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Multimodal Analgesic Management for Cervical Spine Surgery in the Ambulatory Setting

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ABSTRACT

Background: Patient selection and analgesic techniques, such as the multimodal analgesic (MMA) protocol, aid in ambulatory surgical center (ASC) cervical spine surgery. The purpose of this case series is to characterize patients undergoing anterior cervical discectomy and fusion (ACDF) and total cervical disc replacement (CDR) in an ASC with an enhanced MMA protocol.

Methods: A prospectively maintained registry was retrospectively reviewed for cervical surgeries between May 2013 and August 2019. Inclusion criteria included ASC patients who underwent single-level or multilevel CDR or ACDF using an MMA protocol. Baseline, intraoperative, and postoperative characteristics were recorded, including length of stay, visual analog scale pain scores, neck disability index, complications, and narcotics administered.

Results: A total of 178 patients met inclusion criteria with 125 single-level, 52 two-level, and 1 three-level procedure. Of those patients, 127 underwent ACDF and 51 underwent CDR. The longest procedure was 95 minutes and the mean length of stay was 6.1 hours, with 2 patients requiring hospital admission. All other patients were discharged within 10 hours. One of the admitted patients experienced a postoperative seizure that was later determined to be secondary to drug use and serotonin syndrome. The second patient developed an anterior cervical hematoma 5 hours postoperatively, which was immediately evacuated. The patient was admitted for observation and discharged the next day.

Conclusion: In our study, patients experienced considerable improvement in disability scores, with a low likelihood of postoperative complications. A safe and effective MMA protocol may help facilitate anterior cervical surgery in the outpatient setting.

Level of Evidence: 3.

Clinical Relevance: Transitioning anterior cervical discectomy and fusions to the ASC requires an appropriate MMA protocol. Our findings reveal that an enhanced MMA protocol will help improve disability scores while keeping the likelihood of postoperative complications low. This supports the ASC setting for cervical spine procedures in appropriate patient populations.

Cervical Spine

Keywords: cervical spine surgery, anterior cervical discectomy and fusion, cervical disc replacement, multimodal analgesia

INTRODUCTION

Anterior cervical spine surgery, namely anterior cervical discectomy and fusion (ACDF) and total cervical disc replacement (CDR), comprises well-studied treatments for degenerative conditions of the cervical spine that have been observed to facilitate excellent longitudinal clinical outcomes. Furthermore, improvements in minimally invasive surgery, along with advances in anesthesia and analgesic techniques, have enabled these surgeries to take place in the outpatient setting and ambulatory surgery centers (ASC) more than ever before. One of the key barriers to widespread adoption, however, is ensuring safe and sufficient pain control. Appropriate management of pain has been associated with both increased patient satisfaction and lower complication rates.[1,2] Furthermore, when compared with the inpatient hospital setting, ambulatory cervical spine surgery has been associated with superior short-term outcomes, lower complication rates, and lower direct costs related to the procedure.[3–6] Although anesthesia-related factors such as preoperative diet, patient optimization, and avoid-

Table 1. Multimodal analgesic regimen for outpatient spine surgery.

Prior to Admission
Preoperative patient counseling regarding intraoperative and postoperative analgesia at spine surgeon's office.
Day of Surgery
Preoperatively: Oral medications given in holding area about 1 hour prior to 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

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

ance of extended preoperative fasting have all increased the ability to perform ambulatory surgery, multimodal analgesia (MMA) is the key differentiating factor associated with more rapid recovery, decreased opioid use, a lower rate of complications, and increased patient satisfaction.[3,7]

Prior research efforts regarding cervical spine surgery in the outpatient setting have focused on the characterization and avoidance of complications, patient selection criteria, and inpatient admission rates following surgery.[5,8–13] Studies examining the role of an MMA protocol have been limited. Although some efforts have analyzed the effectiveness of MMA protocols for cervical spine surgery in the inpatient setting, the outpatient and ASC settings pose a number of unique challenges that warrant separate investigation. In this study, we highlight a detailed MMA protocol in the ASC setting and report findings from our initial clinical experience. We believe that doing so may help guide surgical teams aiming to grow and streamline their anterior cervical spine surgeries in the ASC setting.

METHODS

Patient Population

Following institutional review board approval (ORA No. 14051301), we performed a retrospective review of consecutive patients undergoing anterior cervical spine surgery, either ACDF or CDR, from a prospectively maintained surgical registry. All surgeries were performed between May 2013 and November 2018 by a single senior surgeon at our institution. Patients included in the study were treated for degenerative spinal pathologies. Empiric medical treatment for these conditions was attempted without symptom relief for all patients prior to operative management. Nonsurgical therapy included the use of anti-inflammatory medications, corticosteroid injections, local anesthetics, and physical therapy. Prior to undergoing cervical spine surgery, each patient was assessed and cleared for surgery by an anesthesiologist and primary care physician.

All patients underwent either a primary or revision single-level or multilevel ACDF or CDR using a standard anterior approach to the cervical spine. Prophylaxis for deep venous thrombosis was achieved through the use of ambulation, and no chemical prophylaxis was used. All patients received a unique MMA protocol specifically designed for the ambulatory setting (Table 1). The ASC did not allow for observation of patients for periods of time greater than 23 hours. All patients who underwent cervical surgery were required to receive a same-day discharge. Per state regulations, the ASC was located within 30 minutes of a hospital with inpatient and intensive care unit capabilities. In the event of an emergency that cannot be adequately treated at the ASC, patients would be transferred to this hospital via ambulance.

Data Collection

Patient demographic factors recorded included age, sex, body mass index (BMI), smoking status,

Charlson Comorbidity Index (CCI), American Society of Anesthesiologists (ASA) score, and preoperative diagnosis. These diagnoses included cervical spinal stenosis, degenerative disc disease, degenerative spondylolisthesis, foraminal stenosis, herniated nucleus pulposus, myelomalacia, myelopathy, myeloradiculopathy, and radiculopathy. Preoperative medical conditions that were recorded at the time of the medical clearance appointment, including arthritis, asthma, cancer, diabetes, hyperlipidemia, hypertension, liver disease, and peripheral vascular disease, were also recorded.

Perioperative characteristics that were recorded included operative location, operative time, estimated blood loss, and ambulatory center length of stay. Patient-reported outcomes including the visual analog scale (VAS) pain score and neck disability index (NDI) score were recorded prior to ASC discharge. Narcotic consumption prior to discharge was calculated following a standard conversion into units of oral morphine equivalents (OME). Postoperative complications were recorded, including acute renal failure, airway obstruction, altered mental status, atelectasis, atrial fibrillation, atrial flutter, aspiration, epidural hematoma, ileus, nausea and vomiting, postoperative anemia requiring transfusion, pulmonary embolism, pneumothorax, seizure of unknown origin, urinary retention, urinary tract infection, and venous thromboembolism.

Surgical Technique

Patients were intubated and placed on the operating table in the supine position. The surgical level was confirmed and localized with intraoperative radiographic fluoroscopy. Injection of local anesthetic, bupivacaine 0.5% with epinephrine 1:200 000, was made to each surgical site prior to incision. A 2- to 3-cm transverse incision medial to the sternocleidomastoid muscle was made through the skin and subcutaneous fat. The Smith-Robinson approach was used, and the platysma muscle was transversely dissected with an incision that was aligned with that of the skin. Next, the sternocleidomastoid muscle and carotid sheath were laterally retracted, and the esophagus, trachea, and thyroid were medially retracted. Further blunt dissection was conducted down to the vertebral body and the pertinent disc space was identified.

Fluoroscopic radiographs were again used to confirm the surgical level. The annulus was then incised. Curved and straight curettes were used to remove the disc material and end-plate cartilage. Resection of the posterior longitudinal ligament was then accomplished with a Kerrison rongeur. Adequate preparation of the disc space was ensured. For patients undergoing ACDF, local autograft, allograft, or bone graft substitute was used to fill an appropriately sized interbody cage, and the cage was placed into the disc space. To help prevent interbody movement and subsidence, supplemental plate fixation was used. For patients undergoing CDR, following disc space preparation various size trials were used and checked under fluoroscopic guidance. Once the ideal size was agreed upon, the CDR implant was placed into the disc space. Once instrumentation was finished, the wound was thoroughly irrigated and evaluated for homeostasis.

RESULTS

Demographic Characteristics

A total of 178 patients met inclusion criteria. Of these, 125 patients underwent a single-level procedure, 52 patients underwent a 2-level procedure, and 1 patient underwent a 3-level procedure (71.3% underwent ACDF, 28.7% underwent CDR; Table 2). The overall cohort consisted of 63.5% men with a mean age of 46.7 ± 9.1 years. Mean BMI was 28.6 ± 4.4 kg/m^2, and 22 patients reported tobacco use at their preoperative appointment. The mean CCI was 0.46 ± 0.8, with the majority of patients (55%) having an ASA score of 2. Preoperative chronic medical conditions and comorbidities were as follows: hypertension (29), asthma (15), hyperlipidemia (3), cancer (2), uncomplicated diabetes mellitus (8), liver disease (1), and peripheral vascular disease (1). Of note, there were no patients in our cohort with a recorded medical history of myocardial infarction, chronic lung disease, renal failure, or gastrointestinal bleeding.

Perioperative and Postoperative Characteristics

A total of 127 patients underwent an ACDF, of which 92.7% were primary procedures (Tables 3 and 4). A total of 51 patients underwent a CDR, of which 90.2% were primary procedures. The most common preoperative diagnosis was myeloradiculopathy for both patients undergoing ACDF (59.8%) and those undergoing CDR (24.1%).

Table 2. Patient demographics and baseline characteristics.

	Total (N = 178)[a]	1 Level (n = 125)	2 Level (n = 52)	≥3 Level (n = 1)
Age, mean ± SD, y	46.7 ± 9.1	45 ± 8.9	52.2 ± 8.8	44.0
Gender, % (n)				
Female	36.5 (65)	36 (45)	38.5 (20)	0.0 (0)
Male	63.5 (113)	64 (80)	61.5 (32)	100.0 (1)
Body mass index (mean ± SD, kg/m^2)	28.6 ± 4.4	29.0 ± 4.5	27.6 ± 4.2	29.8
Smoking status, % (n)				
Nonsmoker	87.4 (153)	86.2 (106)	90.2 (46)	100.0 (1)
Smoker	12.6 (22)	13.8 (17)	9.8 (5)	0.0 (0)
Charlson Comorbidity Index, mean ± SD	0.46 ± 0.8	0.47 ± 0.8	0.44 ± 0.6	0.0 ± 0.0
ASA score, % (n)				
1	45.0 (49)	43.4 (32)	47.1 (16)	100.0 (1)
2	50.5 (55)	54.1 (40)	44.1 (15)	0.0 (0)
≥3	4.6 (5)	2.7 (2)	8.8 (3)	0.0 (0)
Preoperative diagnoses, % (n)[b]				
Hypertension	16.6 (29)	14.6 (18)	21.6 (11)	0.0 (0)
Asthma	8.4 (15)	8.8 (11)	7.7 (4)	0.0 (0)
Arthritis	7.4 (13)	8.1 (10)	5.9 (3)	0.0 (0)
Hyperlipidemia	1.7 (3)	0.8 (1)	3.9 (2)	0.0 (0)
Cancer	1.1 (2)	1.6 (2)	0.0 (0)	0.0 (0)
Uncomplicated diabetes mellitus	4.6 (8)	3.3 (4)	7.8 (4)	0.0 (0)
Liver disease	0.6 (1)	0.8 (1)	0.0 (0)	0.0 (0)
Peripheral vascular disease	0.6 (1)	0.8 (1)	0.0 (0)	0.0 (0)

Abbreviation: ASA, American Society of Anesthesiologists.
[a]Percentages were based on total n of patients without missing data; those that had n < 178 include hypertension, arthritis, cancer, uncomplicated diabetes mellitus, liver disease (n = 175), peripheral vascular disease (n = 174).
[b]There were no patients in our study with a recorded medical history of myocardial infarction, renal failure, chronic lung disease, or gastrointestinal bleeding.

The most common operative level was C6-C7 (30.9%; Table 5). The longest surgical case was 95 minutes with 1 outlier for length of stay at 23 hours (first cervical procedure performed at the ASC). The mean length of stay was 6.1 ± 2.5 hours, and 2 patients required admission at a local hospital. All patients, aside from the first, were discharged within 10 hours of the procedure end. The mean postoperative VAS pain score prior to discharge was 5.1 ± 2.5. The mean narcotics consumed following surgery prior to discharge was 31.4 ± 17.6 OME. The cohort reported considerable improvement in NDI during the postoperative period at 6 weeks (32.1 ± 19.3), 12 weeks (29.5 ± 18.9), 6 months (28.2 ± 19.4), and 1 year (26.4 ± 20.4).

A total of 6 complications were observed in patients during the immediate postoperative period in the ASC (Table 6). Postoperative nausea and vomiting constituted 4 of the complications. All 4 of these patients were discharged in less than 23 hours and did not require admission. Two patients required admission to the hospital following surgery. One of these patients used illicit drugs prior to surgery, a practice unbeknown to our team or the anesthesia providers, and experienced a postoperative seizure of unknown origin. The patient was admitted to a local academic hospital, and the seizures were subsequently determined to be secondary to serotonin syndrome**.** The second admitted

Table 3. Preoperative spinal diagnoses (N = 178).

	Cervical Procedures, N = 178[a]			
	ACDF, n = 127		CDR, n = 51	
	Primary, % (n)	Revision, % (n)[b]	Primary, % (n)	Revision, % (n)[b]
Herniated nucleus pulposus	49.4 (86)	1.7 (3)	16.7 (29)	0.6 (1)
Degenerative disc disease	3.4 (6)	2.3 (4)	2.9 (5)	0.0 (0)
Cervical spinal stenosis	35.1 (61)	4.6 (8)	12.1 (21)	1.7 (3)
Myelomalacia	0.6 (1)	0.0 (0)	0.0 (0)	0.0 (0)
Degenerative Spondylolisthesis	0.0 (0)	0.6 (1)	0.0 (0)	0.6 (1)
Foraminal stenosis	6.3 (11)	2.3 (4)	1.1 (2)	0.0 (0)
Radiculopathy	5.7 (10)	0.6 (1)	1. (2)	0.6 (1)
Myelopathy	0.0 (0)	0.0 (0)	0.6 (1)	0.0 (0)
Myeloradiculopathy	59.8 (104)	2.9 (5)	24.1 (42)	1.7 (3)

[a]Percentages were based on total n of patients without missing data; revision data was limited for 4 patients (n = 174).
[b]Revisions were considered in any case of revision (eg, primary fusion with a revision decompression, a complete revision procedure, reoperation, or additional procedure).

Table 4. Total procedures: primary and revisions (N = 178).[a]

	Primary, % (n)	Revision, % (n)[b]
ACDF (n = 127)	66.1 (115)	5.2 (9)
CDR (n = 51)	26.4 (46)	2.3 (4)

[a]Percentages were based on total n of patients without missing data for all cervical procedures; revision data was limited (n = 174).
[b]Revisions were considered in any case of revision (eg, primary fusion with a revision decompression, a complete revision procedure, reoperation, or additional procedure).

Table 5. Perioperative characteristics.

	Total (n = 178)[a]	1 Level (n = 125)	2 Level (n = 52)	≥3 Level (n = 1)
Operative location, % (n)				
C3-C4	2.8 (5)	4 (5)	0.0 (0)	0.0 (0)
C4-C5	5.1 (9)	7.2 (9)	0.0 (0)	0.0 (0)
C4-C6	7.3 (13)	0.0 (0)	25.0 (13)	0.0 (0)
C4-C7	0.6 (1)	0.0 (0)	0.0 (0)	100.0 (1)
C5-C6	29.8 (53)	42.4 (53)	0.0 (0)	0.0 (0)
C5-C7	22.5 (40)	1.6 (2)	73.1 (38)	0.0 (0)
C6-C7	30.9 (55)	44.0 (55)	0.0 (0)	0.0 (0)
C6-T1	0.6 (1)	0.0 (0)	1.9 (1)	0.0 (0)
C7-T1	0.6 (1)	0.9 (1)	0.0 (0)	0.0 (0)
Operative time[b], mean ± SD, min	63.2 ± 56.8	60.7 ± 67.3	69.1 ± 7.8	83.0
Estimated blood loss, mean ± SD, mL	27.7 ± 9.6	27.2 ± 7.3	29.1 ± 13.8	25.0
Surgery center length of stay, mean ± SD, h	6.1 ± 2.5	5.9 ± 2.3	6.3 ± 2.9	6.7
VAS pain scores, mean ± SD				
POD 0	5.1 ± 2.5	5.0 ± 2.5	5.4 ± 1.9	6.4
Narcotic consumption, mean ± SD, OME				
POD 0	31.4 ± 17.6	29.9 ± 17.3	34.3 ± 17.9	51
NDI, mean ± SD				
Preoperative	40.8 ± 18.5	40.5 ± 17.6	40.9 ± 20.8	50
6 wk	32.1 ± 19.3	32.8 ± 19.9	30.7 ± 18.0	30
12 wk	29.5 ± 18.9	30.1 ± 19.3	28.3 ± 16.8	32
6 mo	28.2 ± 19.4	28.8 ± 20.7	26.7 ± 15.0	14
1 y	26.4 ± 20.4	28.7 ± 20.8	19.8 ± 18.7	—

Abbreviations: NDI, Neck Disability Index; OME, oral morphine equivalents; POD, postoperative day; VAS, visual analog scale.
[a]Percentages were based on total n of patients without missing data; those that had n<178 include estimated blood loss (n = 170), hospital length of stay (n = 165), VAS postoperative day zero average (n = 114), OME postoperative day zero average (n = 114), preoperative NDI (n = 153), 6-wk NDI (n = 132), 12-wk NDI (n = 112), 6-mo NDI (n = 88), 1-y NDI (n = 34)
[b]There were no patients in our study with a recorded medical history of myocardial infarction, renal failure, chronic lung disease, or gastrointestinal bleeding.

patient developed an anterior cervical hematoma that was noted 5 hours postoperatively during the observational period. The hematoma caused shortness of breath concerning for airway obstruction and was immediately evacuated at the ASC. The patient was subsequently admitted to a local academic hospital for 23-hour observation. Both patients were uneventfully discharged the next day following surgery.

Table 6. Postoperative complications.

Complications	Total (N = 178)	1 Level (n = 125)	2 Level (n = 52)	≥3 Level (n = 1)
	0	0	0	0
Acute renal failure	0	0	0	0
Airway obstruction[a]	1	0	1	0
Altered mental status	0	0	0	0
Aspiration	0	0	0	0
Epidural hematoma	0	0	0	0
Ileus	0	0	0	0
Nausea and vomiting[b]	4	3	1	0
Postoperative anemia	0	0	0	0
Seizure of unknown origin[c]	1	1	0	0
Urinary retention	0	0	0	0
Urinary tract infection	0	0	0	0
Venous thromboembolism	0	0	0	0

[a]Single patient received immediate evacuation of cervical hematoma that developed at 5 h postoperatively, transferred to inpatient hospital for observation, and was uneventfully discharged following morning.
[b]All patients discharged in less than 23 h; no admissions or further hospitalizations required.
[c]Single patient was emergently transferred with seizures postoperatively and diagnosed with serotonin surge secondary to illicit drug use prior to surgery

DISCUSSION

Patient Selection

Successful cervical spine surgery in the ambulatory setting begins with appropriate patient selection. Careful screening is essential due to the diminished number of care providers and emergency services compared with the inpatient hospital setting. Exclusion criteria such as obesity, history of chronic obstructive pulmonary disease, hypertension, and stroke have been previously suggested as a general guideline for outpatient surgery, but more specific criteria is needed for cervical surgery.[14] Unfortunately, there has been a paucity of literature guiding successful patient selection specifically for cervical spine surgery in the ambulatory surgical setting.

In light of this, we have proposed multifaceted recommendations for patient selection for cervical surgery in the ASC setting (Table 7). These are based not only on our clinical experience with 178 patients but also the available literature from the inpatient and nonambulatory setting. For example, Bovonratwet et al[8] observed that patients with the following risk factors were more likely to experience postoperative hematoma requiring reoperation following ACDF: preoperative international normalized ratio (INR) > 1.2 relative risk [RR] = 2.85,

Table 7. Recommendations for patient selection for cervical surgery in ASC settings.

Patient factors that may exclude patients from ASC
INR > 1.2[8]
Extremes of BMI[8a]
Medical comorbidities (eg, asthma, NYHA grade 3-4 CHF,[9] myocardial infarction within 6 months,[9] angina pectoris,[9] ASA score ≥ 3,[10,11] increased risk of thromboembolism,[15] nonadherent obstructive sleep apnea[9])
Patient preference
Live greater than 30 min from a hospital[12,13]
No responsible adult that can stay with them to supervise and provide basic care for at least 24 h[12,13]
Surgical factors that may exclude patients from ASC
Operative time (>5 h)
EBL (>300 mL)
>3-Level Procedures

Abbreviations: ASA, American Society of Anesthesiologists; ASC, ambulatory surgical center; BMI, body mass index; CHF, congestive heart failure; EBL, estimated blood loss; NYHA, New York Heart Association.
[a]Interpret in the context of other comorbidities; obesity alone has been observed to have no impact on cervical surgery outcome[16,17,18]; others have observed BMI > 42 to contribute to increased costs[19]; low BMI (≤24) has been found to increase chances of hematoma.[8]

lower BMI (≤24) [RR] = 2.11, ASA ≥ 3 [RR] = 1.67, and male sex [RR] = 1.67. Similarly, patients with BMIs greater than 40 kg/m^2 undergoing cervical spine procedures have an increased risk of experiencing postoperative pulmonary embolism or deep vein thrombosis (odds ratio = 3.34).[20] Adamson et al[10] performed a retrospective review of patients undergoing ACDF both in the outpatient ambulatory center and inpatient setting. They reported[10] a mean age of 49.5 years, a female majority (51.6%), and the majority having ASA ≤ 2. They found that patients undergoing 3 or more levels had a higher risk of experiencing cervical hematomas and dysphagia, a finding that has been supported in other research.[10,16] Efforts made to minimize operative time (<5 hours) and blood loss (<300 mL) may successfully reduce the risk of cervical hematoma and dysphagia, which can result in prolonged intubation and reintubation when present.[22]

The patient cohort in the present study was consistent with those of similar research in that patients were generally thin (mean BMI of 28.6 kg/m^2), healthy (majority of patients with ASA score ≤ 2), mostly women, aged less than 50 years, and undergoing 1- or 2-level procedures. Considering the findings of the present study and the recent pertinent literature, we have proposed the following exclusion criteria for cervical spine surgery in the ambulatory setting: age greater than 50 years; BMI less than 24 kg/m^2 or greater than 40 kg/m^2; INR greater than 2, ASA score greater than or equal to 2, and preoperative comorbid conditions such as asthma, New York Heart Association grade ≥3 congestive heart failure, myocardial infarction within 6 months, angina pectoris, or nonadherent obstructive sleep apnea (Table 7).[9]

ASC Considerations

Performing cervical surgery within the ASC raises a number of unique considerations and challenges. Surgeons must consider their patient population, the extent of surgery performed in regards to the degree of preoperative pathology and number of levels operated on, whether the facility has contracts with specific medical device companies, and personal experience of the surgeon. There is also concern regarding internal and financial bias, because several studies have suggested that physician ownership of ASCs may influence practice patterns and surgical efficiencies.[23,24] Despite potential shortcomings and conflicting interests, inherent attributes of the ASC appear to contribute to improved efficiency. Dedicated staff and operating rooms have contributed to decreased operative duration, estimated blood loss, and increased efficiency.[25–27] Furthermore, single-specialty ASCs have been associated with even lower rates of surgical site infection than multispecialty facilities.[28]

Number of Levels Involved in Operation

When assessing cervical spine surgery, both ACDF and CDR procedures are generally well-tolerated with positive outcomes. For either procedure, a critical presurgical consideration is the number of levels involved in the operation. Single-level ACDF, for example, is one of the most common spine surgeries performed, with generally good outcomes. Given its generally short operative duration, manageable postoperative pain, and a relatively lower requirement for postoperative care, it has been successfully adopted in the outpatient setting.[29] However, considerable concern remains about performing multilevel surgery.

The potential for a postoperative retropharyngeal hematoma is one of the most feared complications associated with ACDF procedures, particularly those involving multiple operative levels. Few studies have investigated the association of multilevel ACDF and retropharyngeal hematoma in the outpatient setting. Although hematomas can occur days after surgery, studies have suggested that these clinically severe hematomas tend to be detected

within 4 to 6 hours postoperatively.[30,31] Whereas research suggests that a 6-hour observational period is the maximum time required after ACDF procedures, the same studies either do not specify the number of levels operated upon or are based on single-level procedures. Unfortunately, studies examining the relationship between multilevel ACDF and postoperative complications such as retropharyngeal hematoma tend to be based on large institutional datasets,[32–34] and 3-level case investigations are especially limited.[29] On the basis of our findings, when patients are selected and counseled appropriately, a multilevel ACDF can be safely performed in the ASC setting.

Postoperative Consideration

Pain Management

The enhanced MMA protocol used within the ASC setting is integral to delivering effective analgesia and adequately managing pain in the perioperative setting. At the heart of a successful MMA protocol is the principle that several analgesics used in a timely combination can result in a synergistic effect. This approach is able to overcome several difficulties that more conventional analgesic techniques still face. First, the use of several medications allows for the synergistic targeting of numerous unique pain pathways. In addition, because MMA is underpinned by more than 1 medication, a lower dose of each medication can be used, thereby minimizing side-effect profiles. Not only does this allow for less usage of potentially habit-forming narcotics, but it also facilitates reduced dosages of medications that could impair patient recovery. An additional advantage unique to spine and orthopedic surgery is the ability to reduce the use of nonsteroidal anti-inflammatory medications due to concerns with impaired arthrodesis.[35]

Postoperative Nausea and Vomiting

A potential obstacle to discharge experienced by 4 of the patients in this study was the development of postoperative nausea and vomiting (PONV).[36] A significant cause of PONV is the administration of opioid medications, which may be prevented through generous application of local anesthetic intraoperatively and postoperative nonnarcotic medications.[36,37] Management of PONV includes preoperative administration of antiemetics (ondansetron or metoclopramide) and adequate hydration.[9]

Postoperative Serotonin Syndrome

A single patient experienced postoperative serotonin syndrome, which was a result of preoperative illicit drug use. The classical triad of symptoms includes neuromuscular abnormalities, altered mental status, and autonomic hyperactivity.[38] Intraoperatively and postoperatively it may be challenging to recognize these symptoms.[39] A key is identifying medications that can contribute to these symptoms. These include common antidepressants (citalopram, fluoxetine, venlafaxine, trazodone), abused opioids (fentanyl, methadone), illicit drugs (MDMA, LSD), and many others.[38,40] After clinically diagnosing serotonin syndrome, management includes removing the offending medication, supportive therapy, and administration of a 5-HT_{2A} antagonist such as cyproheptadine.[38]

CONCLUSIONS

This case series is the one of the largest to date of patients undergoing anterior cervical spine surgery within the ASC with no planned 23-hour observation period. With appropriate patient selection, surgical technique, and a MMA protocol, we were able to effectively perform both ACDF and CDR in the ASC setting. In total, 175 of 178 of the assessed patients were discharged from the surgical center on the day of surgery, and pain was adequately controlled for all patients. Disability scores universally improved in response to surgery, and the few complications were rapidly identified and appropriately treated. For an appropriately chosen patient population, it appears as though outpatient cervical spine surgery with an MMA protocol is a safe and effective treatment option.

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