Cervical Spine Reoperation Rates and Hospital Resource Utilization After Initial Surgery for Degenerative Cervical Spine Disease in 12 338 Patients in Washington State

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OBJECTIVE: Patients undergoing surgery for degenerative cervical spine disease may require future surgery for disease progression. We investigated factors related to the rate of additional cervical spine surgery, the associated length of stay, and hospital charges.

METHODS: The was a longitudinal retrospective cohort study using Washington state's 1998 to 2002 state inpatient databases and International Classification of Diseases–Ninth Revision–Clinical Modification (ICD-9) codes to analyze patients undergoing degenerative cervical spine surgery. Multivariate Poisson regression to identify patient and surgical factors associated with reoperation for degenerative cervical spine disease was used. Multivariate linear regressions to identify factors associated with length of stay and hospital charges adjusted for age, sex, year of surgery, primary diagnosis, payment type, discharge status, and comorbidities were also used.

RESULTS: A total of 12 338 patients underwent initial cervical spine surgeries from 1998 to 2002; the mean follow-up duration was 2.3 years, and 688 patients (5.6%) underwent a reoperation (2.5% per year). Higher reoperation rates were independently associated with younger patients ($P < 0.001$) and a primary diagnosis of disc herniation with myelopathy ($P = 0.011$). Ventral surgery ($P < 0.001$) and fusion ($P < 0.001$) were both associated with lower rates of reoperation; however, a high correlation (Spearman's rho = 0.82; $P < 0.001$) made it impossible to determine which factor was dominant. Longer length of stay was independently associated with nonventral approaches (+1.0 day; $P < 0.001$) and fusion surgery (+0.8 day; $P < 0.001$). Greater hospital charges were independently associated with nonventral approaches (+$2900; $P < 0.001$) and fusion surgery (+$9600; $P < 0.001$).

CONCLUSION: Patients undergoing surgery for degenerative cervical spine disease undergo reoperations at the rate of 2.5% per year. An initial ventral approach and/or fusion seem to be associated with lower reoperation rates. An initial nonventral approach and fusion were more expensive.

KEY WORDS: Cervical vertebrae, Hospital costs, Length of stay, Reoperation, Spine, Surgery

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Cervical spondylosis represents one of the most common indications for spinal surgery in the United States. Approximately 112 400 operations for cervical spondylosis are performed annually in the United States, with hospital charges greater than $2 billion per year (21). A recent study found that the average hospital charge for a cervical spine reoperation is $57 205 (11). Data from administrative databases show that surgery for cervical spondylosis has many early complications as well as late failures potentially leading to reoperations (2, 25). Dorsal cervical spine surgical procedures (compared with ventral surgical

ABBREVIATIONS: ICD-9, International Classification of Diseases–Ninth Revision–Clinical Modification; **IRR**, incidence rate ratio; **LOS**, length of stay; **RCT**, randomized controlled trial; **SID**, State Inpatient Database procedures) are associated with higher complication rates in studies of administrative databases (2, 24). Identifying modifiable factors such as the choice of approach might reduce cervical spine reoperations and might improve public health and curb health care expenditures.

Several state inpatient administrative databases contain unique patient identifiers that permit the longitudinal evaluation of patients (13). This approach was applied using the Washington State Inpatient Database (SID) to determine the reoperation rate after initial lumbar spine surgery (19). To date, studies have not been published that examine the long-term reoperation rate after cervical spine surgery. Recently, however, a cervical spine algorithm based on a published lumbar algorithm was published and used to identify cervical spondylosis surgery hospital discharges from administrative databases (25).

The purpose of this study was to determine the reoperation rate after cervical spine surgery for degenerative disease. We performed a longitudinal review of the population-based Washington SID from 1998 to 2002 to determine the reoperation rates for cervical spine surgery for degenerative disease in a large United States patient population (13). The effect of modifiable factors, including the surgical approach with or without fusion, was analyzed to determine risk factors for cervical spine reoperation.

MATERIALS AND METHODS

Data Source

The SIDs are part of the Healthcare Cost and Utilization Project sponsored by the Agency for Healthcare Research and Quality (13). The SIDs contain data on all inpatient hospital discharges in 39 participating states, including demographics, admission source, month and year of admission and discharge, diagnosis, and procedure codes using the International Classification of Diseases–Ninth Revision–Clinical Modification (ICD-9), diagnostic related group, hospital code, physician code, surgeon code, payer code, charge data, length of stay (LOS), disposition, and inpatient deaths. Most states do not use consistent patient identifiers from year to year; however, the state of Washington is 1 of 5 states that assigns individuals consistent patient identifiers across several years, permitting longitudinal follow-up of individual patients. Unfortunately, even states like Washington that use consistent identifiers from year to year periodically change their methodology of assigning patient identifiers, limiting long-term follow-up. This study examined hospital stays involving cervical spine surgeries for degenerative cervical spine disease using 1998 to 2002 discharge data from the Washington SID, the longest time period with consistent identifiers available at the time of this study.

Data Cleaning

Duplicate records and records for patients younger than 18 years old were purged from the data set, as were records that lacked any ICD-9 diagnosis codes. Cervical spine reoperations that occurred within the same month as the initial procedure were excluded from the analysis. Hospital charges were converted to 2007 US dollars using the Consumer Price Index for Medical Goods and Services (5). During the study period, Washington state used the first 2 letters of the first name, the first 2 letters of the last name, and the date of birth to assign patient identification numbers for each admission. Rarely, 2 or more individuals with similar names who were born on the same day would be assigned the same identification number. This dual assignment could be detected via inconsistencies in the data, e.g., sex change between admissions. All identification numbers with sex inconsistencies were purged from the data set. In addition, individuals who changed their name between admissions (e.g., after marriage or divorce) could be assigned a second identification number (although some hospitals continue to use original names for administrative purposes even after patients have changed their name). Unfortunately, there is no way to identify which individuals changed their name between admissions.

Case Selection Algorithm

An algorithm described by Wang et al. (25) and ICD-9 diagnosis and procedure codes were used to identify surgical procedures associated with degenerative cervical spine disease, defined as spine conditions that might be associated with neck or upper extremity pain or neurological deficit referable to the cervical spine. The algorithm excluded patients with diagnoses indicating infection, pregnancy, inflammatory spondyloarthropathy, neuropathy, myopathy, malignancy, anomalies of the cranium and facial bones, and trauma. For initial surgeries, patients with ICD-9 diagnosis codes associated with repeat procedures were excluded (e.g., 996.4, mechanical complication of internal orthopedic device, implant, and graft); for reoperations, patients with these codes were retained. The algorithm is described in detail in the Appendix.

Charlson Comorbidity Index

The Charlson comorbidity index is an inpatient disease severity classification system that uses diagnoses recorded in the medical record and a scoring system to stratify patients by disease burden (3). ICD-9 diagnosis codes and a published algorithm (6) were used to generate a Charlson comorbidity index for each patient.

Calculation of Follow-up

Duration of follow-up was calculated as the difference between the date of initial surgery and the date of death, the date of a subsequent hospital admission for surgery for degenerative cervical spine disease, or, if alive with no additional cervical spine surgery, the last date possible for inclusion in the database, i.e., December 2002.

Data Analysis

Medians and interquartile ranges were calculated for continuous variables, and ordinal and categorical variables were tabulated. The Mann-Whitney *U* test, Cuzick's nonparametric test for trend, and the Fisher exact test were used to compare continuous, ordinal, and categorical variables, respectively. Multivariate linear regression models were used to assess the relationship between surgical approach, initial versus reoperation, primary diagnosis, fusion, LOS, and total hospital charges while adjusting for age, sex, year of surgery, payment type, discharge status, and Charlson comorbidity index.

Kaplan-Meier plots were used to examine duration from initial surgery to reoperation. A multivariate Poisson regression was used to examine demographics (age in decades, sex, year of surgery), clinical factors (Charlson comorbidity index, primary diagnosis), payment type, discharge status, and surgical factors (ventral versus dorsal approach, fusion surgery) associated with the reoperation rate after initial cervical spine surgery. The output of a Poisson regression has certain advantages over the more familiar Cox regression. Poisson regression provides incidence rate ratios (IRRs) showing the ratio of event rates (i.e., reoperation) between different levels of a variable, and the IRR can be used to

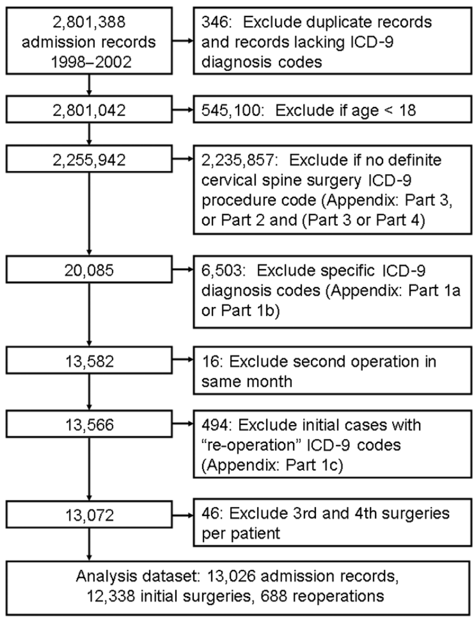

FIGURE 1. *Flow diagram showing identification of admissions for cervical spine surgery for degenerative spine disease in the Washington State Inpatient Database from 1998 to 2002.*

derive absolute event rates (i.e., annual rates of redo surgery). Cox regression provides hazard ratios, which indicate ratios between hazard rates of different levels of a particular variable and the relative strength of association across different variables, but Cox regression cannot be used to calculate absolute event rates. In the final multivariate Poisson model, age, sex, year of surgery, payment type, discharge status, Charlson comorbidity index, and primary diagnosis were retained as adjustment variables, and multivariate Poisson regression was used to select surgical predictor variables for the reoperation rate after initial cervical spine surgery. The data met the assumptions of a Poisson model (goodness-of-fit $\chi^2 = 5231$; $P = 1.000$). Analyses were performed using Stata version 10 (StataCorp, College Station, TX). Two-tailed P values less than 0.05 were considered significant, and values greater than 0.05 and less than 0.10 were considered trends.

RESULTS

Demographic and Clinical Data

For the period from 1998 to 2002, there are 2.8 million hospitalization records in the Washington SID. Applying the case selection algorithm of Wang et al. (25) to the ICD-9 diagnosis and procedure codes in the cleaned data set yielded 12 338 patients with between 1 and 4 admissions for surgery for degenerative cervical spine disease (Fig. 1). The number of patients undergoing 3 or more surgeries was too small for meaningful study (n = 46; 0.4%); thus, the analysis was confined to initial and first reoperations. At the time of their initial surgery, the median (interquartile range) patient age was 48 years (age range, 41–55 years), and 54% were men (Table 1).

TABLE 1. Study population[a]

	Initial surgery (n = 12 338)	Reoperation (n = 688)
Age (y), median (interquartile range)	48 (41–55)	47 (41–54)
Range (y)	18–93	25–83
Gender, no. (%)		
Male	6693 (54)	405 (59)
Female	5645 (46)	283 (41)
Primary diagnosis (ICD-9 code), no. (%)		
Displacement of cervical vertebral disc without myelopathy (722.0)	5743 (47)	221 (32)
Cervical spondylosis without myelopathy (721.0)	2356 (19)	134 (20)
Spinal stenosis in the cervical region (723.0)	1176 (10)	83 (12)
Mechanical complication of internal orthopedic device, implant, or graft (996.4)	0 (0)	78 (11)
Cervical spondylosis with myelopathy (721.1)	1108 (9)	45 (7)
Cervical region intervertebral disc disorder with myelopathy (722.71)	1029 (8)	41 (6)
Other	926 (8)	86 (13)
Charlson comorbidity index, no. (%)		
0	11 234 (91)	630 (92)
1	1004 (8)	53 (8)
2	100 (1)	5 (0.7)
Surgical approach, no. (%)		
Ventral	10 132 (82)	430 (63)
Dorsal	1762 (14)	204 (30)
Ventral and dorsal	435 (4)	29 (4)
Unspecified approach	9 (0.1)	25 (4)
Fusion, no. (%)		
Ventral	10 449 (85)	447 (65)
Dorsal	181 (1)	39 (6)
Ventral and dorsal	118 (1)	12 (2)
Unspecified fusion	19 (0.2)	33 (5)
No fusion	1571 (13%)	157 (23%)
Payment type, no. (%)		
Medicare/Medicaid	2503 (20)	143 (21)
Private insurance	7430 (60)	349 (51)
Self-pay	181 (1)	7 (1)
Other	2224 (18)	189 (27)
Discharge status, no. (%)		
Home	12 937 (97)	659 (96)
Health care facility	389 (3)	28 (4)
Died	12 (0.1)	1 (0.2)

[a] ICD-9, International Classification of Diseases–Ninth Revision–Clinical Modification.

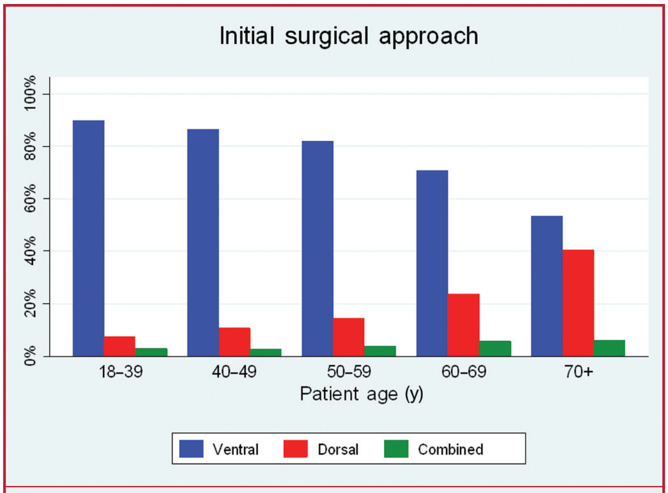

FIGURE 2. *Initial surgical approach stratified by patient age. Note decreasing use of ventral surgery and increasing use of dorsal surgery as patients age.*

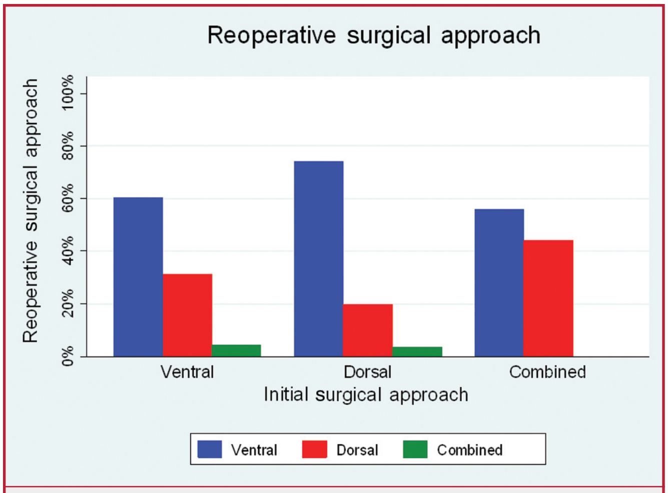

FIGURE 3. *Comparison of initial and reoperation surgical approaches. Ventral surgery is the most popular reoperation approach regardless of the initial approach.*

The most common ICD-9 primary diagnoses were displacement of a cervical vertebral disc without myelopathy (722.0; 47%), cervical spondylosis without myelopathy (721.0; 19%), spinal stenosis in the cervical region (723.0; 10%), cervical spondylosis with myelopathy (721.1; 9%), and cervical region intervertebral disc disorder with myelopathy (722.71; 8%).

Initial Surgery

The initial surgical approaches used for the 12 338 patients were 82% ventral, 14% dorsal, 4% combined, and 0.1% unspecified (Table 1). Ventral approaches were more common in the younger patients, ranging from 90% of surgeries in patients 18 to 39 years old to 53% of surgeries in patients 70 years and older (trend $P < 0.001$) (Fig. 2). Dorsal surgical approaches became more prevalent with increasing patient age, increasing from 7% of surgeries in patients 18 to 39 years old to 41% of surgeries in patients 70 years and older (trend $P < 0.001$). Combined ventral and dorsal approaches composed only 3% to 6% of all surgeries regardless of age. Eighty-seven percent of initial surgeries involved fusion, including ventral (85%), dorsal (1%), and combined ventral and dorsal (1%) fusion procedures (Table 1). Twelve patients (0.1%) died during hospitalization for their initial surgery.

Reoperations

A total of 688 patients (5.6%) had reoperations for degenerative cervical spine disease recorded in the database. The median age of patients undergoing a reoperation was 47 years (age range, 41–54 years), and 59% were men (Table 1). The most common ICD-9 primary diagnoses at reoperation were displacement of a cervical vertebral disc without myelopathy (722.0; 32%), cervical spondylosis without myelopathy (721.0; 20%), spinal stenosis in the cervical region (723.0; 12%), and mechanical complication of internal orthopedic device, implant, and graft (996.4; 11%). Compared with initial surgeries, reoperations were 16% more likely to use a dorsal approach ($P < 0.001$) and 12% less likely to include fusion ($P < 0.001$). A surgical approach different from that used in the initial surgery was used in 49% of reoperations (Fig. 3). The 0.2% hospital mortality rate after reoperations was similar to the initial surgery rate ($P = 0.506$).

Poisson Model of Reoperation

The cohort of 12 338 patients had a total of 27 832 years of follow-up, with a median follow-up duration of 2.3 years (range, 1–59 months). A total of 688 (5.6%) underwent reoperation for degenerative cervical spine disease, a rate of 2.5% per year (95% confidence interval, 2.3%–2.7%) after adjusting for variable follow-up (Fig. 4). In the simple Poisson regression models, higher rates of reoperation were associated with younger patients (versus age 70+ years) (IRR age 18–49 = 2.36; IRR age 50–59 = 1.81; IRR age 60–69 = 1.53; $P < 0.001$), men (IRR = 1.17; $P = 0.038$), a primary diagnosis of herniated cervical disc with myelopathy (ICD-9 722.21; IRR: 1.32; $P = 0.026$), and other type of payment (IRR = 1.75; $P < 0.001$) (Fig. 4). When examining surgical variables, a lower reoperation rate was associated with ventral approaches (IRR = 0.82; $P = 0.036$) and fusion surgery (IRR = 0.75; $P = 0.007$) (Fig. 4). All ventral surgeries included fusion, and 11% of dorsal surgeries involved fusion. This high correlation between ventral surgery and fusion (Spearman's rho = 0.82, $P < 0.001$) prevented us from determining which variable was the dominant effect and precluded including both variables in the same Poisson model. Consequently, we built 2 separate multivariate Poisson regression models: one to examine ventral surgery and a second to examine fusion surgery. Both multivariate models showed that after adjusting for sex, year of surgery, comorbid disease, discharge status, and payment type, higher reoperation rates were

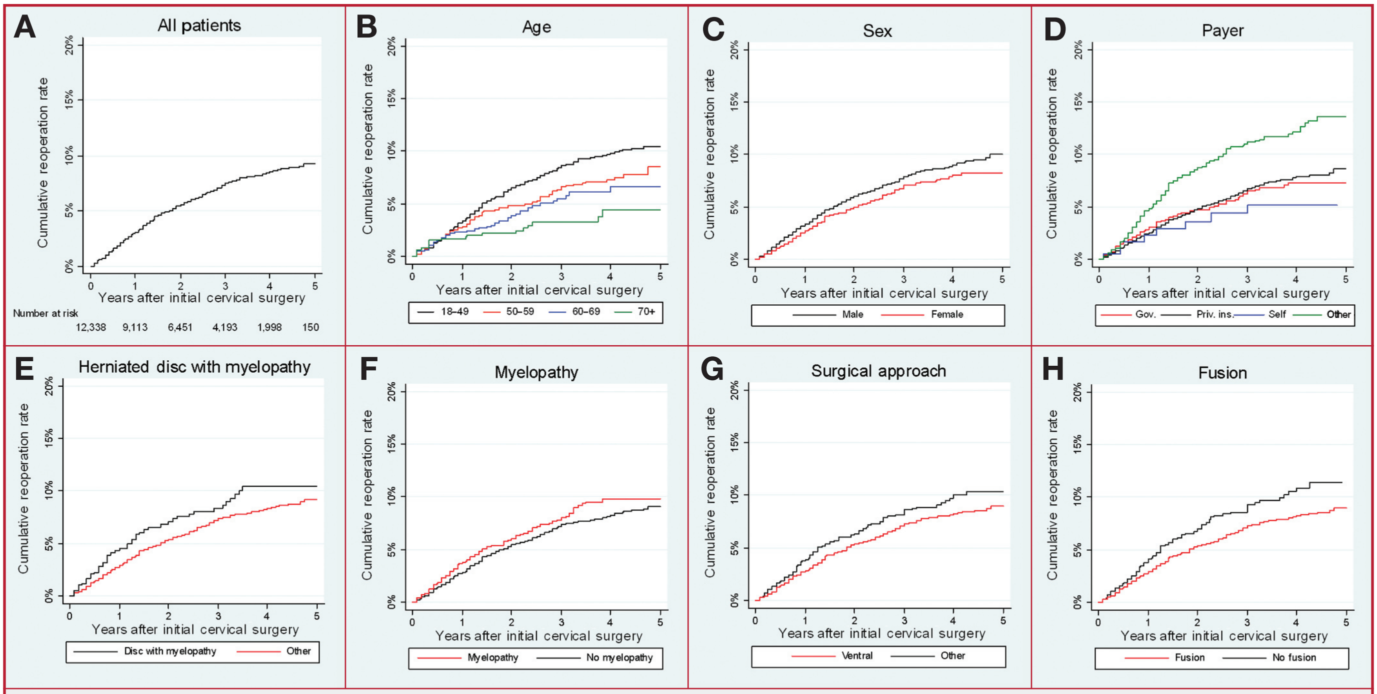

FIGURE 4. *Kaplan-Meier curves showing cumulative reoperations after initial surgery for degenerative cervical spine disease, statistical significance assessed with multivariate Poisson regression.* **A**, *all patients.* **B**, *age stratified in 4 categories of 18 to 49 years, 50 to 59 years, 60 to 69 years, and 70+ years old; $P < 0.001$.* **C**, *male versus female patients, $P < 0.038$.* **D**, *type of payment for hospital admission: government (Gov.), private insurance (Priv. ins.), self-pay versus other, $P < 0.001$.* **E**, *primary diagnosis of herniated cervical disc with myelopathy versus all other primary diagnoses, $P = 0.026$.* **F**, *any diagnosis of cervical myelopathy, $P = 0.078$.* **G**, *ventral versus other (i.e., dorsal, combined, unspecified) surgical approach, $P = 0.036$.* **H**, *fusion surgery versus surgery without fusion, $P = 0.007$.*

TABLE 2. Multivariate Poisson regression models of reoperation[a]

Variable	IRR	95% CI	*P* value
Model containing ventral versus other surgical approach			
Age 18–49 y versus age 70+ y	2.74	1.70–4.42	<0.001
Age 50–59 y versus age 70+ y	2.12	1.30–3.47	0.003
Age 60–69 y versus age 70+ y	1.74	1.03–2.93	0.037
Primary diagnosis herniated cervical disc without myelopathy	1.38	1.08–1.77	0.011
Ventral versus other approach	0.71	0.59–0.86	<0.001
Model containing fusion versus nonfusion			
Age 18–49 y versus age 70+ y	2.76	1.71–4.47	<0.001
Age 50–59 y versus age 70+ y	2.14	1.31–3.51	0.002
Age 60–69 y versus age 70+ y	1.76	1.04–2.97	0.034
Primary diagnosis herniated cervical disc without myelopathy	1.40	1.09–1.80	0.008
Fusion surgery versus no fusion	0.65	0.52–0.80	<0.001

[a] Sex, year of surgery, Charlson comorbidity index, discharge status, and payment type also included in the models as adjustment variables. IRR, incident rate ratio; CI, confidence interval.

independently associated with younger patients and with a primary diagnosis of herniated cervical disc with myelopathy (Table 2). In the first model, ventral surgery was independently associated with lower reoperation rates (IRR = 0.71; $P < 0.001$); in the second model, fusion surgery was independently associated with lower reoperation rates (IRR = 0.65; $P < 0.001$)

TABLE 3. Hospital length of stay[a]

Surgical approach	Mean LOS (SD) Initial surgery (n = 12 338)	Reoperation (n = 688)
Ventral (includes fusion)	1.6 (1.7)	1.7 (1.7)
Dorsal (no fusion)	2.4 (2.4)	2.1 (2.7)
Dorsal (includes fusion)	3.8 (3.4)	4.2 (4.1)
Combined ventral and dorsal (includes fusion)	2.8 (3.2)	2.7 (2.9)
Unspecified (includes fusion)	2.1 (1.3)	2.0 (1.1)
All approaches	1.8 (1.9)	2.1 (2.3)

[a] LOS, length of stay (in days); SD, standard deviation.

(Table 2). We were not able to distinguish between the effects of approach and fusion in our patient population.

LOS and Hospital Charges

Both LOS and hospital charges varied by surgical approach and initial operation versus reoperation. The majority of patients had private insurance (51%–60%), and virtually all were discharged to home (96%–97%) (Table 1). The mean LOS for initial surgeries was less than for reoperations (1.8 days versus 2.1 days; $P < 0.001$). Fifty-nine percent of patients were discharged within 1 day of initial surgery, and 52% within 1 day of their reoperation ($P < 0.001$). The mean LOS was longest for dorsal approaches with fusion (initial surgery, 3.8 days; reoperation, 4.2 days) and shortest for ventral approaches (initial surgery, 1.6 days; reoperation, 1.7 days) (Table 3). The multivariate linear regression model of LOS showed that after adjusting for age, sex, year of surgery, payment type, discharge status, reoperation, primary diagnosis, and comorbid diseases, a longer LOS was independently associated with nonventral approaches (increased LOS 1.0 day; $P < 0.001$) and fusion surgery (increased LOS 0.8 day; $P < 0.001$).

Hospital charges varied between initial operation and reoperation and by surgical approach (Table 4). The median total hospital charges were $14 100 for initial surgeries and $15 100 for reoperations ($P < 0.001$). Dorsal surgeries without fusion had the lowest median hospital charges for both initial and second admissions (initial, $11 600; second, $10 600; $P < 0.001$), and dorsal surgeries with fusion had the highest charges (initial, $23 400; second, $24 100; $P < 0.001$). The multivariate linear regression model of hospital charges showed that after adjusting for age, sex, year of surgery, payment type, LOS, discharge status, reoperation, primary diagnosis, and comorbid diseases, greater hospital charges were independently associated with nonventral approaches (increased charges $3300; $P < 0.001$) and fusion surgery (increased charges $9300; $P < 0.001$).

DISCUSSION

The reoperation rate after initial surgery to treat degenerative cervical spondylosis was measured by analyzing data from a cohort of 12 338 patients who had initial surgery for cervical spondylosis recorded in the Washington SID from 1998 to 2002. The use of an administrative database containing statewide inpatient hospital admissions for a 5-year period helped define the incidence of a relatively rare event (reoperation) in a specific cohort of patients with cervical degenerative disease. With a mean-follow-up period of 2.3 years, 688 patients (5.6%) had a second operation for cervical spondylosis. We used multivariate Poisson regression to model the reoperation rate. Younger age and a primary diagnosis of herniated cervical disc with myelopathy were independently associated with a higher reoperation rate. In contrast, lower reoperation rates were observed after cases using ventral surgery and/or fusion. It was not possible to determine whether fusion or a ventral approach was the better predictor of a lower reoperation rate in our study population. We also used the Washington SID to identify resource use associated with degenerative cervical spine surgery. After adjusting for age, sex, year of surgery, payment type, LOS, discharge status, reoperation, primary diagnosis, and comorbid diseases, nonventral approaches were associated with a $3300 increase in hospital charges, and fusion surgery was associated with a $9300 increase in hospital charges.

TABLE 4. Hospital charges for surgery

Surgical approach	Median charges[a] (interquartile range) Initial surgery (n = 12 333)	Reoperation (n = 688)
Ventral (includes fusion)	$14 300 ($10 800–$19 200)	$15 700 ($12 700–$20 900)
Dorsal (no fusion)	$11 600 ($8400–$15 700)	$10 600 ($8200–$15 800)
Dorsal (includes fusion)	$23 400 ($15 100–$33 400)	$24 100 ($15 500– $34 000)
Combined ventral and dorsal (includes fusion)	$17 300 ($12 600–$26 900)	$21 000 ($15 000 –$40 300)
Unspecified (includes fusion)	$16 300 ($14 900–$18 500)	$16 700 ($12 300–$19 800)
All approaches	$14 100 ($10 500–$19 100)	$15 100 ($11 400–$20 800)

[a] 2007 US dollars.

Surgical approach (ventral versus dorsal) has also been the subject of much debate when treating cervical degenerative pathologies (12).This study found that ventral surgery and/or fusion were associated with a lower reoperation rate. Because ventral surgery was always performed with fusion, it was not possible to determine whether the ventral approach or the choice of fusion was a better predictor. Using a heterogeneous population of patients such as the one in this study to compare surgical approaches may not be useful because we were unable to determine how many levels of disease were being addressed in each case. The higher complication rate associated with 3 or more levels of ventral surgery (especially corpectomy) has led some surgeons to perform ventral surgery only in those patients with 1 or 2 levels of disease (8, 27). Therefore, cervical spondylotic disease at 3 or more levels is often treated using a dorsal approach (7). It would perhaps be more valuable to compare the reoperation rates associated with anterior cervical discectomy and fusion with cervical arthroplasty or posterior cervical foraminotomy with discectomy for single-level cervical spine disease to draw more valid conclusions regarding surgical approach. Current prospective studies comparing ventral versus dorsal surgery for cervical spondylotic myelopathy have compared the 2 approaches using standardized outcomes measures, although these studies are probably underpowered to compare the surgical approaches in terms of reoperation rates (10).

There is considerable debate surrounding the use of fusion when treating degenerative conditions of the cervical spine (14, 16, 17). In the case of cervical myelopathy, the value of adding fusion when performing a dorsal decompression of the cervical spine has not been firmly established (26). Fusion might reduce the repetitive shear injury mechanism that may contribute to the pathophysiology of cervical spondylotic myelopathy (15). Conversely, several studies have shown favorable outcomes after laminoplasty procedures that preserve motion while decompressing the spinal canal (8, 14). In this study, dorsal fusion surgery and reoperation on dorsal fusion surgery patients were so rare that we were unable to study this subgroup. Only 191 of our patients (1.6%) had dorsal fusion surgery, and only 7 required reoperation. The incidence of dorsal cervical spine fusion surgery seems to be increasing according to a recent analysis of the national inpatient sample (23), and thus more recent data sets may contain a sufficient number of cases to compare dorsal surgery with and without fusion in terms of reoperation rate. Proponents of cervical arthroplasty argue that the risk of adjacent-level disease (and therefore risk of reoperation) might be lower with motion preservation when treating cervical spondylosis (22). Examining the risk of reoperation using administrative databases to compare cervical arthroplasty to ventral cervical fusion may be possible in the future if databases reliably contained the relevant codes for the procedures as well as for the number of operated levels.

Ventral surgery accounted for the majority (>80%) of the cases, although the incidence of nonventral surgery approached 50% in older patients. Ventral surgery was more commonly performed when reoperation was required regardless of the initial approach. It is not possible to determine why reoperations were done from this database. Prospective studies will be needed to determine the indications for reoperations and what modifiable risk factors (e.g., surgical approach, use of fusion, number of operated levels) might lead to different rates of deformity, adjacent level disease, or progression of neurological symptoms.

Some patients require extensive ventral decompression via cervical corpectomy. There are many reports indicating that multilevel cervical corpectomy has been associated with a high complication rate of nearly 30% (11, 19). Boakye et al. (4) used the Veterans Health Administration National Surgical Quality Improvement Program database and found a 17.9% reoperation rate for 3-level cervical corpectomy compared with 6.2% for single-level corpectomy. The SID used in the current study did not contain information on the number of surgical levels, and thus we could not examine the relationship between the number of levels of surgery on reoperation rates.

The study identified 1 major factor affecting the reoperation rate that is not modifiable: age. Younger patients had higher reoperation rates. It is not clear whether there is any biological basis for this, although it is conceivable that older patients might have less overall cervical motion and therefore less propensity for adjacent levels to develop disease. It is also possible that surgeons are less likely to offer surgery to older patients because of a perceived greater risk of complications or poorer outcomes. Older patients may also be less likely to accept offers of surgery. Further study will be needed to ascertain the impact of age on cervical spine surgery for degenerative spine disease.

Cost data were estimated in the study by using hospital inpatient charge data. The median charge for reoperation for a cervical spine degenerative disease was $15 100 in 2007 US dollars. Initial dorsal surgery with fusion was significantly more expensive ($23 400) than ventral surgery ($14 300) or dorsal surgery without fusion ($11 600), and reoperation costs showed a similar pattern. A recently published study using the National Inpatient Sample found similar results: the mean inflation-adjusted cost of ventral surgery was $36 835, and for dorsal surgery with fusion, the cost was $57 469 (23). This study suggests that surgical choices can affect the risk of reoperation and hospital charges. Prospective studies are needed to determine whether the use of fusion or a ventral versus dorsal approach is associated with a difference in reoperation rates or the costs of treatment. In addition, it will be particularly important to evaluate the role of fusion versus motion-preservation technology (disc arthroplasty) in treating cervical spondylosis in light of this study's findings that fusion at initial surgery may be associated with a lower reoperation rate.

This retrospective observational longitudinal cohort analysis of 12 338 patients using a large administrative database represents class 2b evidence according to the Oxford system (20). Any observational study that compares different treatment groups is subject to significant bias because confounding variables (known and unknown) are not equally distributed among treatment groups. The traditional belief is that randomized controlled trials (RCTs) represent the highest form of medical evidence for determining whether one intervention is superior, equivalent, or inferior to an alternative. The RCT derives its power from the ability to balance prognostic variables and confounders (known or unknown) equally among treatment groups, providing greater confidence that outcome differences are attributable to treatment effects. Some surgical treatments do not readily lend themselves to randomization because of recruitment issues (patients or surgeons may not acknowledge equipoise between treatment alternatives and refuse randomization) and the difficulty of blinded outcome measurement (the location, presence, or absence of an incision provide clues to the nature of the randomized intervention). Alternative methodologies such as observational studies or case-control studies may be the only practical way to obtain information for some surgical treatments. Recent work has called into question the traditional hierarchy of research study design with the RCT at the pinnacle, emphasizing the need to consider all types of data when scrutinizing evidence of treatment outcomes (4). When attempting to distinguish 2 or more surgical treatment alternatives in terms of an infrequent outcome event (e.g., infection, reoperation), the numbers of patients required for a RCT or even a nonrandomized prospective trial would be prohibitively large.

Large administrative databases have increased our ability to generate meaningful evidence of surgical outcomes. The strength of large administrative databases include large numbers of patients providing the statistical power to examine common outcomes in detail and detect rare outcomes, generalizability because the patients are often drawn from relatively large swaths of the population, and standardized data collection and coding by parties not directly involved in patient care. Wang et al. (25) used the National Inpatient Sample to generate data regarding complications and mortality associated with cervical spine surgery for degenerative disease in the United States. We used the Washington SID because this database contains reliable and consistent patient identifiers that permit longitudinal follow-up of individual patients. Using a similar methodology, the Washington SID was used to study lumbar reoperation rates in the United States (20). There are a number of limitations to using administrative databases for clinical research. Health care administrative databases are usually designed to track resource use, often for billing purposes. Clinical information in administrative databases is typically limited to standardized coding of diseases and procedures using ICD-9 or Current Procedural Terminology codes and may not be capable of addressing questions of interest to clinicians and patients. For example, the ICD-9 procedure codes in the SID only localize degenerative spine disease and spine procedures to the cervical, thoracic, or lumber spine regions and do not encode the exact location of surgery. Administrative databases usually lack information about pain, neurological symptoms and deficits, functional status, health status, and quality of life—all vital considerations when assessing the outcomes of surgical interventions. Administrative databases are limited to specific populations, and merging administrative databases to supplement deficiencies may not be practical. For example, Medicare data sets only include patients 65 years and older, disabled patients, and renal dialysis patients and thus cannot be used to examine nonrenal disease processes in patients younger than 65 years old. The SIDs only track inpatient procedures and thus will not capture the growing proportion of cervical spine procedures that are performed in ambulatory surgery centers. SIDs also do not contain information on patients receiving health care through the Department of Defense or the Department of Veteran Affairs. Follow-up in a SID is limited to reoperations performed in civilian hospitals in the same state and do not capture procedures performed in another state after patients relocate. Deficiencies in follow-up mean that our analysis likely underestimated the rate of cervical spine reoperations. Finally, factors that contributed to selecting a particular type of cervical spine surgery in the Washington state patients (e.g., symptoms, examination findings, imaging studies, surgeon and patient preferences) that are not recorded in the database may also affect the likelihood of reoperation. We must be cautious in attributing causality to the relationship demonstrated in our analysis between ventral and/or fusion surgery and reduced rates of reoperation after initial surgery for degenerative cervical spine disease.

CONCLUSION

The choice of surgical approach when treating degenerative cervical spine disease remains controversial. In this analysis of an administrative database, reoperation after an initial procedure occurs at the rate of 2.5% per year. Ventral surgery and/or fusion surgery seem to have lower reoperation rates. Future studies of administrative databases might help define whether fusion reduces the risk of reoperation after initial dorsal surgery. Prospective studies and possibly well-designed RCTs will help define any possible differences in quality of life and disease-specific outcomes among the different surgical approaches to treating the degenerative cervical spine.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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Appendix

Details of case selection algorithm used by Wang et al. (25) in their 2007 publication to identify surgery for degenerative cervical spine disease using ICD-9 diagnosis and procedure codes (personal communication, M. Wang).

Part 1a: Admission record excluded from the analysis if any of the following diagnostic codes are the primary or secondary ICD-9 diagnosis or if any of the following procedure codes are the primary or secondary ICD-9 procedure, regardless of what other diagnosis or procedures codes are present.[a]

ICD-9 diagnosis code	Description
140–239.9	All neoplasms
324.1	Intraspinal abscess
336.0	Syringomyelia and syringobulbia
340	Multiple sclerosis
341.0–341.9	Other demyelinating diseases of the central nervous system
344.6	Cauda equina syndrome
356.0–356.9	Hereditary and idiopathic peripheral neuropathy
357.0–357.9	Inflammatory and toxic neuropathy
358.0–359.9	Myoneural disorders
359.0–359.9	Muscular dystrophies and other myopathies
630–677	Pregnancy-related diagnoses
714.0–714.9	Rheumatoid arthritis and other inflammatory polyarthropathies
720.0–720.9	Ankylosing spondylitis and other inflammatory spondyloarthropathies
721.4; 721.41–721.42	Thoracic or lumbar spondylosis with myelopathy
722.72–722.73	Thoracic or lumbar intervertebral disc disease with myelopathy
722.9; 722.90–722.93	Other and unspecified disc disorders, discitis, unspecified, cervical, thoracic, lumbar
723.5	Torticollis, unspecified
723.8	Other syndromes affecting cervical region; cervical syndrome NEC, Klippel's disease, occipital neuralgia
724.00	Stenosis, unspecified, not cervical
724.01	Thoracic spinal stenosis
724.02	Lumbar stenosis
724.09	Stenosis, other, not cervical
730.00–730.09	Acute osteomyelitis
730.10–730.19	Chronic osteomyelitis

Continues

ICD-9 diagnosis code	Description
730.20–730.29; 730.30–730.39; 730.70–730.79; 730.80–730.89	Unspecified osteomyelitis; periostitis without mention of osteomyelitis; osteopathy resulting from poliomyelitis; other infections involving bone in diseases classified elsewhere
731.0–731.8	Osteitis deformans and osteopathies associated with other disorders classified elsewhere
733.1; 733.10–733.19	Pathological fracture
739.3–739.4	Nonallopathic lesions, lumbar or sacral spine
756.0	Anomalies of the cranium and facial bones
756.10–756.16; 756.19	Anomalies of the spine except spina bifida occulta
800.0–906.9	Injuries
E800–E849.9	Vehicular accidents
V10.0–V10.9	Personal history of malignancy

ICD-9 procedure code	Description
03.2–03.29	Chordotomy
03.3–03.39	Diagnostic procedures on spinal cord and spinal canal structures
03.51–03.59	Plastic operations on spinal cord structures
03.71–03.79	Shunt of spinal theca
03.8	Injection of destructive agent into the spinal canal
76.4; 76.41–76.46	Operations on facial bones or joints
76.9; 76.91–76.99	Other operations on facial bones or joints
80.10–80.19	80.1 Other arthrotomy (0–9); arthrostomy, excludes that for arthrography (88.32), arthroscopy (80.20–80.29), injection of drug (81.92), operative approach—omit code
80.20–80.29	80.2 Arthroscopy (0–9)
80.30–80.39	80.3 Biopsy of joint structure (0–9); aspiration biopsy
80.4; 80.40–80.49	80.4 Division of joint capsule, ligament, or cartilage (0–9); Goldner clubfoot release; Heyman-Herndon(-Strong) correction of metatarsal varus; release of adherent or constrictive joint capsule joint ligament; excludes symphysiotomy to assist delivery (73.94), that for carpal tunnel syndrome (04.43), tarsal tunnel syndrome (04.44)
81.01	Atlas-axis fusion C1–C2
81.04	Dorsal and dorsolumbar fusion, anterior technique

Continues

ICD-9 procedure code	Description
81.05	Dorsal and dorsolumbar fusion, posterior technique
81.06	Lumbar and lumbosacral fusion, anterior technique
81.07	Lumbar and lumbosacral fusion, lateral transverse process technique
81.08	Lumbar and lumbosacral fusion, posterior technique
81.11–81.18	Repair or plastic operations on joints (foot)
81.20–81.29	Arthrodesis of foot or ankle
81.34–81.38	Refusion of dorsal and dorsolumbar spine, anterior technique, posterior technique; refusion of lumbar and lumbosacral spine, anterior technique, lateral transverse process technique
81.40–81.49	Other repair of joint of lower extremity
81.51–81.59	Joint replacement of lower extremities
83.81–83.89	Other plastic operations on muscle, tendon, and fascia; excludes plastic operations on muscle, tendon, and fascia associated with arthroplasty
84.63	Insertion of spinal disc prosthesis, thoracic
84.64	Insertion of partial spinal disc prosthesis, lumbosacral
84.65	Insertion of total spinal disc prosthesis, lumbosacral
84.67	Revision or replacement of artificial spinal disc prosthesis, thoracic
84.68	Revision or replacement of artificial spinal disc prosthesis, lumbosacral

[a] NEC, not elsewhere coded.

Part 1b: Admission record excluded from the analysis if any of the following diagnostic codes are the primary ICD-9 diagnosis. Records may be retained if the ICD-9 diagnosis code is listed as a secondary ICD-9 diagnosis.

ICD-9 diagnosis code	Description
353.1	Lumbosacral plexus lesions
353.3	Thoracic root lesion
353.4	Lumbosacral root lesions, not elsewhere classified
355.0	Lesion of sciatic nerve
721.2–721.3	Thoracic or lumbar spondylosis without myelopathy
722.10–722.11	Displacement of thoracic or lumbar disc without myelopathy

Continues

ICD-9 diagnosis code	Description
722.30–722.39	Schmorl's nodes, unspecified, thoracic, lumbar, other region
722.51–722.52	Degeneration of thoracic or lumbar disc
723.6	Panniculitis specified as affecting neck
723.9	Unspecified musculoskeletal disorders and symptoms referable to neck
724.1–724.6	Pain in thoracic spine; lumbago; sciatica; thoracic or lumbosacral neuritis or radiculitis, unspecified; radicular syndrome of lower limbs; backache, unspecified; disorders of sacrum, includes instability of lumbosacral joint
724.70–724.71	Disorders of coccyx
724.8–724.9	Other symptoms referable to back; other unspecified back disorders
756.17	Spina bifida occulta

Part 1c: Admission records being considered for initial surgery are excluded from the analysis if any of the following diagnostic codes are a primary or secondary ICD-9 diagnosis code or if any of the following procedure codes are a primary or secondary ICD-9 procedure code, REGARDLESS of what other diagnosis or procedures codes are present. Inclusion of records containing these codes may be acceptable if present in an admission record for reoperation.[a]

ICD-9 diagnosis code	Description
722.80–722.83	Postlaminectomy syndrome; unspecified, cervical, thoracic, lumbar
733.81–733.82	Malunion and nonunion of fracture; pseudoarthrosis
909.3	Late effect of complications of surgical and medical care
996.2	Mechanical complication of nervous system device, implant, or graft (dorsal column stimulator, electrodes in brain, peripheral nerve graft, shunt, etc.)
996.4	Mechanical complication of internal orthopedic device, implant, and graft
996.59	Mechanical complication of other specified prosthetic device, implant, and graft; caused by other implant and internal device, NEC
996.63	Infection and inflammatory reaction caused by internal prosthetic device, implant, and graft in the nervous system (brain electrodes, peripheral nerve graft, spinal canal catheter, shunt, etc.)
996.67	Infection and inflammatory reaction caused by internal prosthetic device, implant, and graft; caused by other internal orthopedic device, implant, graft (bone growth stimulator, internal fixation device, pin, rod, screw)
996.75	Complications of internal prosthetic device (including embolism, fibrosis, hemorrhage, pain, stenosis, thrombus, and NOS)
996.77	Other complications of internal prosthetic device (including embolism, fibrosis, hemorrhage, pain, stenosis, thrombus, and NOS); internal joint prosthesis
996.78	Other complications of internal prosthetic device (including embolism, fibrosis, hemorrhage, pain, stenosis, thrombus, and NOS)
E878.1	Abnormal reaction to implant of artificial internal device (electrodes in brain, pacemaker, heart valve, ortho implant)

ICD-9 procedure code	Description
03.01	Removal of foreign body from spinal canal
03.02	Reopening of laminectomy site
03.4	Excision or destruction of lesion of spinal cord or spinal meninges; curettage of spinal cord or spinal meninges; débridement of spinal cord or spinal meninges; marsupialization of cyst of spinal cord or spinal meninges; resection of spinal cord or spinal meninges; excludes biopsy of spinal cord or meninges (03.32)
03.90–03.94; 03.96–03.99	Other operations on spinal cord and spinal canal structures, excluding blood patch
78.40; 78.49	Other repair or plastic operations on bone, repair of malunion or nonunion fracture; unspecified, other (vertebrae)
78.50; 78.59	Internal fixation of bone without fracture reduction (includes reinsertion of internal fixation device; revision of displaced or broken fixation device); unspecified, other (vertebrae, phalanges, pelvic bones)
78.60; 78.69	Removal of implanted devices from bone; unspecified; other (vertebrae, phalanges, pelvic bones)
80.00–80.09	Arthrotomy for removal of prosthesis (0–9); code also any insertion of cement joint spacer (84.56), removal cement joint spacer (84.57)
81.30–81.33; 81.39	Refusion of spine (81.30 NOS; 81.39 NEC; 81.31 Refusion of atlas-axis spine; 81.32 Refusion of other cervical spine, anterior technique; 81.33 Refusion of other cervical spine, posterior technique)
86.7; 86.70–86.75	Pedicle grafts or flaps

[a] NEC, not elsewhere coded; NOS, not otherwise specified.

Continues

Part 2: Admission records may be included if they contain any of the following primary or secondary ICD-9 diagnosis codes AND any ICD-9 procedure code detailed in Part 3 or Part 4.[a]

ICD-9 diagnosis code	Description
721.0	Cervical spondylosis without myelopathy
721.1	Cervical spondylosis with myelopathy
722.0	Displacement of cervical disc without myelopathy
722.4	Degeneration of cervical intervertebral disc
722.71	Intervertebral disc disorder with myelopathy, cervical
723.0	Spinal stenosis in cervical region
723.1	Cervicalgia
723.2	Cervicocranial syndrome, Barre-Lieou syndrome; posterior cervical sympathetic syndrome
723.4	Brachial neuritis or radiculitis NOS; cervical radiculitis, radicular syndrome of upper limbs
723.7	Ossification of the posterior longitudinal ligament in cervical region
723.9	Unspecified musculoskeletal disorders and symptoms referable to neck, cervical (region) disorder NOS
738.2	Acquired deformity of neck
738.4	Acquired spondylolisthesis (degenerative spondylolisthesis, spondylolysis, acquired: excludes congenital). *Exception!* This is a back specific code and needs to be confirmed as cervical specific. It is not included unless there is a cervical-specific procedure code (Part 3) or there is no diagnosis code in any position from Part 1b and there is a cervical specific diagnosis code from Part 2 in any position.
739.1	Nonallopathic (allopathy: traditional Western medicine) lesions NEC, cervicothoracic region

[a] NOS, not otherwise specified; NEC, not elsewhere coded.

Part 3: Admission records containing any of the following primary or secondary ICD-9 procedure codes are retained in the analysis, UNLESS excluded in Part 1a, Part 1b, or Part 1c.

ICD-9 procedure code	Description
81.02	Other cervical fusion, anterior technique
81.03	Other cervical fusion, posterior technique

Part 4: Admission records containing any of the following primary or secondary ICD-9 procedure codes are retained in the analysis IF the record also has a diagnosis in Part 2 other than 738.4, UNLESS excluded in Part 1a, Part 1b, or Part 1c.[a]

ICD-9 procedure code	Description
03.09	Other exploration and decompression of spinal canal (including decompression, expansile laminoplasty, exploration of nerve root, foraminotomy [without discectomy])
77.70, 77.77, 77.79	Excision of bone for graft; unspecified site; tibia or fibula; other (vertebrae)
78.00, 78.07, 78.09	Bone graft; unspecified site; tibia or fibula; other (vertebrae)
80.5	Excision or destruction of intervertebral disc (category heading)
80.50	Excision or destruction of intervertebral disc unspecified
80.51	Excision of intervertebral disc (any level)
80.52	Intervertebral chemonucleolysis
80.59	Other destruction of intervertebral disc
81.00	Spinal fusion, NOS
81.09	Fusion of spine, any level any technique, NEC (this code retired after 2001)

[a] NEC, not elsewhere coded; NOS, not otherwise specified.

COMMENTS

The authors have presented the details of a methodological study on cervical fusions performed for degenerative disorders in Washington State between 1998 and 2002. Data was available for clinical factors, surgical procedure, complication rates, and reoperation rates. Note that socioeconomic factors such as insurance and race, while briefly discussed, were not adequately emphasized. Discharge disposition will also be an important factor in this environment.

I am highly critical of the conclusions the authors draw on the basis of limited retrospective data. The decision to perform a particular surgery is quite complex. Unfortunately, much of the information that is required to make an intelligent decision was not available in their database. Thus, one cannot, and must not, make a clinical determination based on this article. The fact that effective ventral surgery has a lower rate of reoperation may indeed suggest something as absurd as most of the surgeries not being indicated in the first place. Certainly, the capable authors have pointed out the deficiencies of the database used; one can only conjecture that further information would have altered the outcomes.

Prospective trials are necessary to make determinations on the relative utility of various surgical approaches in the cervical, and for that matter, the entire spine. The reader is cautioned not to draw too many conclusions from this effort.

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King et al. have carefully analyzed reoperations after cervical spine surgery for degenerative changes using a hospital discharge database from Washington State. This database allows the authors to follow adult patients over time using identifiers, unlike other data sources such as the Nationwide Inpatient Sample. Over a mean follow-up duration of 2.3 years, 5.6% of patients underwent a reoperation. Patients undergoing ventral fusion surgery had lower rates of reoperations, even after adjustment for factors such as patient demographics, year of surgery, and comorbid conditions. In addition, younger age and a primary diagnosis of herniated cervical disc with myelopathy were also associated with higher rates of reoperation.

As noted by the authors, there are inherent limitations to using these data. The database does not include information such as indications for surgery, number of levels involved, neurological condition other than myelopathy, and surgeries performed on an outpatient basis or in another state. Although there were 12 338 patients in the cohort, only 191 underwent dorsal fusion surgery. In addition, accuracy of the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes in describing cervical spine surgery has not been studied, especially in regard to reoperations. As King et al. emphasize, conclusions should not be prematurely drawn about which type of surgery is superior as it is likely that the underlying patient populations differ, despite similar ICD-9-CM diagnosis codes. It is also interesting to note that the reported rates of reoperation did not include 13 582 patients who underwent a second operation within a month of their index surgery, 13 566 initial cases with "reoperation" ICD-9-CM codes, and 13 072 patients with third and fourth surgeries, likely underestimating the rate of reoperations.

Despite these limitations, King et al. have presented an important, population-based overview of reoperations after cervical spine surgeries in Washington State, adding to our knowledge base and providing more fuel to promote prospective studies that measure factors that are not contained within these administrative databases.

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