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Trends in Lumbar Fusion Surgery Among Octogenarians: A Nationwide Inpatient Sample Study From 2004 to 2013

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Abstract

Study Design: Retrospective analysis.

Objectives: Given the aging US population and natural degenerative process of the spine, more elderly patients with lumbar spinal disease are surgical candidates. Prior studies have assessed safety and efficacy of lumbar fusion (LF) surgeries in the elderly, but none have reviewed fusion procedures from an epidemiological standpoint. Here, we report 2004-2013 national trends in demographics, discharge time, and economic impact of LF procedures for octogenarians.

Methods: The Nationwide Inpatient Sample database was queried from 2004 to 2013 for LF procedures in patients aged 80 to 89 years. Patients were grouped by fusion level, demographics, comorbidity score, insurance, and hospital characteristics. Post-operative variables include length of stay and total in-hospital charges. Data was evaluated using chi-squared tests and *t* tests.

Results: The national sample included 17 471 LF procedures (mean age = 82.65 years). From 2004 to 2013, the annual number of LF procedures increased from 1144 to 2061 patients. Percentage of multilevel LF was relatively maintained (mean = 18%). The majority of patients were female (mean = 62%). The proportion of males increased during the study period (31.8% to 42.5%; $P < .0001$). The proportion of patients with a comorbidity score of 2 or 3 increased during the study period ($P < .0001$). Over time, average length of stay decreased (from 6 to 4.5 days; $P < .0001$), and total in-hospital charges increased (from $58 471 to $111 235; $P < .0001$).

Conclusions: These results suggest that more lumbar fusion procedures are being performed on octogenarians in recent years. While these patients are discharged from hospitals more quickly after surgery, there is also greater financial burden placed on patients, hospitals, and society.

Keywords

lumbar fusion, epidemiological trends, octogenarian, Nationwide Inpatient Sample

Introduction

Octogenarians (age 80-89 years) comprised 2.8% of the total US population in 2000 and increased to 3.1% of the population in 2010, a 21% increase between 2000 and 2010.[1] As the population ages, the prevalence of octogenarians presenting with debilitating degenerative conditions that may require spinal surgery is also expected to increase.[2-5] Several studies have demonstrated an increase in lumbar surgical intervention (decompression and/or fusion) in the broadly termed elderly population over the past 20 years.[2,3,6-8] Other studies have investigated safety and efficacy of lumbar spine surgery in this age group, with results showing both benefits[9-13] and risks.[14] However, no prior study has specifically identified national trends in the use of lumbar fusion surgery for the octogenarian population, with respect to demographics, discharge time, and economic impact.

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Advanced age may be a concern among patients and surgeons during the preoperative decision-making process. Elderly patients frequently present with more comorbidities than their younger counterparts. Prior studies have shown higher comorbidity scores to be associated with higher rates of mortality and perioperative complications following spinal surgery.[2,15,16] Furthermore, polypharmacy is common in the elderly population and is a known risk factor for increased risk of mortality.[17] Therefore, examining trends in patient characteristics, surgical complexity, and postoperative outcomes in this age group can alter current clinical practice and provide insight into changes in clinical decisions over time.

There is increasing demand for lumbar fusion surgery by older and more medically complex patients. The purpose of this study is to identify trends in the use of lumbar fusion surgery among octogenarians in the United States over the past decade, with regard to extent of the surgery (single vs multilevel), patient and hospital demographics, comorbidity status, length of in-hospital stay, and total hospitalization charges. We hypothesize that there was an increase in the annual number of lumbar fusion procedures performed from 2004 to 2013 on octogenarian patients.

Methods

Data Source

This study used the National Inpatient Sample (NIS), which is a deidentified database and therefore deemed exempt from our institutional review board. The NIS was used to collect data on octogenarian patients (aged 80-89 years) who underwent lumbar fusion from 2004 to 2013. The name of the database was changed from the Nationwide Inpatient Sample to the National Inpatient Sample in 2012, when changes were made to the sampling strategy of the database. However, the NIS includes analytical weights that allow for data to be used simultaneously from both before (pre-2012) and after (2012 to present) the change in sampling strategy.

The NIS records data using International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes.[18-20] Patients were identified by the ICD-9-CM procedure codes for primary lumbar fusion (81.04, 81.05, 81.06, 81.07, 81.08). Revision procedures were excluded.

Study Population

All octogenarian patients who underwent lumbar fusion were included in this study to understand the trends in the use of lumbar fusion among this patient population. Data points included patient demographics (eg, age, gender, race, comorbidity burden, and primary insurance provider) and hospital characteristics (eg, hospital size, geographic location, and teaching status). In the United States, the medical insurance system is divided into private and public insurance providers. Patients who have private health care insurance purchase an insurance plan from a private sector company. Public health care insurance is funded by the national government, and these insurance programs are called Medicare and Medicaid. Medicare provides health care insurance coverage to elderly individuals older than 65 years as well as to individuals with certain disabilities. Medicaid provides health care insurance coverage to individuals earning an income below the federal poverty threshold line that is established by the national government.

Outcome Definitions

The outcome variables measured over time in this study were in-hospital mortality, length of stay (LOS), and hospital charges. The NIS only includes data on in-hospital events; therefore, postdischarge mortality and postdischarge complications could not be assessed in the present study. All hospital charges were adjusted for inflation to 2013 US dollars using the Bureau of Labor Statistics CPI Inflation Calculator.[21]

Statistical Analysis

Absolute values, means, and frequencies for patient demographics, hospital characteristics, and outcomes were calculated for each year from 2004 to 2013. All calculations were done using the sampling weights included in the NIS to account for the complex survey design of the database. The sampling weights used were from after the NIS redesign in 2012, which allowed for trends to be studied across the years before and after the redesign.

Categorical variables (eg, gender, race, comorbidities, insurance status, hospital size, hospital region, academic institution, and mortality) were compared from 2004 to 2013 using chi-squared tests. Independent t tests using the Satterthwaite method were used to compare continuous variables (eg, age, LOS, and hospital charges) from 2004 to 2013. All analyses were performed using SAS version 9.4. The alpha level for determining statistical significance was set at $P < .01$.

Results

Among the octogenarian population (age range 80-89 years), a total of 17 471 lumbar fusions were recorded from 2004 to 2013, and the mean age was 82.6 years, as shown in Table 1. The annual number of lumbar fusion procedures in this population increased from 1144 to 2061 procedures. The percentage of multilevel lumbar fusions remained relatively constant over time (mean 18%). Overall, the majority of patients were female (mean 62%), and the proportion of females significantly decreased during the study period (68.2% to 57.5%; $P < .0001$). There was a statistically significant increase in the proportion of patients who identified as "white" (70.5% to 84.4%, $P < .0001$) and "other" (3.9% to 7.8%, $P = .0009$); there was also an increase, although not statistically significant, in the proportion of patients identifying as "black" (1.5% to 2.3%, $P = .11$). The proportion of patients with at least 2 or 3 comorbidities at the time of surgery increased significantly during the study period ($P < .0001$). Meanwhile, the proportion

Table 1. Patient Demographics, Hospital Characteristics, and Outcomes for Lumbar Fusions in Octogenarians.[a]

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	*P*
No. of total fusions	1144	1224	1292	1633	1780	2014	2032	2324	1967	2061	
Multilevel fusions	209 (18.3)	260 (21.2)	224 (17.3)	337 (20.6)	271 (15.2)	387 (19.2)	362 (17.8)	448 (19.3)	317 (16.1)	347 (16.8)	.3629
Mean age (years)	82.6	82.5	82.7	82.6	82.6	82.6	82.8	82.7	82.7	82.7	.1295
Female*	780 (68.2)	771 (63)	839 (64.9)	1061 (65)	1118 (62.8)	1213 (60.2)	1284 (63.2)	1379 (59.3)	1178 (59.9)	1185 (57.5)	<.0001
Race											
White*	807 (70.5)	840 (68.6)	857 (66.3)	1082 (66.3)	1316 (73.9)	1559 (77.4)	1624 (79.9)	1919 (82.6)	1652 (84)	1739 (84.4)	<.0001
Black	17 (1.5)	21 (1.7)	26 (2)	28 (1.7)	34 (1.9)	34 (1.7)	38 (1.9)	59 (2.5)	49 (2.5)	48 (2.3)	.1107
Other*	45 (3.9)	55 (4.5)	54 (4.2)	74 (4.5)	104 (5.8)	137 (6.8)	123 (6.1)	160 (6.9)	159 (8.1)	161 (7.8)	.0009
Comorbidity											
0	138 (12.1)	123 (10)	105 (8.1)	134 (8.2)	158 (8.9)	207 (10.3)	194 (9.5)	190 (8.2)	164 (8.3)	179 (22.1)	.0078
1	300 (26.2)	318 (26)	296 (22.9)	408 (25)	423 (23.8)	414 (20.6)	462 (22.7)	473 (20.4)	392 (19.9)	455 (23.9)	.0094
2*	345 (30.2)	348 (28.4)	410 (31.7)	438 (26.8)	503 (28.3)	547 (27.2)	502 (24.7)	579 (24.9)	539 (27.4)	492 (45.4)	<.0001
3*	361 (31.6)	435 (35.5)	481 (37.2)	653 (40)	696 (39.1)	846 (42)	874 (43)	1082 (46.6)	872 (44.3)	935 (45.4)	<.0001
Health care insurance											
Medicare	1088 (95.1)	1153 (94.2)	1226 (94.9)	1530 (93.7)	1637 (92)	1863 (92.5)	1931 (95)	2204 (94.8)	1851 (94.1)	1945 (94.4)	.4952
Medicaid	2 (0.2)	4 (0.3)	3 (0.2)	2 (0.1)	6 (0.3)	5 (0.2)	9 (0.4)	3 (0.1)	4 (0.2)	6 (0.3)	.5534
Uninsured	6 (0.5)	0 (0)	2 (0.2)	4 (0.2)	8 (0.4)	5 (0.2)	2 (0.1)	3 (0.1)	8 (0.4)	4 (0.2)	.0945
Private	43 (3.8)	62 (5.1)	49 (3.8)	86 (5.3)	100 (5.6)	120 (6)	75 (3.7)	94 (4)	87 (4.4)	84 (4.1)	.7281
Academic hospital	619 (54.1)	566 (46.2)	645 (49.9)	825 (50.5)	874 (49.1)	909 (45.1)	867 (42.7)	1150 (49.5)	987 (50.2)	1064 (51.6)	.6636
Hospital size											
Small	191 (16.7)	181 (14.8)	144 (11.1)	232 (14.2)	224 (12.6)	263 (13.1)	313 (15.4)	322 (13.9)	267 (13.6)	296 (14.4)	.6309
Medium	224 (19.6)	248 (20.3)	284 (22)	276 (16.9)	434 (24.4)	430 (21.4)	391 (19.2)	483 (20.8)	452 (23)	531 (25.8)	.0278
Large	729 (63.7)	795 (65)	864 (66.9)	1125 (68.9)	1122 (63)	1291 (64.1)	1311 (64.5)	1499 (64.5)	1248 (63.4)	1234 (59.9)	.1467
Hospital region											
Northeast	183 (16)	167 (13.6)	173 (13.4)	228 (14)	277 (15.6)	305 (15.1)	299 (14.7)	360 (15.5)	318 (16.2)	301 (14.6)	.6386
South	435 (38)	447 (36.5)	522 (40.4)	579 (35.5)	682 (38.3)	794 (39.4)	774 (38.1)	919 (39.5)	724 (36.8)	785 (38.1)	.6995
Midwest	261 (22.8)	296 (24.2)	327 (25.3)	449 (27.5)	437 (24.6)	459 (22.8)	504 (24.8)	541 (23.3)	481 (24.5)	488 (23.7)	.8746
West	265 (23.2)	314 (25.7)	270 (20.9)	377 (23.1)	384 (21.6)	456 (22.6)	455 (22.4)	504 (21.7)	444 (22.6)	487 (23.6)	.987
Mortality	11 (1)	8 (0.7)	8 (0.6)	4 (0.2)	11 (0.6)	18 (0.9)	11 (0.5)	10 (0.4)	7 (0.4)	9 (0.4)	.0867
Mean length of stay (days)*	6.0	5.8	5.8	5.4	5.0	5.1	5.2	4.8	4.5	4.5	<.0001
Mean hospital charges ($)*	58471	67195	68064	79665	87668	94318	95511	109121	102248	111235	<.0001

[a] All data is from the Nationwide Inpatient Sample database and include patients between 80 and 89 years of age who underwent lumbar spinal fusion from 2004 to 2013. Data is expressed as a raw value with percentage of total fusions for that year in parentheses. Data from 2004 was compared with 2013 for a single category to determine statistical significance.
* Denotes a statistically significant change over time at $P < .001$.

of patients with fewer than 2 comorbidities at the time of surgery did not exhibit a statistically significant change over this time period.

The majority of patients (mean 94.1%) had Medicare as their primary insurer; the remaining patients were covered under private insurance (mean 4.6%), Medicaid insurance (mean 0.3%), or were uninsured (mean 0.3%). There were no statistically significant changes in insurance coverage noted over the time period. There were no statistically significant changes observed over the study period in the proportion of academic hospitals, hospital size (small, medium, and large), or hospital region (Northeast, South, Midwest, and West).

The immediate postoperative mortality varied between 0.2% and 1% over the 10-year period and the change was not statistically significant. Mean length of stay decreased over time (from 6 to 4.5 days; $P < .0001$). Total in-hospital, inflation-adjusted charges increased significantly during the study period ($58 471 to $111 235; $P < .0001$).

Discussion

Several studies have recently outlined trends of operative intervention for lumbar degeneration in the broadly defined elderly population over the past 20 years.[2,3,6-8] However, these studies often analyze the entire geriatric population as a whole and/or include all operative interventions, regardless of invasiveness. This is the first study to assess trends in lumbar fusion in the octogenarian population. Given the aging population in the United States, octogenarians with lumbar spinal pathologies represent a unique challenge to spine surgeons. The importance of fusion in the elderly patient with an unstable spine has been well documented[22,23]; however, it is currently unknown how surgeons have responded to the potential increase in demand in the surgical management of spinal pathology among the octogenarian population.

Rates of Fusion and Patient Demographics

In the past 2 decades, there have been documented trends of increased operative intervention and increased complexity of surgery offered to the geriatric population in the United States[3,7] and abroad.[6] In an NIS analysis, Deyo et al[3] found that the rate of lumbar fusion surgery increased more than 220% between 1990 and 2001, with the most rapid rate of increase occurring among patients aged 60 years and older. In a later study of 32 000 Medicare patients, Deyo et al[7] found that between 2002 and 2007, the frequency of complex fusions (>2 levels or combined anterior/posterior fusion) increased 15-fold (1.3 to 19.9 per 100 000), while the frequency of isolated decompressions and simple fusions (1-2 levels) decreased (approximately 104 to 90 per 100 000 and 35 to 25 per 100 000; respectively). Similarly, in a 15-year time-series study in England, Sivasubramaniam et al[6] found a 2.8-fold increase of operative intervention in patients aged 60 to 74 and ≥75 years old, from 32.54 to 89.95 and from 24.89 to 70, per 100,000, respectively. In our study, we found a statistically significant increase in the total number of fusions performed on the octogenarian population, from 1114 procedures in 2004 to 2061 procedures in 2013. Many factors may have contributed to this increase, including improvements in technical experience and quality of implants, as well as increased presence and influence from the biotechnology industry. We suggest to readers and surgeons alike that when evaluating a patient's surgical candidacy, it is important to consider overall health status, individual anatomy, any comorbidities, medication list, insurance coverage, social support, and activities of daily living. Interestingly, although the annual number of fusion procedures increased over the study period, the percentage of multi-level fusions remained constant (mean 18%). Given the observed trajectory, we expect the overall number of lumbar spine surgeries in the octogenarian population to continue to rise in the future.

Regarding epidemiological trends, the predominance of the white population in our study is consistent with national demographic proportions based on recent 2016 Census Bureau population estimates: 77% white and 13% black. However, this white predominance among the octogenarian population may also reflect sociological issues in the United States, such as differences in access to health care, cultural influences in selecting surgical management, and racial differences in life expectancy. For example, current literature demonstrates a life expectancy gap between black and white individuals in the United States, with the average life expectancy of black individuals being 4 years less than that of white individuals.[24,25]

Comorbidity Status and Length of Stay

We observed a trend toward an increased number of operations offered to patients with 2 or 3 comorbidities ($P < .0001$), while the average length of stay decreased from 6.01 to 4.46 days ($P < .0001$). This finding is particularly interesting because it may suggest that although higher risk patients undergo surgery, they may experience fewer postoperative complications during the inpatient episode. It may also imply that centers are evolving to streamline acute postoperative care. In the current climate of health care policy and finance that discourages hospital readmissions, a future study is warranted to better understand whether the reduced length of stay among octogenarians has been associated with a change in readmission rates for this population.

Postoperative Outcomes and Complications

While there exists limited data on postoperative outcomes and clinical function following specifically lumbar fusion surgery in the octogenarian population, several studies have looked at postoperative outcomes following various lumbar spine procedures in this age group.[9-13] Nie et al[9] found no difference in post-operative complications between a cohort of 64 octogenarians compared to patients between 40 and 60 years of age after undergoing discectomy. Nie et al[9] reported that both groups experienced significantly improved outcomes with

regard to the visual analog scale (VAS) and Oswestry Disability Index (ODI) scores. Furthermore, Nie et al[9] found no difference in score improvement between the age groups, thus concluding that discectomy was clinically just as successful in octogenarians compared with younger cohorts. Similar results were found in an as-treated analysis of patients in the Spine Patient Outcomes Research Trial (SPORT).[10] In this analysis, Rihn et al[10] found that the octogenarian cohort maintained statistically equal physical function and ODI improvements relative with their younger counterparts, despite having increased comorbidities and undergoing a significantly greater proportion of multilevel laminectomies. In the study by Rihn et al,[10] only 8.6% (n = 5) of the octogenarians underwent instrumented fusion, hence limiting further subgroup analysis for a fusion-only cohort. The clinical success of lumbar decompression surgery in the octogenarian population has been further established in studies by Giannadakis et al,[11] Galiano et al,[12] and Shabat et al.[13] However, it is important to note that these studies address lumbar decompression, but do not address the viability of fusion, which highlights the need to better understand the role of lumbar fusion in the octogenarian population from both a clinical and operative standpoint.

With regard to postoperative complications, a Medicare database study by Puvanesarajah et al[26] looked at patients older than 80 years (n = 12 187) who underwent 1- or 2-level lumbar fusion surgery, and these patients were found to have significantly increased risk of at least 1 major complication (13.87% vs 9.52%; $P < .0001$) and an increase in 90-day mortality rate (0.3% vs 0.09%; $P < .0001$) compared with those aged 65 to 79 years (n = 72 547). Furthermore, Puvanesarajah et al[26] demonstrated that the octogenarian population had a significantly greater mean number of comorbidities relative to younger cohorts, and at 1 year postoperatively, octogenarians were found to have 2.6 times increased odds of mortality. Regarding readmission rates, Deyo et al[7] reported that readmission rates among the elderly population (age >65 years) undergoing lumbar spinal surgeries increased based on the complexity of the surgery, from 7.8% for lumbar decompressions to 13% for complex lumbar fusions. Balabaud et al[14] performed a retrospective review of 121 patients aged 80 years or older who underwent lumbar decompression with or without fusion, and found significantly increased estimated blood loss and increased rates of dural tears and delirium associated with those patients who underwent fusion. Interestingly, Balabaud et al[14] did not find associations of increased rates of mortality or complications—a result that conflicts with other studies in the literature.[27-29] In our study, we observed rates of mortality during hospitalization varying from 0.2% to 1.0% over the 10-year period, with no statistically significant trend from 2004 to 2013. The observed range of rates are consistent with values cited in the literature on mortality rates following lumbar procedures in the elderly population—Oldridge et al[30] (0.52%), Silvers et al[31] (0.8%), Deyo et al[32] (0.6%), and Li et al[33] (0.15%-1.4%). This finding suggests that despite relatively higher mortality rates in the elderly population compared with the younger population,[32] there is strong desire for older patients with symptomatic or progressive degenerative conditions to preserve a good quality of life through surgical intervention, and spine surgeons are more willing to operate on patients with advanced age, given that the risks of surgery are thoroughly discussed and are acceptable to the patients and to the surgeon alike. With regard to multilevel lumbar fusion, a complex and often strenuous procedure with high potential for complications,[34] advanced age alone does not seem to be a contraindication for surgery.

Total Hospitalization Charges

With regard to hospitalization charges, our study found a consistent increase in the mean total charges from $58 471 to $111 235 between 2004 and 2013 ($P < .0001$). The total charges were adjusted for inflation over the specified time period. In a Medicare cohort analysis between 2002 and 2007, Deyo et al[7] found adjusted mean hospital charges of $80 888 for complex fusions and $58 511 for simple fusions, both of which were significantly higher than the cost for decompression alone ($23 724). In a separate review of 1672 Medicare claims between 2005 and 2009, Ong et al[35] found the overall average payment for health care for patients who underwent lumbar spinal fusion to be $36 230 at 3 months, $46 840 at 1 year, and $61 610 at 2 years. Although it may be difficult to correlate hospital charges among different studies due to differences in charges, costs, and payment structure, our study clearly demonstrates an increase in the total charges for lumbar fusions in the octogenarian population. We hypothesize that this finding is multifactorial but may in part be attributable to increased medical resource use associated with treating frail and more medically complex and comorbid patients—a trend that we have recognized in this period.

Limitations

Our study does present itself with several limitations. Although large databases provide access to a heterogeneous population, utility is limited by inaccuracies or inconsistency in coding and lack of operative detail. Spine surgeons may use a range of clinical information to define spinal instability, which may not be reflected through the use of standardized ICD-9 diagnostic codes, and details on symptomology cannot be captured by ICD-9 diagnostic codes. A study by Golorgorsky et al[36] demonstrates that within the NIS database, the ICD-9 codes may not accurately reflect the surgeon's indication for primary fusion. In our study, we did not stratify our lumbar fusion population based on primary ICD-9 diagnostic code; however, a future study is warranted to assess trends in the octogenarian population on indications for lumbar fusion—that is, lumbar spinal stenosis, spinal deformity, traumatic instability, iatrogenic instability, and so on.[37]

Furthermore, the NIS database does not report on operative variables such as anesthesia type, length of surgery, or blood loss—all of which are important measures to consider in order to obtain a more complete picture of surgical trends in the

elderly population.[38] Additionally, recording of immediate postoperative complications into this large database may be inconsistently documented across multiple institutions, and longitudinal follow-up to monitor for postdischarge adverse outcomes are not recorded. Regional variances in coding and billing practices also cannot be accounted for. Despite the limitations in utility of the NIS administrative database, this resource comprises a nationally representative sample of patients in the United States,[39] and is a valuable tool for investigating population-based trends in spine surgery with regard to patient demographics, postoperative course and outcomes, and total hospitalization charges.

Conclusion

This study found a significant increase in the number of lumbar fusions performed annually among octogenarians. Notably, the average charges for lumbar fusion procedures increased substantially during this era, while the average length of hospital stay significantly decreased. Throughout this period, we have found octogenarian patients who underwent surgery to have an increased number of medical comorbidities.

Declaration of Conflicting Interests

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