatory response syndrome; ASA, American Society of Anesthesiologists.

^aEach postoperative complication category was entered into a backward elimination multivariate logistic regression model while adjusting for age, gender, BMI, comorbidities (diabetes, smoking, dyspnea, functional health status prior to surgery, ventilator dependent, ascites, congestive heart failure in 30 days before surgery, hypertension requiring medication, preoperative acute renal failure, preoperative dialysis, chronic steroid use, bleeding disorders, transfusions, prior sepsis/SIRS, >10% weight loss in last 6 months), ASA class, admission status, total operative time, and anesthesia type. Values in bold are statistically significant.

[OR] 1.25 [95% confidence interval (CI) 1.04-1.52]; $P = .019$), superficial SSI (OR 2.68 [95% CI 1.06-6.80]; $P = .038$), discharge destination other than home (OR 1.49 [95% CI 1.05-2.12]; $P = .026$), pneumonia (OR 4.37 [95% CI 2.42-7.88]; $P < .001$), ventilator use >48 hours (OR 5.34 [95% CI 1.88-15.15]; $P = .002$), unplanned reintubation (OR 3.36 [1.48-7.62]; $P = .004$), and 30-day readmissions (OR 1.69 [95% CI 1.20-2.38]; $P = .003$; Table 3).

Discussion

The current study findings show that COPD is an independent factor significantly associated with a longer length of stay and a higher risk of postoperative 30-day complications and readmission. This supports the critical need for an increased focus toward preoperative management and a multidisciplinary approach involving hospitalists, surgeons, and critical care specialists toward medical optimization.

A majority of the 30-day complications affected the pulmonary system, including pneumonia, mechanical ventilation/ventilator use for more than 48 hours postoperatively, and unplanned reintubations. Airway inflammation and narrowing and/or obliteration in COPD results in the intrinsic and extrinsic respiratory muscles being overworked to compensate for the low amount of oxygen entering the alveoli.¹⁶ Therefore, these patients might require prolonged postoperative mechanical ventilation to maintain adequate oxygen saturation levels.¹⁷ The small airway disease can lead to trapping of bacteria and form a nidus of infection in the lung predisposing patients to developing pneumonia.¹⁸ A recent study investigating reintubations after planned extubation in 88 COPD patients revealed that analgesic and sedative use prior to planned

extubation was associated with a higher risk of having a planned reintubation.¹⁹ A more judicious and limited use of sedatives and analgesics prior to extubation in COPD patients may be an effective way of reducing this complication.

Myelopathy has also been known to affect lung function, with studies indicating the patients with chronic cervical myelopathy may have impaired expiratory flow.²⁰ This may further exacerbate underlying COPD symptoms. Physicians and surgeons should stress the need for a more intensive form of the usual lung recovery protocol, consisting of strict intensive spirometry, chest physiotherapy, and noninvasive positive pressure breathing techniques, following fusions in myelopathic patients to prevent complications.

A recent study by Walid et al showed that COPD was associated with a longer length of hospital stay and charges in ACDF female patients.²¹ Though the ACS-NSQIP does not record hospital charges, the findings of our study showing a longer length of stay may result in higher hospital charges. Capua et al also concluded that the presence of a pulmonary comorbidity was associated with a longer length of stay following elective ACDF.²² However, they combined both preoperative ventilator use and the presence of COPD into one variable defined as “presence of pulmonary comorbidity.” Their finding of prolonged length of stay may or may not be directly related to COPD itself.

For various orthopedic procedures, complications and extended length of hospital stay are important drivers of costs of total episode of care. Minhas et al reported that length of stay was tied to an approximate increase of \$1551/per additional day.²³ As we move toward a value-based health care system, which defines its foundations on promoting quality while minimizing expenditures, caregivers and providers should focus on the prevention of these complications in an attempt to minimize the costs associated with hospital stays.

There are several limitations to the current study. The NSQIP database only captures complications occurring up to 30 days following the index procedure. It is plausible that there may be COPD-associated complications occurring beyond the specified time period. As with any database study, we were unable to study disease severity, radiographic findings, and patient reported outcomes. The data does not contain specific clinical information with regard to preoperative and postoperative anesthetic regimens and opioid usage. We were also unable to measure health care costs from this database. Finally, the ACS-NSQIP database largely consists of academic medical centers and may not be representative of a true national population. Despite the limitations posed by the database, the current study utilizes a large cohort and effectively highlights the increased risk of adverse outcomes in these patients.

Conclusion

The study reveals that COPD is independently associated with a higher risk of prolonged length of hospital stay, postoperative complications, and readmission within 30 days after 1- to 2-level ACDF. This data from a large cohort of patients may be used for preoperative counseling to convey the risk of

complications and readmissions in patients with COPD after ACDF. These findings are also important in determining appropriate risk adjustment. Specific focus on optimization of patients with COPD will be beneficial in reducing the risk of postoperative complications.

Authors' Note

The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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