Multimodal Analgesic Management for Lumbar Decompression Surgery in the Ambulatory Setting: Clinical Case Series and Review of the Literature

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BACKGROUND: **Effective pain control is vital for successful surgery in the ambulatory setting. Our study aims to characterize a case series of patients who underwent lumbar decompression (LD) in the ambulatory surgical center (ASC) with the use of a multimodal analgesic (MMA) protocol.**

METHODS: **A prospective surgical registry was retrospectively assessed for patients who underwent single or multilevel LD in an ASC using MMA from 2013 to 2019. Observation in excess of 23 hours was not permitted at the ASC, and patients were required to be discharged the same day. Length of stay, patient-reported visual analog scale pain scores before discharge, and the quantity of narcotic medications administered to patients before discharge were recorded. Quantity of narcotic medications were converted into units of oral morphine equivalents and summed across all types of narcotic medications prescribed.**

RESULTS: **A total of 499 patients were included. In total, 86.0% (429) of the patients underwent a single-level decompression procedure, 13.8% (69) of patients underwent a 2-level, and 0.2% (1) of the patients underwent a 3-level procedure; 83.6% (417) of the patients in this study underwent a primary LD, and 14.0% (70) underwent a revision decompression.**

CONCLUSIONS: **This is the largest clinical case series focused on LD procedures within an ASC requiring no planned 23-hour observation. This study demonstrates the feasibility of performing LD surgery in an ASC with proper patient selection, surgical technique, and MMA protocol. All patients were discharged from the surgical center on the same day of surgery.**

INTRODUCTION

The clinical management of lumbar spine pathology is resource-intensive, with an estimated annual cost of $90 billion in the United States alone.[1] A viable strategy for cost reduction has been transitioning surgical care to the outpatient setting.[2] Among Medicare patients alone, the past decade has seen a rise in the proportion of outpatient surgeries performed to 40% and an increase of 60% for ambulatory surgery center procedures.[3] Lumbar laminectomy, with or without discectomy, is both one of the first procedures to be popularized in the outpatient setting and the most commonly performed spine operation in the United States.[4,5] Early reports suggest that the outpatient setting for surgery may be associated with both lower complication rates and a likelihood of patient satisfaction.[6,7] In light of these compelling factors, the

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- Ambulatory surgery center
- Discectomy
- Enhanced recovery after surgery
- Length of hospital stay
- Low back pain
- Multimodal analgesia
- Outpatient surgical center

Abbreviations and Acronyms
ASA: American Society of Anesthesiologists
BMI: Body mass index
IV: Intravenous
LD: Lumbar decompression
MCS: Mental Component Summary
MMA: Multimodal analgesic
PCA: Patient-controlled analgesia
PONV: Postoperative nausea and vomiting
PROM: Patient-reported outcome measure
SF-12: 12-Item Short Form

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continued growth of outpatient centers for lumbar decompression (LD) surgery represents a major area of interest for patients, physicians, and policymakers alike.

A primary concern and barrier in transitioning LD surgery to the outpatient setting is ensuring adequate pain control. In fact, insufficient pain control has been reported as the most common reason for unplanned postoperative admission.[8] Although improvements in anesthesia and surgical technique over the last decade have contributed to improved patient-reported outcomes, some degree of acute postoperative pain is inevitable. In the hospital setting, altering discharge plans when necessary is feasible, but at stand-alone outpatient surgery centers, providers do not share this same ability. Therefore, the application of a safe, effective, and reproducible multimodal analgesia (MMA) protocol in this setting is essential for both patient and provider confidence.

Based on this need, our team has developed an MMA protocol that targets multiple causes of pain following spine surgery, including inflammation, muscle spasticity, neuropathic pain, and a lowered central nervous system pain threshold.[9] In doing so, we aim to provide safe and reliable pain relief while minimizing reliance on opioid medications. In this study, we highlight a detailed MMA protocol and report findings from our initial clinical experience. We believe that doing so may help guide surgical teams aiming to grow and streamline their LD surgeries in the outpatient setting.

METHODS

Selection

After institutional review board approval (ORA# #14051301) and patient-informed consent were obtained, a retrospective review for eligible patients who underwent LD between May 2013 and August 2019 was performed. Inclusion criteria consisted of consecutive patients undergoing single or multilevel LD using our MMA protocol (Table 1). All patients previously had not responded to conservative therapy (e.g., physical therapy, nonsteroidal anti-inflammatory drugs, and corticosteroid injections) and were evaluated by their primary care physician and an anesthesiologist for surgery clearance. The senior author performed all surgeries at an institution associated with an ambulatory surgery center, where observation >23 hours was not permitted.

Data Collection

Baseline characteristics were recorded, including sex, age, body mass index (BMI), comorbidity burden as evaluated by Charlson Comorbidity Index, smoking status, American Society of Anesthesiologists (ASA) score, preoperative medical conditions, and spinal diagnoses.

Intraoperative data were collected, including primary or revision status, number of operative levels, index level, operative duration (from skin incision to closure), and estimated blood loss. Postoperative variables evaluating inpatient pain, narcotic use, and observation duration were recorded, including surgery center length of stay, patient-reported visual analog scale pain scores before discharge, and quantity of narcotic medications administered before discharge (i.e., converted into units of oral morphine equivalents and summed across all types of narcotic medications prescribed). Complications experienced during the immediate postoperative time period were recorded. Following surgery, patient-reported outcome measures (PROMs) were collected to evaluate patient improvement longitudinally. Pain was evaluated using the visual analog scale for back and leg pain. Disability was evaluated using the Oswestry Disability Index. Physical function was assessed using both the 12-Item Short Form (SF-12) Physical Component Summary and the Patient-Reported Outcomes Measurement Information System Physical Function questionnaire. Mental health was evaluated using 12-item Short Form Mental Component Summary (MCS). All outcome measures were collected at a preoperative time point as their baseline, as well as at 6 weeks, 12 weeks, 6 months, and 1-year postoperatively. PROMs at postoperative time points were compared against preoperative baseline with paired *t* test to assess for significant improvements.

MMA Protocol

Our team follows a standardized protocol used for all procedures that can be modified on an individual basis (Table 1).[10] Successful use of the protocol begins at the patient's preoperative visit, at which time he or she is educated regarding expectations and the perioperative course of care. On the day of surgery, pre-emptive analgesia is administered before the start of surgery, including cyclobenzaprine, pregabalin, and oxycodone. Intraoperatively, patients are induced under anesthesia using propofol and ketamine. Anesthesia is maintained via sevoflurane gas and a fentanyl infusion. Additional medications given intraoperatively include locally injected bupivacaine with epinephrine, acetaminophen, dexamethasone, ondansetron, and famotidine. Postoperatively, patients are given a detailed regimen of PO medications.

Surgical Technique

Fluoroscopic imaging is used to localize the affected lumbar level(s). A unilateral approach is used through an 18-mm longitudinal skin incision, approximately 1.5 cm lateral to the midline on the side of the pathology. Sharp dissection is carried out down to the level of the deep fascia. A fasciotomy is performed that is the same length of the skin incision. At this point, a starting dilator is passed on docked onto the level of interest. On the lateral fluoroscopic view, the docking site should be on the inferior portion of the superior lamina, immediately lateral to the interspinous space. Once the dilator is at the appropriate site, sequential dilation is performed followed by placement of the tubular retractor. The final working portal is either a 16- or 18-mm nonexpandable tube.

The inferior portion of the superior lamina, interlaminar space, and facet joint are identified. A high-speed drill is used to perform a laminectomy with partial facetectomy and foraminotomy. The underlying ligamentum flavum is resected using a 3-mm Kerrison rongeur. In patients also requiring a concomitant discectomy, the traversing nerve root is gently retracted medially, and the underlying disc fragment resected using a sharp knife and straight pituitary rongeur. Any vessels overlying the disc are coagulated with bipolar electrocautery. Once the decompression and discectomy are completed, the traversing nerve roots are directly visualized and ensured to have an excursion distance of greater than 1 cm.

Table 1. Multimodal Analgesic Regimen for Outpatient Spine Surgery

Before admission
Preoperative patient counseling regarding intraoperative and postoperative analgesia at spine surgeon's office.
Day of surgery
Preoperatively
Oral medications given preoperatively in holding area about 1 hour before surgery:
1. Cyclobenzaprine 10 mg
2. Pregabalin 150 mg
3. Oxycodone controlled-release 10 mg
Intraoperatively
■ Induction of anesthesia: propofol 2 mg/kg plus ketamine 50 mg
■ Maintenance of anesthesia: sevoflurane with fentanyl 1–2 μg/kg titrated to clinical effect
■ Additional medications administered intraoperatively:
1. Bupivacaine 0.5% with epinephrine 1:200,000 injected at incision site
a. 20 mL per side if patient weight <70 kg
b. 30 mL per side if patient weight ≥70 kg
2. Acetaminophen 1000 mg IV
3. Dexamethasone 10 mg IV
4. Ondansetron 4 mg IV
5. Famotidine 20 mg IV
Postoperatively in recovery room
1. Tramadol 50 mg
2. Cyclobenzaprine 10 mg orally for spasms
3. Oxycodone immediate release
a. 5 mg q4h as needed for pain (VAS Pain >3) for opioid-naïve patients
b. 10 mg q4h as need for pain (VAS Pain >4) for opioid-tolerant patients
Discharge medications
POD 0
1. Tramadol 50 mg
2. Oxycodone 5 mg
a. 5 mg as needed for pain (VAS 4–6)
b. 10 mg as needed for pain (VAS 7–10)
3. Cyclobenzaprine 10 mg
4. Pregabalin 75 mg
5. Cold compress applied to surgical site
POD 1
1. Oxycodone discontinued by 9 AM
2. Hydrocodone/paracetamol 5 mg
a. 1 tablet as needed for pain (VAS Pain 4–6)
b. 2 tablets as needed for pain (VAS Pain 7–10)
3. Cyclobenzaprine 10 mg

IV, intravenously; q4h, every 4 hours; VAS, visual analog scale for pain (where 0 = no pain and 10 = worst possible pain); POD, postoperative day.

RESULTS

Patient Demographics

A total of 499 consecutive patients were included in the study. The distribution of operative levels consisted of 429 (86.0%) single-level, 69 (13.8%) 2-level, and 1 (0.2%) 3-level LD (Table 2). The study cohort had a majority of male subjects (71.5%), nonsmokers (85.3%), ASA score of 1 (50.3%), with an average BMI of 28.2 kg/m^2, and average Charlson Comorbidity Index of 0.4. The 3 most common preoperative comorbid conditions were hypertension (15.0%), asthma (6.0%), and arthritis (4.0%). 83.6% (417) of the patients in this study underwent a primary LD and 14.0% (70) underwent a revision decompression (Table 3). The majority of primary and revision single-level procedures were performed for diagnosis of herniated nucleus pulposus (94.1% and 86.2%). Two-level procedures were performed most often for spinal stenosis in the case of primary (56.9%) and herniated nucleus pulposus for revisions (80.0%). The lone 3-level procedure was for spinal stenosis.

Perioperative Outcomes

The most common level to be decompressed was L5–S1 (45%) followed by L4–L5 (39.1%) (Table 4). The longest surgical case had a duration of 105 minutes, whereas the mean was 44.1 ± 13.3 minutes. The longest inpatient length of stay was 7.6 hours, whereas the mean was 2.5 ± 1.1 hours. All patients were discharged within 7.6 hours of the procedure end. The only postoperative complication was nausea and vomiting (7 patients, 1.46%) (Table 5). All patients who experienced nausea and vomiting had resolution of their symptoms and were discharged in less than 23 hours after surgery.

Postoperative Outcomes

Table 6 summarizes PROMs for patient cohort. At all time points and for all PROMs, significant improvement was noted when compared with preoperative baseline, except for SF-12 MCS at 2 years.

DISCUSSION

In this study, we report a large case series of patients undergoing LD surgery in the outpatient setting treated with a novel MMA protocol. As expected, patients were relatively young and healthy with a mean length of stay of a mere 2.5 hours and narcotic consumption on postoperative day zero of 20.5 oral morphine equivalents. The majority of patients did well, with only 7 experiencing nausea or vomiting. In addition, majority of patients

Table 2. Patient Demographics and Baseline Characteristics

Demographic Variables	Total (n = 499)*	1 Level (n = 429)	2 Level (n = 69)	≥3 Level (n = 1)
Age, mean ± SD, years	43.4 ± 11.9	42.2 ± 11.4	50.6 ± 12.1	65.6 ± 0.0
Sex				
Female	28.5% (142)	28.4% (122)	29.0% (20)	0.0% (0)
Male	71.5% (357)	71.6% (307)	71.0% (49)	100.0% (1)
Body mass index, n	28.2 ± 5.1	28.0 ± 5.0	29.4 ± 5.7	30.0 ± 0.0
Smoking status, n				
Nonsmoker	85.3% (422)	86.4% (368)	77.9% (53)	100.0% (1)
Smoker	14.8% (73)	13.6% (58)	22.1% (15)	0.0% (0)
Charlson Comorbidity Index, mean ± SD	0.4 ± 0.8	0.4 ± 0.8	0.7 ± 0.7	0.0 ± 0.0
ASA score				
1	50.3% (167)	50.2% (145)	51.2% (22)	0.0% (0)
2	47.3% (157)	47.4% (137)	46.5% (20)	100.0% (1)
≥3	2.4% (8)	2.4% (7)	2.3% (1)	0.0% (0)
Preoperative diagnoses				
Hypertension	15.0% (74)	13.4% (57)	25.0% (17)	0.0% (0)
Asthma	6.0% (30)	6.5% (28)	2.9% (2)	0.0% (0)
Arthritis	4.0% (20)	3.3% (14)	8.8% (6)	0.0% (0)
Cancer	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)
Chronic lung disease	2.0% (10)	1.9% (8)	2.9% (2)	0.0% (0)
Uncomplicated diabetes mellitus	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)
Liver disease	1.6% (8)	1.6% (7)	1.5% (1)	0.0% (0)
Peripheral vascular disease	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)
Myocardial infarction	0.4% (2)	0.5% (2)	0.0% (0)	0.0% (0)
Renal failure	0.6% (3)	0.7% (3)	0.0% (0)	0.0% (0)

There were no patients in our study with a recorded medical history of gastrointestinal bleeding, or hyperlipidemia.
SD, standard deviation; ASA, American Society of Anesthesiologists.
*Percentages were based on total n of patients without missing data; those that had $n < 499$ include body mass index ($n = 483$); smoking status, hypertension, arthritis, chronic lung disease, uncomplicated diabetes mellitus, liver disease, peripheral vascular disease, myocardial infarction, renal failure ($n = 495$); Charlson Comorbidity Index ($n = 434$); and ASA ($n = 332$).

experienced significant improvement for majority of PROMs at all time points when compared with preoperative baseline, except for SF-12 MCS at 2 years (Table 6). Finally, all patients were discharged to home directly from the surgery center, without admission or further hospitalization required.

We determined that the key to these positive findings is appropriate perioperative patient management and an effective MMA protocol. The goal of such a protocol is to achieve adequate pain control, limit postoperative narcotic use, and limit medication-related adverse events.[9] Two randomized controlled trials have shown that MMA protocols following spine surgery can contribute to successfully lower cumulative pain scores and improve disability scores without increasing complication rates.[11,12] A previous study also performed a retrospective analysis of patients undergoing transforaminal lumbar interbody fusion with an MMA protocol versus a standard morphine patient-controlled analgesia (PCA) protocol, demonstrating that the MMA cohort had decreased inpatient narcotic consumption, decreased nausea/vomiting, shorter length of hospital stay, and no difference in pain scores.[10] The outpatient setting, however, poses unique challenges to both physicians and patients, alike. To follow we review some of the effective features that contribute to the success of our MMA protocol in this novel context.

Patient Selection

Before considering an MMA regimen, the first step in a successful outpatient LD is selecting an appropriate patient. Chin et al.[13] generated criteria for outpatient spine surgery based on a cohort of patients who had successfully undergone similar outpatient orthopedic procedures, demonstrating that approximately 85% of all LDs performed by their practice could have safely been attempted in the outpatient setting. The list of criteria included

Table 3. Preoperative Spinal Diagnoses*

	Decompression Procedures $N = 499$*					
	1-Level		2-Level		3-Level	
Diagnosis	Primary ($n = 354$)	Revision† ($n = 65$)	Primary ($n = 62$)	Revision† ($n = 5$)	Primary ($n = 1$)	Revision† ($n = 0$)
Herniated nucleus pulposus	94.1% (333/354)	86.2% (56/65)	50.0% (31/62)	80.0% (4/5)	0.0% (0)	0.0% (0)
Spinal stenosis	66.1% (234/354)	56.9% (37/65)	88.7% (55/62)	80.0% (4/5)	100.0% (1/1)	0.0% (0)
Spinal cyst	1.9% (7/354)	1.5% (1/62)	1.6% (1/62)	0.0% (0)	0.0% (0)	0.0% (0)
Degenerative spondylolisthesis	3.3% (7/211)	0.0% (0)	3.0% (1/33)	0.0% (0)	0.0% (0)	0.0% (0)
Isthmic spondylolisthesis	2.9% (6/209)	2.4% (1/41)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)

*Percentages were based on total n of patients without missing data; those that had $n < 486$ include, revision data were limited ($n = 474$), isthmic spondylolisthesis ($n = 279$).
†Revisions were considered in any case of revision, e.g., primary fusion with a revision decompression, a complete revision procedure, reoperation or additional procedure.

living within 30 minutes of a hospital, BMI <42, clearance from a general practitioner and/or cardiologist, ASA score ≤3, and living with a responsible adult. Although age was not a significant criterion, other studies have reported that age older than 65 is a substantial risk factor for postoperative complications.[7,14] In their review of 4310 lumbar discectomy cases, of which 1652 were performed in the outpatient setting, Pugely et al.[7] found that age, diabetes, pre-existing wound infection, blood transfusion, and operative times longer than 150 minutes were independent risk factors for short term complications. Although LD is well-tolerated by most patients in the outpatient setting, our group urges caution when considering patients aged older 65 years, patients with diabetes, and those with an ASA ≥3.

Pre-emptive Analgesia

Preemptive analgesia is a powerful tool that is thought to reduce postoperative pain by prophylactic inhibition of the central autonomic hyperactivity that accompanies painful stimuli. This involves the administration of medications both in the preoperative holding area, and during the surgery itself. Previous research has found that preoperative administration of either nonsteroidal anti-inflammatory drugs, tramadol, COX-2 inhibitors, or opioids is

Table 4. Perioperative Characteristics

Operative Variables	Total ($n = 499$)*	1 Level ($n = 417$)	2 Level ($n = 68$)	≥3 Level ($n = 1$)
Decompression location				
L2—L3	0.8% (4)	0.9% (4)	0.0% (0)	0.0% (0)
L3—L4	4.6% (23)	5.4% (23)	0.0% (0)	0.0% (0)
L4—L5	39.1% (195)	45.5% (195)	0.0% (0)	0.0% (0)
L5-S1	41.5% (207)	48.3% (207)	0.0% (0)	0.0% (0)
L2—3 + L3—4	1.0% (5)	0.0% (0)	7.3% (5)	0.0% (0)
L3—4 + L4—5	5.6% (28)	0.0% (0)	40.6% (28)	0.0% (0)
L4—5 + L5-S1	7.2% (36)	0.0% (0)	52.2% (36)	0.0% (0)
L3—4 + L4—5 + L5-S1	0.2% (1)	0.0% (0)	0.0% (0)	100.0% (1)
Operative time,* mean ± SD, minutes	44.1 ± 13.3	41.9 ± 11.6	57.0 ± 15.0	74.0 ± 0.0
Estimated blood loss, mean ± SD, mL	26.6 ± 12.0	25.9 ± 5.9	30.8 ± 27.8	20.0 ± 0.0
Surgery center length of stay, mean ± SD, hours	2.5 ± 1.1	2.5 ± 1.1	2.4 ± 1.0	7.2 ± 0.0
VAS pain scores, mean ± SD, POD 0	4.6 ± 1.9	4.5 ± 1.9	4.8 ± 2.3	0.0 ± 0.0
Narcotic consumption, mean ± SD, OME, POD 0	20.5 ± 15.0	19.8 ± 13.4	25.0 ± 21.1	0.0 ± 0.0

SD, standard deviation; VAS, visual analog scale; POD, postoperative day; OME, oral morphine equivalents.
*Percentages were based on total n of patients without missing data; those that had $n < 499$ include operative time ($n = 485$), estimated blood loss ($n = 498$), hospital length of stay ($n = 483$), VAS postoperative day zero average ($n = 290$), OME postoperative day 0 average ($n = 357$).

Table 5. Postoperative Complications

Complications*	Total (n = 479)	1 Level (n = 410)	2 Level (n = 68)	≥3 Level (n = 1)
Complications	0	0	0	0
Acute renal failure	0	0	0	0
Altered mental status	0	0	0	0
Arrhythmia	0	0	0	0
Aspiration	0	0	0	0
Atelectasis	0	0	0	0
Dysphagia	0	0	0	0
Epidural hematoma	0	0	0	0
Fever	0	0	0	0
Ileus	0	0	0	0
Nausea and vomiting	7	6	1	0
Pleural effusion	0	0	0	0
Pneumonia	0	0	0	0
Pneumothorax	0	0	0	0
Postoperative anemia	0	0	0	0
Urinary retention	0	0	0	0
Urinary tract infection	0	0	0	0
Venous thromboembolism	0	0	0	0

*All patients discharged in less than 23 hours; no admissions or further hospitalizations required.

associated with lower self-reported levels of pain, fewer patients requiring PCA use, improved activity levels, lower depression scores, and improved self-care scores compared to traditional postoperative pain control.[15,16] Administration approximately 1 hour before the start of the procedure may also help to relieve patient anxiety.

Acetaminophen

Acetaminophen reduces cyclooxygenase activity primarily within the central nervous system and has been widely adopted in orthopedic surgery for postoperative pain management. In regards to Level I evidence within spine surgery, Cakan et al.[17] randomized patients undergoing lumbar laminectomy and discectomy to receive either 1000 mg of intravenous (IV) acetaminophen or a placebo within the concluding 15 minutes of the operation. They found that IV acetaminophen did not decrease overall narcotic requirements but was associated with improved postoperative pain scores. Shimia et al.[18] also found that the administration of 1000 mg of IV acetaminophen at the conclusion of lumbar discectomy was associated with improved analgesia and a nonsignificant decrease in opioid usage when compared with placebo. Acetaminophen is effective and cheap, relative to other available analgesics, with a large Cochrane Review suggesting that more than one half of patients across a number of subspecialties experience adequate postoperative pain control due to acetaminophen alone.[19]

Anticonvulsant Agents

Anticonvulsants such as gabapentin and pregabalin have commonly been used in spine surgery patients to treat neuropathic pain. These medications decrease sensory neuron excitability by inhibiting the release of neurotransmitters and may be effective for postoperative analgesia, treatment of spastic pain, preoperative anxiolysis, and chronic pain prevention.[20] Kim et al.[21] demonstrated that lumbar fusion patients who received 150 mg of pregabalin 1 hour before surgery and 12 hours after surgery used significantly less PCA over the first 48 hours postoperatively. Khurana et al.[22] reported that patients who underwent lumbar discectomy and received either 300 mg of gabapentin or 75 mg of pregabalin 1 hour before surgery followed by every 8 hours for 7 days experienced lower pain, disability, and opioid use up to 3 months postoperatively. A similar study also reported that use of 1200 mg of gabapentin 1 hour before surgery resulted in lower acute postoperative pain scores and less breakthrough opioid use.[23] Although these studies analyzed surgeries with greater morbidity and inpatient hospitalization, the same potential for pain relief and low side effect profile is ideal for the outpatient setting.

Our team also used the muscle relaxant cyclobenzaprine preoperatively, postoperatively, and upon discharge. Although muscle relaxants have not been widely studied in the perioperative period, their effectiveness has been well-established in the nonoperative setting. A Cochrane review of 30 randomized controlled trials analyzing the use of muscle relaxants in the management of low

Table 6. PROMs after Lumbar Decompression in the Outpatient Setting

PROM	Mean ± SD*	*P* Value†
VAS Back		
Preoperative	6.0 ± 2.6 (431)	–
6 weeks	2.9 ± 2.6 (350)	**<0.001**
12 weeks	3.4 ± 2.9 (231)	**<0.001**
6 months	3.5 ± 2.8 (175)	**<0.001**
1 year	3.5 ± 2.8 (113)	**<0.001**
2 years	3.9 ± 3.0 (64)	**<0.001**
VAS Leg		
Preoperative	6.1 ± 2.6 (420)	–
6 weeks	2.8 ± 2.7 (340)	**<0.001**
12 weeks	3.0 ± 2.9 (223)	**<0.001**
6 months	3.0 ± 2.8 (174)	**<0.001**
1 year	2.8 ± 2.8 (114)	**<0.001**
2 years	2.5 ± 2.9 (63)	**<0.001**
SF-12 MCS		
Preoperative	47.9 ± 11.6 (390)	–
6 weeks	52.7 ± 10.0 (267)	**<0.001**
12 weeks	52.6 ± 11.1 (164)	**<0.001**
6 months	53.0 ± 10.7 (145)	**<0.001**
1 year	52.1 ± 11.4 (142)	**<0.001**
2 years	50.7 ± 11.4 (99)	0.229
ODI		
Preoperative	43.0 ± 17.6 (427)	–
6 weeks	25.9 ± 19.0 (345)	**<0.001**
12 weeks	26.1 ± 20.2 (229)	**<0.001**
6 months	25.6 ± 19.0 (176)	**<0.001**
1 year	23.9 ± 20.5 (112)	**<0.001**
2 years	22.3 ± 20.1 (63)	**<0.001**
SF-12 PCS		
Preoperative	31.8 ± 7.9 (390)	–
6 weeks	38.1 ± 10.3 (267)	**<0.001**
12 weeks	39.8 ± 10.8 (164)	**<0.001**
6 months	40.1 ± 11.0 (145)	**<0.001**
1 year	41.1 ± 11.2 (143)	**<0.001**
2 years	43.6 ± 9.7 (99)	**<0.001**
PROMIS-PF		
Preoperative	36.1 ± 6.3 (281)	–
6 weeks	42.7 ± 8.0 (205)	**<0.001**
12 weeks	44.2 ± 9.8 (130)	**<0.001**
6 months	44.2 ± 9.2 (117)	**<0.001**
1 year	45.7 ± 10.8 (111)	**<0.001**
2 years	46.3 ± 9.1 (107)	**<0.001**

Values in bold indicate significance.
PROM, patient-reported outcome measures; SD, standard deviation; VAS, visual analog scale; SF-12, 12-Item Short Form; MCS, Mental Component Summary; ODI, Oswestry Disability Index; PCS, Physical Component Summary; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function; BMI, body mass index.
*Numbers in parentheses indicates number of patients.
†*P* values calculated using the *t* test.

back pain suggested there is strong evidence to support their use for short term relief in patients with acute low back pain.[24] We believe that a similar therapeutic effect is realized in the perioperative period and may be a valuable direction for future research.

Local Anesthesia

Local agents such as lidocaine and bupivacaine provide pain relief through the inhibition of voltage-gated sodium channels and persistent depolarization of sensory nerves. For outpatient surgery, these are typically administered as a one-time dose in the surrounding tissue near the conclusion of the procedure. This can provide substantial pain relief, particularly with procedures that involve a high degree of soft-tissue mobilization and stretching. Elder et al.[25] found that patients who received local 0.5% bupivacaine—hydrochloride had improved pain scores and reduced opioid use following posterior cervical fusion when compared with a case-matched cohort. Similarly, Reynolds et al.[26] found that administration of 0.25% bupivacaine was associated with significantly less opioid use following thoracolumbar fusion for idiopathic scoliosis when compared to patients who did not receive local anesthetic. Importantly, this local administration of anesthetic contributes to pain relief while also limiting systemic side effects.

Postoperative Nausea and Vomiting

A potential obstacle to discharge experienced by 7 of the patients in our cohort was the development of postoperative nausea and vomiting (PONV). The most common cause of PONV in this setting is the administration of opioid medications.[27,28] This potential for PONV can be decreased through the use of the above modalities, especially a reliance on local anesthesia that doesn't reach clinically significant systemic levels. Appropriate management of PONV with our protocol includes the preoperative administration of anti-emetics, such as ondansetron or metoclopramide, and adequate hydration.[29]

Postoperative Patient Status

Significant mean improvements in PROMs were observed at all time points and for all PROMs except for SF-12 MCS at 2 years. This would suggest that our patient cohort treated with our novel

MMA protocol in an outpatient setting had significant postoperative improvement in disability, physical function, and pain.

Limitations

There are notable limitations to present study. All surgeries were carried out by a single attending spine surgeon at set of ambulatory surgery centers associated with an academic hospital, limiting generalizability of results. The goal of the study was to validate the efficacy of an MMA protocol for LD in an outpatient spine setting. Given stringent selection criteria for outpatient surgery, patients selected as candidates were younger and in relatively good health. As such, conclusions on efficacy of this protocol in patients who have obesity (BMI >30), with significant comorbidity burdens, or are older (age >65) cannot be made. Although older patients and patients with less health may experience a similar degree of pain relief, there most likely will differences in outcome measures. Although prevalence of spine surgery in an outpatient setting is increasing, the field is still in its relative infancy. Future studies will need to replicate and validate anesthesia protocols in patient population who have obesity with greater comorbidity burden. The current study was retrospective case review and as such did not include a control group for comparison. Inclusion of a control group would have strengthened our study. Although we were pleased with these reported outcomes, future fine-tuning of the protocol may result in better pain control with less narcotics consumed.

CONCLUSIONS

The number of spine surgeries being performed in ambulatory surgery centers is rapidly growing. This is especially true for lumbar laminectomy and discectomy, which are both incredibly common and have the longest proven record of safety in this setting. Adequacy of pain control remains a key factor in the success of these procedures. In this study, our group introduces a specific multimodal protocol based on a review of high-quality literature and our own clinical experience. Similar groups may learn from our findings and adopt aspects to their own unique MMA protocols.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Michael T. Nolte: Conceptualization, Methodology, Visualization, Formal analysis, Software, Investigation, Writing — original draft, Writing — review & editing. **James M. Parrish:** Conceptualization, Methodology, Visualization, Formal analysis, Software, Investigation, Writing — original draft, Writing — review & editing. **Nathaniel W. Jenkins:** Conceptualization, Methodology, Visualization, Formal analysis, Software, Investigation, Writing — original draft, Writing — review & editing. **Elliot D.K. Cha:** Writing — original draft, Writing — review & editing. **Conor P. Lynch:** Writing — original draft, Writing — review & editing. **Caroline N. Jadczak:** Project administration, Data curation, Investigation, Writing — review & editing. **Cara E. Geoghegan:** Project administration, Data curation, Investigation, Writing — review & editing. **Shruthi Mohan:** Project administration, Data curation, Investigation, Writing — review & editing, Conceptualization, Methodology, Supervision, Resources, Investigation, Writing — review & editing. **Jeffrey Podnar:** Conceptualization, Methodology, Supervision, Resources, Investigation, Writing — review & editing. **Asokumar Buvanendran:** Conceptualization, Methodology, Supervision, Resources, Investigation, Writing — review & editing. **Kern Singh:** Conceptualization, Methodology, Supervision, Resources, Investigation, Writing — review & editing.

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