Lumbar Spine Surgery and Mortality among Medicare Beneficiaries, 1986

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Introduction

Data on the effectiveness of lumbar spine surgery in elderly patients (those 65 years of age and older) are rare. We were able to identify few outcome studies that supported or negated Parrish’s 1962 recommendation that age, at least up to 72 years, should not deprive patients of the benefits of surgery in the treatment of “lumbar disc syndrome” if the appropriate indications exist.1 We were also able to identify only one randomized trial of surgery vs conservative care, that carried out by Weber2 with 126 patients 22 to 55 years of age who had herniated lumbar discs. There was significant improvement at 1 year in those who had undergone surgery; by 4 years, however, the differences between surgery and conservative care were no longer significant. A literature search for low back pain and spine surgery citations in older patients identified nine articles published between 1987 and 1991 involving a total of 370 patients (mean age = 66.6 years; range = 45 to 89 years), approximately equal numbers of whom were male and female.3-11 In a recent study based on a hospital discharge registry for the state of Washington, mortality, morbidity, and complications following lumbar spine procedures were demonstrated to increase with increasing age, particularly among those patients more than 64 years of age, and with more extensive surgery such as fusion and procedures associated with spinal arthrodesis.12

Increasingly, elderly people demand medical care, including surgery, not only to save life but to increase the quality of it. There are a number of treatments for low back pain with leg pain and refractory neurologic deficits, from conservative care to surgery. With the increasing sophistication and range of available treatment options, lumbar spine surgery for low back pain in the elderly will no doubt continue to be more prevalent in the future, accelerated by the increasing number of older patients and by the rising demand for surgery by older patients seeking an improved quality of life.

The 1989 National Health Interview Survey,13 ranked orthopedic impairment as the most frequently reported chronic condition after arthritis and hearing impairment among patients 65 years of age and older. Back impairment, including intervertebral disc disorder, accounted for the largest proportion of orthopedic impairment,13 and, after emphysema, it accounted for the most restricted activity and bed disability days.14 Medical advances in anesthesia techniques, systems monitoring, and spine surgery instrumentation have made spinal surgery possible for an increasing number of older patients. However, the sheer size of the increase in surgery between 1979 and 1989 (e.g., a 204% increase in excision, a 232% increase in decompression, and a more than 350% increase in fusion15,16) is staggering, especially in light of the pa...
city of outcome results and the lack of randomized clinical trials in elderly patients with lumbar spine surgery for low back pain. The striking dichotomy between the relatively stable prevalence of back impairment and the more than twofold increase in lumbar spine surgery rates for patients 65 years old and older deserves close attention.

Development of guidelines for medical and surgical practices through assessment of patient outcomes demands evaluation of the effectiveness of medical and surgical interventions. Access to medical care is becoming a more critical issue in medicine, particularly for elderly patients, who make up the most rapidly increasing population segment in the country. As access becomes more important, analysis of existing national databases (e.g., the Health Care Financing Administration's [HCFA] Medicare databases) should provide useful information for policymakers, practitioners, and patients. In 1986, Medicare covered hospitalization expenses for about 95% of the US population 65 years of age and older. Although patients included in these databases are not randomized to intervention, the databases have been used extensively and recent reports have demonstrated that they provide a valuable research tool.

Our primary purpose in this descriptive epidemiological study was to gather data on in-hospital, 30-day postdischarge, and 1-year mortality following lumbar spine surgery in the elderly in the United States. We analyzed a 100% sample of the 1986 Medicare Provider Analysis and Review inpatient HCFA claims files databases for patients 65 years of age and older (eliminating a primary cancer diagnosis) undergoing surgery for low back pain. We then compared surgical procedures by age, gender, and number of comorbidities with respect to mortality.

**Methods**

The data for this study were derived from HCFA's 1986 Medicare Provider Analysis and Review inpatient claims files records, which include the nature of the patient's medical status and hospital stay from the hospital billing claim form filed with Medicare for the hospitalization (Medicare Part A, UB82 billing forms). The data fields include up to five International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis codes; up to three procedure codes; the diagnostic-related group billing category claimed; dates of admission and discharge; and information on summary charges. Additional data are obtained from other HCFA and social security files on the level of Medicare reimbursement; patient (beneficiary) age, race, and sex; zip code of beneficiary's residence; and date of death of beneficiary. Date of death information is updated from the Social Security Master File at 3-month intervals for 2 years following the end of the reporting year (i.e., in this instance, through March 31, 1988). Population and annual mortality statistics for 1986 were obtained from data published by the US Bureau of the Census and the National Center for Health Statistics.

Hospitalization records for all 1986 Medicare patients 65 years of age or older were screened for the initial 1986 admission to the hospital with an anatomical low back pain diagnosis that may or may not have resulted in lumbar spine surgery. ICD-9-CM diagnostic codes for anatomical low back pain, excluding principal cervical and thoracic diagnoses and primary cancer diagnoses (codes 141.0 to 160.9, 162.0 to 172.9, and 174.0 to 209.89), indicated in at least one of the five diagnostic fields of the record included spondylolisthesis (721.0 to 721.99), disc disease (722.0 to 722.99), spinal stenosis (724.0 to 724.99), and spondylolisthesis (738.4). The same hospitalization records were searched separately for an initial lumbar spine surgical procedure in 1986. Selection of lumbar spine surgery cases was based on the first 1986 file record with an ICD-9-CM procedure code indicated in at least one of the three procedure fields of the record: exploration and decompression (laminectomy) of spinal canal structures (03.00, 03.09), excision or destruction (discectomy) of intervertebral disc (80.5, 80.50, 80.51, 80.59), and spinal fusion (at one or more vertebral levels, with and without excision, decompression, or instrumentation) (81.00, 81.06, 81.07, 81.09). The two files were merged, and patients with lumbar spine surgery were grouped by 5-year age increments from 65 to 84 years, with all patients 85 years old and older constituting the last group.

Mortality was defined as occurring before discharge (in-hospital mortality), within 30 days of discharge (30-day postdischarge mortality), or within 1 year of the date of the first hospital admission (1-year mortality) for surgery for low back pain in 1986. Mortality for each procedure (i.e., excision, decompression, decompression plus excision, and fusion, including fusion combinations) and mortality by age group and gender were calculated with the respective number of patients undergoing surgery as the denominator. Fusion, fusion plus decompression, and fusion plus excision were combined in one
category for analysis purposes because their numbers alone by 5-year age group were small, making the interpretation of the analysis of procedure by age and gender difficult, and because significant differences in outcome do not differ with widely differing fusion procedures.\textsuperscript{36} On the basis of data recorded at the time of the surgery admission, patients were assigned to diagnostic, or comorbidity, categories based on the ICD-9-CM diagnostic code fields. The relationships between the following factors were studied: age (in 5-year age groups starting at 65 years), gender, and comorbid diagnoses. The most frequently reported comorbidities (excluding cancers) were acute ischemic heart disease (ICD-9-CM codes 410 to 411.99), cerebrovascular disease (430 to 438.99), chronic heart failure (428 to 428.99, 402.01, 402.11, 402.91), diabetes (250 to 250.99), hepatic disease (571 to 572.99), hypertension (401 to 405.99), other heart disease (393 to 398, 412 to 414.99), psychiatric disease (290 to 290.99, 294 to 299.99), pulmonary disease (480 to 493.99, 496 to 496.9), and renal disease (582 to 583.99, 585 to 587.99).

Chi-square analyses were used to test for associations between mortality and a given factor or comorbidity. Analyses of variance were used in comparisons of mortality rates by age group and procedure for all patients 65 years of age and older in the United States admitted to the hospital and undergoing spine surgery for low back pain. In appropriate instances, the relative risk (RR, using the ratio of rates) of mortality in one vs another level of patient characteristic is reported. In order to examine the effects of comorbidity on mortality, patients were selected on the basis of 0, 1, 2, and 3 or more comorbid diagnoses. Multiple logistic regression analysis was used to study factors associated with in-hospital, 30-day postdischarge, and 1-year mortality.

### Results

Among Medicare patients 65 years of age and older, there were 217,565 first hospital admissions (median age = 73 years) in 1986 involving a primary anatomical diagnosis of low back pain. Of the patients admitted, 144,692 were women (mean age = 75.8 years, SD = 7.3) and 72,873 were men (mean age = 73.9 years, SD = 6.7); the median age was lowest for patients with disc disease (Table 1). Also, 91.1% were White, 5.1% were Black, and 3.8% were of other races.
Procedures

There were 34,418 lumbar spine surgical procedures (first procedure in 1986) for low back pain among Medicare patients 65 years of age and older (median age = 71 years), 19,692 involving women (mean age = 72.3 years, SD = 5.4) and 14,726 involving men (mean age = 71.8 years, SD = 5.2). The median age was highest for those undergoing decompression and fusion procedures (Table 1). The proportion of women admitted to the hospital was 66.5%, in comparison with 57.2% of those with a procedure. Of the patients with a procedure, 92.1% were White, 3.8% were Black, and 4.1% were of other races. Patients 80 years of age and older with low back pain accounted for 29% of those who did not have surgery and 10% of those who did. There were 1943 patients who underwent an initial lumbar spine surgery procedure in 1986 but who did not meet the diagnostic eligibility criteria for low back pain; the reasons for surgery in these patients were primarily fracture of the vertebral column, benign neoplasms, and other, multiple, ill-defined dislocations (Table 1). These patients were excluded from the mortality analyses.

The mean length of stay with a procedure was 12.1 days (12.9 days for decompression, 11.4 days for excision, 14.5 days for fusion, 15.0 days for excision plus fusion, 14.0 days for decompression plus fusion, and 12.0 days for decompression plus excision). The estimated hospital charges for 1986 were as follows: $688.57 million for admissions not involving a subsequent surgical procedure (mean length of stay = 7.8 days, mean charge = $3800), $265.02 million for lumbar spine surgical procedures (mean charge = $7700, with fusions the highest at $11,400), and $34.20 million for lumbar spine surgery procedures not associated with a low back pain diagnosis (mean length of stay = 21.0 days, mean charge = $17,600). Thus, the total hospital charges for all 217,565 admissions amounted to an estimated $987.79 million.

Mortality

The in-hospital mortality rate among the 34,418 patients undergoing a first spine surgical procedure for low back pain in 1986 was 0.52% (0.72% in men vs 0.37% in women; \( P < .001 \)). When adjusted for age, in-hospital mortality was higher in men than in women for decompression and for excision procedures \( (P < .01) \) (Table 2). In-hospital mortality with decompression and decompression plus excision procedures increased significantly at 85 years of age in both men and women, although numbers were small for the combined procedure; with excision, mortality increased significantly at 80

<table>
<thead>
<tr>
<th>Age Distribution, y</th>
<th>65–69</th>
<th>70–74</th>
<th>75–79</th>
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<tbody>
<tr>
<td>Decompression</td>
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<td>Men</td>
<td>1.17</td>
<td>0.93</td>
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<td>Women</td>
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<td>Excision</td>
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<td>Men</td>
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<td>0.77</td>
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<td>Women</td>
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<td>0.93</td>
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<td>Decompression plus excision</td>
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<td>Men</td>
<td>0.84</td>
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<td>Women</td>
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<td>Fusion plus fusion combinations</td>
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<td>Men</td>
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<td>Women</td>
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\( ^a \) No deaths.
years of age only in women, and, with fusions, mortality also increased significantly at 80 years of age but only in men (Table 2). The highest in-hospital mortality for men was seen with decompression and decompression plus excision procedures; the highest mortality for women involved excision and decompression plus excision procedures. The overall 30-day postdischarge mortality rate was 0.31%, (0.38% in men and 0.25% in women; P < .05). Age-adjusted, gender-specific 30-day postdischarge mortality was higher in men than women only for excision (P < .025) (Table 2). Thirty day postdischarge mortality increased (P < .05) at 85 years of age only in women and only with decompression and excision.

The 1-year mortality rate was 3.52% (4.38% in men vs 2.89% in women; P < .001). Age-adjusted, gender-specific 1-year mortality was significantly higher in men than women with decompression and excision (P < .0001) (Table 2). One-year mortality increased significantly at 80 years of age with excision and fusion procedures in both men and women; the age pattern for the other procedures was not as consistent, but the rates were higher in older subjects. The gender-specific 1-year mortality for each of the procedures is presented graphically in Figure 1; in all instances in which there were significant differences between the genders, men had the higher event rate. The relative risk for 1-year mortality with spinal surgery for low back pain, in comparison with the expected mortality in the US population 65 years old and older for 5-year age groups, was less than 1.00 in more than 75% of the Age x Gender x Procedure cells (Table 3).

The univariate techniques used to identify associations between the various comorbidities identified in the UB82 billing forms and mortality showed significant relative risks of 2.00 and greater for in-hospital, 30-day postdischarge, and 1-year mortality in regard to acute ischemic disease (RRs = 32.9, 5.6, and 7.4, respectively), renal disease (RRs = 9.9, 7.5, and 9.1), other heart disease (RRs = 4.7, 2.0, and 2.0), and cerebrovascular disease (RRs = 3.2, 6.0, and 3.1). Pulmonary disease and congestive heart failure were significant for in-hospital (RRs = 3.8 and 3.3) and 1-year mortality (RRs = 2.1 and 3.0), while hepatic disease was significant for 30-day postdischarge (RR = 27.3) and for 1-year mortality (RR = 7.3). Hypertension was consistently protective (RRs = 0.57, 0.51, and 0.80 for in-hospital, 30-day postdischarge, and 1-year mortality, respectively).

The multiple logistic regression model was then used to determine the relationships between age- and gender-adjusted mortality and number of comorbidities. A relative risk of 1.00 was used for mortality observed in patients with no comorbidities listed; in-hospital, 30-day postdischarge, and 1-year mortality, as expected, increased with the number of comorbidities (Table 4).

**Discussion**

Although health services data derived from administrative billing information may be criticized when used for clinical decision making, recent studies demonstrate that hospital billing records can, with careful planning (e.g., consideration of age, gender, and comorbidity) provide a valuable research tool. While the accuracy of diagnostic and comorbidity coding remains a concern, the coding of major surgical procedures in the Medicare claims databases is highly accurate, ranging from sensitivities of 0.88 to more than 0.95 for 10 of the 15 procedures examined and positive predictive values of .89 to more than .99 for 7 of the 15 procedures examined. Medicare claims databases similar to those used in this study have been the basis of extensive seminal research in the field of health services. Recently we used the same Medicare databases for reports involving hospital characteristics and mortality rates, and factors influencing coronary artery bypass surgery. In 1986, 217,565 Medicare beneficiaries 65 years of age and older were admitted to US hospitals with a diagnosis of anatomical low back pain and 34,418 underwent lumbar spine surgery. The cumulative 1-year mortality in patients with lumbar spine surgery was 3.52% (of which approximately 15% had occurred before discharge from hospital) and was significantly higher in men than in women. The age-adjusted 1-year mortality ranged from a low of 2.31% in women with fusion and fusion combination procedures to a high of 4.93% in men with decompression procedures. One-year mortality data for patients of comparable age with spinal surgery for low back pain are not available, but the expected US population rate of 3.61% for this age group is similar to that observed here. On the other hand, comparable data in older patients undergoing spinal surgery for low back pain are available for in-hospital mortality rate; this rate was 0.52% in the present study and, again, significantly higher in men than in women, as previously reported by Deyo et al. The 80- to 85-year age range appears to be a threshold for a significant increase for both in-hospital and 1-year mortality, reinforcing the importance of factors other than age when selecting patients for spinal surgery. Ramirez and Thisted reported an in-hospital mortality rate of 0.059% in patients over the age of 18 years undergoing lumbar disectomy, while Deyo and colleagues reported an overall in-hospital mortality rate of 0.07%, increasing with age from 0.01% at 41 to 64 years, to 0.21% at 65 through 74 years, and 0.60% at 75 years and older. In the present study, the 0.28% in-hospital mortality rate with lumbar spine surgery for low back pain in patients 65 to 74 years of age was similar to that reported by Deyo et al. for patients in the same age range; however, in those patients 75 years of age and older, the rate of 1.3% observed in this study was approximately twice that reported by Deyo et al. for patients of the same age. The large difference between the overall in-hospital mortality reported by Ramirez et al. and that reported here is due, in part, to the differences between
the studies with respect to the procedures considered for analysis and with respect to age (the patients included in the Ramirez study underwent lumbar discectomy and were 18 years of age and older). A desire for an improved quality of life on the patient's part may be the most important factor driving the increase in number of lumbar spinal procedures. Today the elderly live longer, healthier, and more active lives, and factors such as life expectancy, overall health status, and the ability of patients to tolerate the surgery and subsequent rehabilitation need to be considered when making treatment decisions. The importance of the discrepancy between functional and chronological age, and therefore the need to question age per se as an exclusionary criterion for surgery, has been reinforced in recent investigations of various surgical procedures (e.g., coronary bypass surgery in octogenarians and nonagenarians). Logically, increasing age and associated medical conditions, together with the stress of surgery, should be expected to result in increased mortality. However, appropriately selected patients 90 years of age and older do tolerate the stress of surgery relatively well, although age bias might be more widespread than warranted, at least for elderly patients with either cancer or heart disease. The 1-year mortality rate among the 181,204 patients admitted with low back pain but without subsequent surgery was 10.1%. We can find no publications describing the treatment and outcome of hospitalization in elderly patients who are admitted to the hospital for low back pain but do not undergo lumbar spine surgery. However, the difference in mortality in favor of patients undergoing surgery is probably associated with a patient selection bias inherent in making decisions about older patients as candidates for lumbar spine surgery. When patient age was less than 75 years, the relative risk for 1-year mortality, in comparison with the expected mortality in the US population 65 years old and older, was greater than 1.00 in 25% of the Age × Gender × Procedure cells; however, it was greater than 1.00 in only 12.5% of the cells when patient age was 75 years or older. Patient selection, particularly with increasing age, appears to be as, or more, important than the procedure when considering patient outcome. In the present study, at least up to the age of 80 years, the low mortality associated with lumbar spinal procedures for low back pain extends the relevance of Parrish's 1962 recommendation that, if the appropriate indications exist, age per se should not deprive patients of the benefits of surgery in the treatment of low back pain.

While the age effect per se, at least between 65 and 80 years, in those undergoing lumbar spine surgery does not appear to greatly increase the risk of death after such surgery, the number of comorbid conditions does increase this risk, supporting observations with other surgical procedures in the elderly. The extent to which comorbid conditions in this study affected mortality was quite marked; the relative risk for in-hospital mortality increased from 1.00 for no coexistent comorbidity to 21.59 with three or more comorbidities; the corresponding 30-day postdischarge risk was 10.49, and the 1-year mortality was 8.63. Factors that probably contribute to the increasing risk (particularly in-hospital and 30-day postdischarge) with lumbar spine surgery seen at 80 years of age and older are an increasingly weaker bone stock and greater neural involvement, an increasingly high likelihood of serious comorbidities, and a poorer physical status (per the American Society of Anesthesiology classification). While the HCFA billing records are not as reliable with respect to comorbidities as they are with respect to surgical procedures, the relative risk for in-hospital, 30-day, and 1-year mortality, as might be expected, was significantly increased with one or more comorbidity, particularly with coexistent ischemic heart and renal disease. The paradoxical protective effect of hypertension observed in this study has been reported previously, but without a definitive explanation.

In summary, this study of the large HCFA claims files for 1986 helps define age and gender demographics related to low back pain and outcome following lumbar spine surgery in all elderly Medicare beneficiaries in the United States. In 34,418 elderly patients who underwent lumbar spine surgery, male gender was associated with higher in-hospital and 1-year age-adjusted mortality than that observed in women. Also, 80 years of age appeared to be a threshold for increased mortality, and, as expected, increasing numbers of comorbid conditions were associated with an increased risk of age-adjusted mortality. An important limitation inherent in this Medicare database is the lack of data on the impact of lumbar spinal surgery for low back pain on functional status and the health-related quality of life in the elderly. However, the low mortality associated with lumbar spinal procedures for low back pain, at least in patients up to 80 years of age, extends the relevance of Parrish’s aforementioned recommendation.

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References
16. National Center for Health Statistics. De-


### Supplement on Exercise and Aging Available

"Exercise and Aging: Prescription for Wellness," a supplement to the May 1994 issue of *Southern Medical Journal*, is available from the Southern Medical Association. The supplement reflects the contents of a symposium held in Gainesville, Fla, in September 1992, for the purpose of updating health professionals on developments in the field of basic and applied exercise science for both healthy and chronically ill elderly persons.

Topics covered in the supplement include the effects of exercise on age and disease, skeletal muscle function, bones, metabolism, arthritis, and the nervous and cardiac systems; respiratory and spinal considerations; and motivating and establishing programs for the elderly.

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4. William B. Lo, François Mathieu, Jay Riva-Cambrin, John R.W. Kestle, Abhaya V. Kulkarni. Using Multicenter Clinical Registries to Improve Outcomes 141-167. [Crossref]


6. Houssam Bouloussa, Abdulmajeed Alzakri, Soufiane Ghailane, Claudio Vergari, Simon Mazas, Jean-Marc Vital, Pierre Coudert, Olivier Gille. 2017. Is it safe to perform lumbar spine surgery on patients over eighty five?. *International Orthopaedics* 41:10, 2091-2096. [Crossref]


10. Joseph M. Zavatsky, David Briski, Juan S. Uribe. Lateral Lumbar Interbody Fusion (LLIF) for the Treatment of Adult Spinal Deformity (ASD) 163-199. [Crossref]


22. Jin-Young Lee, Seong-Hwan Moon, Bo-Kyung Suh, Myung Ho Yang, Moon Soo Park. 2015. Outcome and Complications in Surgical Treatment of Lumbar Stenosis or Spondylolisthesis in Geriatric Patients. *Yonsei Medical Journal* 56:5, 1199. [Crossref]


24. Ilyas S. Aleem, Y. Raja Rampersaud. 2014. Elderly Patients Have Similar Outcomes Compared to Younger Patients After Minimally Invasive Surgery for Spinal Stenosis. *Clinical Orthopaedics and Related Research®* 472:6, 1824-1830. [Crossref]


34. Kyu Jung Cho, Seung Rim Park, Myoung Joo Park. 2012. Clinical Results of Lumbar Spinal Fusion in Degenerative Spine Disease in Patients over 75 Years Old: Comparative Study of Patients over 65 Years Old and Patients less than 75 Years Old. *Journal of the Korean Orthopaedic Association* 47:5, 330. [Crossref]


40. Gordon R. Bell. Degenerative Spondylolisthesis 1101-1115. [Crossref]


42. Yan Ma, Peter Passias, Licia K. Gaber-Baylis, Federico P. Girardi, Stavros G. Memtsoudis. 2010. Comparative in-hospital morbidity and mortality after revision versus primary thoracic and lumbar spine fusion. *The Spine Journal* 10:10, 881-889. [Crossref]


47. Dae-Jean Jo, Jae-Kyun Jun, Ki-Tack Kim, Sung-Min Kim. 2010. Lumbar Interbody Fusion Outcomes in Degenerative Lumbar Disease: Comparison of Results between Patients Over and Under 65 Years of Age. *Journal of Korean Neurosurgical Society* 48:5, 412. [Crossref]


55. Maxwell Boakye, Chirag G. Patil, Justin Santarelli, Chris Ho, Wendy Tian, Shivanand P. Lad. 2008. CERVICAL SPONDYLOTIC MYELOPATHY. *Neurosurgery* 62:2, 455-462. [Crossref]

57. James A. Browne, Chad Cook, Ricardo Pietrobon, M Angelyn Bethel, William J. Richardson. 2007. Diabetes and Early Postoperative Outcomes Following Lumbar Fusion. *Spine* 32:20, 2214-2219. [Crossref]


69. Zhong Yuan, Gregory S. Cooper, Douglas Einstadter, Randall D. Cebul, Alfred A. Rimm. 2000. The Association Between Hospital Type and Mortality and Length of Stay. *Medical Care* 38:2, 231-245. [Crossref]

70. Tokuya Fujita, John P. Kostuik, Cameron B. Huckell, Ann N. Sieber. 1998. COMPLICATIONS OF SPINAL FUSION IN ADULT PATIENTS MORE THAN 60 YEARS OF AGE. *Orthopedic Clinics of North America* 29:4, 669-678. [Crossref]


75. Neil B. Oldridge. 1996. Outcomes Measurement: Health-Related Quality of Life. *Assistive Technology* 8:2, 82–93. [Crossref]