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HEALTH SERVICES RESEARCH

Opioid-sparing Anesthesia Decreases In-hospital and 1-year Postoperative Opioid Consumption Compared With Traditional Anesthesia

A Propensity-matched Cohort Study

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Study Design. Propensity-matched cohort.

Objective. The aim of this study was to determine if opioid-sparing anesthesia (OSA) reduces in-hospital and 1-year postoperative opioid consumption.

Summary of Background Data. The recent opioid crisis highlights the need to reduce opioid exposure. We developed an OSA protocol for lumbar spinal fusion surgery to mitigate opioid exposure.

Materials and Methods. Patients undergoing lumbar fusion for degenerative conditions over one to four levels were identified. Patients taking opioids preoperatively were excluded. OSA patients were propensity-matched to non-OSA patients based on age, sex, smoking status, body mass index, American Society of Anesthesiologists grade, and revision *versus* primary procedure. Standard demographic and surgical data, daily in-hospital opioid consumption, and opioid prescriptions 1 year after surgery were compared.

Results. Of 296 OSA patients meeting inclusion criteria, 172 were propensity-matched to non-OSA patients. Demographics were similar between cohorts (OSA: 77 males, mean age = 57.69 yr; non-OSA: 67 males, mean age = 58.94 yr). OSA patients had lower blood loss (326 mL *vs.* 399 mL, $P = 0.014$), surgical time (201 *vs.* 233 min, $P < 0.001$) emergence to extubation time (9.1 *vs.* 14.2 min, $P < 0.001$), and recovery room time (119 *vs.* 140 min, $P = 0.0.012$) compared with non-OSA patients. Fewer OSA patients required nonhome discharge (18 *vs.* 41, $P = 0.001$) compared with the non-OSA cohort, but no difference in length of stay (90.3 *vs.* 98.5 h, $P = 0.204$). Daily opioid consumption was lower in the OSA *versus* the non-OSA cohort from postoperative day 2 (223 *vs.* 185 morphine milligram equivalents, $P = 0.017$) and maintained each day with lower total consumption (293 *vs.* 225 morphine milligram equivalents, $P = 0.003$) throughout postoperative day 4. The number of patients with active opioid prescriptions at 1, 3, 6, and 12 months postoperative was statistically fewer in the OSA compared with the non-OSA patients.

Conclusions. OSA for lumbar spinal fusion surgery decreases in-hospital and 1-year postoperative opioid consumption. The minimal use of opioids may also lead to shorter emergence to extubation times, shorter recovery room stays, and fewer discharges to nonhome facilities.

Key words: lumbar fusion, opioid-sparing anesthesia, pain control, opioid consumption

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Over the past 20 years, opioid misuse and addiction have become an increasing problem across the United States.[1–3] Beyond the contribution of illicit drug use, this crisis was also fueled by increased opioid prescribing as part of standard medical and surgical care.[4–6] In part this has been attributed to The Joint Commission and the Veterans Health Administration's emphasis on pain as the fifth vital sign.[7,8] Reassurance to physicians by pharmaceutical companies about the low risk of addiction from opioid use for subacute or chronic pain has also led to the increased accessibility of opioids.[9,10] All this has contributed to the United States accounting for >80% of opioid consumption worldwide.[2,3]

Opioids are frequently prescribed after lumbar fusion surgery. Prior studies have shown that as many as 18% of previously opioid-naive patients are still on opioids 6 months after surgery.[5] In addition, specific total in-hospital opioid

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thresholds have been previously identified as risk factors for sustained or long-term use in lumbar fusion surgery.[11,12] This has drawn attention to the extent of opioid utilization preoperatively, intraoperatively, and postoperatively in patients undergoing lumbar fusion surgery as risk factors for developing sustained opioid use or opioid dependence.

Recently, the Centers for Disease Control (CDC) and the National Institutes of Health (NIH) have developed strategies to address this nationwide crisis.[13,14] Multimodal opioid-sparing anesthesia (OSA) has demonstrated the ability to limit perioperative opioid consumption, decreasing the length of hospital stay, readmissions, and overall hospital costs across several surgical specialties.[15]

The purpose of this study is to compare perioperative and postoperative process measures, in-hospital opioid consumption, and 1-year opioid prescriptions in patients not preoperatively consuming narcotics receiving OSA *versus* traditional non-OSA for lumbar spinal fusion for degenerative conditions.

MATERIALS AND METHODS

This is a retrospective, single-center propensity-matched observational cohort study of patients who underwent one- to four-level lumbar fusions for degenerative conditions. Patients utilizing opioids daily were excluded from the study. Preoperative opioid use was determined based on the medication list on their electronic medical record. Non-OSA patients had surgery from January to December 2016, received optional midazolam and antiemetic but no preoperative oral regimen. Induction was with bolus doses of lidocaine, diprivan, rocuronium, succinylcholine, and fentanyl. Maintenance of anesthesia was inhalational, with infusion or bolus doses of diprivan, rocuronium, fentanyl, and or hydromorphone without any regional blocks. Emergence was done with reversal of muscle relaxant, antiemetics, fentanyl, and or hydromorphone.

Patients in the OSA arm had surgery from January to December 2019 and received an oral regimen of cyclobenzaprine (10 mg), gabapentin (300–600 mg), acetaminophen (650–1 g), optional midazolam, and antiemetic preoperatively. Induction was with bolus doses of lidocaine, diprivan, rocuronium, succinylcholine, ketamine, magnesium, dexmedetomidine, and esmolol as needed. Table 1 shows a recommended dosing range with maximum doses. Maintenance of anesthesia was inhalational and or infusion or boluses of diprivan, ketamine, magnesium, dexmedetomidine, rocuronium, and esmolol. Emergence was completed with the reversal of muscle relaxant and antiemetics. All patients in the OSA cohort received regional blocks.

Regional blocks for anterior spine fusion (transversus abdominis plane; TAP)[16,17] and/or posterior spine fusion (erecter spinae block; ESB).[18] Our TAP technique has been previously described.[16] The ESB was administered before emergence. The lumbar spinal process was identified using a parasagittal probe (Fujifilm Sonosite Edge II, S2, and PX with linear HFL38xi and L12-3 transducers) hold, scanning caudally until sacrum is noted. Then, the target vertebral level (T12) is chosen by counting from sacrum cranially. Maintaining the parasagittal probe hold, the transducer is pushed laterally so that lamina is appreciated continuing to transverse process (TP), finally stopping over the lateral-most aspect of the TP. The view is optimized to appreciate the striated paraspinous muscles overlying TP, the repeating pattern of TP all in a row, the deep thoracolumbar fascia connecting TP, possibly pleura, and the articulation of rib with TP. Ambiguous target anatomy would be delineated using a transverse probe hold or by changing to a different probe. Once target anatomy is identified, a 20 g×100 mm Braun Stimuplex ultra 360 needle is guided in-plane to the ultrasound beam to the lateral-most TP injection site, leaving a 30 mL aliquot of 0.25% plain ropivacaine there, thus performing the low thoracic ESB procedure.

All five surgeons were fellowship-trained in spine surgery who have been in practice for at least 10 years and contributed to both the OSA and non-OSA cohorts.

To control for bias inherent in a retrospective study, patients receiving OSA were propensity-matched to non-OSA patients based on age, sex, smoking status, body mass index, American Society of Anesthesiologists grade, insurance status, number of levels fused and revision *versus* primary procedure. A propensity score, the probability of any subject included in the study to be assigned to the OSA arm, was determined using binary logistic regression. Each patient in the OSA arm was matched to a non-OSA patient with the closest propensity score using nearest neighbor matching using a caliper width of 0.2 SD of the logit of the propensity score.[19,20] Postoperatively, a standard opioid escalation protocol was utilized for both arms. Patients were started on hydrocodone 5 mg one to two tablets q6hours, escalated to 7.5 mg one to two tablets q6hours if pain is uncontrolled further escalated to 5 mg oxycodone q6hours.

We evaluated surgical parameters (estimated blood loss and surgical time time), immediate perioperative parameters (time from emergence to extubation, time spent in the recovery room, pain scores (0–10)[7] on transfer in and transfer out of the recovery room), and length of stay. Intraoperative and in-hospital daily opioid consumption from immediately after surgery [postoperative day (POD) 0 to POD4 was collected using a direct query from the electronic medical record and converted to morphine milligram equivalents (MME). The electronic medical record was reviewed to determine the last opioid prescription written and the daily MME prescribed.

All analyses were performed using IBM SPSS, v28.0 (IBM Corp., Armonk, NY). Continuous variables were compared between the OSA and non-OSA groups using unpaired *t* tests. Categorical variables were compared using the Fisher exact test. Significance was set at a *P*-value <0.05.

TABLE 1. Recommended Dosing

	Bolus Recommended dosing	Infusion Reserve for increasing complexity of case	Dilution	Maximum dose
Magnesium	0.5–1.0 g before incision	0.4 g/h Stop 30 min before closure	Bolus—1–2 g in 10 mL syringe Infusion—1–2 g in 100 mL NS	2 g
Ketamine	0.3 mg/kg	0.1 mg/kg/h Stop 30 min before closure	Pre-prepared as 10 mL	2 mg/kg
Dexmedetomidine	2–4 mcg, maximum 40 mcg	0.2–0.5 mcg/kg/h Stop 30 min before closure for VA and 60 min before closure for TIVA	200 mcg in 100 mL NS = 2 mcg/mL	0.6 mcg/kg
Lidocaine	0.5 mg/kg, ?mcg/kg/h	1–2 mg/kg/h Stop 30 min before closure	Add 25 mL of 2% lidocaine to 100 mL (125 mL total volume) NS = 4 mg/mL	50 mL/h of 0.4% lidocaine
Esmolol	0.3 mg/kg	5–30 mcg/kg/min	Add 100 mg of 10 mg/ mL esmolol to 90 mL NS for final concentration of 1 mg/ mL esmolol	

NS indicates normal saline; TIVA, total intravenous anesthesia; VA, volatile anesthetic.

RESULTS

Of 296 OSA patients meeting inclusion criteria, 172 OSA patients were successfully propensity-matched to 172 non-OSA patients. Consistent with propensity matching, there were no differences in baseline demographic parameters between cohorts (Table 2). Patients in the OSA group received less opioids intraoperatively (19.55) compared with the non-OSA group (38.83 MME, $P < 0.001$). Patients undergoing OSA had lower estimated blood loss (326 *vs.* 399 mL, $P = 0.014$) surgical time (201 *vs.* 233 min, $P < 0.001$) emergence to extubation time (9.1 *vs.* 14.2 min, $P < 0.001$) and time spent in the recovery room (119 *vs.* 140 min, $P = 0.0.012$) compared with non-OSA patients (Table 3). There was a lower proportion of patients requiring nonhome discharge in the OSA cohort (18 *vs.* 41, $P = 0.001$) compared with the non-OSA cohort, but no difference in length of stay (90.3 *vs.* 98.5 h, $P = 0.204$). Daily opioid consumption was lower in the OSA *versus* the non-OSA cohort starting from POD2 (223 *vs.* 185 MME, $P = 0.017$) and maintained each day with lower total consumption (293 *vs.* 225 MME, $P = 0.003$) throughout POD4. Pain score on transfer out of postanesthesia care unit was similar for OSA and non-OSA patients (5.8 *vs.* 5.7, $P = 0.886$).

The proportion of patients with active opioid prescriptions at 1, 3, 6, and 12 months after surgery was consistently statistically fewer in the OSA compared with the non-OSA patients (Table 4). Comparing patients still receiving opioids, the daily MMEs prescribed were similar between the two groups.

DISCUSSION

Historically, intraoperative and subsequent postoperative pain control regimens for spine surgery have relied heavily on opioid medications. Opioids were an integral part of the anesthetic regimen and were provided at intervals in response to patient-reported pain postoperatively.[21] This repeated exposure combined with a societal expectation of minimal pain even after invasive procedures such as lumbar fusions, has resulted in an excess of patients utilizing opioids longer than necessary. As a result of the further understanding of the detrimental effects of opioids, OSA techniques are being developed and implemented.[22,23] Various strategies including combinations of nonopioid medications with different mechanisms of action have been advocated, but no single regimen has demonstrated clear superiority.[22,23] We provide a quick reference in Table 1 for providers to easily implement an OSA protocol. In addition, regional anesthesia techniques in spine surgery are now emerging to supplement more traditional anesthetic protocols with promising preliminary results.[16–18]

The results of this study demonstrate that the daily mean and total opioid consumption postoperatively was significantly less in the OSA cohort compared with the non-OSA cohort. This assumed benefit of OSA has not been clearly demonstrated in previous literature. Choi *et al*[24] found a decrease in opioid consumption only on the second POD. Rajpal *et al*[25] did not find a significant difference in total postoperatively opioid consumption despite a decrease in the first 24 hours postoperative. Haffner *et al*[26] showed opioid reduction only in the first 2 days postoperative. In the current study, a consistent decreased opioid consumption was demonstrated starting at the second POD and maintained throughout the patient's admission, up to 4 days postoperative with a total reduction of 23%.

The sparing use of opioids minimizes their known vasodilatory effects.[27] In addition, if less intraoperative hypotension is seen by removing the opioids, then less pressor use is may be likely. The minimization of these blood pressure fluctuations

TABLE 2. Summary of Baseline Data

	n (%)		
	Non-OSA	OSA	*P*
N	172	172	
Females	95 (54)	105 (60)	0.277
Age [mean (SD)] (yr)	57.69 (11.71)	58.94 (11.73)	0.325
BMI [mean (SD)] (kg/m^2)	32.41 (6.88)	31.44 (6.27)	0.172
Smoking status			0.373
Nonsmoker	67 (38)	74 (42)	
Former	59 (34)	63 (36)	
Current	46 (26)	35 (20)	
ASA grade			0.254
1	1 (1)	4 (2)	
2	43 (25)	52 (30)	
3	125 (71)	115 (66)	
4	3 (2)	1 (1)	
Public insurance	108 (62)	101 (58)	0.440
Diagnosis			0.592
Stenosis	50 (29)	51 (30)	
Spondylolisthesis	76 (44)	74 (43)	
Mechanical disk collapse	33 (19)	33 (19)	
Nonunion	13 (8)	14 (8)	
Revision	79 (45)	73 (42)	0.515
Number of surgical levels			0.569
1	101 (58)	106 (61)	
2	53 (30)	47 (27)	
3	13 (7)	10 (6)	
4	5 (3)	9 (5)	
Approach			1.000
Posterior only	56 (32)	56 (32)	
Posterior—TLIF	61 (35)	61 (35)	
Combined	45 (36)	45 (36)	

ASA indicates American Society of Anesthesiologists; BMI, body mass index; OSA, opioid-sparing anesthesia; TLIF, transforaminal lumbar interbody fusion.

may contribute to less estimated blood loss during the procedure.

Advantages not previously reported with OSA seen in this study include the shorter emergence to extubation time, the shorter time spent in the recovery room, and fewer patients needing nonhome after discharge. This may be attributable to the absence of known detrimental effects of IV opioids on cognition and motor function.[28] All these lead to decreased hospital costs. However, the most important finding from the current study is that a 43% fewer patients in the OSA cohort were still receiving opioid prescriptions 1 year after surgery compared with the non-OSA cohort. There are more than double the number of patients still being prescribed opioids in the non-OSA cohort compared with the OSA cohort. The use of OSA protocols may decrease the risk of patients still being on opioids 1 year after lumbar fusion surgery. In addition, more patients were able to stop opioids earlier with 23% fewer taking opioids at 1 month in the OSA cohort. Whether this decrease in postoperative opioid use is due to patients not needing opioids or due to a change in the physicians' opioid prescribing behavior needs to be further investigated.

Our study has limitations, it is retrospective design which by definition lacks the blinded randomization between the cohorts to reduce bias. Pain scores were not routinely collected during each POD after surgery. The development of the OSA protocol at our institution started in 2017. As the protocol has been gradually refined, recovery room personnel and anesthesiologists have anecdotally noted that patients postoperatively are more alert and coherent and are more readily mobilized. Thus OSA components are now widely adopted by anesthesiologists. This ethically prevents the institution from performing a randomized clinical trial as we are past equipoise. To mitigate the selection bias in this retrospective study, propensity matching was used creating two comparable groups. In addition, we recognize that the time

TABLE 3. Summary of Surgical Data

	Mean (SD)		
	Non-OSA	OSA	*P*
EBL (mL)	399.33 (289.87)	326.98 (252)	0.014
Time (min)			
Procedure	233.22 (98.59)	201.6 (74.89)	< 0.001
Emergence to extubation	14.26 (10.97)	9.06 (8.61)	< 0.001
Recovery room	139.88 (86.23)	119.26 (64.32)	0.012
Recovery room pain score			
On transfer in	7.65 (2.4)	7.61 (2.29)	0.885
On transfer out	5.78 (2.07)	5.74 (2.03)	0.886
Pain score change	1.66 (2.2)	1.68 (2.23)	0.938
Intraoperative morphine milligram equivalents	38.83 (18.57)	19.55 (11.09)	< 0.001
Cumulative morphine milligram equivalents			
Postoperative day 0	64.13 (44.32)	62.04 (43.17)	0.643
Postoperative day 1	149.62 (99.79)	135.70 (103)	0.185
Postoperative day 2	223.46 (149.8)	185.61 (154.83)	0.017
Postoperative day 3	267.53 (178.51)	212.16 (182.36)	0.003
Postoperative day 4	292.84 (201.65)	225.23 (195.57)	0.001
Length of hospital stay (h)	98.53 (54.31)	90.35 (64.55)	0.204
Nonhome discharge [n (%)]	41 (23)	18 (10)	0.001

EBL indicates estimated blood loss; OSA, opioid-sparing anesthesia.

intervals of the OSA *versus* non-OSA are not contemporaneous. The rationale behind this is due to the initiation of the OSA protocol. It is not an all *versus* none implementation, especially when first starting. Typically, there are several new medications providers are not familiar with, so starting the protocol with all of these medications is not safe and not advised. As we initiated the protocol, it evolved over time to our current protocol. Therefore we selected distinct time intervals preceding the initiation of the protocol and an OSA time interval after we finalized (not transition phase). Although we hope to reduce the learning curve for others with our protocol being presented here, we encourage a transition to get comfortable with new medications.

Another limitation is the exclusion of patients who were taking opioids daily before their surgery, so the results of this study may not be applicable to opioid-tolerant patients. In addition, these patients may have a medical history of taking opioids and cannot be considered opioid-naïve. Future studies of all patients regardless of baseline opioid usage are underway.

OSA for lumbar spinal fusion surgery may decrease in-hospital and 1-year postoperative opioid consumption by 23% and 43%, respectively. The minimal use of opioids may also lead to shorter emergence to extubation times, shorter recovery room stays, and fewer discharges to non-home facilities. Future studies are needed to identify additional advantages of OSA.

TABLE 4. Postdischarge Opioid Prescriptions

	Non-OSA	OSA	*P*
N	172	172	
Number of patients with opioid prescriptions [n (%)]			
1 mo postoperative	161 (94)	122 (71)	< 0.0001
3 mo postoperative	139 (81)	81 (47)	< 0.0001
6 mo postoperative	128 (74)	62 (36)	< 0.0001
12 mo postoperative	120 (70)	46 (27)	< 0.0001
Daily morphine milligram equivalents [mean (SD)]	21.28 (16.02)	20.03 (14.96)	0.259

OSA indicates opioid-sparing anesthesia.

➢ Key Points

- ❑ Of 296 patients who underwent lumbar fusion for degenerative conditions under OSA meeting inclusion criteria, 172 were propensity-matched to non-OSA patients.
- ❑ OSA patients had lower blood loss, shorter surgical time, emergence to extubation time, and time spent in the recovery room compared with non-OSA patients.
- ❑ Daily opioid consumption was lower in the OSA versus the non-OSA cohort from POD2 and maintained each day with lower total consumption throughout POD4.
- ❑ The number of patients with active opioid prescriptions at 1, 3, 6, and 12 months postoperative was statistically fewer in the OSA compared with the non-OSA patients.

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