Research Paper

PAIN®

Use of prescription opioids before and after an operation for chronic pain (lumbar fusion surgery)

Richard A. Deyo[a,b,*], Sara E. Hallvik[c], Christi Hildebran[c], Miguel Marino[a,d], Nicole O'Kane[c], Jody Carson[c], Joshua Van Otterloo[e], Dagan A. Wright[e], Lisa M. Millet[e], Wayne Wakeland[f]

Abstract

Lumbar fusion surgery is usually prompted by chronic back pain, and many patients receive long-term preoperative opioid analgesics. Many expect surgery to eliminate the need for opioids. We sought to determine what fraction of long-term preoperative opioid users discontinue or reduce dosage postoperatively; what fraction of patients with little preoperative use initiate long-term use; and what predicts long-term postoperative use. This retrospective cohort study included 2491 adults undergoing lumbar fusion surgery for degenerative conditions, using Oregon's prescription drug monitoring program to quantify opioid use before and after hospitalization. We defined long-term postoperative use as ≥4 prescriptions filled in the 7 months after hospitalization, with at least 3 occurring >30 days after hospitalization. Overall, 1045 patients received long-term opioids preoperatively, and 1094 postoperatively. Among long-term preoperative users, 77.1% continued long-term postoperative use, and 13.8% had episodic use. Only 9.1% discontinued or had short-term postoperative use. Among preoperative users, 34.4% received a lower dose postoperatively, but 44.8% received a higher long-term dose. Among patients with no preoperative opioids, 12.8% became long-term users. In multivariable models, the strongest predictor of long-term postoperative use was cumulative preoperative opioid dose (odds ratio of 15.47 [95% confidence interval 8.53-28.06] in the highest quartile). Cumulative dose and number of opioid prescribers in the 30-day postoperative period were also associated with long-term use. Thus, lumbar fusion surgery infrequently eliminated long-term opioid use. Opioid-naive patients had a substantial risk of initiating long-term use. Patients should have realistic expectations regarding opioid use after lumbar fusion surgery.

Keywords: Opioids, Spine surgery, Spinal fusion, Chronic pain

1. Introduction

Increased use of prescription opioids over the past 2 decades has been associated with major increases in opioid-related overdoses and addiction treatment.[28,30] One response has been closer examination of factors leading to opioid initiation, including analgesic prescriptions after surgical procedures.[1,7,31]

Many studies of postoperative opioid prescribing have included surgical procedures not primarily performed for chronic pain symptoms, such as cataract surgery, transurethral prostate resection, cesarean section, or thyroidectomy.[1,7,31] Surgical procedures for patients with chronic painful conditions, such as many orthopedic procedures, pose additional challenges because many patients receive long-term opioids before surgery.

Spine surgery, in particular, may be associated with a high risk of preoperative and persistent postoperative opioid use.[7,23] Lumbar fusion surgery for degenerative spinal disorders is usually undertaken to treat chronic back pain, and is more invasive than decompression surgery alone. Nationally, the number of spinal fusion operations has tripled in the past 2 decades.[17]

Patients considering fusion surgery often expect to discontinue opioids after surgery. For example, among patients scheduled to undergo lumbar fusion surgery for degenerative disc disease, over 90% "considered continued narcotic requirements to be neither an expected nor acceptable outcome."[8] However, recent studies find that 30% to 60% of patients receive long-term opioids after spine surgery.[4,12,24] Preoperative opioid use is consistently a major predictor of long-term postoperative use.[2,4,12]

However, data on long-term opioid use after spine or other orthopedic surgery are often limited by reliance on patient self-report,[4] continual insurance enrollment,[12,24] or relatively small patient samples.[4,26] For spinal fusion surgery, few data address how preoperative dosage may influence the likelihood of long-term postoperative opioid use or the ability to reduce dosage, what fraction of those with no preoperative opioid use initiate long-term use postoperatively, or how perioperative opioid management influences the likelihood of long-term postoperative use.

We used a state hospital discharge registry linked with statewide prescription drug monitoring program (PDMP) data to identify lumbar fusion operations and opioid prescription fills, regardless of insurance coverage or source of prescriptions. We

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

[a] Department of Family Medicine, Oregon Health and Science University, Portland, OR, USA, [b] Department of Medicine, The Oregon Institute for Occupational Health Sciences, Oregon Health and Science University, Portland, OR, USA, [c] HealthInsight Oregon, Portland, OR, USA, [d] Biostatistics Group, OHSU-PSU School of Public Health, Oregon Health and Science University, Portland, OR, USA, [e] Injury and Violence Prevention Program for the State of Oregon, Oregon Health Authority, Portland, OR, USA, [f] Systems Science Program, Portland State University, Portland, OR, USA

*Corresponding author. Address: Department of Family Medicine, Oregon Health and Science University, 3181 SW. Sam Jackson Park Rd, Mail code FM, Portland, OR 97239, USA. Tel.: 503-494-1694; fax: 503-494-2746. E-mail address: deyor@ohsu.edu (R.A. Deyo).

PAIN 0 (2018) 1–8

http://dx.doi.org/10.1097/j.pain.0000000000001202

addressed the following questions: (1) What fraction of patients undergoing lumbar fusion surgery have short-term or long-term opioid use before and after surgery? (2) Among patients with long-term preoperative opioid use, what fraction discontinues, reduces dosage, maintains the same dosage, or increases dosage postoperatively? (3) Among patients with only short-term or no opioid use before surgery, what fraction initiates long-term use postoperatively? (4) What patient demographics, clinical characteristics, procedural factors, and opioid-prescribing patterns predict long-term postoperative opioid use?

2. Methods

Study activities were approved by Institutional Review Boards at Oregon Health & Science University and the Public Health Division of the Oregon Health Authority, where the PDMP is housed.

2.1. Data preparation

Data were obtained from the Oregon PDMP and linked to the statewide hospital discharge registry. Preparation of the research database has been described in detail elsewhere.[15,27] Oregon's PDMP is maintained by a commercial vendor, who uses a largely deterministic, proprietary algorithm for linking filled prescriptions for individual patients. This procedure may not always uniquely identify patients in the face of misspellings, nicknames, transposed characters, name changes, or changes in residence. An analyst at the Public Health Division therefore used probabilistic linking software (the Link King v7.1.21) to match individuals within the PDMP and between the PDMP and the hospital registry, using name, birthdate, and ZIP Code. Because of the sensitivity of opioid use, the analyst then removed all identifiers for patients, prescribers, and pharmacies.

2.2. Inclusion and exclusion of procedures

We used diagnosis-related group (DRG) codes 453, 454, 456, 459, and 460 to identify adults undergoing lumbar fusion procedures with admission dates between October 2012 and September 2013. If a patient had more than 1 eligible procedure, we counted only the first, so each patient is represented only once. These codes exclude procedures performed primarily for scoliosis, malignancy, infection, or those involving 9 or more vertebrae. Procedures in DRGs 453, 454, and 455 were labeled as "complex fusions" because they include combined anterior and posterior fusion procedures. Cases in DRGs 453, 454, and 459 are defined as having complicating conditions. We then linked operations with *International Classification of Diseases version 9, Clinical Modification* (*ICD-9-CM*) codes indicating lumbar spine diagnoses of herniated disk, probable degenerative changes, spinal stenosis, possible instability, nonspecific backache, or sequelae of previous back surgery. Only these diagnoses were included. *ICD-9-CM* codes were grouped into these diagnostic categories using a previously described approach.[10] These conditions are largely related to degenerative spinal changes. Because multiple diagnoses for a single patient were common, we tabulated patients according to the likely primary reason for performing a fusion procedure. For this purpose, we adapted a previously developed hierarchy,[22] classifying patients by the highest-numbered diagnosis in this list: (1) nonspecific diagnoses, (2) degenerative spinal changes, (3) herniated disk, (4) sequelae of previous surgery, (5) lumbar stenosis, and (6) possible instability (mostly spondylolisthesis).

We excluded patients younger than 18 years and those with diagnoses of fractures, inflammatory spondylopathies, cancer, or spinal infection (**Fig. 1**).

2.3. Filled prescriptions

Using PDMP data, we identified outpatient opioid prescriptions filled during the 7 months before index hospitalization and 7 months after it. We used Food and Drug Administration (FDA) National Drug Codes to identify opioid prescriptions. Tramadol was not included in the PDMP during study years, and we excluded combination of buprenorphine–naloxone preparations. We used conversion reference tables from the Centers for Disease Control (CDC) to calculate morphine milligram equivalents (MMEs) for each prescription. We also identified benzodiazepine use in the 7 months before and after hospitalization.

We defined a "perioperative period" as the 30 days before and 30 days after index hospitalization. We separately examined the 180 days before and 180 days after the perioperative period. We defined short-term preoperative opioid use as any opioid prescription filled within 30 days before the index hospitalization, but with none in the previous 180 days. Short-term postoperative use was any outpatient prescription for opioids filled in the 30 days immediately after index hospitalization, but with none in the 180 days after that. Thus, short-term use meant opioids filled only in the perioperative period.

Long-term preoperative opioid use was defined as at least 4 opioid fills in the 7 months before index hospitalization, with at

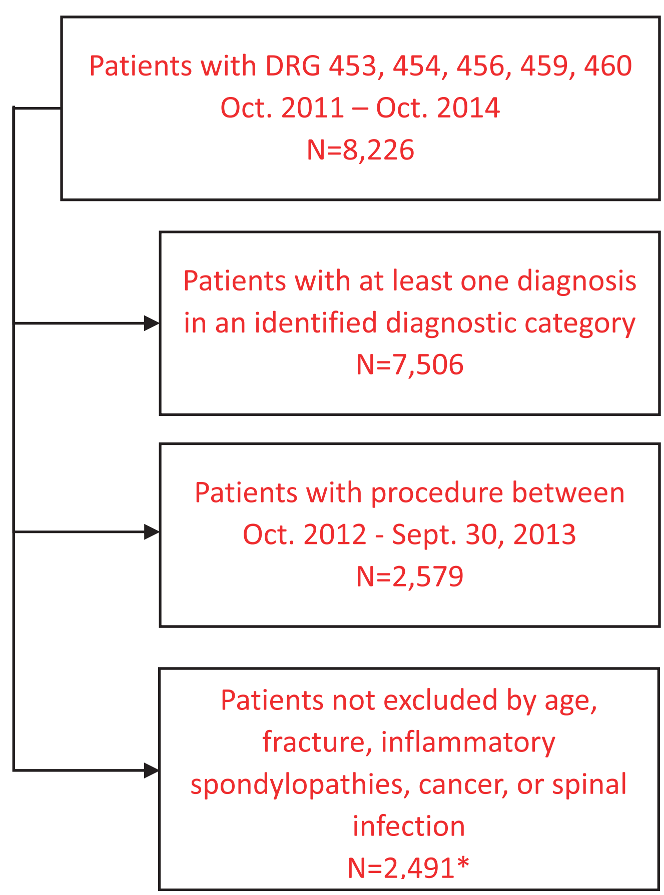

Figure 1. Selection of study patients. *Forty-one patients had more than 1 procedure within the time frame; only the index procedure was retained for this study. DRG, diagnosis-related group.

least 3 fills in the 180 days before the perioperative period. Long-term postoperative use was at least 4 opioid fills in the 7 months after index hospitalization, with at least 3 of those more than 30 days after hospitalization. These definitions of long-term use were consistent with a definition of 6 fills in 12 months which has been used in previous studies, and which was associated with a 7-fold increase (vs those with fewer fills) in hospitalizations with opioid-related adverse events.[15,25]

Some patients who received opioids would not fit our definitions of short-term or long-term use. For example, a patient with 2 prescriptions before the perioperative period, or one who had a single prescription in the preoperative 30 days and a single prescription before that, would meet neither definition. We labeled such patients as having "episodic" opioid use. Our data included only outpatient prescription fills. Opioids used during inpatient care, or provided from the hospital at discharge, were not identified in our data.

The "long-term preoperative cumulative dose" was defined as the sum of all MMEs prescribed in the 180 days before the perioperative period. The "long-term postoperative cumulative dose" was defined as the sum of all MMEs filled in the 180 days after the perioperative interval. These definitions of cumulative dose excluded medications during the perioperative period, when greater analgesic doses are usually necessary and expected. A cumulative dose exceeding 16,200 MMEs in 180 days (an average of ≥90 MMEs/d) was defined as "high dose."[16] A change from preoperative cumulative dose to postoperative cumulative dose of ≥10% was considered an increase or a decrease. A change of <10% was considered a stable dose. Changes in opioid doses were based on cumulative MMEs filled during the 180 days before and the 180 days after the perioperative interval. All definitions were established before data analysis.

2.4. Comorbid conditions

We calculated the *ICD-9-CM* version of the Charlson comorbidity index[14] using diagnoses recorded in the index hospital discharge record.

2.5. Analysis

Characteristics of patients who did or did not become long-term postoperative opioid users were compared with χ^2 statistics, rank-sum tests, or *t* tests as appropriate. Independent predictors of long-term postoperative opioid use were identified using multivariable logistic regression. Candidate predictors included patient demographic characteristics, comorbidity score, surgical procedure characteristics, and features of preoperative and perioperative opioid prescribing. The final regression model included all these variables, so predictors of long-term use were adjusted for possible confounding by each of these features. To assess the impact of opioid dose on predicting long-term use, we first constructed a logistic model without dosing information, but with an indicator for whether the patient received long-term preoperative opioids. We then constructed a second logistic model incorporating preoperative and perioperative opioid dose information. The distribution of opioid doses was right skewed. Rather than identifying and removing outliers to use dose as a continuous variable, we decided to keep all patients in the study and categorize cumulative opioid doses into quartiles. This mitigates any effect of patients with very high doses and allows the relationship to vary arbitrarily in the logit (ie, does not assume linearity in the logit). Dividing into quartiles also helped to facilitate clinical understanding of the results, as opposed to determining odds ratios (ORs) for every milligram increase in dose. Regarding surgical indications, we combined the least specific diagnoses (nonspecific, miscellaneous, and degenerative changes) as a reference category, because of small numbers in the nonspecific category. Statistical tests were 2 sided and significance was defined as $P < 0.05$; analyses were performed using SAS v.9.3. Model fit was assessed with the Hosmer–Lemeshow statistic and the area under a receiver-operating characteristic curve (AUC) distinguishing those who exhibited long-term postoperative opioid use from those who did not.

We also conducted a sensitivity analysis using an alternative definition of long-term opioid use: at least 3 opioid fills in the 7 months before index hospitalization, with at least 2 fills in the 180 days before the perioperative period. Long-term postoperative use was at least 3 opioid fills in the 7 months after index hospitalization, with at least 2 of those more than 30 days after hospitalization. The results of this sensitivity analysis were qualitatively the same as our base case analysis and are not presented here.

3. Results

3.1. Patients and procedures

There were 2491 patients who underwent an eligible fusion operation and all were included. Over half (59.7%) were female, 45.8% were aged 65 years or older, and only 12.6% were younger than 45 years. Reflecting the Oregon population, 93.5% were white (**Table 1**).

Most surgical procedures (n = 2113; 84.8%) were classified in DRG 460: "fusion without major complicating conditions." Next, most frequent (n = 207; 8.3%) was "combined anterior and posterior fusion without complicating conditions." Overall, 6.9% of procedures were coded with complications (DRGs 453, 454, and 459). Combined anterior and posterior procedures (with or without complications) accounted for 12.9% (n = 320).

The most common primary reason for surgery was "possible instability" (n = 1479, 59.4%) which was mainly spondylolisthesis (n = 1421, or 96.1% of the category). Degenerative spinal changes accounted for 12.0% (n = 299). Spinal stenosis primarily accounted for 298 procedures (12.0%) and herniated disk for 256 cases (10.3%). There were 133 cases (5.3%) with diagnosis codes indicating sequelae of previous back surgery, and the remainder (1.0%) fell into miscellaneous or nonspecific diagnostic categories (**Table 1**).

3.2. Opioid use

More patients received long-term opioids after spinal fusion surgery than before. Overall, 1045 patients received preoperative long-term opioids, and 1094 received long-term postoperative opioids. Among patients receiving long-term preoperative opioids, 806 (77.1%) continued long-term postoperative use, and 144 (13.8%) had episodic postoperative use. Only 95 (9.1%) discontinued opioids or had short-term postoperative use only (**Table 2**). Among those with long-term postoperative use were 352 receiving high-dose opioids (32.2%) (**Table 1**).

There were 609 (24.5%) patients with episodic preoperative opioid use, and 133 patients (5.3%) with short-term preoperative opioid use. Another 704 (28.3%) had no opioid use in the 7 months before hospitalization. Among patients with no preoperative opioid use, 90 (12.8%) received long-term postoperative opioids (**Table 2**).

Table 1

Demographic, clinical, and prescription features of full patient sample and patients with or without long-term postoperative opioid use (percents are column percents).

	Full sample (n = 2491)	No long-term postoperative opioid use (n = 1397)	Long-term postoperative opioid use (n = 1094)	P*
Sex, female, n (%)	1486 (59.7)	833 (59.6)	653 (59.7)	0.98
Age category, n (%)†				
18-44	310 (12.6)	133 (9.7)	177 (16.2)	
45-54	412 (16.7)	169 (12.3)	243 (22.2)	
55-64	616 (24.9)	309 (22.5)	307 (28.1)	<0.001
65-74	763 (30.9)	502 (36.5)	261 (23.9)	
75+	369 (14.9)	263 (19.1)	106 (9.7)	
Race, n (%)				
American Indian or Alaska Native	29 (1.2)	13 (0.9)	16 (1.5)	
Asian	36 (1.5)	25 (1.8)	11 (1.0)	
African American	22 (0.9)	7 (0.5)	15 (1.4)	0.06
Native Hawaiian or Pacific Islander	3 (0.1)	1 (0.07)	2 (0.2)	
White	2328 (93.5)	1313 (94.0)	1015 (92.8)	
Ethnicity, n (%)†				
Hispanic or Latino	70 (2.8)	40 (2.9)	30 (2.7)	0.3
Not Hispanic	2378 (95.5)	1338 (95.8)	1040 (95.1)	
Residence, n (%)†				
Rural	1017 (41.2)	579 (42.1)	438 (40.0)	<0.001
Urban	1316 (53.3)	684 (49.7)	632 (57.8)	
Indication for surgery (diagnosis), n (%)				
Nonspecific backache, miscellaneous	26 (1.0)	12 (0.9)	14 (1.3)	<0.0001
Probable degenerative changes	299 (12.0)	151 (10.8)	148 (13.5)	
Herniated disk	256 (10.3)	119 (8.5)	137 (12.5)	
Sequelae of previous back surgery	133 (5.3)	53 (3.8)	80 (7.3)	
Spinal stenosis	298 (12.0)	176 (12.6)	122 (11.2)	
Possible instability	1479 (59.4)	886 (62.4)	593 (54.2)	
Comorbidity				
Comorbidity score, mean (SD)	0.57 (0.86)	0.53 (0.82)	0.62 (0.90)	0.009
Surgery features				
Complex fusion procedure‡, n (%)	320 (12.9)	159 (11.4)	161 (14.7)	0.01
Procedure with complications§, n (%)	171 (6.9)	90 (6.4)	81 (7.4)	0.4
Opioid-prescribing features				
Long-term prehospital opioids, n (%)	1045 (58.5)	239 (30.5)	806 (80.3)	<0.001
Total prehospital MMEs (7 mo), median (IQR) (median MME/d)	950 (4950) (4.5/d)	200 (1020) (0.95/d)	5175 (13,140) (25/d)	<0.001
MME in 30 d posthospital, median (IQR) (median MME/d)	1600 (2413) (53/d)	960 (975) (32/d)	3000 (3950) (100/d)	<0.001
Preoperative benzodiazepine, n (%)	743 (29.8)	303 (21.7)	440 (40.2)	<0.001
Opioid prescribers in 30 d postoperative, median (IQR)	2.00 (2.00)	1.00 (1.00)	3.00 (2.00)	<0.001
High-dose opioids (cumulative MME ≥16,200) in 7 mo after surgery, n (%)	355 (14.3)	3 (0.26)	352 (32.2)	<0.001

* Comparing patients with or without long-term postoperative opioid use; *t* test or χ^2.

† Twenty-one missing age category; 73 unknown or other race; 43 unknown ethnicity; 158 residence unknown or outside Oregon.

‡ Combined anterior and posterior fusion, DRGs 453, 454, and 455.

§ DRGs 453,454, and 459.

DRG, diagnosis-related group; IQR, interquartile range; MME, morphine milligram equivalent.

3.3. Opioid dosage

Among the 1045 patients with long-term preoperative opioid use, 34.4% received a lower comparative dose postoperatively, and 9.1% discontinued opioids after the perioperative period. However, 44.8% received a higher dose postoperatively, and 11.8% received an equivalent dose. Among patients with episodic preoperative opioid use, 13.0% decreased dosages postoperatively, and 41.4% received no opioids beyond the perioperative interval. However, 41.7% increased cumulative doses after the perioperative interval (**Table 3**).

3.4. Predictors of long-term postoperative opioid use

In simple bivariate comparisons between those who did or did not receive long-term postoperative opioids, younger age, urban residence, indication for surgery, complex fusion procedures, preoperative benzodiazepine use, and all opioid-prescribing variables were significantly associated with greater long-term postoperative use (**Table 1**). Long-term postoperative opioid users had higher comorbidity scores (0.62 vs 0.53, $P = 0.009$).

In regression models, 21 patients with missing age data were excluded. In our first logistic regression model, excluding opioid

Table 2

Prehospitalization and posthospitalization opioid use (n = 2491).

Posthospitalization opioid use	Prehospitalization opioid use			
	None, n = 704	Short term only, n = 133	Episodic, n = 609	Long term, n = 1045
None, n = 220*	109 (15.5)	35 (26.3)	60 (9.85%)	16 (1.5)
Short term only, n = 649†	340 (48.3)	38 (28.6)	192 (31.5)	79 (7.6)
Episodic, n = 528‡	165 (23.4)	29 (21.8)	190 (31.2)	144 (13.8)
Long term, n = 1094§	90 (12.8)	31 (23.3)	167 (27.4)	806 (77.1)

Tabulated numbers are frequency counts (column %).
* No opioid fills in the 7-month posthospitalization.
† Some opioids in the 30-day posthospitalization, none in the subsequent 6 months.
‡ Patients who do not meet definitions of no opioid use, short-term opioid use, or long-term opioid use.
§ At least 4 opioid fills in 7 months after surgery, at least 3 of which were >30 days after surgery.

dose variables, long-term preoperative opioid use was the strongest predictor of long-term postoperative use, with an OR of 10.8 (95% confidence interval [CI] 8.2-13.2) (**Table 4**). Any preoperative use of benzodiazepines was also significant (OR 1.49; 95% CI 1.20-1.85). Patient sex and urban residence were not statistically significant. Increasing age was monotonically associated with lower risk of long-term opioid use, and increasing Charlson comorbidity score was monotonically associated with increasing risk. Complex fusion procedures were no longer associated with long-term opioid use after adjustment for other factors. The AUC was 0.82.

In our second regression model, incorporating opioid dose information, patient demographics, urban or rural residence, and surgical indication were not independently associated with long-term postoperative opioid use (**Table 5**). Preoperative long-term opioid use remained a significant independent predictor of long-term postoperative use (OR 1.68, 95% CI 1.19-2.34), but the opioid dose variables now showed the strongest associations, in dose–response fashion. The strongest predictor was cumulative opioid dose in the 7 months before surgery. There was a monotonic increase in the odds of long-term postoperative use with increasing preoperative dose, with OR 15.47 (95% CI 8.53-28.06) in the highest quartile (cumulative doses >8100 MMEs in the previous 7 months, or a mean daily dose >39 MME) (**Table 4**). Even after adjusting for cumulative preoperative opioid dose, the total MME prescribed in the 30-day immediate postoperative period remained significantly associated with long-term opioid use, again in dose–response fashion. In the highest quartile (cumulative dose >3300 MMEs, or a mean daily dose >110 MME), the OR was 7.96 (95% CI 4.25-14.91).

The number of opioid prescribers in the 30-day immediate postoperative period was also significantly associated with odds of long-term opioid use, even after adjustment for the dosing variables, in a "dose-response" fashion. After adjusting for opioid dosing and numbers of prescribers, preoperative benzodiazepine use was no longer associated with the probability of long-term opioid use. The Hosmer–Lemeshow goodness-of-fit index for this model was acceptable at 0.85, and the AUC improved to 0.90.

4. Discussion

More patients received long-term opioids after spinal fusion surgery than before surgery. Most patients receiving long-term preoperative opioids continued, and 57% maintained the same dose or increased their dose by more than 10% after the perioperative interval. Furthermore, almost 13% of patients who received no preoperative opioids ended up receiving long-term postoperative opioids. The strongest independent predictors of long-term postoperative opioid use were the cumulative preoperative dose and the cumulative dose of opioids prescribed in the immediate postoperative (30 days postdischarge) interval.

Our findings are consistent with other studies indicating that long-term opioid use is common for both before and after lumbar surgery, and that preoperative long-term opioid use is a powerful predictor of long-term postoperative use.[4,12] Our data further suggest the importance of both the cumulative preoperative dose and the cumulative dose in the immediate postoperative period. The latter may argue for devising anesthetic and operative techniques that minimize postoperative opioid use,[13,19] along with greater use of nonpharmacologic and nonopioid medication strategies for pain management.[29] Strategies to help patients taper opioids in the immediate postoperative period and attention to the amount of opioids prescribed are also likely to be helpful.

Table 3

Postoperative change from cumulative preoperative opioid dose among long-term and episodic preoperative opioid users.*

Posthospitalization opioid dose, 6 mo after the perioperative interval	Prehospitalization opioid use	
	Episodic use, n = 609†	Long-term use, n = 1045‡
No opioids after the perioperative interval, n (column %)	252 (41.4)	95 (9.1)
Decreased dosage by >10%, n (column %)	79 (13.0)	359 (34.4)
Same dose as prehospitalization (<10% change), n (column %)	24 (3.9)	123 (11.8)
Increased dose by >10%, n (column %)	254 (41.7)	468 (44.8)

* Cumulative doses calculated using prescriptions filled in the 6 months preceding the perioperative interval and 6 months after the perioperative interval (excluding the perioperative interval of 30-day prehospitalization and 30-day posthospitalization).
† Patients who do not meet definitions of no opioid use, short-term opioid use, or long-term opioid use.
‡ At least 4 opioid fills in 7 months before surgery, at least 3 of which were >30 days before hospitalization.

Table 4

Multivariable logistic model without dosing information, predicting long-term postoperative opioid use, n = 2470.*

Independent variables	Odds ratio	95% CI	*P*
Sex, female	1.00	0.82-1.23	0.97
Age category			
18-44	Reference		
45-54	1.11	0.77-1.60	<0.001†
55-64	0.87	0.62-1.22	
65-74	0.52	0.37-0.73	
75+	0.45	0.30-0.67	
Non-white race	0.99	0.65-1.50	0.95
Hispanic ethnicity	1.05	0.56-1.96	0.91
Residence			
Rural	Reference		
Urban	1.13	0.92-1.38	0.23
Missing	0.51	0.30-0.87	0.013
Indication for surgery (diagnosis)			
Probable degenerative changes, nonspecific backache, miscellaneous	Reference		
Herniated disk	1.33	0.89-2.00	0.17
Sequelae of previous back surgery	1.77	1.06-2.96	0.03
Spinal stenosis	0.95	0.64-1.40	0.78
Possible instability	1.08	0.80-1.46	0.62
Comorbidity score			
0	Reference		
1	1.21	0.96-1.52	0.005†
2	1.30	0.88-1.90	
3+	1.83	1.12-2.99	
Complex fusion	1.06	0.76-1.47	0.57
Procedure with complications	1.06	0.69-1.62	0.76
Received long-term preoperative opioids	10.80	8.23-13.21	<0.001
Any preoperative benzodiazepine use (7 mo)	1.49	1.20-1.85	0.004

* Excludes 21 patients with missing age.
† *P* value is a test for trend.
CI, confidence interval.

Other investigators have noted that presurgical opioid use predicts several other adverse outcomes, including worse surgical site pain, increased hospital length of stay, delayed return to work, greater surgical complications, and adverse functional outcomes.[2,5,20,21] Together with the increased likelihood of long-term opioid use, and the paucity of evidence for efficacy of long-term opioids,[11] these findings suggest that minimizing long-term opioids for back pain may be important. An association of preoperative opioid use with anxiety and depression also suggests that addressing mood disorders may be important in minimizing opioid use.[3]

Surgical patients in general seem often to receive excessive postoperative opioid prescriptions, exceeding requirements for analgesia.[6,18,21] In a study of women after cesarean section, the quantity of opioids prescribed exceeded the amount consumed by a substantial margin. Smaller opioid prescriptions were associated with lower consumption, but no worse pain scores or satisfaction.[6] Our findings suggest that minimizing the postoperative dose may also help to reduce the likelihood of long-term use. Our data further suggest that minimizing the number of opioid prescribers in the perioperative period may help minimize this risk, a concern noted with other orthopedic procedures.[26]

Our results, and others, indicate that discontinuation of long-term opioids after spinal fusion surgery is not the norm. One explanation would be that many patients do not achieve the expected pain relief from surgery. However, the fact that preoperative opioid use is a major predictor of long-term postoperative use suggests that opioid dependence may be equally or more important, making postoperative discontinuation or dose reduction more difficult. Patients considering fusion surgery for degenerative conditions should be informed that discontinuation of long-term opioid medications is an unlikely result.

Our study has the advantage of representing a true population-based sample, regardless of insurance coverage or sources of payment. Use of the PDMP assured identification of all prescriptions filled, even with insurance changes or out-of-pocket payments. This measure of opioid use does not depend on patient recall or continuous insurance coverage.

However, there are important limitations as well. We cannot know whether patients consumed the medications they received. Patient's race and ethnicity are not routinely collected with consistent methods. Controlled prescriptions not filled by a licensed Oregon outpatient pharmacy were not captured in the PDMP. We had no information on inpatient opioid prescribing and have not characterized the impact of individual clinician prescribing habits. The definitions of long-term postoperative opioid use are not standardized, although our results are consistent with studies using other definitions. In 2014, Oregon had relatively high use of prescription opioids compared with

Table 5

Multivariable logistic model with dose information, predicting long-term postoperative use, n = 2470.*

Independent variables	Odds ratio	95% CI	*P*
Sex, female	1.14	0.90-1.45	0.27
Age category			
18-44	Reference		
45-54	1.31	0.85-2.55	
55-64	1.20	0.80-1.81	0.79†
65-74	1.03	0.68-1.54	
75+	1.36	0.85-2.19	
Non-white race	1.33	0.84-2.12	0.23
Hispanic ethnicity	1.18	0.59-2.35	0.64
Residence			
Rural	Reference		
Urban	1.14	0.91-1.44	0.26
Missing	0.59	0.31-1.13	0.11
Indication for surgery (diagnosis)			
Probable degenerative changes, nonspecific backache, miscellaneous	Reference		
Herniated disk	1.12	0.70-1.81	0.64
Sequelae of previous back surgery	1.38	0.75-2.55	0.30
Spinal stenosis	0.96	0.61-1.51	0.86
Possible instability	1.07	0.74-1.52	0.73
Comorbidity score			
0	Reference		
1	1.22	0.94-1.59	0.005†
2	1.32	0.86-2.03	
3+	2.09	1.21-3.62	
Complex fusion	1.055	0.72-1.54	0.69
Procedure with complications	1.07	0.65-1.77	0.78
Received long-term preoperative opioids	1.68	1.19-2.34	0.004
Total preoperative MMEs (7 mo), quartiles			
0	Reference		
1-750 (mean 0.005-3.6/d)	1.41	0.99-2.00	
751-2350 (mean 3.6-11.2/d)	2.56	1.77-3.69	<0.001†
2351-8100 (mean 11.2-38.6/d)	6.54	4.15-10.30	
≥8101 (mean ≥ 38.6/d)	15.47	8.53-28.06	
Total MME in 30 d postoperative, in quartiles			
0	Reference		
1-887 (mean 0.03-29.6/d)	1.93	1.21-3.07	
888-1600 (mean 29.6-53.3/d)	2.52	1.53-4.14	<0.001†
1601-3300 (mean 53.3-110/d)	3.92	2.23-6.68	
≥3301 (mean ≥ 110/d)	7.96	4.25-14.91	
Any preoperative benzodiazepine use (7 mo)	1.09	0.85-1.41	0.50
Opioid prescribers in 30 d postoperative			
1	Reference		
2	1.701	1.21-2.39	
3	2.065	1.38-3.09	<0.001†
4+	5.047	3.17-8.04	

* Excludes 21 patients with missing age.
† *P* value is a test for trend.
CI, confidence interval; MME, morphine milligram equivalent.

most other states,[9] and we cannot know how well our results generalize to other states.

In summary, lumbar fusion surgery infrequently reduced the use of opioid therapy postoperatively, especially among those receiving long-term opioids preoperatively. Among opioid-naive patients undergoing surgery, there was a substantial risk of initiating long-term opioid use. Patients should be well informed and have realistic expectations regarding opioid use when considering lumbar fusion surgery. Clinicians treating patients with back pain may need to give greater attention to minimizing long-term opioid use; addressing mood disorders; minimizing postoperative opioid use; and minimizing numbers of opioid prescribers in the perioperative setting. In predicting prolonged postoperative opioid use, previous prescription opioid exposure may be more important than patient characteristics or surgical complexity and is a factor that clinicians control.

Conflict of interest statement

R.A. Deyo discloses that he receives royalties from UpToDate for authoring topics on low back pain. His salary at Oregon Health & Science University is supported in part by an endowment from Kaiser Permanente. He received a financial gift from NuVasive as part of a lifetime achievement award from the International Society for Study of the Lumbar Spine. None of the other authors report financial arrangements that may represent a possible conflict of interest.

This project was supported by grant number R01 DA031208 from the National Institute on Drug Abuse and by grant number UL1 RR024140 from the National Center for Advancing Translational Sciences. The opinions and conclusions presented are those of the authors, and not necessarily those of the sponsors.

The sponsors had no role in design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

J. Van Otterloo and S.E. Hallvik had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. R.A. Deyo, S.E. Hallvik, M. Marino, and J. Van Otterloo are responsible for the data analysis.

Article history:
Received 30 November 2017
Received in revised form 8 February 2018
Accepted 2 March 2018
Available online 6 March 2018

References

[1] Alam A, Gomes T, Zheng H, Mamdani MM, Juurlink DN, Bell CM. Long-term analgesic use after low-risk surgery: a retrospective cohort study. Arch Intern Med 2012;172:425–30.

[2] Anderson JT, Haas AR, Percy R, Woods ST, Ahn UM, Anh NU. Chronic opioid therapy after lumbar fusion surgery for degenerative disc disease in a workers compensation setting. Spine (Phila Pa 1976) 2015;40:1775–84.

[3] Armaghani SJ, Lee DS, Bible JE, Archer KR, Shau DN, Kay H, Zhang C, McGirt MJ, Devin CJ. Preoperative narcotic use and its relation to depression and anxiety in patients undergoing spine surgery. Spine (Phila Pa 1976) 2013;38:2196–200.

[4] Armaghani SJ, Lee DS, Bible JE, Archer KR, Shau DN, Kay H, Zhang C, McGirt MJ, Devin CJ. Preoperative opioid use and its association with perioperative opioid demand and postoperative opioid independence in patients undergoing spine surgery. Spine (Phila Pa 1976) 2014;39:E1524–30.

[5] Armaghani SJ, Lee DS, Bible JE, Shau DN, Kay H, Zhang C, McGirt MJ, Devin CJ. Increased pre-operative narcotic use and its association with postoperative complications and length of hospital stay in patients undergoing spine surgery. Clin Spine Surg 2016;29:E93–8.

[6] Bateman BT, Cole NM, Maeda A, Burns SM, Houle TT, Huybrechts KF, Clancy CR, Hopp SB, Ecker JL, Ende H, Grewe K, Raposo Corradini B, Schoenfeld RE, Sankar K, Day LJ, Harris L, Booth JL, Flood P, Bauer ME, Tsen LC, Landau R, Leffert LR. Patterns of opioid prescription and use after cesarean delivery. Obstet Gynecol 2017;130:29–35.

[7] Brummett CM, Waljee JF, Goesling J, Moser S, Lin P, Englesbe MJ, Bohnert ASB, Kheterpal S, Nallamothu BK. New persistent opioid use after minor and major surgical procedures in US adults. JAMA Surg 2017;152:e170504.

[8] Carragee EJ, Cheng I. Minimum acceptable outcomes after lumbar spinal fusion. Spine J 2010;10:313–20.

[9] Centers for Disease Control and Prevention. Opioid overdose: U.S. prescribing rate maps. Available at: https://www.cdc.gov/drugoverdose/maps/rxrate-maps.html. Accessed September 8, 2017.

[10] Cherkin DC, Deyo RA, Volinn E, Loeser JD. Use of the International Classification of Diseases (ICD-9-CM) to identify hospitalizations for mechanical low back problems in administrative data bases. Spine (Phila Pa 1976) 1992;17:817–25.

[11] Chou R, Turner JA, Devine EB, Hansen RN, Sullivan SD, Blazina I, Dana T, Bougatsos C, Deyo RA. The effectiveness and risks of long-term opioid therapy for chronic pain: a systematic review for a National Institutes of Health Pathways to Prevention Workshop. Ann Intern Med 2015;162:276–86.

[12] Connolly J, Javed Z, Raji MA, Chan W, Kuo YF, Baillargeon J. Predictors of long-term opioid use following lumbar fusion surgery. Spine (Phila Pa 1976) 2017;42:1405–11.

[13] Devin CJ, Lee DS, Armaghani SJ, Bible J, Shau DN, Martin PR, Ehrenfeld JM. Approach to pain management in chronic opioid users undergoing orthopedic surgery. J Am Acad Orthop Surg 2014;22:614–22.

[14] Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol 1992;45:613–9.

[15] Deyo RA, Hallvik SE, Hildebran C, Marino M, Dexter E, Irvine JM, O'Kane N, Van Otterloo J, Wright DA, Leichtling G, Millet LM. Association between initial opioid prescribing patterns and subsequent long-term use among opioid-naïve patients: a statewide retrospective cohort study. J Gen Intern Med 2017;32:21–7.

[16] Dowell D, Haegerich TM, Chou R. CDC guideline for prescribing opioids for chronic pain—United States, 2016. JAMA 2016;315:1624–45.

[17] HCUPnet. Agency for healthcare research and quality. Available at: https://hcupnet.ahrq.gov/. Accessed May 24, 2017.

[18] Hill MV, McMahon ML, Stucke RS, Barth RJ Jr. Wide variation and excessive dosage of opioid prescriptions for common general surgical procedures. Ann Surg 2017;265:709–14.

[19] Kharasch ED, Brunt LM. Perioperative opioids and public health. Anesthesiology 2016;124:960–5.

[20] Lee D, Armaghani S, Archer KR, Bible J, Shau D, Kay H, Zhang C, McGirt MJ, Devin C. Preoperative opioid use as a predictor of adverse postoperative self-reported outcomes in patients undergoing spine surgery. J Bone Joint Surg Am 2014;96:e89.

[21] Lee JS, Hu HM, Brummett CM, Syrjamaki JD, Dupree JM, Englesbe MJ, Waljee JF. Postoperative opioid prescribing and the pain scores on hospital consumer assessment of healthcare providers and systems survey. JAMA 2017;317:2013–15.

[22] Martin BI, Lurie JD, Tosteson ANA, Deyo RA, Tosteson TD, Weinstein JN, Mercer SK. Indications for spine surgery: validation of an administrative coding algorithm to classify degenerative diagnoses. Spine (Phila Pa 1976) 2014;39:769–79.

[23] Menendez ME, Ring D, Bateman BT. Preoperative opioid misuse is associated with increased morbidity and mortality and after elective orthopedic surgery. Clin Orthop Relat Res 2015;473:2402–12.

[24] Mino DE, Munterich JE, Castel LD. Lumbar fusion surgery for degenerative conditions is associated with significant resource and narcotic use 2 years postoperatively in the commercially insured: a medical and pharmacy claims study. J Spine Surg 2017;3:141–8.

[25] Morden NE, Munson JC, Colla CH, Skinner JS, Bynum JPW, Zhou W, Meara E. Prescription opioid use among disabled Medicare beneficiaries: intensity, trends, and regional variation. Med Care 2014;52:852–9.

[26] Morris BJ, Zumsteg JW, Archer KR, Cash B, Mir HR. Narcotic use and postoperative doctor shopping in the orthopedic trauma population. J Bone Joint Surg Am 2014;96:1257–62.

[27] O'Kane N, Hallvik SE, Marino M, Van Otterloo J, Hildebran C, Leichtling G, Deyo RA. Preparing a prescription drug monitoring program data set for research purposes. Pharmacoepidemiol Drug Saf 2016;25:993–7.

[28] Okie S. A flood of opioids, a rising tide of deaths. N Engl J Med 2010;363:1981–5.

[29] Qaseem A, Wilt TJ, McLean RM, Forciea MA; Clinical Guidelines Committee of the American College of Physicians. Noninvasive treatments for acute, subacute, and chronic low back pain: a clinical practice guideline from the American College of Physicians. Ann Intern Med 2017;166:514–30.

[30] Rudd RA, Aleshire N, Zibbell JE, Gladden RM. Increases in drug and opioid overdose deaths—United States, 2000-2014. MMWR Morb Mortal Wkly Rep 2016;64:1378–82.

[31] Sun EC, Darnall BD, Baker LC, Mackey S. Incidence of and risk factors for chronic opioid use among opioid-naïve patients in the postoperative period. JAMA Intern Med 2016;176:1286–93.