



Differences in clinical outcomes and health care utilization between octogenarians and nonagenarians following decompression for lumbar spinal stenosis. A market scan analysis



Mayur Sharma^a, Nicholas Dietz^a, Beatrice Ugiliweneza^a, Dengzhi Wang^a, Doniel Drazin^b, Maxwell Boakye^{a,*}

^a Department of Neurosurgery, University of Louisville, 200 Abraham Flexner Hwy, Louisville, KY, 40202, USA

^b Pacific Northwest University of Health Sciences College of Medicine, Yakima, WA, USA

ARTICLE INFO

Keywords:

Decompression
Lumbar spinal stenosis
Octogenarians
Nonagenarians
Outcomes

ABSTRACT

Objective: Lumbar spinal stenosis (LSS) in octogenarians and beyond has a significant impact on quality of life requiring surgical decompression and hence impact on health care utilization. Risk of surgical failure and impact on health care resources is always a concern in this patient population (more so in nonagenarians). The aim of our study was to compare clinical outcomes and healthcare utilization in patients (80–89 vs.90+) undergoing decompression for LSS.

Patients and methods: Data was extracted using ICD9/10 and CPT codes from MarketScan (2001–2015) in this retrospective study. We defined the comparative groups based on the age groups (80–89 and 90+), in patients with LSS. Outcomes of interest were: length of hospital stay, discharge disposition and utilization in the index hospitalization, 6- months, 12 months following index procedure as well as the associated health care utilization. Patient characteristics and outcomes among cohorts were compared using univariate tests. Outcomes were further compared using adjusted multivariable regression models. Statistical analysis was performed with SAS 9.4.

Results: A cohort of 5387 was identified from the database, 96.38% were in the 80–89 age group and 3.62% were in the 90+ age group. The proportion of patients undergoing surgery for LSS among 80–89 (95.7–98.5%) and 90+ age group (1.5–4.3%) remained constant through the years. Interestingly, 13.83% and 16.92% of patients had Elixhauser comorbidity index of 3+ in 80–89 age group and 90+ age groups respectively. Decompression with fusion was performed in 19.4% of patients in 80–89 age group, compared to 9.74% of patients in 90+ age group. There was no difference in median length of hospital stay (3 days, $p = 0.19$) and complications across the cohorts (80–89: 16.7%; 90+: 18.46% $p = 0.51$). 70.6% of patients in 80–89 age groups were discharged to home compared to 60.5% in 90+ age group ($p = 0.0023$). At 6 months follow-up, overall rate of new decompression, new fusion, re-fusion at index level were 2.38%, 0.59% and 0.33% only, with no differences across the cohorts. Interestingly, patients in 80–89 age group incurred higher outpatient services, number of medication refills and related payments at 6-months and 12-months follow-up, compared to patients in 90+ age group. Overall, combined median post-discharge payments at 12 months were similar across the groups [80–89 (median \$ 40,257) and 90+ (median\$ 36,161), $p = 0.14$].

Conclusion: Using MarketScan database, there has been a gradual decline in the number of decompressions being performed for LSS in elderly patients (> 80 years of age), however there is no change in the proportion of octogenarians and nonagenarians undergoing decompression for LSS. There was no difference in rate of re-operations and overall health care utilization among the groups. Surgery for LSS can be offered to nonagenarians (in appropriately selected patients) with no difference in clinical outcomes and health care utilization, compared to octogenarians.

Abbreviations: LSS, lumbar spinal stenosis; NIS, Nationwide inpatient sample database; SD, standard deviation; IQR, interquartile range; LOS, length of stay; SE, standard error; OR, odds ratio; RR, relative risk; CI, confidence interval; ASA, American Society of Anesthesiologists

* Corresponding author at: Department of Neurosurgery, University of Louisville, School of Medicine, 220 Abraham Flexner Way, Louisville, KY, 40202, USA.

E-mail address: Maxwell.boakye@ulp.org (M. Boakye).

<https://doi.org/10.1016/j.clineuro.2019.04.031>

Received 5 February 2019; Received in revised form 2 April 2019; Accepted 30 April 2019

Available online 01 May 2019

0303-8467/ Published by Elsevier B.V.

1. Introduction

By 2050, the number of elderly (> 65 years) Americans is projected to be 88.5 million compared to 40.2 million in 2010 [1]. With advances in medical care and this increase in number of elderly patients, we are likely to see octogenarian and nonagenarian patients with degenerative spine conditions such as lumbar spine stenosis (LSS). This patient population present unique challenge to treating physician in terms of advanced physiological age with associated medical comorbidities, severity of degenerative spinal disease leading to deformity and therefore anesthetic and post-operative complications [2–6]. Surgical intervention in patients with LSS has been shown to result in significant improvement in pain, ambulation and overall quality of life with decrease in consumption of opioid medications [7–10].

Given the trend of an aging United States population coupled with medical advances, investigation of outcomes and potential economic impact of surgery informs standards of care. Due to higher rates of complications, delayed wound healing, and quality of life considerations, the risks of surgery in older adults has been traditionally perceived to outweigh potential benefits [3,11–13]. Within spine surgery for octogenarians, an increase in one level was associated with an additional 11% complication risk with 30-day mortality rate of 5.6% [14]. However, advances in spinal surgeries for elderly cohorts, demonstrate acceptable safety profiles for octogenarians and nonagenarians with careful preoperative screening and selection of appropriate surgical candidates [4,7,14].

In the present study, we investigate outcomes associated with decompression for LSS in octogenarians and nonagenarians. Specifically, we compare length of stay, readmission, complications, and outpatient services between groups with up to 12 months follow up. To the best of our knowledge, this is first study comparing outcomes and healthcare utilization in octogenarians and nonagenarian patients (80–89 vs.90+) undergoing decompression for LSS.

2. Materials and methods

2.1. Data source

For this project, we used MarketScan data from Truven Health Analytics - IBM Watson Health. We have used this data in our previous projects [15,16]. This data is built from paid claims by employer-sponsored insurance, COBRA, private insurance managed Medicaid and Medicare Supplemental (also known as Medigap). It is a comprehensive database in which more than 100 payers contribute data. Insurance holders and their dependents enter this database when enrollment starts and they exit when that coverage ends. While enrolled, their continuum of care is captured along with corresponding payment. This data provides a snapshot of health during this period. In the data, Each individual has a unique encrypted ID that can be used to link to different databases [17] and the data is de-identified. This data has been extensively used for medical, public health and epidemiology research for decades [17]. We have a custom subset of this database with individuals who have experienced a neurological /neurosurgical conditions at some points from 2000 to 2016. We have 3 insurance types (private, Medicaid and Medicare supplemental) covering inpatient admissions, outpatient services and outpatient medications. For this project, we extracted elderly patients 80+ years old who have had a spinal stenosis and underwent surgery.

2.2. Patient selection and follow up

We extracted patients 80 years and older with a primary diagnosis of lumbar stenosis from the inpatient tables. All the patients included had to have a concurrent decompression (laminectomy, laminotomy, discectomy, vertebrectomy, corpectomy, foreign body removal and repair of vertebral fracture) with or without fusion. We wanted to

compare the outcomes of patients 90 years or older to those 80–89 so we divided the extracted sample into 2 groups. The claim codes used for extraction are in Supplemental table a. All cases under 80 were excluded. For each patient, the first occurring case satisfying the above conditions was flagged as the index hospitalization. We wanted an incidence cohort, therefore, we required every patient included to have 12 months look-back continuous enrollment among which there was no lumbar decompression, fusion or refusion. The outcomes of interest were the outcomes and healthcare utilization in the 6 months and 12 months following injury; therefore, only patients who had 12 months post-surgery continuous enrollment in their insurance were included in the analysis data set. The look-back and follow-up time were calculated as follows: *Pre-diagnosis look-back time = surgery admission date – start enrollment date (or first claim date in the data set)*; *Post-surgery follow up time = end enrollment date (or last claim date in the data set) – surgery discharge date*.

2.3. Patient characteristics

Baseline characteristics were noted at the time of index hospitalization: age, gender, year of index hospitalization, insurance type (commercial, Medicaid, Medicare) and comorbidities. For comorbidities, we used the Elixhauser comorbidity score [18] computed using an adaptation to ICD-9-CM and ICD-10 codes developed by Quan et al [19]. These were summarized and included in multivariable analyses.

2.4. Post-surgery outcome variables

The main interest in our project was to compare the outcomes and utilization in the index hospitalization, within 30-days after discharge and within the 6 months and 12 months following surgery with the associated payments. We looked at complications, repeat surgery, healthcare utilization and associated payments:

- Complications:** We evaluated complications during the index hospitalization. Complications of interest were: renal, cardiac, general neurosurgical, general neurological, Deep Vein Thrombosis or Pulmonary Embolism (DVT/PE), pulmonary, infection, wound infection, and pneumonia.
- Repeat surgery:** A patient was considered to have had surgery if there was a claim of decompression, fusion or refusion in the follow-up period following discharge from the index hospitalization. We screened the claims occurring within 6 months and 12 months of discharge.
- Healthcare resources use:** The index hospitalization resources use outcomes were the length of stay and discharge disposition. For post-discharge health resource use outcomes, we focused on 6- and 12-month hospital admissions, Emergency Room (ER) admissions, outpatient services and medication refills.
- Healthcare resources payment:** All the payments associated with the healthcare utilization described above were evaluated. Payments were the sum of all hospitalizations (inpatient payments), all outpatient services (outpatient payments) and all prescription medication refills (medications payments). We also looked at a combination of all three. ER services are a subset of the inpatient admissions or outpatient services therefore they were not added in the summation. All payments were inflated to 2016 US dollars using the medical component of the consumer price index accessible through the United States Bureau of Labor Statistics website [20].

2.5. Statistical analysis

Means and standard deviations, median and interquartile range as well as the full range (minimum to maximum) were used to summarize the continuous variables. Categorical variables were summarized using counts and percentages. To compare the patient characteristics and

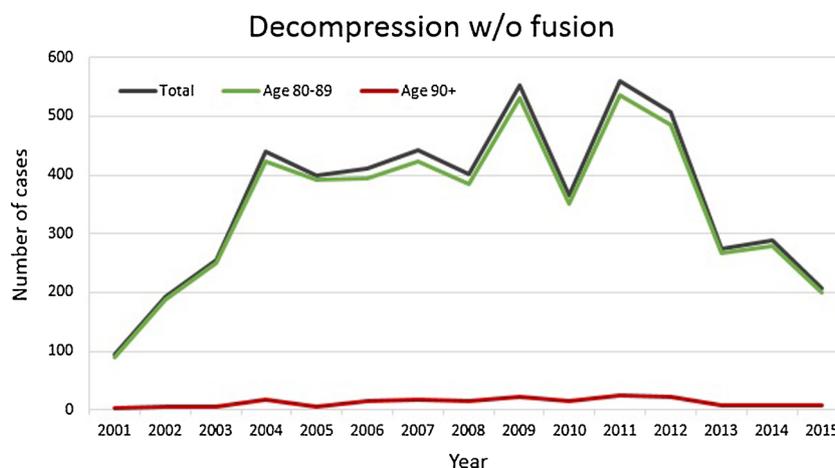


Fig. 1. Graph showing the trends (2001–2015) of decompression for LSS in octogenarian, nonagenarians and total cohort, using MarketScan database.

outcomes among the 2 age groups, we used the Wilcoxon Rank Sum test for continuous variables and Chi-square test for categorical variables [21]. In addition, we also performed a multivariable analysis for each outcome accounting for all patient characteristics (gender, elixhauser index and insurance type) in the comparison of the 2 age groups. We used the linear regression on log-transformed values for continuous outcomes and the logistic regression for categorical outcomes. Adjusted comparisons were presented in terms of Relative Risk (RR) for continuous variables and Odds Ratio (OR) for categorical variable with associated 95% confidence intervals (CI) as a measure of precision. We used the software SAS 9.4M5 (SAS Institute, Inc, Cary, NC) for data preprocessing and data analysis [22].

3. Results

A cohort of 5387 was identified from the database from 2001 to 2015 during the study period. Number of patients undergoing surgical decompression for LSS gradually increased from 2001 to 2009, with maximum number of cases in years 2009 and 2011. Recently, there has been a gradual decline in the number of decompressions being performed in this patient population, Fig. 1. The proportion of patients undergoing surgery for LSS among 80–89 (95.7–98.5%) and 90+ age group (1.5–4.3%) remained constant through the years.

3.1. Patient demographics

Of 5387 patients, 5192 patients (96.38%) were in the 80–89 age group and 195 patients (3.62%) were in the 90+ age group. Overall, median age was 82 years (range: 81–103 years), only one patient was > 100 year old (103 years). Males constituted majority of patients overall (51.7%) and in 80–89-age cohort (51.8%), whereas female constituted the majority in 90+ age group (51.3%). Medicare was the most common insurance utilized across the cohorts (96%). Interestingly, only 13.83% and 16.92% of patients had Elixhauser comorbidity index of 3+ in 80–89 age group and 90+ age groups respectively, with no differences across the groups. Overall, decompression without fusion was performed in 81% of patients and decompression with fusion was performed in 19% of patients. Decompression with fusion was performed in 19.4% of patients in 80–89 age group, compared to 9.74% of patients in 90+ age group ($p = 0.0008$), Table 1.

3.2. Outcomes at index hospitalization, 6-months and 12-months post-discharge

There was no difference in median length of hospital stay (3 days,

$p = 0.19$) and complications across the cohorts (80–89: 16.7%; 90+ : 18.46% $p = 0.51$). 70.6% of patients in 80–89 age groups were discharged to home compared to 60.5% in 90+ age group ($p = 0.0023$). Also, there was no difference in payments during index hospitalization across the groups (80–89: median \$14,291; 90+ : median \$ 13,301 $p = 0.33$), Tables 2 and 3.

At 6 months following index procedure, overall rate of new decompression, new fusion, re-fusion at index level were 2.38%, 0.59% and 0.33% only, with no differences across the cohorts. Similarly, no differences in ER admission and hospital re-admissions were noted among the groups at 6 months follow-up. Interestingly, patients in 80–89 age group incurred higher outpatient services, number of medication refills and related payments, compared to patients in 90+ age group. However, there was no difference in combined payments (index + overall payments during 6 months follow up) among 80–89 (median \$ 27,818) and 90+ (median\$ 26,550) age groups, Tables 2 and 3.

Similar results were also noted at 12 months following decompression for LSS, with patients in 80–89 age group incurring higher outpatient services, medication refills and related payments compared to the older cohort. There were no differences in rate of new decompression, new fusion or re-fusion at index level at 12 months follow-up. Overall, combined median post-discharge payments at 12 months were similar across the groups [80–89 (median \$ 40,257) and 90+ (median\$ 36,161), $p = 0.14$] Tables 2 and 3, Fig. 2. Compared to patients who had decompression without fusion, outcomes in patients who had decompression with fusion showed longer length of hospital stay (median 3 days vs. 4 days), less likely to be discharged home (73% vs. 58%), higher complications (15.7% vs. 21%) and higher payments (median \$12,653 vs. \$34,442), Table 4.

4. Discussion

In our study, we found that the number of patients undergoing surgery for LSS gradually decreased in recent years, however proportion of octogenarian and nonagenarian patients remained constant during the study period. Decompression with fusion was performed in 19.4% of patients in 80–89 age group, compared to 9.74% of patients in 90+ age group.

4.1. Length of hospital stay, complications, discharge disposition and comparison with literature

We found no difference in median length of hospital stay (3 days) and complications during index hospitalization across the cohorts (80–89: 16.7%; 90+ : 18.46%). As expected, 70.6% of patients in 80–89

Table 1
Demographics comparisons across groups.

		Complete cohort	Decompression		p-value
			Age 80-89	Age 90+	
Demographics	Mean (SD)	N = 5387 83.1 (2.9)	N = 5192 (96.38%) 82.8 (2.4)	N = 195 (3.62%) 91.4 (1.9)	
Age	Median (IQR)	82 (81, 85)	82 (81, 84)	91 (90, 92)	< 0.0001
	Range, min-max	80-103	80-89	90-103	
Gender: Female, n (%)		2602 (48.3%)	2502 (48.19%)	100 (51.28%)	0.3962
Insurance	Commercial, n (%)	1 (0.02%)	1 (0.02%)	0 (0%)	0.8704
	Medicaid, n (%)	187 (3.47%)	179 (3.45%)	8 (4.1%)	
	Medicare, n (%)	5199 (96.51%)	5012 (96.53%)	187 (95.9%)	
Elixhauser Index	0, n (%)	1719 (31.91%)	1664 (32.05%)	55 (28.21%)	0.2529
	1, n (%)	1872 (34.75%)	1810 (34.86%)	62 (31.79%)	
	2, n (%)	1045 (19.4%)	1000 (19.26%)	45 (23.08%)	
	3+, n (%)	751 (13.94%)	718 (13.83%)	33 (16.92%)	
Decompression	Without Fusion, n (%)	4363 (80.99%)	4187 (80.64%)	176 (90.26%)	0.0008
	With Fusion, n (%)	1024 (19.01%)	1005 (19.36%)	19 (9.74%)	

Patients aged 80 and above were diagnosed with lumbar spinal stenosis without concurrent spondylolisthesis or neoplasm and had at least 1 year of pre- and post-operative enrollment.

Table 2
Outcome comparison for patients undergoing decompression for LSS.

		Combined	Decompression		p-value
			Age 80-89	Age 90+	
		N = 5387	N = 5192 (96.38%)	N = 195 (3.62%)	
Index hospitalization outcomes					
	Length of stay, median (IQR)	3 (2, 4)	3 (2, 4)	3 (2, 4)	0.1969
	Payment, median (IQR)	14263 (9281, 29566)	14291 (9274, 29671)	13301 (9327, 23560)	0.3359
	Discharge home, n (%)	3788 (70.32%)	3670 (70.69%)	118 (60.51%)	0.0023
	Complications, n (%)	903 (16.76%)	867 (16.7%)	36 (18.46%)	0.5177
Post discharge outcomes, 6 months					
Reoperation					
	New decompression, n (%)	128 (2.38%)	124 (2.39%)	4 (2.05%)	1
	New fusion, n (%)	32 (0.59%)	30 (0.58%)	2 (1.03%)	0.3234
	Refusion, n (%)	18 (0.33%)	17 (0.33%)	1 (0.51%)	0.4856
	At least one of above, n (%)	136 (2.52%)	132 (2.54%)	4 (2.05%)	1
ER admissions					
	Admitted, n (%)	63 (1.17%)	59 (1.14%)	4 (2.05%)	0.2433
Hospital admissions					
	Admitted, n (%)	721 (13.38%)	685 (13.19%)	36 (18.46%)	0.0339
	# Readmissions, median (IQR)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0.035
	Payments, median (IQR)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0.043
Outpatient services					
	# Services, median (IQR)	35 (17, 64)	36 (17, 64)	34 (18, 60)	0.5048
	Payments, median (IQR)	3890 (1622, 8393)	3897 (1624, 8351)	3729 (1584, 9853)	0.9012
Medication refills					
	# refills, median (IQR)	48 (24, 75)	48 (24, 75)	45 (24, 72)	0.5503
	Payments, median (IQR)	3762 (1139, 7330)	3804 (1151, 7342)	2661 (760, 6905)	0.0281
	Overall payments, median (IQR)	10027 (5072, 18089)	10023 (5085, 18022)	10040 (4796, 18719)	0.8498
	Combined (Index hospital + overall), median (IQR)	27760 (17273, 46796)	27818 (17320, 46792)	26550 (15709, 47597)	0.4599
Post discharge outcomes, 12 months					
Reoperation					
	New decompression, n (%)	238 (4.42%)	232 (4.47%)	6 (3.08%)	0.3533
	New fusion, n (%)	80 (1.49%)	78 (1.5%)	2 (1.03%)	1
	Refusion, n (%)	27 (0.5%)	26 (0.5%)	1 (0.51%)	1
	At least one of above, n (%)	249 (4.62%)	243 (4.68%)	6 (3.08%)	0.2952
ER admissions					
	Admitted, n (%)	93 (1.73%)	88 (1.69%)	5 (2.56%)	0.3603
Hospital admissions					
	Admitted, n (%)	1454 (26.99%)	1400 (26.96%)	54 (27.69%)	0.8222
	# Readmissions, median (IQR)	0 (0, 1)	0 (0, 1)	0 (0, 1)	0.8272
	Payments, median (IQR)	0 (0, 2562)	0 (0, 2602)	0 (0, 2119)	0.9443
Outpatient services					
	# Services, median (IQR)	66 (36, 113)	67 (36, 113)	59 (35, 104)	0.0761
	Payments, median (IQR)	7852 (3789, 15682)	7881 (3817, 15662)	6930 (3121, 17272)	0.3199
Medication refills					
	# Refills, median (IQR)	93 (48, 144)	93 (48, 146)	90 (45, 138)	0.4014
	Payments, median (IQR)	7786 (2395, 14950)	7866 (2435, 14984)	6137 (1624, 12921)	0.0251
	Overall payments, median (IQR)	21176 (10996, 37517)	21188 (11063, 37589)	20206 (8675, 35154)	0.1375
	Combined (Index hospital + overall), median (IQR)	40059 (25089, 65547)	40257 (25178, 65807)	36161 (21927, 60489)	0.0529

Table 3
Outcome adjusted comparison^a among different age groups.

	Decompression		p-value
	Age 80-89 N = 5192 (96.38%)	Age 90+ N = 195 (3.62%)	
Index hospitalization outcomes			
Length of stay, median (IQR)	Reference [§]	1.082 (0.986, 1.188)	0.0965
Payment, median (IQR)	Reference	0.988 (0.869, 1.123)	0.8519
Discharge home, n (%)	Reference	0.618 (0.457, 0.837)	0.0019
Complications, n (%)	Reference	1.105 (0.759, 1.61)	0.6029
Post discharge outcomes, 6 months			
Reoperation			
New decompression, n (%)	Reference	0.862 (0.315, 2.363)	0.7734
New fusion, n (%)	Reference	1.956 (0.46, 8.313)	0.3634
Refusion, n (%)	Reference	1.716 (0.225, 13.091)	0.6026
At least one of above, n (%)	Reference	0.819 (0.299, 2.242)	0.6975
ER admissions			
Admitted, n (%)	Reference	1.866 (0.437, 7.971)	0.4001
Hospital admissions			
Admitted, n (%)	Reference	1.436 (0.989, 2.085)	0.057
# Readmissions, median (IQR)	Reference	1.308 (0.955, 1.791)	0.0946
Payments, median (IQR)	Reference	0.773 (0.536, 1.115)	0.1681
Outpatient services			
# Services, median (IQR)	Reference	0.903 (0.884, 0.923)	< 0.0001
Payments, median (IQR)	Reference	1.017 (0.848, 1.22)	0.8528
Medication refills			
# Refills, median (IQR)	Reference	0.964 (0.945, 0.983)	0.0003
Payments, median (IQR)	Reference	0.964 (0.945, 0.983)	0.0003
Overall payments, median (IQR)	Reference	1.054 (0.902, 1.233)	0.5077
Combined (Index hospital + overall), median (IQR)	Reference	1.007 (0.905, 1.12)	0.9053
Post discharge outcomes, 12 months			
Reoperation			
New decompression, n (%)	Reference	0.686 (0.301, 1.565)	0.371
New fusion, n (%)	Reference	0.705 (0.171, 2.899)	0.6276
Refusion, n (%)	Reference	1.136 (0.152, 8.478)	0.9007
At least one of above, n (%)	Reference	0.657 (0.288, 1.498)	0.3182
ER admissions			
Admitted, n (%)	Reference	1.517 (0.337, 6.815)	0.587
Hospital admissions			
Admitted, n (%)	Reference	1 (0.725, 1.379)	0.9988
# Readmissions, median (IQR)	Reference	0.951 (0.746, 1.212)	0.6839
Payments, median (IQR)	Reference	0.797 (0.592, 1.072)	0.1332
Outpatient services			
# Services, median (IQR)	Reference	0.867 (0.853, 0.881)	< 0.0001
Payments, median (IQR)	Reference	0.91 (0.773, 1.071)	0.2538
Medication refills			
# Refills, median (IQR)	Reference	0.924 (0.911, 0.937)	< 0.0001
Payments, median (IQR)	Reference	0.768 (0.642, 0.92)	0.0042
Overall payments, median (IQR)	Reference	0.881 (0.762, 1.019)	0.0885
Combined (Index hospital + overall), median (IQR)	Reference	0.926 (0.834, 1.028)	0.1475

*Adjusted comparisons are obtained from linear contrasts obtained from multivariable regression models, which include covariates gender, insurance, elixhauser index, decompression with/without fusion, addition to age group.

[§]Age group 80–89 was used as reference for multivariable regression model across all outcomes.

age groups were discharged to home compared to 60.5% in 90+ age group. These findings can be attributed to the fact that nonagenarian patients who underwent surgery for LSS may represent highly selective group of patients who were otherwise medically fit to undergo a surgical procedure with good life expectancy. Also, discharge disposition of this patient population may be influenced by the preoperative social status. According to profile of older Americans (2017), about 28% of non-institutionalized older persons in US lived alone (35% older women and 20% older men) [23].

Advancing age and comorbidities have been consistently recognized as the factor responsible for non-favorable outcomes following surgery for lumbar spinal stenosis [2–4]. Murphy et al [2] reported that patients with > 80 years of age were likely to have extensive lumbar surgeries for LSS, which resulted in longer length of hospital stay, discharges other than home and complications, using National Surgical Quality Improvement Program database. Similarly, another study using Market scan database reported that age at diagnosis, female sex, Charlson's Comorbidity Index scores and non-private insurance were associated

with higher odds of complications in patients who underwent surgery (decompression only or decompression and fusion) for degenerative spinal stenosis at all levels. Similar results were also reiterated by another study of the same group focusing on octogenarians and nonagenarians [4]. This study showed that fusion had longer length of hospital stay, highest complication rate, most non-routine discharges and was expensive compared to decompression only. These findings were also reiterated in our study with similar outcomes in patients' with decompression and with/without fusion.

In contrast to above-mentioned studies, Wang et al [7] reported the safety profile of lumbar decompression procedure in 26 elderly patients (> 85 years, mean 87 years) with degenerative conditions. Average number of lumbar levels treated was 2.17 (range 1–4) and interestingly 73% of patients underwent fusion in this study. Minimally invasive surgery was used in 46% of patients. Complications were noted in 19.2% of patients, 3.8% permanent and 15.4% temporary. Length of surgical time (> 180 min) was significantly associated whereas patients' age, blood loss, comorbidity index, ASA physical status class, number of

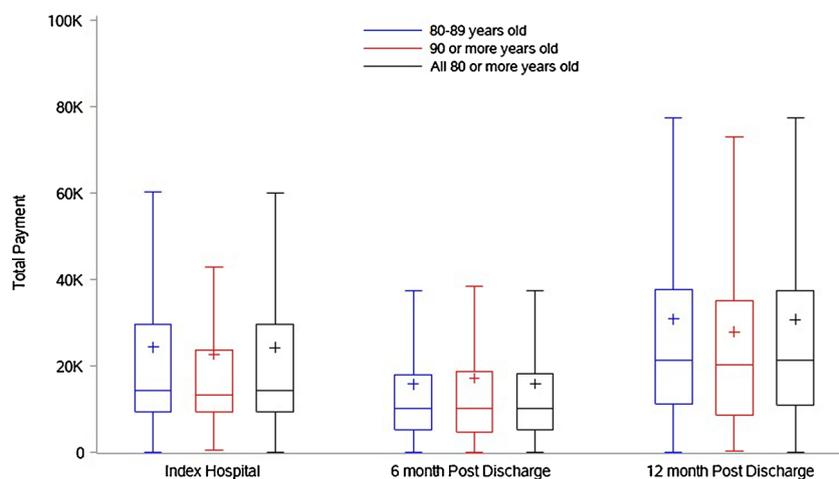


Fig. 2. Bar graph showing payments during index hospitalization, at 6 months and 12 months post-discharge in octogenarian, nonagenarians and total cohort following decompression for LSS.

levels treated and fusion surgery were not associated with complications in this retrospective study. In contrast, another study based on Medicare database reported that elderly patients (> 80 years of age) with lumbar spinal stenosis (with spondylolisthesis or scoliosis) and underwent surgical decompression (only decompression and decompression with fusion) were likely to have longer length of hospital stay (mean 3.6 days vs. 3.0 days) [24], 22.6% of these patients were discharged to nursing homes and 11.8% of these patients were re-hospitalized within 30 days of procedure. In our study, we found that overall length of hospital stay was 3 days (range 2–4) and 70.2% were discharged to home following surgery for LSS in the combined cohort, which is comparable to above-mentioned study. Similar study based on Medicare database evaluated elderly patients (> 65 years) who underwent decompression or fusion for LSS did not find the correlation of comorbidities with 30-day complication rates in this study [25]. Drazin et al [4] reported decompression, discectomy and fusion in octogenarian and nonagenarian patients with spinal stenosis at all spinal levels using Nationwide inpatient sample database (NIS). In this study, authors reported that patients who underwent fusion had longest LOS, highest complication rate and discharges to other facilities and patients who underwent only discectomy had favorable outcomes on all these parameters [4].

4.2. Health care utilization in octogenarians and nonagenarians

Surgical treatment for degenerative spondylolisthesis and spinal stenosis have been shown to be cost effective (per quality adjusted life year) compared to non-operative treatment [10]. In our study, at index hospitalization, there was no difference in payments across the cohorts

(80–89: median \$14,291; 90 +: median \$ 13,301). Similarly at 6 and 12 months follow-up, there were no differences in terms of reoperation rates across the cohorts. Interestingly, octogenarian patients incurred higher outpatient services, number of medication refills and related payments at 6-months and 12-months follow-up, compared to nonagenarian. Overall, combined median post-discharge payments at 6 months and 12 months were similar across the groups [6 months: 80–89 (median \$ 27,818) and 90 + (median\$ 26,550); 12 months: 80–89 (median \$ 40,257) and 90 + (median\$ 36,161)]. Our findings were similar to other study, which reported median total charges of \$18,102 following decompression for spinal stenosis at all levels using NIS database [4]. Similarly, another study using Medicare database reported median Medicare payment of \$6609 (IQR 4258,17684) following decompression for LSS in elderly patients (> 65 years).

4.3. Selection of octogenarian and nonagenarian patients for surgical intervention

Various series have shown that surgical decompression offers clinically significant improvement in patients with degenerative LSS using validated scale such as Zurich Claudication Questionnaire or Oswestry disability index (ODI) with acceptable complications rate [7,8,30,31]. Although results of our study showed that nonagenarian patients had no significant differences in clinical and health care utilization outcomes compared to octogenarians, using Market scan database, we acknowledge that these results may be due to inherent limitations of selection bias attributable to such national database and should be interpreted cautiously. In view of contrasting literature in terms of age being a negative prognostic factor, we advocate that

Table 4 Outcome adjusted comparison* among decompression with and without fusion groups.

Index hospitalization outcomes		Decompression		p-value
		No Fusion 4187 (80.64%)	With Fusion 1005 (19.36%)	
Length of stay	Median (IQR)	3 (1, 4)	4 (3, 5)	< 0.0001
	RR (95% CI)	Reference	1.398 (1.337, 1.462)	< 0.0001
Payment	Median (IQR)	12653 (8980, 19697)	34442 (26313, 48198)	< 0.0001
	RR (95% CI)	Reference	2.483 (2.336, 2.64)	< 0.0001
Discharge home	Median (IQR)	3193 (73.18%)	595 (58.11%)	< 0.0001
	OR (95% CI)	Reference	0.531 (0.459, 0.614)	< 0.0001
Complications	Median (IQR)	688 (15.77%)	215 (21%)	< 0.0001
	OR (95% CI)	Reference	1.362 (1.143, 1.622)	0.0005

*Adjusted comparisons are obtained from linear contrasts obtained from multivariable regression models, which include covariates gender, insurance, elixhauser index, age group, addition to group of decompression (no fusion vs with fusion).

physicians should consider medical co-morbidities and life expectancy, while selecting nonagenarian patients for any surgical intervention for LSS. Extensive discussion with the patient regarding realistic expectations, quality of life and possible complications is prudent for successful clinical outcome. Patients' with healthy and active life style are likely to receive the benefits of surgical decompression while avoiding the morbidity associated with continued spinal canal stenosis and need for opioid medications for pain relief [16,26]. In addition, surgical approaches can be tailored according to the patient's need; such as minimally invasive spine surgery (MISS) have been shown to be safe and feasible in elderly patients (65–89 years) with degenerative and traumatic thoraco-lumbar diseases [7,27,28]. Percutaneous endoscopic techniques using local anesthesia can also be considered in these patients [29].

5. Strengths and limitations

A major advantage of MarketScan database is that it provides longitudinal follow-up of patients with utilization of corresponding health care resources (outpatient visits, medication refills etc.) and payments made by the insurance companies. Therefore, this database provides a unique advantage of following patients with rare conditions over an extended period of time and understanding health care utilization during this period. Our study showed that nonagenarians with LSS could undergo surgical decompression with no differences in clinical and health care outcomes compared to octogenarians.

Lack of clinical information and imaging data related to individual patients are potential limitations of this database. Therefore, clinical decision-making, surgical approach and extent of surgical invasiveness used by the treating physician cannot be extrapolated using this database. Due to these limitations, potential for selection bias cannot be excluded and therefore results need to be interpreted and generalized with caution. Also, ICD and CPT billing codes were used to extract the data and therefore, potential for coding error cannot be completely excluded. Also, quality of life data and complications specific to the surgical procedure cannot be extracted using this database. Despite these limitations, MarketScan database provide an opportunity to evaluate and study trends of a rare clinical problem on a national basis.

6. Conclusion

Using MarketScan database, there has been a gradual decline in the number of decompressions being performed for LSS in elderly patients (> 80 years of age). Nonagenarians were less likely to be discharged to home compared to octogenarians, whereas octogenarians incurred higher outpatient and medication health care utilization at 6 and 12 months follow-up. There was no difference in rate of reoperations and overall health care utilization among the groups. Surgery for LSS can be offered to nonagenarians (in appropriately selected patients) with no difference in clinical outcomes and health care utilization, compared to octogenarians. Careful attention to preoperative comorbidities and discussion regarding realistic expectations is of paramount importance for successful postoperative outcomes in this patient cohort.

Disclosures

The authors have no conflicts of interest or financial disclosures.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.clineuro.2019.04.031>.

References

[1] G.K. Vincent, V.A. Velkoff, U.S.C. Bureau, *The Next Four Decades: The Older Population in*

- the United States: 2010 to 2050, (2010).
- [2] M.E. Murphy, H. Gilder, P.R. Maloney, B.A. McCutcheon, L. Rinaldo, D. Shepherd, P. Kerezoudis, D.S. Ubl, C.S. Crowson, W.E. Krauss, E.B. Habermann, M. Bydon, Lumbar decompression in the elderly: increased age as a risk factor for complications and non-home discharge, *Journal of neurosurgery*, Spine 26 (3) (2017) 353–362.
- [3] C. Lagman, B. Ugiliweneza, M. Boakye, D. Drazin, Spine surgery outcomes in elderly patients versus general adult patients in the United States: a MarketScan analysis, *World Neurosurg.* 103 (2017) 780–788.
- [4] D. Drazin, C. Lagman, S. Bhargava, M. Nuno, T.T. Kim, J.P. Johnson, National trends following decompression, discectomy, and fusion in octogenarians and nonagenarians, *Acta Neurochir.* 159 (3) (2017) 517–525.
- [5] F.L. Acosta Jr., J. McClendon Jr., B.A. O'Shaughnessy, H. Koller, C.J. Neal, O. Meier, C.P. Ames, T.R. Koski, S.L. Ondra, Morbidity and mortality after spinal deformity surgery in patients 75 years and older: complications and predictive factors, *Journal of neurosurgery*, Spine 15 (6) (2011) 667–674.
- [6] C.S. Raffo, W.C. Lauerman, Predicting morbidity and mortality of lumbar spine arthrodesis in patients in their ninth decade, *Spine* 31 (1) (2006) 99–103.
- [7] M.Y. Wang, G. Widi, A.D. Levi, The safety profile of lumbar spinal surgery in elderly patients 85 years and older, *Neurosurg. Focus* 39 (4) (2015) E3.
- [8] M.Y. Wang, B.A. Green, S. Shah, S. Vanni, A.D. Levi, Complications associated with lumbar stenosis surgery in patients older than 75 years of age, *Neurosurg. Focus* 14 (2) (2003) e7.
- [9] S.J. Atlas, R.B. Keller, Y.A. Wu, R.A. Deyo, D.E. Singer, Long-term outcomes of surgical and nonsurgical management of lumbar spinal stenosis: 8 to 10 year results from the maine lumbar spine study, *Spine* 30 (8) (2005) 936–943.
- [10] J.S. Harrop, A. Hilibrand, K.E. Mihalovich, J.R. Dettori, J. Chapman, Cost-effectiveness of surgical treatment for degenerative spondylolisthesis and spinal stenosis, *Spine* 39 (22 Suppl 1) (2014) S75–85.
- [11] M.B. Hamel, W.G. Henderson, S.F. Khuri, J. Daley, Surgical outcomes for patients aged 80 and older: morbidity and mortality from major noncardiac surgery, *J. Am. Geriatr. Soc.* 53 (3) (2005) 424–429.
- [12] Y. Imajo, T. Taguchi, M. Neo, K. Otani, T. Ogata, H. Ozawa, N. Miyakoshi, H. Murakami, T. Iguchi, Complications of spinal surgery for elderly patients with lumbar spinal stenosis in a super-aging country: an analysis of 8033 patients, *J. Orthop. Sci.* 22 (1) (2017) 10–15.
- [13] S.T. Kha, H. Ilyas, J.E. Tanenbaum, E.C. Benzel, M.P. Steinmetz, T.E. Mroz, Trends in lumbar fusion surgery among octogenarians: a nationwide inpatient sample study from 2004 to 2013, *Global Spine J.* 8 (6) (2018) 593–599.
- [14] H.G. Mihailidis, S. Manners, L. Churilov, G.M.Y. Quan, Is spinal surgery safe in octogenarians? *ANZ J. Surg.* 87 (7–8) (2017) 605–609.
- [15] M. Sharma, B. Ugiliweneza, P. Sirdeshpande, D. Wang, M. Boakye, Opioid Dependence and Health Care Utilization After Decompression and Fusion in Patients With Adult Degenerative Scoliosis, *Spine* 44 (4) (2019) 280–290.
- [16] M. Sharma, B. Ugiliweneza, Z. Aljuboori, M. Boakye, Health care utilization and overall costs based on opioid dependence in patients undergoing surgery for degenerative spondylolisthesis, *Neurosurg. Focus* 44 (5) (2018) E14.
- [17] L.G. Hansen, S. Chang, Health Research Data for the Real world: The Thomson Reuters MarketScan Databases, *The MarketScan Databases (White papers)*, (2012).
- [18] A. Elxhauser, C. Steiner, D.R. Harris, R.M. Coffey, Comorbidity measures for use with administrative data, *Med. Care* 36 (1) (1998) 8–27.
- [19] H. Quan, V. Sundararajan, P. Halfon, A. Fong, B. Burnand, J.C. Luthi, L.D. Saunders, C.A. Beck, T.E. Feasby, W.A. Ghali, Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data, *Med. Care* 43 (11) (2005) 1130–1139.
- [20] A.A. Parikh Alexander, The effect of health insurance status on the treatment and outcomes of patients with colorectal cancer, *J. Surg. Oncol.* 110 (3) (2019) 227–232.
- [21] R.C. Littell, W.W. Stroup, R.J. Freund, SAS for Linear Models, fourth ed., SAS Institute Inc., Cary, NC, 2002.
- [22] M. Stokes, C. Davis, G. Koch, *Categorical Data Analysis Using the SAS System*, second ed., SAS Institute Inc., Cary, NC, 2000.
- [23] *Administration on Aging, A Profile of Older Americans: 2017*, Available at: (2018) <https://acl.gov/sites/default/files/AgingandDisabilityinAmerica/2017OlderAmericansProfile.pdf>.
- [24] R.A. Deyo, S.K. Mirza, B.I. Martin, W. Kreuter, D.C. Goodman, J.G. Jarvik, Trends, major medical complications, and charges associated with surgery for lumbar spinal stenosis in older adults, *Jama* 303 (13) (2010) 1259–1265.
- [25] D. Drazin, F. Shweikeh, C. Lagman, B. Ugiliweneza, M. Boakye, Racial disparities in elderly patients receiving lumbar spinal stenosis surgery, *Global Spine J.* 7 (2) (2017) 162–169.
- [26] M. Sharma, B. Ugiliweneza, Z. Aljuboori, M.A. Nuno, D. Drazin, M. Boakye, Factors predicting opioid dependence in patients undergoing surgery for degenerative spondylolisthesis: analysis from the MarketScan databases, *J. Neurosurg. Spine* 29 (3) (2018) 271–278.
- [27] G.M.V. Barbagallo, G. Raudino, M. Visocchi, A.A. Alobaid, A.A. Al-Mutair, T. Naveen, F. Certo, Restoration of thoracolumbar spine stability and alignment in elderly patients using minimally invasive spine surgery (MISS). A safe and feasible option in degenerative and traumatic spine diseases, *Acta Neurochir. Suppl.* 124 (2017) 69–74.
- [28] M. Khashan, Z. Lidar, K. Salame, L. Mangel, R. Lador, M. Drexler, E. Sapirstein, G.J. Regev, Minimally invasive spinal decompression in patients older than 75 years of age: perioperative risks, complications, and clinical outcomes compared with patients younger than 45 years of age, *World Neurosurg.* 89 (2016) 337–342.
- [29] K. Sairyo, T. Chikawa, A. Nagamachi, State-of-the-art transforaminal percutaneous endoscopic lumbar surgery under local anesthesia: discectomy, foraminoplasty, and ventral facetectomy, *J. Orthopaed. Sci.* 23 (2) (2018) 229–236.
- [30] S.K. Fokter, S.A. Yerby, Patient-based outcomes for the operative treatment of degenerative lumbar spinal stenosis, *Eur. Spine J.* 15 (11) (2006) 1661–1669.
- [31] R.J. Mobbs, J. Li, P. Sivabalan, D. Raley, P.J. Rao, Outcomes after decompressive laminectomy for lumbar spinal stenosis: comparison between minimally invasive unilateral laminectomy for bilateral decompression and open laminectomy: clinical article, *Journal of neurosurgery*, Spine 21 (2) (2014) 179–186.