Anterior Versus Posterior Decompression for Degenerative Thoracic Spine Diseases: A Comparison of Complications

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Abstract

Study Design: Retrospective database.

Objectives: Although posterior decompression is the most common approach for surgical treatment of degenerative thoracic spine disease, anterior approach is gaining interest due to its advantage in disc visualization. The objective of this study was to compare the intra- and postoperative medical complication rates between anterior and posterior decompression for degenerative thoracic spine pathologies.

Methods: A national US insurance database was queried for patients with degenerative diagnoses who had undergone anterior or posterior thoracic decompression. Incidence of intra- and postoperative complications were evaluated on the day of surgery and within 1 and 3 months. Two subgroups were matched based on age, gender, and comorbidity. The association of decompression approach and complications was assessed using logistic regression.

Results: A total of 1459 patients were included, consisting of 1004 patients in posterior and 455 patients in anterior group. Respiratory complications were the most common complications on the day of surgery (8.57%) and within 30 days (17.75%). Matched analysis showed that anterior approach was associated with organ failure, gastrointestinal, and device-/implant-/graft-related complications in all follow-up periods; and with cardiovascular, deep venous thrombosis/pulmonary embolism, and respiratory complications in at least 1 follow-up period. Among respiratory complications, anterior decompression was significantly associated with noninfectious etiologies on the day of surgery (odds ratio [OR] = 1.72), within 30 days (OR = 2.05), and within 90 days (OR = 1.92).

Conclusions: Anterior approach was associated with increased rates of several complications. High rates of respiratory complications necessitate comprehensive preoperative risk stratification to identify those who may benefit more from posterior approach.

Keywords
spinal decompression, thoracic spine, complications, anterior decompression, posterior decompression, morbidity, degenerative disc disease

Introduction

Thoracic spine is unique in terms of biomechanical properties when compared with other spinal regions, particularly owing to differences in zygapophyseal joint angulation and the stability provided by rib cage in all primary movement directions.⁴-⁵ Despite the large number of studies on pathophysiology, epidemiology, and burden of degenerative disorders in cervical and lumbar spine, the literature on thoracic spine is scarce. Early reports estimate the annual incidence of thoracic disc

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herniation to be 1 per million capita. Despite the relative rarity of symptomatic thoracic spine disorders, their diagnosis and treatment are challenging. Thoracic disc herniation commonly presents with radiculopathy and nonspecific pain, which are due to neural compression and increase in inflammatory cytokines. However, atypical manifestations such as chronic abdominal pain, gastrointestinal symptoms, and cardiopulmonary presentations are not uncommon. These unusual presentations often overlap with other thoraco-abdominal pathologies and hinder a timely diagnosis.

Historically, direct posterior decompression with laminectomy was used for surgical treatment of thoracic disc herniation. This technique was associated with increased risks of iatrogenic spinal cord injury due to limitation of the space available for thoracic cord. Therefore, this approach was abandoned in favor of other methods. Current techniques for surgical decompression of thoracic spine are broadly categorized to posterior and anterior approaches, the former being the most common approach and the latter gaining increasing interest due to its advantage in disc visualization. Minimally invasive techniques have recently shown promise in reducing morbidity while offering similar exposure compared with conventional transthoracic approaches. However, these techniques have been criticized due to their “steep learning curve,” in addition to the risk of iatrogenic injury to thoracic organs inherent to all transthoracic interventions.

Current literature on surgical treatment of thoracic pathologies is mostly limited to single approach studies, hindering in-depth comparison of outcomes and complications between different techniques. A recent meta-analysis of the literature showed that anterior and posterior approaches yield comparable results in terms of neurological worsening, re-operation rates, and overall neurological improvement, including the American Spinal Injury Association score, myelopathy, radiculopathy and pain. Yet selecting the optimal surgical approach for treatment of thoracic degenerative pathologies is a dilemma. Considering the similarity of neurological outcomes, medical morbidity rates seem to be the key determinants of optimal approach. Therefore, the objectives of this study were to describe the incidence of complications following thoracic decompression for degenerative spinal pathologies, and to compare anterior and posterior decompression in terms of intra- and postoperative medical complications.

Materials and Methods

Patient Database

A private insurance database (Humana) was queried using the PearlDiver Patient Records Database (PearlDiver Technologies). This database covers over 68 million patient encounters in the United States and contains the medical records, including demographic characteristics, comorbidities, procedural data, drug prescription, outcomes and reimbursement data. Although the PearlDiver contained the patient data from 2007 to 2016, we restricted our query to the second quarter of 2015, in order to allow sufficient follow-up period. Current Procedural Terminology (CPT) codes were used to identify the potentially eligible patients who had undergone the surgical procedures of interest. International Classification of Diseases, Ninth Revision (ICD-9) codes were used to apply additional eligibility criteria (ie, the diagnoses), and to evaluate the risk factors, comorbidities and outcomes.

Eligibility Criteria

Details of the eligibility criteria and corresponding ICD-9 and CPT codes are presented in Supplemental Material 1. Patients who had undergone surgical decompression for degenerative pathologies in thoracic spine were eligible for inclusion. Those included posterior decompression with or without laminectomy, laminotomy, foraminotomy, or discectomy; posterolateral decompression including the transpedicular and costovertebral techniques; and anterior/anterolateral approach, including transthoracic, thoracolumbar, transperitoneal, and retroperitoneal approaches for corpectomy and anterior discectomy. Lateral extracavitary approach was initially included in the query. However, after examination of the preliminary data, it was excluded due to small number of patients. Additionally, patients with combined anterior-posterior decompression were excluded. Surgical approaches were combined to make 2 cohorts of patients with either posterior or anterior decompression. Consequently, patients were screened based on the diagnostic criteria, and the following diagnoses were deemed eligible for inclusion: thoracic spondylolisthesis, degenerative disc disease, spondylolysis and stenosis (Supplemental Material 1). Patients diagnosed with spinal infection, trauma, fracture, and benign or malignant spinal neoplasms were excluded (Supplemental Material 1).

Matched Cohorts

In order to eliminate the effect of potential confounders, 2 subsamples were matched one-on-one, based on age, gender, and the Charlson Comorbidity Index (CCI). CCI was used as a broad measure of comorbidity, and covers several categories of conditions, such as cardiovascular diseases, malignancies, and metabolic disorders. Each comorbid condition receives a weighted score based on its severity, and scores are summed to generate a total comorbidity score. Other background characteristics were initially considered for matching. However, addition of more factors in matching process would significantly decrease the sample size and thereby analytical power of matched comparisons. Therefore, logistic regression analysis was utilized to account for potential confounding effect of 3 clinically sensible factors: (1) smoking, which is the foremost risk factor for early complications following orthopedic and spine surgery; (2) diabetes as a systemic comorbidity with known association with complications following spine surgery; and (3) chronic obstructive pulmonary disease (COPD), due to its remarkable impact on complications of transthoracic
surgery and emphasis of current literature on respiratory complications following anterior thoracic decompression.23,24

Risk Factors, Comorbidities, and Complications

The database was queried for the following risk factors within 1 year prior to the index surgery: smoking, diabetes, and COPD (Supplemental Material 1). Intraoperative complications included accidental puncture/laceration of organs during surgery, excessive hemorrhage, surgical emphysema, and accidental dural laceration. Postoperative complications were assessed on the day of surgery, within 1 month, and within 3 months after the operation. These complications were categorized into the following groups: respiratory, cardiovascular, organ failure, central nervous system, wound, device-/implant-/graft-related, infectious, gastrointestinal, and deep vein thrombosis/pulmonary embolism. Respiratory complications were further classified to infectious and noninfectious subcategories.

Statistical Analysis

Statistical analysis was performed using R statistical package. Incidence of complications was reported using count and percentage. Other variables were described using mean and standard deviation (SD) or median (Mdn) and interquartile range (IQR) based on distribution. Comparison of CCI between the 2 cohorts was performed using the Mann-Whitney U test. Two subsamples were matched one-on-one, based on age, gender, and CCI. In order to evaluate the association of surgical approach with complications, logistic regression was performed using the data from matched groups, controlling for diabetes, smoking, and COPD as covariates. Odds ratios (ORs) with 95% CIs were calculated and Hosmer and Lemeshow test was used for assessment of goodness of fit. Models with P values >.05 for this test were considered well-calibrated. Other analyses were considered to be statistically significant if the P value was less than .05.

Results

Our database query initially identified 3365 patients who had undergone thoracic decompression. After exclusion of patients with combined anterior-posterior approach and application of diagnostic criteria, a total of 1459 patients (729 men, 49.97%) were included (Figure 1). The most common age group was 65 to 69 years with 317 patients (21.73%), and 810 individuals (55.52%) were older than 65 years. The surgical approach was posterior in 1004 (68.81%) and anterior in 455 (31.19%) patients. Cohorts were comparable with regard to history of COPD. Anterior group had a significantly higher number of smokers. However, the proportion of men, patients 65 years of age or older, diabetics, and patients with mean CCI score were significantly lower in this group (Table 1). Two subgroups from the study population were matched based on age, gender, and overall comorbidity (CCI), each consisting of 358 subjects. In each subgroup, 219 patients (61.17%) were men, and patients between 65 and 69 years of age constituted the most common age group (Figure 2). The proportion of patients with COPD was comparable between matched cohorts, and there was a trend toward significance with regards to smoking and diabetes status (Table 2).

Incidence of Complications

Incidence rates of complications following each surgical approach are presented in Table 3. Intraoperative complications occurred in 64 patients (4.39%), most commonly due to accidental dural laceration (n = 40, 2.74%). Among medical complications, respiratory complications were the most
common adverse events on the day of surgery and within 30 days, with incidence rates of 8.57% and 17.75%, respectively. With 296 cases (20.29%), infectious complications were the most common category of adverse events within 90 days of surgery, followed by respiratory complications (n = 290, 19.88%) and major organ failure (n = 208, 14.26%). Hemodynamic complications were rare during the whole follow-up period.

### Association of Decompression Approach With Complications (Matched Cohorts)

Logistics regression analysis was performed with decompression as independent variable, complications as dependent variables, and diabetes, COPD and smoking history as covariates. In all three follow-up points, logistic regression revealed a significant association between the anterior decompression approach and organ failure, gastrointestinal, and device-/implant-/graft-related complications (Table 4). Furthermore, there was a significant association between anterior approach and cardiovascular, deep venous thrombosis/pulmonary embolism and total respiratory complications in at least one follow-up point (Table 4).

Among all complications, cardiovascular complications on the day of surgery and deep venous thrombosis/pulmonary embolism within 30 days of operation had the largest ORs following anterior decompression (both ORs = 6.22, \( P < .05 \)). With regard to respiratory complications, anterior decompression was significantly associated with noninfectious respiratory complications on the day of surgery (OR = 1.72, 95% CI 1.16-2.58, \( P = .007 \)), within 30 days (OR = 2.05, 95% CI 1.51-2.81, \( P < .0001 \)), and within 90 days (OR = 1.92, 95% CI 1.43-2.61, \( P < .0001 \)) following surgery. The model was underpowered to assess the association of surgical approach with infectious respiratory complications.

### Discussion

Various surgical approaches are available for treatment of thoracic degenerative conditions. However, on account of low incidence rate of symptomatic thoracic degeneration and paucity of literature on this topic, selecting the optimal approach is challenging. The present study described the incidence of complications following thoracic decompression and revealed that anterior approach is associated with several major complications.

In agreement with current literature, posterior approach (68.81%) was the most common approach for thoracic decompression in this study.\(^{18,23,24}\) This approach is considered advantageous in terms of neurological outcomes, safety, and length of hospital stay.\(^5,25\) However, it can require extensive paravertebral muscle dissection and substantial bone resection, leading to increased postoperative morbidity.\(^{12,25}\) Moreover, the posterior approach does not provide sufficient access for ventral dural decompression in central disc herniations.\(^{25,27}\)

Anterior transthoracic approaches, including the transsternal, trans-pleural, and retro-pleural techniques\(^{23}\) provide enhanced disc visualization, lower the risk of iatrogenic spinal cord injury, and preserve the integrity of posterior elements.\(^5,12,18,25\) However, our study showed that patients

### Table 2. Comparison of Chronic Obstructive Pulmonary Disease, Diabetes, and Smoking Status Between the Matched Cohorts.

| Decompression Approach | Anterior (n = 358) | Posterior (n = 358) | \( \chi^2 \) | DF | P |
|------------------------|-------------------|-------------------|-------------|----|---|
| Smoking                | 83                | 63                | 3.429       | 1  | 0.064 |
| COPD                   | 70                | 61                | 0.753       | 1  | 0.385 |
| Diabetes               | 88                | 110               | 3.379       | 1  | 0.066 |

Abbreviations: DF, degrees freedom; COPD, chronic obstructive pulmonary disease.

Figure 2. Distribution of age and Charlson Comorbidity Index in matched cohorts.

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undergoing anterior surgery are at significant risk of cardiovascular, gastrointestinal, respiratory, and device-/implant-/graft-related complications, as well as deep vein thrombosis/pulmonary embolism and organ failure. In a similar study focused on thoracic disc herniation, Yoshihara et al.\textsuperscript{24} compared the complications of anterior and nonanterior decompression using discharge data from the Nationwide Inpatient Sample (NIS) database. In their study, anterior approach was associated with higher overall rates of intrahospital complications (26.8\% vs 9.6\%).\textsuperscript{24} Similar to our findings, they showed the association of anterior approach with several categories of complications, such as cardiac, respiratory, and gastrointestinal complications, as well as pulmonary embolism.\textsuperscript{24} Furthermore, they found that anterior approach is more costly, and it is associated with higher mortality and longer hospital stay.\textsuperscript{24} In both anterior and posterior groups, complications rates in our study were generally higher than Yoshihara et al.\textsuperscript{24} This difference is in part due to dissimilarity of inclusion criteria and broader definition of complications in our study. Considering the short length of hospital stay of patients undergoing thoracic decompression, our longer follow-up seems to better estimate the true incidence of complications compared with the discharge data from the study by Yoshihara et al.\textsuperscript{24}

In this study, respiratory complications occurred in 19.88\% of the whole study population within three months of operation. Postoperative pulmonary complications are estimated to cost

| Complication                              | Time Interval | Anterior (n = 455) | Posterior (n = 1004) | Total (n = 1459) |
|-------------------------------------------|---------------|-------------------|---------------------|-----------------|
| Intraoperative                            |               | n %               | n %                 | n %             |
| Cardiovascular                            | Day of surgery | 28 6.15           | 36 3.59             | 64 4.39         |
|                                           | Day of surgery | 12 2.64           | 21 2.09             | 33 2.26         |
|                                           | 1 mo postoperative | 30 6.59           | 49 4.88             | 79 5.41         |
|                                           | 3 mo postoperative | 33 7.25           | 69 6.87             | 102 6.99        |
| Central nervous system                    | Day of surgery | \(< 10 \leq 2.20\) | 14 1.39             | NR              |
|                                           | 1 mo postoperative | \(< 10 \leq 2.20\) | 37 3.69             | NR              |
|                                           | 3 mo postoperative | 16 3.52           | 51 5.08             | 67 4.59         |
| Deep venous thrombosis/pulmonary embolism | Day of surgery | \(< 10 \leq 2.20\) | \(\leq 10 \leq 1.00\) | NR              |
|                                           | 1 mo postoperative | 25 5.49           | 33 3.29             | 58 3.98         |
|                                           | 3 mo postoperative | 32 7.03           | 50 4.98             | 82 5.62         |
| Device-, implant-, or graft-related       | Day of surgery | 59 12.97          | 44 4.38             | 103 7.06        |
|                                           | 1 mo postoperative | 64 14.07          | 51 5.08             | 115 7.88        |
|                                           | 3 mo postoperative | 72 15.82          | 59 5.88             | 131 8.98        |
| Gastrointestinal                          | Day of surgery | 23 5.05           | 17 1.69             | 40 2.74         |
|                                           | 1 mo postoperative | 37 8.13           | 44 4.38             | 81 5.55         |
|                                           | 3 mo postoperative | 39 8.57           | 53 5.28             | 92 6.31         |
| Hemodynamic                               | Day of surgery | \(< 10 \leq 2.20\) | \(< 10 \leq 1.00\) | NR              |
|                                           | 1 mo postoperative | \(< 10 \leq 2.20\) | \(< 10 \leq 1.00\) | NR              |
|                                           | 3 mo postoperative | \(< 10 \leq 2.20\) | \(< 10 \leq 1.00\) | NR              |
| Infectious                                | Day of surgery | 18 3.96           | 50 4.98             | 68 4.66         |
|                                           | 1 mo postoperative | 65 14.29          | 145 14.44           | 210 14.39       |
|                                           | 3 mo postoperative | 86 18.90          | 210 20.92           | 296 20.29       |
| Organ failure                             | Day of surgery | 26 5.71           | 65 6.47             | 91 6.24         |
|                                           | 1 mo postoperative | 53 11.65          | 118 11.75           | 171 11.72       |
|                                           | 3 mo postoperative | 61 13.41          | 147 14.64           | 208 14.26       |
| Respiratory (infectious)                  | Day of surgery | \(< 10 \leq 2.20\) | \(< 10 \leq 1.00\) | NR              |
|                                           | 1 mo postoperative | 23 5.05           | 35 3.49             | 58 3.98         |
|                                           | 3 mo postoperative | 32 7.03           | 51 5.08             | 83 5.69         |
| Respiratory (noninfectious)               | Day of surgery | 47 10.33          | 72 7.17             | 119 8.16        |
|                                           | 1 mo postoperative | 97 21.32          | 135 13.45           | 232 15.90       |
|                                           | 3 mo postoperative | 101 22.20         | 155 15.44           | 256 17.55       |
| Respiratory (any)                         | Day of surgery | 50 10.99          | 75 7.47             | 125 8.57        |
|                                           | 1 mo postoperative | 108 23.74         | 151 15.04           | 259 17.75       |
|                                           | 3 mo postoperative | 114 25.05         | 176 17.53           | 290 19.88       |
| Wound                                     | Day of surgery | \(< 10 \leq 2.20\) | 18 1.79             | NR              |
|                                           | 1 mo postoperative | 28 6.15           | 53 5.28             | 81 5.55         |
|                                           | 3 mo postoperative | 43 9.45           | 77 7.67             | 120 8.22        |

Abbreviation: NR, not reportable.

\(*\) Exact count of complications with incidence of \(< 10\) in any subgroup is not shown in compliance with the Health Insurance Portability and Accountability Act (HIPAA) agreement.
up to $120,579 in surgical patients, and result in $7233 of additional costs in patients with spinal conditions.28,29 Furthermore, respiratory complications are associated with significant increase in postoperative mortality, length of stay, and health care utilization.30 The odds of respiratory complications on the day of surgery was 1.88 times larger in anterior group compared to the age-, gender- and comorbidity-matched cohort who had undergone posterior surgery, and this association remained significant within one month after surgery. This finding is in line with the fact that surgical interventions involving the thoracic cavity are inherently associated with higher risk of respiratory morbidities.18 Surprisingly, the incidence of respiratory complications was considerably high in the posterior approach (17.53% within 3 months after posterior decompression), signifying the importance of preemptive respiratory measures in both approaches. Noninfectious etiologies constituted the majority of respiratory adverse events in both groups (Table 3) and included potentially life threatening complications such as pulmonary embolism and infarction, acute respiratory failure, lung edema, pulmonary collapse, and pneumothorax. The morbidity associated with pulmonary complications can be reduced by preoperative risk stratification, early

| Complication                                | Time Interval          | Anterior (n = 358) | Posterior (n = 358) | Anterior Vs Posterior Decompression (Logistic Regression Analysis) |
|---------------------------------------------|------------------------|--------------------|--------------------|-------------------------------------------------------------------|
| Intraoperative Day of surgery               | 21 5.87 ≤10 <2.8       | NA                 | 1.99 1.10-3.75 .026 |
| Cardiovascular Day of surgery               | ≤10 <2.8 ≤10 <2.8      | .998 6.22 2.09-26.70 .004b |
| I mo postoperative                          | 25 6.98 ≤10 <2.8      | .049 3.47 1.95-6.53 <.0001b |
| 3 mo postoperative                          | 27 7.54 12 3.35       | .255 3.38 1.90-5.95 <.0001b |
| Central nervous system Day of surgery       | ≤10 <2.8 ≤10 <2.8      | NA                 | 1.6 0.31-11.67 .593 |
| I mo postoperative                          | ≤10 <2.8 ≤10 <2.8      | .74 1.83 0.84-4.31 .142 |
| 3 mo postoperative                          | 12 3.35 ≤10 <2.8     | .554 1.44 0.78-2.73 .246 |
| Deep venous thrombosis/pulmonary embolism   | ≤10 <2.8 ≤10 <2.8      | .736 0.66 0.13-3.03 .588 |
| I mo postoperative                          | 20 5.59 ≤10 <2.8      | .992 6.22 3.06-14.43 <.0001b |
| 3 mo postoperative                          | 25 6.98 13 3.63       | .287 3.35 1.95-6.05 <.0001b |
| Device-/implant-/graft-related Day of surgery| 44 12.29 19 5.31     | .358 2.44 1.61-3.79 <.0001b |
| I mo postoperative                          | 47 13.13 23 6.42      | .335 2.18 1.47-3.29 <.001b |
| 3 mo postoperative                          | 53 14.8 26 7.26       | .484 2.47 1.70-3.65 <.0001b |
| Gastrointestinal Day of surgery             | 19 5.31 ≤10 <2.8      | .463 2.3 1.22-4.59 .013b |
| I mo postoperative                          | 32 8.94 ≤10 <2.8      | .661 2.99 1.76-5.32 <.0001b |
| 3 mo postoperative                          | 33 9.22 13 3.63       | .676 2.62 1.58-4.51 <.001b |
| Hemodynamic Day of surgery                  | ≤10 <2.8 ≤10 <2.8      | .965 1.07 0.20-5.88 .932 |
| I mo postoperative                          | ≤10 <2.8 ≤10 <2.8      | .747 0.5 0.10-1.91 .328 |
| 3 mo postoperative                          | ≤10 <2.8 ≤10 <2.8      | .733 0.41 0.09-1.49 .199 |
| Infectious Day of surgery                   | 16 4.47 20 5.59       | .147 0.87 0.53-1.45 .603 |
| I mo postoperative                          | 50 13.97 55 15.63     | .528 0.94 0.68-1.29 .683 |
| 3 mo postoperative                          | 70 19.55 81 22.63     | .179 0.77 0.38-1.01 .06 |
| Organ failure Day of surgery                | 24 6.7 20 5.59        | .153 1.65 1.03-2.69 .039b |
| I mo postoperative                          | 46 12.85 34 9.5       | .832 1.49 1.03-2.16 .035b |
| 3 mo postoperative                          | 53 14.8 38 10.61      | .952 1.61 1.13-2.29 .008b |
| Respiratory (infectious) Day of surgery     | ≤10 <2.8 ≤10 <2.8      | NA                 | 2.68 0.61-18.42 .231 |
| I mo postoperative                          | 17 4.75 13 3.63       | .004 1.66 0.96-2.97 .075 |
| 3 mo postoperative                          | 23 6.42 19 5.31       | .003 1.42 0.88-2.33 .154 |
| Respiratory (noninfectious) Day of surgery  | 39 10.89 26 7.26      | .987 1.72 1.16-2.58 .007b |
| I mo postoperative                          | 78 21.79 46 12.85     | .867 2.05 1.51-2.81 <.0001b |
| 3 mo postoperative                          | 82 22.91 51 14.25     | .672 1.92 1.43-2.61 <.0001b |
| Respiratory (total) Day of surgery          | 42 11.73 26 7.26      | .999 1.88 1.28-2.81 .002b |
| I mo postoperative                          | 86 24.02 54 15.08     | .642 1.93 1.44-2.60 <.0001b |
| 3 mo postoperative                          | 91 25.42 62 17.32     | .772 1.72 1.30-2.29 <.001b |
| Wound Day of surgery                        | ≤10 <2.8 ≤10 <2.8     | NA                 | 0.25 0.06-0.65 .008 |
| I mo postoperative                          | 21 5.87 21 5.87       | .029 0.76 0.45-1.29 .314 |
| 3 mo postoperative                          | 34 9.5 33 9.22        | .528 1 0.67-1.52 .986 |

Abbreviations: OR, odds ratios; CI, confidence interval; NA, not available.

*Exact count of complications with incidence of ≤10 is not shown in compliance with the Health Insurance Portability and Accountability Act (HIPAA) agreement.

bSufficient model fit and statistically significant association.
detection, and intensive postoperative care. Even though several risk assessment measures exist, usefulness of current measures for thoracic spine surgery is unknown.

Limitations

Retrospective design is an important limitation of this study. Also, only few factors were considered in the matching process. However, addition of other potential confounders would decrease the sample size and thereby the power of our statistical comparisons. Three additional potential confounders were accounted for using logistic regression analysis.

Conclusion

Overall, anterior approach was associated with higher risks of postoperative morbidities, especially respiratory complications. Our future steps are to identify the predictive factors of respiratory compromise following thoracic decompression; to assess the morbidity, mortality, and costs associated with respiratory complications; and to develop a risk assessment score which may be used to identify the patients at risk of respiratory complications who may benefit from posterior decompression.

Declaration of Conflicting Interests

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Supplemental Material

The supplemental material is available in the online version of the article.

References

1. Busscher I, van Dieen JH, Kingma I, van der Veen AJ, Verkerke GJ, Veldhuizen AG. Biomechanical characteristics of different regions of the human spine: an in vitro study on multilevel spinal segments. Spine (Phila Pa 1976). 2009;34:2858-2864. doi:10.1097/BRS.0b013e3181b4c75d
2. Masharawi Y, Rothschild B, Dar G, et al. Facet orientation in the thoracolumbar spine: three-dimensional anatomic and biomechanical analysis. Spine (Phila Pa 1976). 2004;29:1755-1763.
3. Watkins R 4th, Watkins R 3rd, Williams L, et al. Stability provided by the sternum and rib cage in the thoracic spine. Spine (Phila Pa 1976). 2005;30:1283-1286.
4. Ross JS, Perez-Reyes N, Masaryk TJ, Bohman H, Modic MT. Thoracic disc herniation: MR imaging. Radiology. 1987;165: 511-515. doi:10.1148/radiol.165.2.3659375
5. Janes EA, Onishi FJ, Benites VDM, Yuens RM, Elia AJR, Cavalherio S. Thoracic disc herniation: Case series and protocol for surgical approaches. Coluna/Columna. 2016;15: 299-302.
6. Buser Z, Chung AS, Abedi A, Wang JC. The future of disc surgery and regeneration. Int Orthop. 2019;43:995-1002. doi:10. 1007/s00264-018-4254-7
7. Rohde RS, Kang JD. Thoracic disc herniation presenting with chronic nausea and abdominal pain. A case report. J Bone Joint Surg Am. 2004;86:379-381.
8. Shirzadi A, Drazin D, Jeswani S, Lovely L, Liu J. Atypical presentation of thoracic disc herniation: case series and review of the literature. Case Rep Orthop. 2013;2013:621476. doi:10.1155/2013/621476
9. Fransen P, Collignon F, Van Den Heule B. Foraminal disc herniation Th9-Th10 mimicking abdominal pain. Acta Orthop Belg. 2008;74:881-884.
10. Stetkova I, Chrobok J, Ehler E, Kofler M. Segmental abdominal wall paresis caused by lateral low thoracic disc herniation. Spine (Phila Pa 1976). 2007;32:E635-E639. doi:10.1097/BRS. 0b013e3181573ce5
11. McCormick WE, Will SF, Benzel EC. Surgery for thoracic disc disease. Complication avoidance: overview and management. Neurosurg Focus. 2000;9:e13.
12. Smith JS, Eichholz KM, Shafizadeh S, Ogden AT, O’Toole JE, Fessler RG. Minimally invasive thoracic microendoscopic discectomy: surgical technique and case series. World Neurosurg. 2013;80:421-427. doi:10.1016/j.wneu.2012.05.031
13. Paholpak P, Abedi A, Chamnan R, et al. Kinematic evaluation of thoracic spinal cord sagittal diameter and the space available for cord using weight-bearing kinematic magnetic resonance imaging. Spinal Cord. 2019;57:276-281. doi:10.1038/s41393-018-0198-4
14. Anand N, Regan JJ. Video-assisted thoracoscopic surgery for thoracic disc disease: classification and outcome study of 100 consecutive cases with a 2-year minimum follow-up period. Spine (Phila Pa 1976). 2002;27:871-879.
15. Han PP, Kenny K, Dickman CA. Thoracoscopic approaches to the thoracic spine: experience with 241 surgical procedures. Neurosurgery. 2002;51(S suppl):S88-S95.
16. Dickman CA, Rosenthal D, Karahalios DG, et al. Thoracic vertebrectomy and reconstruction using a microsurgical thoracoscopic approach. *Neurosurgery*. 1996;38:279-293.
17. Regan JJ, Mack MJ, Picetti GD 3rd. A technical report on video-assisted thoracoscopic surgery in thoracic spinal surgery. Preliminary description. *Spine (Phila Pa 1976)*. 1995;20:831-837.
18. Hurley ET, Maye AB, Timlin M, Lyons FG. Anterior versus posterior thoracic discectomy: a systematic review. *Spine (Phila Pa 1976)*. 2017;42:E1437-E1445. doi:10.1097/brs.0000000000002202
19. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40:373-383.
20. Moller AM, Pedersen T, Villebro N, Munksgaard A. Effect of smoking on early complications after elective orthopaedic surgery. *J Bone Joint Surg Br*. 2003;85:178-181.
21. Sanden B, Forsth P, Michaelsson K. Smokers show less improvement than nonsmokers two years after surgery for lumbar spinal stenosis: a study of 4555 patients from the Swedish spine register. *Spine (Phila Pa 1976)*. 2011;36:1059-1064. doi:10.1097/brs.0b013e3181e92b36
22. Guzman JZ, Iatridis JC, Skovrlj B, et al. Outcomes and complications of diabetes mellitus on patients undergoing degenerative lumbar spine surgery. *Spine (Phila Pa 1976)*. 2014;39:1596-1604. doi:10.1097/brs.000000000000482
23. Yoshihara H. Surgical treatment for thoracic disc herniation: an update. *Spine (Phila Pa 1976)*. 2014;39:E406-E412. doi:10.1097/brs.000000000000171
24. Yoshihara H, Yoneoka D. Comparison of in-hospital morbidity and mortality rates between anterior and nonanterior approach procedures for thoracic disc herniation. *Spine (Phila Pa 1976)*. 2014;39:E728-E733. doi:10.1097/brs.0000000000000322
25. Arts MP, Bartels RH. Anterior or posterior approach of thoracic disc herniation? A comparative cohort of mini-transthoracic versus transpedicular discectomies. *Spine J*. 2014;14:1654-1662. doi:10.1016/j.spinee.2013.09.053
26. Bilsky MH. Transpedicular approach for thoracic disc herniations. *Neurosurg Focus*. 2000;9:e3.
27. Le Roux PD, Haglund MM, Harris AB. Thoracic disc disease: experience with the transpedicular approach in twenty consecutive patients. *Neurosurgery*. 1993;33:58-66.
28. Fuller RL, McCullough EC, Bao MZ, Averill RF. Estimating the costs of potentially preventable hospital acquired complications. *Health Care Financ Rev*. 2009;30:17-32.
29. Whitmore RG, Stephen J, Stein SC, et al. Patient comorbidities and complications after spinal surgery: a societal-based cost analysis. *Spine (Phila Pa 1976)*. 2012;37:1065-1071. doi:10.1097/brs.0b013e31823da22d
30. Sabate S, Mazo V, Canet J. Predicting postoperative pulmonary complications: implications for outcomes and costs. *Curr Opin Anaesthesiol*. 2014;27:201-209. doi:10.1097/aco.0000000000000045