Rates of Mortality in Cervical Spine Surgical Procedures and Factors Associated With Its Occurrence Over a 10-Year Period: A Study of 342,477 Patients on the Nationwide Inpatient Sample

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ABSTRACT

Background: Risk of death is important in counseling patients and improving quality of care. Incidence of death in cervical surgery is not firmly established due to its rarity and limited sample sizes, particularly in the context of different surgeries, demographics, and risk factors. Particularly, different patient risk profiles may have varying degrees of risk in terms of surgeries, comorbidities, and demographics. This study aims to use a large patient cohort available on a national database to study the prevalence of death associated with cervical spine surgery.

Methods: This study was a retrospective review of the Nationwide Inpatient Sample (NIS) years 2003–2012. A total of 342,477 patients were identified by International Classification of Diseases, Ninth Revision, Clinical Modification codes undergoing spinal fusion or decompression for disc degeneration, stenosis, spondylosis, myelopathy, postlaminectomy syndrome, scoliosis, or neck pain associated with the cervical region. Patients with malignancy were excluded from analysis. Incidence of mortality was assessed by \( \chi^2 \) tests across different patient demographics and comorbidities, procedures performed, and concurrent in-hospital complications. Binary logistic regression identified significant increases or decreases in risk of death while controlling for comorbidities, race, sex, and Mirza invasiveness. Significance was defined as \( P < .05 \) differences relative to overall cohort.

Results: The study analyzed 342,477 patients with an overall mortality rate of 0.32%. A total of 231,977 simple fusions (single approach and \(< 3 \) levels) experienced a mortality rate of 0.256%; 49,594 complex fusions (combined approach or \( \geq 3 \) levels) had a mortality rate of 0.534%; and 61,285 decompression-only procedures reported a 0.424% mortality rate, all \( P < .001 \) from overall rate. In reporting rates across different demographics, male patients experienced a significantly higher risk for mortality (odds ratio [OR], 2.16; 95% CI, 1.87–4.49), as did black patients (OR, 1.58; CI, 1.32–1.90) and patients over age 75 (OR, 7.55; 95% CI, 6.58–8.65), all \( P < .001 \). Patients with liver disease reported 6.40% mortality. Similarly, patients with congestive heart failure (3.91%), cerebrovascular disease (3.41%), and paraplegia (3.79%) experienced high mortality rates, all in cohorts of over 2000 patients, all \( P < .001 \). Concurrent in-hospital complications with the highest risk of mortality were shock (OR, 51.41; 95% CI, 24.08–109.76), pulmonary embolism (OR, 25.01; 95% CI, 14.70–42.56), and adult respiratory distress disorder (OR, 14.94; 95% CI, 12.75–17.52), all \( P < .001 \).

Conclusion: In 342,477 cervical spine surgery patients an overall mortality rate of 0.32% was reported. The rate was 3.91% in a cohort of 59,33 patients with congestive heart failure and 3.79% in a cohort of 69,47 patients with paraplegia. These findings are consistent with previous estimates and may help counsel patients and improve in-hospital safety.

Level of Evidence: 3

INTRODUCTION

The risk of mortality is a rare but devastating occurrence for patients undergoing elective spinal surgical procedures. The reported mortality rate in cervical spine surgery based on currently available literature ranges from 0.14% to 1.53%. With the increasing age of the population and subsequent rise in demand for procedures being performed each year, further investigation is warranted to better identify patients at risk for mortality.

Smith et al. identified major causes of mortality in spinal deformity correction surgeries as respira-
tory failure, cardiac compromise, and sepsis, accounting for 159 of the 197 deaths in the study. This study did not include patients with malignancy, which account for a significant proportion of mortalities in cervical spine surgery. Risk of these events causing mortality may be elevated in spine surgeries due to their longer operative times and hemodynamic shifts. The overall strength of evidence in establishing mortality and morbidity based on existing literature on the cervical spine is low. Capturing true mortality rates among cervical spinal surgeries may be difficult given their uncommon occurrence with individual surgeons and institutions.

There are a number of individual studies looking at perioperative mortality in a wide range of sample populations, but they focus on analyzing data surrounding specific cervical spine pathologies or procedures. Larger studies have looked at epidemiologic trends in cervical spine procedures including surgical volume, patient demographics, costs, and/or length of hospitalization. Recent literature that specifically evaluates mortality in the cervical spine is limited. The purpose of this study, therefore, is to establish rates of mortality in cervical spine surgery according to procedure type, patient comorbidities, and complications experienced and to determine risk factors for their development. Use of a large national database, such as the National Inpatient Sample (NIS), will allow capture of nationwide trends of this uncommon occurrence.

**METHODS**

**Data Source**

The NIS is a database developed for the Healthcare Cost and Utilization Project (HCUP) and is the largest publicly available, all-payer inpatient health care database in the United States. It draws from nearly 8 million hospital stays each year and is designed to provide an approximated 20% stratified sample of participating community hospitals. The states participating in the NIS are estimated to represent more than 97% of the US population. For each discharged patient, the NIS provides data elements including primary and secondary diagnoses and procedures in *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* format, patient demographics, total charges, length of stay, and comorbidity measures. To improve representation, national estimates are generated using discharge weight files. More detailed information is available at https://www.hcup-us.ahrq.gov/nisoverview.jsp.

**Inclusion and Exclusion Criteria**

A retrospective review of the NIS database years 2003 through 2012 was performed. Patients included were age 18 years and over and, identified by ICD-9 coding, undergoing cervical fusion (81.00, 81.30, 81.39, 81.04-81.08, 81.34-81.38, 81.61-81.64), laminectomy (03.02), discectomy (80.50, 80.51), or other decompression (03.09). Included patients were treated for disc degeneration, stenosis, spondylisis, myelopathy, postlaminectomy syndrome, scoliosis, or neck pain (Appendix A).

**Mortality Predictors**

Procedures were classified as simple spinal fusions (anterior [81.01, 81.02, 81.34, 81.36, 81.37] or posterior approach [81.03, 81.33] less than 3 levels), complex fusions (involving 3 or more levels [81.61, 81.63, 81.64] or a combined approach), or decompression-only procedures (03.09, 03.02, 80.50, 80.51). Interbody device use (84.51) and bone morphogenic proteins (BMP; 84.52) were also assessed. Demographics were stratified by age (18–40, 41–54, 55–64, 65–74, and 75+ years), gender, and race (white, black, Asian, or other). Inpatient comorbidities were assessed using established protocol to construct the Charlson Comorbidity Index by ICD-9-CM coding. Next, concurrent complications (Appendix B) and diagnoses (Appendix A) were analyzed as predictors.

**Statistical Analysis**

Incidence of mortality was analyzed according to procedure, demographics, inpatient complications, and patient comorbidities using HCUP-provided hospital and year adjusted weights. Analysis of variance linear trends analysis described changes in mortality over the years studied. Predictors were transformed into categorical values to facilitate analysis to establish clinically relevant relative risk. After establishing incidence, binary logistic regression analyzed predictors independent contribution to risk of death controlling for race, Charlson Comorbidity Index, gender, age, and procedure performed. Predictors were removed from the list of controls when analyzed as an independent risk
factor. Significance was set at $P < .05$. IBM SPSS Statistics version 23.0 (IBM Corp, Armonk, New York) was used to perform all descriptive and comparative statistics. Odds ratios are reported as OR (95% CI).

RESULTS

A total of 342,477 patients age 18 or older undergoing cervical spine procedures from 2003 through 2012 were identified in the NIS database (average age = 53.05 years, female = 51%, male = 49%); 1109 deaths were found (0.32% mortality). There was no significantly increasing or decreasing mortality trend across the decade studied ($P = .094$; Figure).

Demographics

Male patients experienced significantly higher mortality (0.467%) than women (0.182%) (OR, 2.16 [95% CI, 1.87–4.49]; Table 1). Black race was an independent risk factor for mortality (OR, 1.58 [95% CI, 1.32–1.90]), whereas white race demonstrated a protective effect (OR, 0.75 [95% CI, 0.67–0.85]). Patients over age 75 experienced 2.35% mortality (OR, 7.55 [95% CI, 6.58–8.65]).

 Procedure and Complication

Stratification by procedure type is shown in Table 2. The mortality rate in simple fusions was 0.256% (OR, 0.63 [95% CI, 0.55–0.72]), and in complex fusions 0.534% (OR, 1.10 [95% CI, 0.95–1.28]). Decompression-only procedures were associated with an elevated mortality rate (0.424%) but lower risk after adjustment for confounders (OR, 0.59 [95% CI, 0.47–0.74]). Use of an interbody device or BMP to achieve spinal fusion was associated with a mortality rate of 0.229% (OR, 0.63 [95% CI, 0.55–0.73]) and 0.471% (OR, 1.28 [95% CI, 1.04–1.57]), respectively.

Table 1. Rates of mortality stratified on type of demographics.

| Procedure  | n  | No. of Deaths | Mortality, % | OR (95% CI) |
|------------|----|---------------|--------------|-------------|
| Overall    | 342,477 | 1109 | 0.32         |             |
| Gender     |     |               |              |             |
| Male       | 170,768 | 798  | 0.47         | 2.16 (1.87–4.49) |
| Female     | 171,273 | 311  | 0.18         | 0.46 (0.40–0.53) |
| Race       |     |               |              |             |
| White      | 220,082 | 674  | 0.31         | 0.75 (0.67–0.85) |
| Black      | 25,991  | 127  | 0.49         | 1.58 (1.32–1.90) |
| Asian      | 14,163  | 58   | 0.41         | 1.06 (0.81–1.40) |
| Other      | 82,241  | 250  | 0.30         | 1.15 (0.99–1.32) |
| Age        |     |               |              |             |
| 18–40      | 47,407  | 62   | 0.13         | 0.56 (0.43–0.73) |
| 41–54      | 146,388 | 149  | 0.10         | 0.28 (0.23–0.34) |
| 55–64      | 79,021  | 186  | 0.24         | 0.65 (0.55–0.76) |
| 65–74      | 46,432  | 213  | 0.46         | 1.10 (0.93–1.29) |
| 75+        | 21,220  | 498  | 2.35         | 7.55 (6.58–8.65) |

Abbreviation: OR, odds ratio.

Table 2. Rates of mortality stratified on type of procedure.

| Procedure  | n  | No. of Deaths | Mortality, % | OR (95% CI) |
|------------|----|---------------|--------------|-------------|
| Simple fusion | 231,977 | 594  | 0.26         | 0.63 (0.55–0.72) |
| Anterior   | 215,404 | 467  | 0.22         | 0.58 (0.51–0.66) |
| Posterior  | 2042    | 0    | 0.00         | NA          |
| Complex fusion | 49,594 | 265  | 0.53         | 1.10 (0.95–1.28) |
| Anterior   | 35,684  | 158  | 0.44         | 1.07 (0.9–1.28) |
| Posterior  | 1050    | 0    | 0.83         | 1.34 (0.49–3.87) |
| Combined   | 722     | 6    | 0.83         | 1.34 (0.49–3.87) |
| Decompression only | 61,285 | 260  | 0.42         | 0.59 (0.47–0.74) |
| Interbody device | 133,433 | 305  | 0.23         | 0.63 (0.55–0.73) |
| BMP        | 24,192  | 114  | 0.47         | 1.28 (1.04–1.57) |

Abbreviation: BMP, bone morphogenic proteins; OR, odds ratio.
Complications

In-hospital complications associated with the highest mortality risk (see Table 3) were shock (OR, 51.41 [95% CI, 24.08–109.76]), pulmonary embolism (OR, 25.01 [95% CI, 14.70–42.56]), and acute respiratory distress syndrome (OR, 14.94 [95% CI, 12.75–17.52]). Other complications associated with significant risk of mortality included cardiac compromise, deep vein thrombosis, nervous system disorders, respiratory complications, and infection.

Comorbidities

Comorbidities were designated as defined by the Charlson/Deyo clinical comorbidity index.22 Those linked with significantly higher mortality included moderate to severe liver disease (OR, 8.44 [95% CI, 4.44–16.04]), congestive heart failure (OR, 3.86 [95% CI, 3.23–4.62]), paraplegia (OR, 6.59 [95% CI, 5.57–7.79]), cerebrovascular disease (OR, 4.09 [95% CI, 3.28–5.09]), and renal disease (OR, 2.86 [95% CI, 2.40–3.41]; see Table 4). Other comorbidities include history of acute or chronic myocardial infarction (OR, 2.17 [95% CI, 1.77–2.66]), diabetes with chronic complication (OR, 1.45 [95% CI, 1.01–2.08]), and peripheral vascular disease (OR, 1.17 [95% CI, 0.84–0.63]).

Diagnoses

Risk of mortality was higher in treating certain diagnoses, which were established by querying the primary diagnosis (Table 5). Fracture (OR, 3.44 [95% CI, 2.84–4.26]), cord injuries (OR, 3.52 [95% CI, 2.73–4.53]), and myelopathy (OR, 1.61 [95% CI, 1.39–1.87]) diagnoses displayed increased risk. However, neither scoliosis (OR, 1.10 [95% CI, 0.78–1.54]) nor kyphosis (OR, 1.09 [95% CI, 0.73–1.34]) was a risk factor for mortality.

DISCUSSION

Despite the low incidence of mortality involved with spine surgery, it is important to be able to identify patients at increased risk for the ultimate adverse occurrence prior to making a decision to proceed with surgery. An understanding of where mortality occurs in cervical spine surgery can help practitioners evaluate current practices and find ways to better optimize patients before surgery.

The incidence of mortality in this study (0.32%) is consistent with existing literature on cervical spine surgery. Wang et al.1 found a mortality rate of 0.14% in a nationwide database study from 1992 to 2001 of patients with degenerative cervical spine disease. The lower rate may be explained by the younger patients in the study, with only 13% of the cohort being 65 years of age or older, as well as the use of stricter exclusion criteria. In a more recent study by Skolasky et al.,2 the mortality rate in all

Table 4. Rates of mortality stratified on type of comorbidities.

| Comorbidity                              | n   | No. of Deaths | Mortality, % | OR (95% CI)          |
|------------------------------------------|-----|---------------|--------------|----------------------|
| Previous myocardial infarction           | 9189| 135           | 1.47         | 2.17 (1.77–2.66)     |
| Congestive heart failure                 | 5933| 232           | 3.91         | 3.86 (3.23–4.62)     |
| Peripheral vascular disease              | 4069| 51            | 1.25         | 1.17 (0.84–0.63)     |
| Cerebrovascular disease                  | 3867| 132           | 3.41         | 4.09 (3.28–5.09)     |
| Dementia                                 | 502 | 15            | 2.99         | 2.12 (1.24–3.63)     |
| Chronic pulmonary disease                | 48,000| 189         | 0.39         | 0.99 (0.83–1.18)     |
| Rheumatic disease                        | 7361| 20            | 0.27         | 0.70 (0.44–1.12)     |
| Peptic ulcer disease                     | 1505| 12            | 0.80         | 1.32 (0.67–2.63)     |
| Mild liver disease                       | 2356| 42            | 1.78         | 4.05 (2.90–5.64)     |
| Diabetes without chronic complication    | 44,780| 179         | 0.40         | 0.72 (0.60–0.87)     |
| Diabetes with chronic complication       | 3760| 39            | 1.04         | 1.45 (1.01–2.08)     |
| Hemiplegia or paraplegia                | 6957| 264           | 3.79         | 6.59 (5.57–7.79)     |
| Renal disease                            | 8964| 208           | 2.52         | 2.86 (2.40–3.41)     |
| Moderate or severe liver disease         | 172 | 11            | 6.40         | 8.44 (4.44–16.04)    |
| Any malignancy                           | 1177| 87            | 7.39         | 1.17 (0.88–1.56)     |
| Metastatic solid tumor                   | 1081| 96            | 8.88         | 4.38 (3.34–6.09)     |

Abbreviation: OR, odds ratio.
cervical spine procedures between 2000 and 2009 was found to be 0.42%. This, along with the current analysis, may be more reflections of true mortality based on their inclusion of patients with malignancy.

Our findings are also consistent with the results of large systematic reviews that looked at spine surgery as a whole. Dekutoski et al. compiled data from 11 studies and found surgeries involving the cervical or lumbar spine were associated with mortality rates <1%. Thoracic spine surgery, however, had a considerably higher mortality rate ranging from 3% to 7%. This may be explained by the higher incidence of complications, particularly pulmonary, associated with thoracic surgeries and their proximity to vital structures. A recent single-institution study with access to surgical details, which are not available in the NIS, found operations of the cervical spine to be a significant predictor of postoperative mortality. This study, however, did not find an increased risk of mortality with thoracic procedures, but attributed this to low power from a small sample of cases involving the thoracic spine.

Prior studies have looked at mortality based on specific spinal procedures. Anterior cervical fusions account for approximately 80% of the total cervical spine procedures performed annually in the United States. Memtsoudis et al. examined noncervical spinal fusions and mortality based on approach and found higher rates with anterior and combined anterior/posterior spinal fusions. Our study found consistent results, with the combined approach being associated with the highest procedure-derived mortality rate at 0.83%. Despite the use of a national database, the sample size for posterior approaches in this study did not have sufficient power to establish a decreased risk for mortality. Our findings regarding mortality risk associated with procedures must be interpreted within that context.

Literature detailing BMP’s effect in the cervical spine has not found a significant increase in mortality with BMP use. The current study found it as an independent risk factor by a slim margin, which may represent more invasive surgeries that were not adequately controlled in multivariate analysis.

To our knowledge, patient age may be the most scrutinized aspect of patient demographics in literature about outcomes in spinal surgery. Increased age has been identified as an independent predictor of mortality in various studies involving pathology and procedures of the spine. This is supported by our results, which reveal that an increase in mortality risk with male sex in our analysis was also associated with significantly increased risk of mortality following cervical spine surgery. Schoenfeld et al. examined effect of gender in spine surgery and found that males had a 63% increase in postoperative odds of death compared with females. However, 5 of the 11 studies included were based on the lumbar spine, whereas another 5 looked at spine surgery in general. Skolasky et al. examined the impact of race on outcomes after cervical spine surgery, and our results support their findings of blacks being at increased risk of death (after adjusting for confounders). The etiology for these findings is thought to be multifactorial and should be a focus for future research because it is not within the scope of this database to establish causality.

Desai et al. performed a study examining independent predictors of mortality following spine surgery and found increased age and cervical location to be prognostic indicators of 30-day postoperative mortality. Demographics were not identified as an independent predictor in their findings. However, the study was based on single-institution data and the generalizability of their results was limited. The results of our study also found black race to be associated with an increased risk of mortality, consistent with the findings of Skolasky et al. This was postulated to be a result of patients presenting at later clinical stages or with more comorbidities. Our findings also indicated that male sex was associated with increased mortality rates.

The limitations of this study arise primarily from the design of the NIS database used for our analysis. Though we were able to comprehensively capture mortality rates, the study does not address morbidity associated with cervical spine surgery. Events such as wound complications, neurologic deficits, or postoperative neuropathic pain may lead to readmission and are important when considering the longitudinal nature of many cervical disease processes. Procedure type was used as a surrogate for case complexity, but the database limits us from further detailing the surgical procedure (ie, blood loss, length of surgery, individual case complexity, preoperative American Society of Anesthesiologists grade). In addition, patient comorbidities are not
fully specified (eg, severity, length of disease, patient medication compliance). Last, the severity of complications is not quantified; we are aware of the end point only if it involved mortality. This study cannot be generalized to all cervical spine surgeries because it does not include cases involving malignancy. The NIS database design also prevents the capture of mortality rates for outpatient cervical spine procedures, which are being performed with increasing frequency.\(^{26}\) It may underestimate overall mortality for this reason\(^1,9\) but is likely accurate in the context of elective cervical procedures.

**CONCLUSION**

Having realistic expectations of the anticipated outcome of a procedure is beneficial to both the physician and patient in the decision-making process. This study looked at 342,477 cervical spine surgery patients and found an overall mortality rate of 0.32%. Characteristics that place patients at increased risk of mortality include increased age, male sex, and black race. Patient comorbidities that may require careful preoperative evaluation and optimization are moderate to severe liver disease, congestive heart failure, and paraplegia. Complications of cervical spine surgery associated with high risk of mortality were shock and pulmonary embolism. Further research is required to establish causation, but these precursory findings can help surgeons determine risk prognosis and counsel patients who are considering surgical intervention.

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Appendix A. ICD-9-CM codes used in this analysis to identify relevant spinal diagnoses.

| Code   | Region | Diagnosis                                      |
|--------|--------|-----------------------------------------------|
| 72210  | Lumbar | Disc displacement                              |
| 72402  | Lumbar | Spondylysis                                   |
| 72220  | Cervical| Disc displacement                              |
| 72252  | Lumbar | Degeneration                                   |
| 7384   | Non-specific | Spondylysis                                   |
| 7213   | Lumbar | Spondylysis                                   |
| 7211   | Cervical| Spondylyotic myelopathy                        |
| 7210   | Cervical| Spondylysis                                   |
| 72271  | Cervical| Disc displacement w myelopathy                 |
| 7230   | Cervical| Stenosis                                      |
| 7224   | Cervical| Disc degeneration                             |
| 75612  | Non-specific | Spondylysis                                   |
| 99649  | Non-specific | Mechanical complication of internal ortho device |
| 72273  | Lumbar | Disc displacement w myelopathy                 |
### Appendix A.  Continued.

| Code      | Region                      | Diagnosis                                      |
|-----------|-----------------------------|-----------------------------------------------|
| 7222      | Cervical                    | Degeneration of IVD                           |
| 83906     | Cervical                    | Dislocation                                   |
| 34981     | Nonspecific                 | Rhinorrhea                                    |
| 7200      | Nonspecific                 | Ankylosing Spondy                             |
| 83908     | Cervical                    | Dislocation                                   |
| 3361      | Nonspecific                 | Vascular myelopathy                           |
| 7212      | Thoracic                    | Spondylosis                                   |
| 83904     | Cervical                    | Dislocation                                   |
| 72281     | Cervical                    | Postlaminectomy                               |
| 80608     | Cervical                    | Central cord syndrome                         |
| 71888     | Nonspecific                 | Derangement nec                               |
| 389       | Nonspecific                 | Hearing loss                                  |
| 7231      | Cervical                    | Neck pain                                     |
| 73018     | Nonspecific                 | Osteomyelitis                                 |
| 74101     | Nonspecific                 | Spina bifida                                  |
| 80604     | Cervical                    | Cord injury                                   |
| 80503     | Cervical                    | Fracture                                      |
| 75619     | Nonspecific                 | Anomaly                                       |
| 7385      | Nonspecific                 | Deformity                                     |
| 3812      | Cervical                    | Head and neck vessels                         |
| 4373      | Nonspecific                 | Cerebral aneurysm                             |
| 80621     | Thoracic                    | Fracture                                      |
| 99851     | Nonspecific                 | Infection                                     |
| 95200     | Cervical                    | Spinal cord                                   |
| 3369      | Nonspecific                 | Spinal cord                                   |
| 7202      | Lumbar                      | Sacroilitis                                   |
| 7243      | Nonspecific                 | Sciatica                                      |
| 99675     | Nonspecific                 | Complication                                  |
| 72292     | Thoracic                    | Disc degen                                    |
| 7238      | Cervical                    | Syndrome                                      |
| 72400     | Nonspecific                 | Stenosis                                      |
| 80601     | Cervical                    | Fracture                                      |
| 80603     | Cervical                    | Fracture                                      |
| 80620     | Thoracic                    | Fracture                                      |
| 72190     | Nonspecific                 | Spondy wo myelo                               |
| 95205     | Cervical                    | Spinal cord                                   |
| 83903     | Cervical                    | Dislocation                                   |
| 73734     | Thoracic                    | Scoliosis                                     |
| 99663     | Nonspecific                 | Graft comp                                    |
| 7245      | Nonspecific                 | Back ache                                     |
| 72282     | Thoracic                    | Postlaminectomy                               |
| 3314      | Nonspecific                 | Hydrocephalus                                  |
| 3482      | Nonspecific                 | Tumor                                         |
| 99647     | Nonspecific                 | Implant                                       |
| 7320      | Nonspecific                 | Juvenile osteochondrosis                      |
| 95204     | Cervical                    | Spinal cord                                   |
| 4412      | Thoracic                    | Aneurysm                                      |
| 73329     | Nonspecific                 | Bone cyst                                     |
| 7248      | Nonspecific                 | Other back                                    |
| 80624     | Thoracic                    | Cord injury                                   |
| 42        | Nonspecific                 | Esophagus                                     |
| 7292      | Nonspecific                 | Neuralgia                                     |
| 73320     | Nonspecific                 | Cyst of bone                                  |
| 7237      | Cervical                    | Ossification cerv                             |
| 4417      | Thoracic                    | Aneurysm                                      |
| 99832     | Nonspecific                 | Disruption                                    |
| 73390     | Nonspecific                 | Bone and cartilage disorder nos               |
| 7226      | Nonspecific                 | IVD degeneration                              |
| 4320      | Nonspecific                 | Hemorrhage                                    |
| 2148      | Nonspecific                 | Lipoma                                        |
| 431       | Nonspecific                 | Hemorrhage                                    |
| 3480      | Nonspecific                 | Cerebral cyst                                 |
| 7542      | Nonspecific                 | Congenital musculoskeletal deformity          |
| 8056      | Lumbar                      | Fracture                                      |
| 99659     | Nonspecific                 | Malfunction of device                         |
| 3559      | Nonspecific                 | Mononeuritis                                  |
| 7249      | Nonspecific                 | Back disorder                                 |
| 33818     | Nonspecific                 | Postop pain                                   |
| 99641     | Nonspecific                 | Mechanical loosening of joint                 |
| 99677     | Nonspecific                 | Complication of joint                         |
| 34931     | Nonspecific                 | Puncture of dura                              |

Abbreviations: ICD-9, International Classification of Diseases, Ninth Revision, Clinical Modification; IVD, intervertebral disc.
## Appendix B.

### Procedure-Related Complications  
**ICD-9-CM Codes**

| Complication                        | Codes                           |
|-------------------------------------|---------------------------------|
| **Organ-specific complications**   |                                 |
| Dysphasia                          | 478.30, 478.31, 478.32, 478.33, 478.34, 784.4, 787.2 |
| Nervous system                      | 997.0, 997.00, 997.01, 997.02, 997.09 |
| Cardiac                             | 997.1                           |
| Peripheral vascular                 | 997.2                           |
| Respiratory                         | 997.3, 997.30, 997.39           |
| Digestive system                    | 997.4                           |
| Urinary                             | 997.5                           |
| **Other complications of procedures** |                                 |
| Device-related                      | 996.00, 996.4, 996.40, 996.41, 996.42, 996.43, 996.44, 996.45, 996.46, 996.47, 996.49 |
| Post-op shock                       | 998.0                           |
| Hematoma/seroma                     | 998.1, 998.12, 998.13           |
| Puncture vessel/nerve               | 998.2                           |
| Wound dehiscence                    | 998.3, 998.30, 998.31, 998.32, 998.33 |
| Postoperative infection             | 998.5, 998.51, 998.59           |
| Acute posthemorrhagic anemia        | 285.1                           |
| Adult respiratory distress syndrome | 518.5                           |
| Pulmonary embolism                  | 415.1, 415.11, 451.19           |
| Deep vein thrombosis                | 451.11, 451.19, 451.2, 451.81, 451.9, 453.40, 453.41, 453.42, 453.9 |
| Venous thrombotic events            | 415.1, 415.11, 451.19, 451.11, 451.19, 451.2, 451.81, 451.9, 453.40, 453.41, 453.42, 453.9 |

Abbreviation: **ICD-9-CM**, *International Classification of Diseases, Ninth Revision, Clinical Modification.*