Lumbar Spine Surgeries and Medication Usage During Hospital Stay: One-Center Perspective

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Abstract

Background: Pain after spine surgery is usually managed with opioid and nonopioids. The rate of lumbar spine surgeries (LSS) is rising, but current practices on LSS are not known. A current trend in LSS and medication usage by age group is needed to gain a better understanding of how LSS and its pain management vary by age. **Objective:** The aim of this study was to report current practices of LSS of discectomy, laminectomy, and fusion in patients aged 18 and older and to gain an understanding of medication use for management of LSS. **Methods:** This retrospective study analyzed data of the University of Kansas Medical Center from 2007 to 2014 of patients (>18 years of age) undergoing laminectomy, discectomy, and fusion. **Results:** A total of 19 463 patients underwent LSS between 2007 and 2014 at Kansas University hospital. For the purpose of this study, 3115 patients' medical records were observed. A 50% increase in LSS between 2007 and 2014 was noted. Specifically, more than 2-fold increase in LSS was observed in patients aged 65 years and older. Among those aged 65 years and older, laminectomy was the most commonly performed surgery (69.6%) while discectomy was the most common surgery performed among those aged 18 to 34 (82.9%) and those aged 35 to 44 (72%). The medication use also increased with a highest usage in opioids alone (55%), followed by opioids combined with other analgesics (42.7%), regardless of lumbar surgery type or age. **Conclusion:** The information of increase in both LSS and the medication usage over the 7 years can be used to gain a better understanding of quality, expenditure, and outcomes following LSS. This knowledge may help health care providers plan patient care and rehabilitation services for older adults, as the trajectory of lumbar spine surgery is likely to rise with growing prevalence of older adults. The information regarding increased opioid utilization may also help clinicians to refine opioid usage and consider alternative approaches to manage acute postoperative pain, in light of the current concerns related to overutilization of opioids.

Keywords

lumbar spine surgery, laminectomy, discectomy, fusion, prevalence, opioids, male gender, analgesia, age category, older population

Introduction

Low back pain (LBP) is a common condition with estimated lifetime prevalence of 60% to 80%¹ and the leading cause of absenteeism from work and functional limitations throughout the world. LBP is among the top 10 diseases that account for the highest number of disability-adjusted life years (DALY) worldwide.² In the United States, about 149 million work days are lost annually³ and about \$100 to 200 billion US dollars are spent every year due to LBP.^{4,5} Although the causes of LBP may vary with age and demography, the commonest causes are the degenerative changes in the lumbar spine and discogenic pain. These issues often warrant lumbar spine surgery (LSS), especially in older adults.

The older population in the United States is rapidly increasing, with their composition in terms of gender and race undergoing a major change. Released in August 2008,

the national population projection report states that by 2030, there would be 88.5 million older adults (65 years and older) in the United States.⁶ This projected increase in the number of older adults is expected to increase the health care expenditures as well.⁷ It has been reported that annually, more than 17 million people who are 65 years and above experience at least 1 episode of LBP.² Due to the presence of age-related degenerative changes affecting spine and joints in

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older adults, there has been increasing incidence of surgical approaches for these conditions among this population.⁸ Although the United States has similar incidence and prevalence rates of spine disorders as in other countries, it has the highest rates of spine surgery in the world.⁹ LSS such as laminectomy (excision of lamina) or fusion (arthrodesis) is a common treatment option for LBP,¹⁰ especially among older adults for whom conservative treatments have failed.⁷

Despite the fear of adverse effects associated with opioids, the postoperative pain following lumbar surgeries is primarily managed by opioids.⁸⁻¹⁰ Alternatively, a multimodal analgesia approach,^{11,12} which is a combination of opioid and nonopioid analgesia, is also being widely used. However, multimodal approach may not be available or feasible for all patients. Nevertheless, the prevalence of opioid and nonopioid medications use to manage postoperative spine surgery is not well known. Pain medication studies have mainly focused on younger populations,¹³⁻¹⁶ which limit generalizability of study findings to patients of all ages following spine surgeries.

The authors made a recent endeavor to review the literature for the current prevalence of LSS among older adults. However, searches using the accepted key terms brought up published information only until 2007. Health, United States (2010), which is the 34th report on the health status of the Nation, compiled by the Centers for Disease Control and Prevention's (CDC) National Center for Health Statistics (NCHS) reported that among persons 65 years of age and older, excision of intervertebral disc and spinal fusion procedure rates increased 67%, from 17 to 28 per 10 000 population, between 1996-1997 and 2006-2007.¹⁷ Most of the other studies were also based on patient databases that provided information until 2007. Likewise, the prevalence of opioids, nonopioids, and multimodal analgesia approach following spine surgery is also not well known.

We therefore studied patients undergoing LSS (discectomy, laminectomy, and fusion) from the Kansas University (KU) hospital's database to (1) determine the proportion of LSS across various age groups and (2) report use of opioids and other medications for the management of acute post-LSS pain during hospital stay.

Methods

Study Design and Cohort

This is a retrospective cross-sectional study where we reviewed the records of a subset of total patients (19 463) who underwent LSS at the KU hospital between 2007 and 2014. We identified our cohort of interest from the Healthcare Enterprise Repository for Ontological Narration (HERON) system using the i2b2 query and analysis tool¹⁸ with specific current procedural terminology (CPT) codes. CPT codes used to identify surgery types were 22612, 22630, 22632, 22840, 22841, 22842, 63005, 63011, 63012, 63017, 63020, 63030, 63035, 63042, 63043, 63044, 63045, 63046, 63047, 63048, 63048,

63056, 63057, 63185, 63190, 63200, 63267, 63268, 63272, and 63273. HERON contains de-identified clinical assessment and treatment data from KU hospital and is updated monthly. It is linked to the KU hospital and clinics' electronic medical records (Epic Corporation) and other administrative, research, and public data sources such as the clinics' billing system (GE IDX), and the University HealthSystem Consortium (UHC) to incorporate hospital billing and visit details (<https://www.uhc.edu>). The i2b2 query and analysis tool was used to select patients who had LSS consisting of discectomy, laminotomy, laminectomy, or fusion (arthrodesis).

Medical records for patients aged 18 years or older who had data on postoperative analgesics were included. Medical records were excluded for patients with a history of neoplasm, intraspinal abscess, spinal deformity (ie, scoliosis and kyphoscoliosis), spine fractures, vertebroplasty, osteomyelitis, and cauda equina syndrome. We used the surgery medical encounter to search all variables of interest occurring on the same encounter (from one hospital admission). Based on these criteria, we identified 3115 patients from 2007 to 2014.

Outcomes Measure and Analytical Variable Creation

The variables of interest included the demographic (ie, age, gender, race, and ethnicity) and clinical characteristics of the patients. Clinical characteristics included type of LSS performed (ie, laminectomy, fusion, discectomy, or a combination of any of these surgeries), type of analgesic used (ie, opioids alone, opioids combined with other medications, and nonopioids) during hospital stay, and patients' discharge disposition (eg, discharged home or discharged for further care). We created several analytical variables to analyze study objectives. Medication categories were created based on the following categories: (1) Drugs in the "opioid alone" category include any dosage form (ie, generic, brand, or salt form) of buprenorphine, butorphanol, codeine, fentanyl, hydromorphone, hydrocodone, meperidine, methadone, morphine, oxycodone, oxymorphone, remifentanyl, and tapentadol; (2) drugs in the "opioid combination" category include any of the drugs in the "opioid alone" that are in combination with any of acetaminophen, aspirin, ibuprofen, and caffeine; and (3) drugs in the "nonopioids" category include acetaminophen, aspirin, ibuprofen, and tramadol, alone or in combination with other agents such as caffeine and butalbital. Medications in HERON are mapped to the RxNorm terminology and organized by NDF-RT drug classes¹⁹ in a manner similar to the work by Palchuk et al.²⁰

Statistical Analyses

Statistical analyses included descriptive statistics including frequencies, percentages, and means on the demographic and clinical characteristics. We also conducted several bivariate chi-square cross-tabulations. These included cross-tabulations of (1) the type of surgery performed and age categories (18-34, 35-44, 45-54, 55-64, and 65 years and over) and (2)

the type of postoperative analgesic used and age categories. All data manipulations and analyses were performed using IBM SPSS Statistics Version 23 (SPSS Inc, Chicago, Illinois), while graphs were constructed using Microsoft Excel 2013 (Microsoft Corporation, Redmond, Washington). Statistical significance was evaluated at $P < .05$.

Results

Sample Characteristics

A total of 19 463 patients underwent LSS between 2007 and 2014 at KU hospital. For the purpose of this study, we were able to observe 3115 patients' medical records from 2007 to 2014. Characteristics of patient population studied are presented in Table 1. We found that greater percentage of LSS was performed on male patients (56.1%) compared with female patients (43.9%). Our sample primarily constituted of Whites (84.9%) and patients of non-Hispanic origin (96.9%). Multiple surgeries (eg, fusion and laminectomy, fusion and discectomy, laminectomy and discectomy) were performed at a greater rate (34.8%) compared with single surgeries. Fusion alone (10%) was the least performed monoprocedure. Among patients who underwent LSS, a majority (53.4%) utilized opioid alone while 41.5% used opioid in combination with other drugs. Post LSS, 88% of the patients were discharged to home and 2.9% needed further care.

LSS Pattern and Types

Overall, we observed a rise in the number of LSS over a period of 7 years (Figure 1). Figure 1 shows a positive trend of all LSS performed over time from 2007 to 2014. When data from 2007 and 2014 were compared across age categories (Figure 2), the proportion of LSSs performed slightly increased among patients aged 65 years and above (27.3% vs 34.2%). The trend of LSSs slightly decreased among patients aged 45 to 54 years (24.9% vs 18.3%). Table 2 shows the proportion of each surgery type performed across various age categories. The chi-square analysis results indicate that the type of surgery performed was not independent of patients' age ($\chi^2 = 555.2$, $df = 8$, $P < .001$). For example, patients aged 55 years and above received laminectomy more frequently compared with other surgery types, whereas patients aged below 55 years received discectomy more frequently compared with other surgery types. While examining the proportion of individual surgery within each age category, we noticed an increase in fusion procedure rate over time but mainly in older population.

Analgesic Usage

The chi-square analysis in Table 3 shows that the type of medication prescribed post surgery was not independent of patients' age ($\chi^2 = 58.6$, $df = 8$, $P < .001$). For example, opioids alone were used by 55% of patients aged 55 years and

Table 1. Demographics and Clinical Characteristics.

Characteristics	n (%)
Gender (N = 3115)	
Male	1749 (56.1)
Female	1366 (43.9)
Race (N = 3110) ^a	
White	2639 (84.9)
Black	253 (8.1)
Asian	14 (0.5)
American Indian	7 (0.2)
Other ^b	197 (6.3)
Ethnicity (N = 3014) ^a	
Non-Hispanic	2922 (96.9)
Hispanic	92 (3.1)
Discharge status (N = 3115)	
Home	2740 (88.0)
Further care ^c	89 (2.9)
Others ^d	286 (9.2)
Surgery type (N = 3115)	
Fusion	312 (10.0)
Laminectomy	857 (27.5)
Discectomy	862 (27.7)
Multiple surgeries ^e	1084 (34.8)
Medications (N = 3115)	
Opioid alone	1663 (53.4)
Opioid combination ^f	1292 (41.5)
Nonopioids ^g	71 (2.3)
Multiple medications ^h	89 (2.9)

^aN is less than 3115 due to missing values.

^bInclude 2 races and "other" race classification.

^cOther referral facilities (acute or chronic) other than home or self-care.

^dOther destination different from home and further care.

^eThese include patients who had more than 1 type of surgery performed.

Of the 1084 patients: fusion + laminectomy (n = 724, 66.8%), fusion + discectomy (n = 155, 14.3%), laminectomy + discectomy (n = 105, 9.7%), and fusion + laminectomy + discectomy (n = 100, 9.2%).

^fInclude opioid drugs that are in a combined dosage form with drugs such as acetaminophen, aspirin, ibuprofen, and caffeine.

^gInclude acetaminophen, aspirin, ibuprofen, and tramadol, alone or in combination with other agents such as caffeine and butalbital.

^hThese include patients who used more than 1 category of medication (eg, opioid alone + nonopioids).

Figure 1. Trend of lumbar spine surgery from 2007 to 2014.

Figure 2. Trend of lumbar spine surgery by age categories.

Table 2. Surgery Type by Age Categories.

Age, y	Fusion, n (%)	Laminectomy, n (%)	Discectomy, n (%)	Total, n (%)
18-34	21 (8.5)	21 (8.5)	204 (82.9)	246 (100.0)
35-44	41 (12.9)	48 (15.1)	229 (72.0)	318 (100.0)
45-54	94 (23.9)	121 (30.7)	179 (45.4)	394 (100.0)
55-64	66 (14.8)	230 (51.7)	149 (33.5)	445 (100.0)
65 and older	90 (14.3)	437 (69.6)	101 (16.1)	628 (100.0)
Total	312 (15.4)	857 (42.2)	862 (42.4)	2031 (100.0) ^a

$\chi^2 = 555.2$, $df = 8$, $P < .001$.

^aTotal N is less than 3115 because chi-square analysis did not include those categorized as having multiple surgeries ($n = 1084$).

Table 3. Proportion of Medication Use by Age Categories.

Age, y	Opioid alone, ^a n (%)	Opioid combination, ^b n (%)	Nonopioids, ^c n (%)	Total, n (%)
18-34	166 (10.0)	127 (9.8)	0 (0.0)	293 (9.7)
35-44	228 (13.7)	169 (13.1)	0 (0.0)	397 (13.1)
45-54	354 (21.3)	231 (17.9)	7 (9.9)	592 (19.6)
55-64	437 (26.3)	290 (22.4)	23 (32.4)	750 (24.8)
65 and older	478 (28.7)	475 (36.8)	41 (57.7)	994 (32.8)
Total	1663 (100.0)	1292 (100.0)	71 (100.0)	3026 (100.0) ^c

$\chi^2 = 58.6$, $df = 8$, $P < .001$

^aInclude patients who used any dosage form (ie, generic, brand, or salt form) of buprenorphine, butorphanol, codeine, fentanyl, hydromorphone, hydrocodone, meperidine, methadone, morphine, oxycodone, oxymorphone, remifentanyl, and tapentadol.

^bInclude patients who used opioids that are in a combined dosage form with drugs such as acetaminophen, aspirin, ibuprofen, and caffeine.

^cInclude acetaminophen, aspirin, ibuprofen, and tramadol, alone or in combination with other agents such as caffeine and butalbital.

^dTotal N was less than 3115 because chi-square analysis did not include those categorized as using multiple medications ($N = 89$).

above compared with 45% of patients aged below 55 years. Similar trends were observed among users of opioid combination therapy (59.2% for patients aged 55 years and above vs 40.8% for patients aged below 55 years). Nonopioid medications were used mainly for patients 55 years of age and above (90.1% vs 9.9%).

When data for 2007 versus 2014 were compared (Figure 3), the proportion of LSS patients who used opioid alone increased for those aged 65 years and above (24.3% vs 30.1%), 55 to 64 years (26.1% vs 32.2%), and 35 to 44 years (7.8% vs 13.3%), whereas it decreased for those aged 45 to 54 years (29.6% vs 20.3%) and 18 to 34 years (12.2% vs 4.2%).

Figure 3. Proportion of lumbar spine surgery patients who are using opioids alone overtime within each age categories.

Discussion

The objectives of this retrospective study were to gain an understanding of LSS trend across various age groups and to explore the use of opioids and other medications for management of acute post-lumbar surgical pain during hospital stay. We observed a positive upward trend in LSS performed at our local hospital, particularly in 65 years and older age group. There was a slight decrease in LSS in middle aged patients (45-54 years) over the 7 years from 2007 to 2014. In this population, multiple procedures were more commonly performed than individual surgeries such as discectomy, laminectomy, or fusion. However, among individual surgeries, laminectomy was the most frequent procedure performed in older adults (>65 years) and discectomy was most frequent procedure performed in younger patients. The usage of opioids alone in postoperative pain management is ubiquitous across all lumbar surgery types and all age categories. Overall, medication use (opioid or in combination) increased with age. Reasons for the increase in LSS rate and medication use in older population are unclear but may be due to increasing prevalence of chronic LBP,²¹ aging population,⁶ and seeking health care services²²⁻²⁴ or a combination of any of these contributing factors.

LSS Trend

We observed an upward trend in the LSS between 2007 and 2014, which echoes findings from other studies that reported a similar increase in LSS prevalence till 2007.^{21,25,26} Previous studies conducted prior to 2007 showed significant increases in prevalence of LSS. Using state data and patient survey, Freburger et al. reported a 157% increase in lumbar surgical procedures per person in North Carolina population between 1997 and 2005.²¹ Deyo et al. reported a 15-fold increase in

spinal fusion surgeries from 2002 to 2007.²² We report near 50% increase in LSS from 2007 to 2014 in this one-center study. The prevalence of LSS in the United States is at least 40% higher than in any other country in the world, and 5 times higher than in England and Scotland.^{25,26}

While examining surgery types, we found that multiple procedures (34.8%) were performed most frequently in this cross-sectional study population. Laminectomy and discectomy procedures were performed in equal percentage (about 30%), and the fusion procedures (alone) constituted only 10% of all the LSS performed. The rise in LSS procedures was about 2 times in patients aged 65 years and older over this time period. About 31% of patients (628 of 2031) who underwent LSS were aged 65 years and older. Patients aged 65 years and older constituted the majority among those who had spinal laminectomy (51%; 437 of 857). We observed the rate of laminectomy procedure increased with patients' age, whereas the rate of discectomy procedure decreased with patients' age, but this should be confirmed in future with large-scale studies.

Findings from this study is in accordance with other studies that have reported a rise in LSS among the older population. The US NCHS reported a 67% increase in LSS till 2007 for patients aged 65 years and older.¹⁷ No additional studies have examined the prevalence of LSS specifically in patients aged 65 and older. Majority of these patients and patients between ages of 55 and 64 underwent laminectomy. Meanwhile, patients in younger age categories had greater prevalence of discectomy procedures.

Medication Usage

Following any surgery, approximately 75% of patients experience moderate to severe postoperative pain,^{11,27-29} emphasizing that effective pain management is an important aspect

of postoperative care. At present, there is no clear consensus regarding pharmacological management of postoperative pain during hospital stay. Postoperative pain management largely depends on patient's factors (ie, history of medication use, comorbidities, etc), surgery type, and physician's practice pattern. Although multimodal analgesic approach is gaining momentum,³⁰ opioids are still considered gold standard to manage postoperative pain.^{12,31,32} Our results are in agreement with these observations and suggest that patients following LSS are mostly treated with opioids alone (53.4%; 1663 of 3115), followed by opioid in conjunction with other medications (41.5%; 1292 of 3115), regardless of lumbar surgery type or age categories. We also observed that medication usage increased as patient ages.

Specifically for older population, evidence is lacking to recommend appropriate opioid use or when its risks outweigh its benefits for postoperative management. However, in this study, 8% differences identified (Table 3: 28.7% vs. 36.8%) in use of opioid alone compared with opioid combined with other pain medications may illustrate a lack of comfort or increased concern in using opioids in older populations. Further robust study is needed to determine medication impact on surgical outcomes in larger diversified population. Current study results can be used to gain a better understanding of LSS patterns and analgesic medication usage across various age groups and the gap in knowledge currently filled by this study can help in the design of future studies.

The study highlights an increased trend in laminectomy among older adults and use of opioid medications. This knowledge can help health care providers better plan patient care and rehabilitation services for older adults, as the trajectory of LSS is likely to rise with growing prevalence of older adults. The information regarding increased opioid utilization may also help clinicians refine opioid usage and consider alternative approaches to manage acute postoperative pain, in light of the current concerns related to overutilization of opioids.

Limitations

The results from this study represent only one hospital's surgical outcomes, and thus, findings cannot be generalized; however, the KU hospital is located in a large metropolitan city and patients from nearby regions seek expertise of spine surgeons. Thus, our results may be representative of surgical practice within the Midwest region. Changes in insurance coverage may also influence the choice of LSS performed. Second, the patient population reported is mostly white (84.9%) and non-Hispanic (96.9%). This result may not represent population of other ethnicity or race. However, patient demographics are generally not by choice as spine surgeries are considered elective procedures and largely dependent on surgeons' and patients' choice as well as geographical location. Finally, other important data such as pain variables,

patients' employment, as well as insurance coverage would have provided a more comprehensive report of the population type seeking LSS procedures. However, the strength of our study was that we included a general trend in use of medication for postoperative pain management using observational data. We could not follow these patients to collect post-hospital outcomes, and we could not view whether these patients went home with these medications. A critical area for future research should address how to reverse the current trend of opioid crisis, including opioid overdose and opioid use disorder, which has engulfed our nation.^{33,34} Our results, although limited to one institute, address the gap in current knowledge and provide timely information about pattern of LSS in various age groups.

Conclusion

In summary, we observed an increase in LSS procedures between 2007 and 2014, nearly a 2-fold increase in LSS in older adults. In addition, this study reports a rise in LSS with age. Specifically, laminectomy procedures are more common in older population, whereas discectomy procedure is more common in the younger population. Use of opioids alone followed by opioids in combination with other analgesics is more prevalent in all age groups. Larger study samples representing national data are needed to further understand the rising trend in LSSs and associated pain characters, and medication usage.

Authors' Note

Dr. Olotu was a postdoctoral fellow under the supervision of Dr. Rasu at the time of the study at University of Kansas. Mrs. Mathew was a Modale Fellow of University of Kansas Medical Center at the time of the study under the supervision of Dr. Sharma.

Declaration of Conflicting Interests

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