Minimally Invasive Spine Surgery Techniques in the Ambulatory Setting: Are they Safe and Effective?

Dominic D. Villa, MD,[1] Evangeline K. Villa, MD[1] and Rafael C. Bundoc, MD[2]

[1]*Department of Anesthesiology, College of Medicine and Philippine General Hospital, University of the Philippines Manila*
[2]*Department of Orthopedics, College of Medicine and Philippine General Hospital, University of the Philippines Manila*

ABSTRACT

Background. Minimally invasive spine surgical techniques (MISST) are associated with less intraoperative blood loss, shorter duration of surgery, and less post-operative pain. In the last two decades, MISST have been performed on an outpatient basis in developed countries but it is still performed primarily on an inpatient basis in the Philippines. This study aims to determine the safety and effectiveness of performing MISST in an ambulatory surgical center in the Philippines.

Methods. A retrospective chart review of patients who underwent MISST in an ambulatory surgical center (ASC) in Manila, Philippines, from January 2014 to December 2018 was done. The different types of MISST were identified and analyzed as to patient demographic characteristics, anesthetic perioperative management, outcomes and complications.

Results. Out of 337 patients included in the review, 8 types of MISST were identified. The average patient age was 55.61 years. Majority (98.2%) of the patients were classified as American Society of Anesthesiologists (ASA) physical status I or II.

All patients had a statistically significant ($p < 0.05$) reduction in pain scores. ASC length of stay varied based on the complexity of the procedure ranging from 2.1 to 12.9 hours. There was a 0.89% incidence of surgery-related complications. Majority (94.4%) of the patients were discharged to home. There was no mortality.

Conclusion. Even in a developing country, transitioning MISST from inpatient to the ambulatory setting can be performed with minimal complications and unplanned hospital admissions while still achieving significant pain reduction. The key elements include careful patient selection, close coordination between the anesthesia and spine surgical teams, and provision of multimodal analgesia.

Key Words: minimally invasive spine surgery, ambulatory surgery, multimodal analgesia, MISST

INTRODUCTION

Back pain remains a common public health problem despite medical advances and improved access to health care. It affects both genders and all socioeconomic status globally. Disability-adjusted life-years from neck and low back pain has even increased by 18.7% over the last 10 years (2005-2015).[1] Low back pain remains the top leading cause of disability in the Philippines and is the most common type of occupational disease affecting Filipinos.[2,3] Most back pain can be managed medically; but when conservative measures fail, the option of surgical treatment is considered.

Recognition of the association between sciatica and disc herniation in the 1930s led to surgical approaches to address it.[4] However, the restoration of function post-operatively proved to be a challenge. In 1931, Burman pioneered the

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Corresponding author: Dominic D. Villa, MD
Department of Anesthesiology
College of Medicine
Philippine General Hospital
University of the Philippines Manila
Taft Avenue, Ermita, Manila 1000, Philippines
Email: ddvilla1@up.edu.ph

concept of direct spinal cord visualization via myeloscopy.[5] Although promising, complications related to insertion of a large-bore scope into the dural cavity led to its natural falling out.

Technological advances involving real-time intraoperative imaging in the form of fluoroscopy and incorporation of endoscopes renewed interest in minimally invasive spine surgery. By 1997, MED system consisting of a series of concentric dilators and thin-walled tubular retractors of variable length allowing for a minimally invasive splitting approach was introduced into clinical practice.[4] Since then, the range of MISST has evolved to include placement of implants such as transforaminal lumbar interbody fusion (TLIF), balloon kyphoplasty (BKP), and interspinous process decompression (IPD).

A shorter hospital stay, less blood loss, less postoperative pain, faster return to work, and cost savings are reasons for its acceptance and popularity.[6-8] It even appears to be preferred over the open technique among patients with risk factors such as advanced age, obesity, and smoking history.[9]

These promising results coupled with preoperative screening and increasing use of multimodal analgesia has allowed MISST to be performed in an ambulatory setting in developed countries for the past two decades with a note of lower complication rates compared to those treated as inpatients.[10,11] Recently, the feasibility and safety of outpatient microscopic lumbar discectomy in a developing country was published.[12]

In the Philippines, MISST are primarily performed on an inpatient basis. The general objective of this study is to determine the safety and effectiveness of performing MISST in the ambulatory setting. The specific objectives include describing the demographic profile of the patients, perioperative anesthetic management, outcomes and complications.

METHODOLOGY

Upon approval by the UP-Manila Review and Ethics Board, this retrospective study was conducted in QualiMed Manila, a free-standing private multi-specialty outpatient diagnostic and surgical center situated within the University of the Philippines Manila – Philippine General Hospital grounds.

The study population included patients who underwent elective minimally invasive spine surgery technique (MISST) under general anesthesia or intravenous sedation performed by a single orthopedic spine surgeon and a dedicated team of two anesthesiologists from January 1, 2014 to December 31, 2018. Patients who had percutaneous neuroforaminal steroid injection under local anesthesia were excluded.

Eligible charts were identified through automatic query of QualiMed Manila's electronic health information system (Bizbox). Search terms that were used in the Bizbox were minimal access spine technique discectomy, minimal access spine technique decompression, balloon kyphoplasty, transforaminal lumbar interbody fusion, percutaneous endoscopic lumbar discectomy, interspinous process decompression, and transpedicular spine biopsy. To ensure that all eligible charts were identified, results from the Bizbox query were counterchecked by manual review of the ASC's logbook of operating room (OR) cases. Once retrieved, these paper charts were handed over to a trained independent data abstractor for data collection.

Collected data included demographic variables, American Society of Anesthesiologists (ASA) physical status classification, surgical procedure, anesthetic technique, anesthetic agents used, duration of surgery, amount of blood loss, intraoperative and post-operative pain meds, post-anesthesia care unit (PACU) rescue meds, complications, pre-operative and post- operative pain scores, total length of stay in ASC and disposition.

Data were encoded in and analyzed using Microsoft Excel 2016. Continuous variables were reported as mean values ± standard deviations and discrete variables were reported as percentages. Normality of data distribution was checked using the Shapiro-Wilk test. Wilcoxon signed rank test was used to analyze statistical significance. A P value of less than 0.05 was considered significant.

RESULTS

Demographic profile of patients

A total of 337 patients were included in the study. We identified 8 types of MISST. The average patient age was 55.61 years. The youngest patient was a 5-year-old boy who underwent transpedicular spine biopsy (TSB) to rule out Pott's disease versus malignancy while the oldest patient was a 92-year-old man who underwent BKP for an L1 vertebra osteoporotic vertebral compression fracture (OVCF). There was almost equal distribution of men and women. A majority (70.1%) of patients had a normal BMI or were slightly overweight. Obese patients accounted for less than 10%. (Table 1)

Almost all (98.2%) of the patients were classified as ASA Classification I or II. Six patients classified as ASA III had multiple comorbidities with an age range of 66–87 years. Majority (83.3%) were taking combination anti-coagulants (clopidogrel and aspirin) chronically, which were discontinued seven days before the surgery. They were all optimized medically by an internist, had uneventful surgeries and were discharged home after the surgery.

Anesthetic Management

Pre-operative

All patients were seen by an anesthesiologist days ahead of their scheduled surgery to screen for suitability for ambulatory surgery. Patients foreseen to require overnight monitoring due to complexity of comorbidity, may require

Table 1. Demographic profile of patients (n, %)

	All patients* (N = 337)	MAST Disc (N = 118)	MAST Decomp (n = 101)	BKP (N = 38)	TLIF (N = 23)	TSB (N = 19)	BKP + sext (N = 14)	PELD/PED (N = 14)	IPD (N = 10)
Age (mean, SD; range)	55.6 ± 16.1 (5–92)	42.3 ± 12.2 (15–78)	63.9 ± 8. 4 (64–80)	69. 9 ± 10.9 (47–92)	59.4 ± 13.0 (31–77)	57.0 ± 17.6 (5–75)	72.2 ± 10.2 (46–85)	43.3 ± 15.7 (23–67)	48.9 ± 9.7 (27–59)
Gender									
Male	156 (46.3)	55 (46.6)	50 (49.5)	8 (21)	6 (26.1)	12 (63.2)	6 (42.9)	8 (57.1)	4 (40)
Female	181 (53.7)	63 (53.4)	51 (50.5)	30 (79)	17 (73.9)	7 (36.8)	8 (57.1)	6 (42.9)	6 (60)
BMI†									
Underweight	16 (4.7)	6 (5.1)	5 (4.9)	1 (2.6)	2 (8.7)	2 (10.5)	0	0	0
Normal	117 (34.8)	47 (39.8)	25 (24.8)	14 (36.8)	8 (34.8)	7 (36.8)	6 (42.9)	7 (50.0)	3 (30)
Overweight	122 (36.2)	43 (36.5)	42 (41.6)	14 (36.8)	8 (34.8)	6 (31.6)	2 (14.2)	3 (21.4)	4 (40)
Obese	33 (9.8)	11 (9.3)	12 (11.9)	3 (7.9)	2 (8.7)	1 (5.3)	0	3 (21.4)	1 (10)
Unable to compute‡	49 (14.5)	11 (9.3)	17 (16.8)	6 (15.8)	3 (13.0)	3 (15.8)	6 (42.9)	1 (7.2)	2 (20)
ASA class¶									
I	101 (30.0)	76 (64.4)	5 (4.9)	1 (2.6)	4 (17.4)	4 (21.1)	1 (7.2)	6 (42.8)	4 (40)
II	230 (68.2)	42 (35.6)	93 (92.1)	37 (97.4)	19 (82.6)	15 (78.9)	10 (71.4)	8 (57.2)	6 (60)
III	6 (1.8)	0	3 (3.0)	0	0	0	3 (21.4)	0	0

** Values are presented as mean ± standard deviation (range) or as frequency (percentage).*

† BMI classification: Underweight: BMI <18.5, Normal: BMI 18.5–24.9, Overweight: BMI 25.0–29.9, Obese: BMI of 30 and above. BMI of pediatric patient <10 years old was based on WHO BMI-for-age for boys.

‡ Patients who were either stretcher-borne, wheelchair-borne or ambulatory with debilitating pain who cannot assume erect position for a sustained period

¶ ASA classification: ASA I – healthy patient, no systemic disease, ASA II – patient with mild systemic disease, ASA III – patient with severe systemic disease

MAST disc – Minimal access spine technique discectomy; MAST decomp – Minimal access spine technique decompression; BKP – Balloon kyphoplasty; TLIF – Transforaminal interbody fusion; TSB – Transpedicular spine biopsy; BKP + sext – Balloon kyphoplasty + sextant; PELD – Percutaneous endoscopic lumbar discectomy; PED – Percutaneous endoscopic debridement; IPD – Interspinous spine decompression

long-acting opioids, with obstructive sleep apnea, with features of possible difficult airway were identified and scheduled for inpatient surgery instead. Non-prescription over-the-counter drugs that may affect the coagulation system were identified by the anesthesiologist and discontinued in compliance with existing standards of care. Patients were referred to an internist for medical optimization whenever applicable.

On the day of surgery, all patients except a 5-year-old boy who refused intravenous (IV) access received midazolam for anxiolysis. 92.3% of patients received IV prophylactic antibiotics (Cefazolin 1–2 g or cefuroxime 1.5 g) after negative skin or IV test within one hour of surgical incision. Tranexamic acid 20 mg/kg was given IV prior to incision to most patients (79.2%). (Table 2)

Intra-operative

Inhalational-based (sevoflurane) general endotracheal anesthesia (GETA) was the technique in 94.1% of patients while 5.9% had IV sedation without an advanced airway. Multimodal, preventive analgesia was employed in all MISST. Prior to skin incision, all patients had skin, muscle and periosteal infiltration with local anesthetic (1% lidocaine and 0.25% bupivacaine with 1:200,000 epinephrine) along the instrument tracts. Prior to skin closure, this was repeated in MISST lasting more than three hours or those with surgical instrumentation (TLIF and BKP with sextant). Intraoperative analgesia with IV fentanyl was given

Table 2. Anesthetic management of the patients (N = 337)

Management	Frequency (%)
Preoperative evaluation	337 (100)
Midazolam premedication	336 (99.7)
Adjuncts	
Antibiotics	311 (92.3)
Tranexamic acid	267 (79.2)
Anesthetic technique	
General endotracheal anesthesia	317 (94.1)
IV sedation	20 (5.9)
Peri-operative analgesics	
Preemptive skin, muscle, and periosteal infiltration with local anesthetic (1% lidocaine and 0.25% bupivacaine with 1: 200,000 epinephrine)	337 (100)
IV fentanyl	337 (100)
Parecoxib/Ketorolac/Dexketoprofen	98 (29.1)
Parecoxib/Ketorolac/Dexketoprofen and paracetamol	40 (11.8)
Parecoxib/Ketorolac/Dexketoprofen and nalbuphine	63 (18.7)
Parecoxib/Ketorolac/Dexketoprofen and paracetamol and nalbuphine	99 (29.4)
Nalbuphine	5 (1.5)
PACU prn meds	
Nalbuphine	20 (5.9)
Ondansetron	3 (0.9)
Nalbuphine and LA/incision site	1 (0.3)

IV – Intravenous; PACU – Post-anesthesia care unit

to all patients. Before extubation, varying combinations consisting of IV paracetamol, NSAIDs (parecoxib, ketorolac or dexketoprofen) and nalbuphine were given. (Table 2)

In MISST involving patients where nerve compression was the pathology and when nerve retraction/trauma during surgical exposure could have happened, injection in the perineural space of a steroid (1 ml of methylprednisolone 40 mg) combined with a dilute local anesthetic (1 ml of 1% lidocaine) was done by the surgeon under direct visualization prior to closure.

Post-operative

In the PACU, 6.2% (n=21) of patients required additional analgesia for post-op pain control in the form of IV nalbuphine. Postoperative nausea and vomiting (PONV) in 0.9% of patients (n=3) was addressed using IV ondansetron.

OUTCOMES

Duration of surgery, blood loss and length of stay

The length of surgery defined as the time from incision until the last stitch varied among MISST, the shortest being TSB (17.6 ± 9.3 min) and the longest being TLIF (215.2 ± 46.6 min). Intraoperative blood loss was variable for each MISST. In most patients, the MISST incurred 20–40 ml of blood loss. (Table 3)

The length of stay (LOS), defined as the time from the start of induction until time of discharge, varied for each MISST. The least invasive MISST TSB had the shortest average LOS of 3.5 ± 1.0 (2.1 – 6) hours while the most invasive MISST TLIF had the longest average LOS of 9.4 ± 1.5 (6.8 –12.9) hours. The LOS for the rest of the MISST was around 6–7 hours.

Pain reduction

Using the 10-point pain numeric rating scale (NRS) (0, no pain; 1–3, mild pain; 4–6 moderate pain; 7–10, severe pain), all the patients across all MISST had a statistically significant reduction in pain scores (Table 4). The average preoperative pain scores of patients for all MISST were in the severe pain category while the average postoperative pain score was within the mild pain range.

OVCF patients who had BKP ± sextant stabilization showed the greatest (7.2) pain reduction. Seventeen OVCF

Table 3. Duration of surgery, blood loss, and length of stay (LOS)*

MISST	Patients = n	Duration (mins)	Blood loss (mL)	LOS† (hours
MAST discec	118	71.9 ± 23.0 (30–150)	20.6 ± 8.9 (10–50)	6.6 ± 1.4 (3.2–10.2)
1 level	112	70.0 ± 21.4 (30–150)	20.4 ± 8.9 (10–50)	6.59 ± 1.4 (3.2–10.2)
2 levels	6	109.2 ± 22.7 (90–150)	22.5 ± 8.8 (15–35)	7.76 ± 0.7 (6.5– 8.7)
MAST decomp	101	95.4 ± 34.4 (30–260)	32.5 ± 70.4 (10–700)	6.7 ± 1.4 (2.6–10.8)
1 level	67	81.0 ± 21.4 (30–150)	31.4 ± 83.4 (10–700)	6.3 ± 1.3 (2.6–9.4)
2 levels	32	125.5 ± 37.5 (63–260)	35.0 ± 32.0 (15–200)	7.5 ± 1.2 (5.6–10.8)
3 levels	2	155.0 ± 0 (155)	27.5 ± 10.6 (20–35)	8.5 ± 0.3 (8.3–8.7)
BKP	38	55.4 ± 17.8 (24–110)	14.1 ± 1.4 (10–30)	6.0 ± 1.4 (3.1– 9.1)
1 level	26	48.5 ± 16.8 (24–110)	13.3 ± 4.4 (10–30)	5.9 ± 1.6 (3.1–9.1)
2 levels	9	67.0 ± 7.2 (55–75)	15.0 ± 4.3 (10–25)	6.2 ± 1.1 (4.5–8.0)
3 levels	2	80.0 ± 7.1 (75–85)	17.5 ± 10.6 (10–25)	6.6 ± 0.1 (6.5–6.7)
4 levels	1	80	20	7.1
TLIF	23	215.2 ± 46.6 (165–345)	276.5 ± 330 (50–1500)	9.4 ± 1.5 (6.8–12.9)
1 level	21	204.0 ± 29.4 (165–275)	268.1 ± 327.9 (50–1500)	9.2 ± 1.5 (6.8–12.9)
2 levels	2	332.5 ± 17.7 (320–345)	400 ± 424.3 (100–700)	10.7 ± 0.8 (10.1–11.2)
TSB	19	17.6 ± 9.3 (8–50)	7.0 ± 3.1 (5–15)	3.5 ± 1.0 (2.1–6)
BKP + sext	14	100.2 ± 28.1 (60–165)	23.9 ± 9.0 (15–50)	7.2 ± 1.2 (4.7–9.2)
BKP 1 level + sext	13	98.7 ± 28.7 (60–165)	23.4 ± 9.4 (15–50)	7.0 ± 1.2 (4.7–9.2)
BKP 2 levels + sext	1	120	25	8.5
PELD	14	80.0 ± 27.1 (35–150)	17.5 ± 5.4 (10 – 30)	6.4 ± 1.5 (3.9 – 10.4)
IPD	10	40.0 ± 17.5 (25–75)	10.7 ± 3.7 (5 – 15)	5.8 ± 1.5 (3.7 – 8.2)
1 level	8	41.2 ± 19.4 (25–75)	8.9 ± 4.9 (5 - 15)	6.3 ± 1.3 (4.7 - 8.2)
2 levels	2	35.0 ± 7.1 (30–40)	13.5 ± 2.1 (10 - 15)	3.8 ± 0.2 (3.6 - 4.0)

** Values are presented as mean ± standard deviation (range).*

† LOS – Length of stay is time from induction of anesthesia to time of discharge from ASC PACU.

MAST disc – Minimal access spine technique discectomy; MAST decomp – Minimal access spine technique decompression; BKP – Balloon kyphoplasty; TLIF – Transforaminal interbody fusion; TSB – Transpedicular spine biopsy; BKP + sext – Balloon kyphoplasty + sextant; PELD – Percutaneous endoscopic lumbar discectomy; PED – Percutaneous endoscopic debridement; IPD – Interspinous spine decompression

patients who were using either an assistive device (n=5), wheelchair-borne (n=11) or stretcher-borne (n=2) were able to assume an upright position and walk unassisted after the procedure. On the other hand, TSB had the least pain reduction.

Complications and disposition

Surgery-related complications were limited to three patients; two patients had excessive bleeding from the epidural vessels and one patient had a dural tear (Table 5).

Table 4. NRS Pain scores of MISST

MISST	Pre-op*	Post-op†	Reduction	P value‡
MAST discec	7.1 ± 0.3	0.8 ± 1.0	6.2 ± 1.0	< 0.00001
MAST decomp	7.0 ± 0.3	0.8 ± 1.0	6.2 ± 1.0	< 0.00001
BKP	7.8 ± 0.4	0.6 ± 0.9	7.2 ± 1.0	< 0.00001
TLIF	7.0 ± 0.4	0.7 ± 1.0	6.3 ± 1.1	< 0.00001
TSB	7.4 ± 0.8	2.0 ± 2.0	5.4 ± 2.5	0.00007
BKP + sext	7.7 ± 0.5	0.9 ± 1.1	6.8 ± 1.3	0.00048
PELD	7.3 ± 0.6	0.8 ± 1.0	6.4 ± 1.3	0.00048
IPD	7.0 ± 0.0	0.4 ± 0.8	6.6 ± 0.8	0.00256

** Taken before induction*
† Taken just prior to discharge from ASC
‡ Statistically significant at P value < 0.05
MAST disc – Minimal access spine technique discectomy; MAST decomp – Minimal access spine technique decompression; BKP – Balloon kyphoplasty; TLIF – Transforaminal interbody fusion; TSB – Transpedicular spine biopsy; BKP + sext – Balloon kyphoplasty + sextant; PELD – Percutaneous endoscopic lumbar discectomy; PED – Percutaneous endoscopic debridement; IPD – Interspinous spine decompression

Table 5. Complications and patient disposition

Complication	Frequency	%
Dural tear	1	0.3
Excessive bleeding of epidural vessels	2	0.6
Epidural hematoma	0	0.0
Death	0	0.0
Conversion to open technique	0	0.0
No complication	334	99.1
Disposition	**Frequency**	**%**
Discharged	318	94.4
Planned hospital admission after surgery	17	5.0
HMO requirement for reimbursement	5	
Patient request: distant place of residence	8	
Continue ongoing chemotherapy	2	
Sent back to hospital where patient was previously admitted	1	
Start IV antibiotic therapy	1	
Unplanned hospital admission after surgery	2	0.6
Unexpected excessive blood loss	1	
Significant intraoperative hypotension and bradycardia	1	
Discharged but readmitted	0	0.0

IV, Intravenous

Excessive bleeding was noted in two patients who were scheduled for TLIF. Both had no history of coagulopathy nor anticoagulant intake. The first patient was a 69 y/o man, ASA II (hypertension, DM type 2, asthma, overweight) with a diagnosis of lumbar stenosis with spondylolisthesis. He incurred a blood loss of 700 mL during the MAST decompression portion accompanied by episodes of hypotension despite fluid resuscitation and vasopressors. The surgery was stopped upon completion of the decompression. He was discharged to home after an uneventful PACU stay. On follow-up a week later, he had good operative results.

The second patient was a 57 y/o woman, ASA II (hypertension, DM type 2, obesity) with a diagnosis of spondylolisthesis. She completed her TLIF despite having a total blood loss of 1,500 ml, which was still within her allowable blood loss. She was admitted for an overnight observation and had good operative results.

Dural tear occurred in a 48 y/o man, ASA I, diagnosed with central and foraminal stenosis due to junctional instability, who had 1-level MAST decompression. The dural leak was not repaired but was packed with gel foam. He was treated conservatively with bed rest and IV hydration while in the PACU and was sent home on acetazolamide QID x 7 days.

Almost all patients (94.4%) went home as planned. Patients who had planned hospital admission after surgery satisfied the ASC PACU discharge criteria but were planned ahead of time to be admitted to a hospital for an overnight stay. Most of these were primarily for non-medical causes. A few were admitted to start or continue ongoing medical treatment and not due to surgery or anesthesia-related complications.

The indication for the two unplanned hospital admissions was further monitoring. One patient incurred an unexpected intraoperative excessive bleeding (total 1,500 ml) and another patient (64-year-old overweight hypertensive male) with undisclosed history of recent chest pain (< 2 weeks) necessitating an ER consult developed intraoperative hemodynamic instability. His planned TLIF was limited to the decompression portion of the surgery due to significant intraoperative hypotension and bradycardia. Both patients did not require any additional intervention during their overnight stay.

DISCUSSION

Demographic profile of patients

Minimal access spine technique (MAST) discectomy and percutaneous endoscopic lumbar discectomy (PELD) were performed among those in the 4th decade of life consistent with reported literature describing the highest incidence of herniated nucleus pulposus (HNP) among those aged 30 to 50 years old.[13,14] MAST decompression, TLIF, BKP with and without sextant were performed among the elderly population reflecting the indications

for these procedures which were either due to age-related degenerative changes (spinal stenosis, spine joint instability) or age-related susceptibility to osteoporosis. This is likewise congruent with other reported findings.[15-17] TSB patients represented a wide age range wherein younger patients were afflicted with infectious pathology and older patients were suspected of malignancy.

A female preponderance was only observed for MAST discectomy and BKP. Reports suggest a racial association regarding gender distribution of HNP wherein incidence is higher in European men while it has a slightly higher incidence in female Koreans.[13,14] Women had BKP almost 4 times more (30:8) compared to men. This can be due to post-menopausal hormonal effects and inherently less bone mass in females.[17-19]

A high BMI is not a contraindication to ambulatory surgery per se but requires additional precautions. During the preoperative evaluation, diligence was exercised to identify and exclude patients with obstructive sleep apnea (OSA). These patients could pose difficulty in airway management, have higher perioperative risks as well as have higher unplanned readmission rates.[20]

Despite the ASA physical status classification being traditionally viewed as a risk predictor, a high ASA score is not necessarily a contraindication to ambulatory surgical procedures. In a study by Ansell[21] among ASA III patients who underwent outpatient day case surgeries, there was no significant differences in unplanned admission rates, unplanned contact with health care services or postoperative complications in the first 24 hours after discharge between ASA III and ASA I or II patients as long as there was good pre-surgical assessment and preparation.

Anesthetic Management

Pre-operative

Anesthesiologists have a different perspective compared to a surgeon, hence, has a contribution to patient selection.[22] It is the practice of this group for surgical candidates to be referred to an anesthesiologist ahead of their scheduled surgery. Adequate preoperative evaluation has been identified to decrease surgery cancellation.[23,24] Ensuring that patients are medically optimized can decrease complications, hospital transfer and readmission.[25]

Midazolam, a short-acting benzodiazepine, has been widely used as an anxiolytic, sedative and anesthetic adjuvant. Lately, avoiding midazolam in elderly patients has been recommended to decrease the likelihood of postoperative delirium.[26] However, recent findings may not support this recommendation.[27,28] There was no note of postoperative delirium among the patients included in this study and everyone regained their preoperative mental status prior to discharge.

In addition, midazolam use appears to decrease analgesic requirements.[29,30] The mechanism behind this is still unclear but it may be related to its anxiolytic effect. Pain is a multidimensional experience that includes the emotional aspect. Preoperative anxiety has been identified as a predictor of postoperative pain.[31] The possible antinociceptive effect of midazolam allowed giving lower doses of inhalational agent and/or opioid leading to earlier recovery from the anesthesia and decreased likelihood of postoperative nausea and vomiting.

IV prophylactic antibiotics was not given to those who underwent TSB, have infectious pathology and with known cephalosporin allergy. For the last group of patients, they took oral co-amoxiclav an hour prior to surgery with sips of water. MISST with its limited tissue exposure and less blood loss is expected to have a lower incidence of surgical site infection (SSI) compared to an open technique. Preliminary studies on SSI for MISST show an SSI incidence ranging from 0.09–0.22%.[32,33] It is worth noting that in these preliminary studies, preoperative IV antibiotics were administered.

Tranexamic acid, an antifibrinolytic agent, was given IV prior to incision to most patients (79.2%) to lessen intraoperative bleeding. Patients for TSB, IPD, and BKP were not given tranexamic acid as these were percutaneous procedures that made blood loss unlikely. Tranexamic acid given IV has been proven to decrease blood loss in spine surgeries.[34,35] Although blood loss was not expected in these MISST, efforts were exerted to minimize blood oozing in the limited operative field as this greatly improved surgical field of view and lessened operative time.

Intra-operative

GETA was used in the majority of MISST (94.1%) because it afforded a secured airway and better control of respiration in a patient placed in the prone position. It also ensured immobility through the use of muscle relaxants during surgical exposure and dissection of vital spine structures. Spinal anesthesia (SAB) has been used and found as effective as general anesthesia for one level lumbar microdiscectomy.[36] The disadvantage found with SAB is the need to convert to GETA if it failed or when the surgery lasted more than expected. In addition, GETA afforded quicker recovery of the motor function of the lower extremities enabling the surgeon to check for any neurological deficits immediately post-operatively.

In 5.9% of cases, deep level of IV sedation and LA with supplemental oxygen via nasal cannula was the technique of choice. This involved 17 TSB, 2 PELD and 1 BKP patients.

Seventeen out of 19 patients who had TSB received IV sedation mainly because of the procedure's short duration averaging 17.6 minutes, the fastest being 8 minutes. Reported literature indicates that TSB can be performed under LA with or without sedation.[37,38] General anesthesia is reserved for pediatric patients or adult patients in severe back pain.[38,39] In this study, the two patients who received GETA involved a 5-year-old man (Pott's disease vs. malignancy) and a 65-year-old man with infectious discitis who was

wheelchair-borne due to severe debilitating pain preventing him to tolerate any positional change.

PELD was done under GETA in 85% (12 out of 14) of patients in this study. GETA was done when the PELD approach was interlaminar for patients with an L5-S1 pathology where a high iliac crest precluded a transforaminal approach. Transforaminal PELD was done under LA + sedation similar to the technique done by Oksar.[40] "Conscious sedation" for PELD has the advantage of the patient being able to report intense pain associated with nerve trauma during the procedure. In other countries, this has been the preferred technique. Being a new MISST in this ASC, PELD was done under GETA to factor in the surgeon's learning curve and possible long duration of the surgery.

BKP was done under GETA in all cases except one (37 out of 38). The only case under IV sedation and LA involved a 92 y/o man with OVCF in his L1, where the risk of GETA was high. Both LA and GETA has been shown to be safe and effective for TSB depending on the patient population.[41]

Preemptive analgesia refers to the administration of analgesic treatment before the surgical incision while preventive analgesia is more encompassing and refers to the administration of analgesic regimen before (preemptive analgesia), during and after the surgical procedure. Multimodal analgesia refers to the administration of two or more drugs that act by different mechanisms for providing analgesia. It may be administered via the same route or by different routes. This approach aims to improve pain control via synergism while decreasing individual drug dose requirements and side effects.[42]

Attention to pain management in these patients is crucial. They all had pre-existing pain and had various types of pain, namely, nociceptive, inflammatory and neuropathic. Aside from the surgical procedure addressing the spine pathology, multimodal preventive analgesia was incorporated with the aim of achieving a pain level that is easily managed by oral analgesics so they can be sent home after the surgery.

Local anesthetic infiltration before incision blocks the pain pathway at the transmission level. Its value in postoperative analgesia in different forms of surgeries has been proven.[43] It has been incorporated in the multimodal analgesia protocol for TLIF in ambulatory setting.[44] This approach afforded less use of IV fentanyl and sevoflurane intraoperatively, which translated to faster wake-up time and less post-operative nausea and vomiting (PONV). Dose-dependent use of opioids and general inhalational anesthetics have been documented risk factors for PONV.[45]

The injection in the perineural space of a steroid (1 ml of methylprednisolone 40 mg) with a dilute local anesthetic concentration (1 ml of 1% lidocaine) afforded additional immediate postoperative (lidocaine effect) as well as long-term (steroid effect) analgesic benefit.

Depending on the MISST (from least to most tissue trauma: TSB to TLIF) and patient profile (age, renal function, pain tolerance), one or more IV analgesics were given. Prior to discharge from ASC, these IV analgesics were shifted to oral forms (e.g., paracetamol ± tramadol, coxibs, dexketoprofen) to be taken round the clock for the next five days. Patients who have been taking anticonvulsants like pregabalin and gabapentin for neuropathic pain were advised to continue these drugs for at least two more weeks. There is now evidence supporting the value of multimodal analgesia for MISST.[44,46] However, it is still unclear which is the optimal multimodal analgesia protocol.

Post-operative

Nalbuphine was the opioid of choice for treating breakthrough pain for the 20 patients as shown in Table 2. Nalbuphine was given for these patients because it had the same analgesic effect as the strong opioid morphine but devoid of unwanted side effects such as pruritus and respiratory depression.[47] Nalbuphine-induced nausea and vomiting are lower compared with other opioids. In addition, nalbuphine has been shown to have no effect on bladder detrusor muscles and has less effect on bowel smooth muscles allowing earlier return of bladder and bowel functions.[48]

PONV along with pain has been shown to delay patient discharge from ambulatory procedures. Despite the absence of prophylactic anti-emetic administration, it only occurred in three patients (0.9%), which was a very low incidence compared to some reports (30–80%).[49] These patients were promptly relieved after administration of IV ondansetron. Although propofol was only used as an induction agent and not as a maintenance medication as stated in the recommendation for reducing risk of PONV, use of multimodal analgesia including local infiltration allowed minimization of opioid and volatile anesthetic which contributed to decreasing PONV risk.[49]

OUTCOMES

Duration of surgery, blood loss, and length of stay

The duration of surgery of MAST discectomy, MAST decompression, BKP, BKP with sextant, TLIF, TSB, IPD in this study were comparable while the duration of PELD were noted to be longer with existing literature.[6,38,50-54] This could be attributed to the surgeon's experience with these techniques.

One of the benefits of MISST is less blood loss. Among the MISST included in this study, TLIF was the most complex consisting of an initial decompression phase followed by instrumentation. The high average blood loss in TLIF of 276.5 ml was skewed by one patient who incurred an unexpected blood loss of 1,500 ml. If this patient was not considered in the computation, the average blood loss for TLIF would have been 171.5 ml. In a systematic review of open vs minimally invasive TLIF, mean blood loss was 247.82 ml in the minimally invasive TLIF group vs. 568.18 ml in the open TLIF group.[55]

The length of stay varied for each MISST with the least invasive having the shortest stay while the most invasive had the longest stay. The patient's average LOS allowed them to be discharged either to home or another hospital within the ASC's operating hours (6AM–8PM). Since length of stay was defined as time from induction until time of discharge, it did not accurately reflect the rate of patient's recovery from anesthesia and ability to fulfill the discharge criteria. Also, some patients already fulfilled the discharge criteria but stayed longer since their vehicle is prohibited on the road due to the MMDA Unified Vehicular Volume Reduction Program (number coding).

Pain reduction

In BKP, cannulas are placed percutaneously into the fractured vertebra which allows insertion of inflatable balloons. The balloons are inflated to create a cavity wherein bone cement is injected after deflation and removal of the balloon.[56] Observed pain reduction can be attributed to restoration of vertebral height and the exothermic nature of the polymethylmethacrylate bone cement "killing" surrounding pain fibers.[57] BKP is essentially a pain-relieving procedure that has shown immediate benefit post-procedure in terms of significantly reducing pain, increasing mobility and functional capacity and improving quality of life in the long term.[56] BKP with sextant has also shown significant pain reduction in reported literature.[52]

In MAST discectomy, serial tubular dilators are used for muscle splitting and a non-expandable retractor is set in place. Through this small window, the herniated disc is identified and removed. In PELD, an endoscope is inserted to visualize and remove the herniated disc. PELD is a good option for foraminal and transforaminal disc herniations. Removal of the herniated disc has been shown to decrease the pain scores immediately after the surgery. The pain reduction observed in a similar study was of lesser magnitude (3-point reduction) for MAST discectomy but is comparable for PELD in this review.[50,54] This is probably due to the injection in the perineural space of a steroid with a dilute concentration of local anesthetic by the surgeon under direct visualization prior to closure.

Similar to MAST discectomy, serial tubular dilators and a non-expandable tubular retractor were used in MAST decompression. Bony decompression was achieved through laminectomies, facetectomies and foraminotomies using a high-speed burr. Immediate pain reduction due to mechanically relieving the nerve root from compression has been shown in a similar study though with a lesser magnitude compared to this study.[58] Likewise, this can be attributed to the injection of steroid with local anesthetic in the perineural space.

IPD device insertion is intended to decompress neurological structures in degenerative lumbar stenosis. With fluo-roscopic guidance, size-based color-coded distraction trocars are inserted percutaneously and advanced toward the desired interspinous space. Once the optimal size for decompression has been identified, the IPD is deployed. Once inserted, the IPD causes immediate pain reduction as it increases interspinous space, reduces load on the disc, annulus and facet joints as well as limits extension movement. Pain reduction in reported literature was comparable to this study.[59]

In TLIF, aside from an initial MAST decompression, bone grafts were delivered between two unstable vertebrae to fuse it, interbody cage was placed between two vertebrae to maintain its height and pedicle screws and rods were inserted percutaneously using the Sextant delivery system to stabilize the joint. Immediate pain reduction occurs due to decompression of neural elements. The fusion component stabilizes the surrounding ligaments and aids in restoring a more normal spinal alignment. The pain reduction observed in this study is comparable to published literature.[60]

Transpedicular spine biopsy had the least pain reduction among the MISST in this study. It was primarily diagnostic in nature and afforded pain relief in cases of infectious pathology.

Complications and disposition

In a patient placed in a prone position, the abdominal contents compress on the inferior vena cava. This increase in intra-abdominal pressure (IAP) is transmitted to the valveless epidural veins. This IAP elevation becomes of greater magnitude as the BMI increases.[61] As such, a high BMI has been identified as an independent risk factor for greater blood loss during spinal fusion.[61,62] Careful attention to patient positioning as well as an infusion of tranexamic acid after an initial loading dose may aid in decreasing blood loss for such patients.[35]

Dural tear has been shown as one of the most common complications of lumbar spine surgery. In a limited field of view in MISST, the dura may be susceptible to tears from high-speed drills. In an analysis by Phan, there was no evidence to suggest differences in rates of dural tears and CSF leak between minimally invasive and conventional laminectomy.[63]

Household proximity to hospital facilities is a social factor considered in ambulatory surgeries as these patients should be able to go to emergency services within 1 hour.[64] An option the team has offered and has been acceptable for many patients was for them to stay in a nearby hotel overnight instead of being admitted to a hospital.

Acute myocardial injury promotes release of inflammatory mediators to facilitate healing. This healing process is believed to take four to six weeks.[65] Current recommendation based on existing data states that ≥ 60 days should elapse after a MI before noncardiac surgery in the absence of a coronary intervention.[66] The patient who had significant intraoperative hypotension and bradycardia was in severe pain and later admitted not disclosing his recent chest pain as it might warrant cancellation of his surgery.

Scope and Limitations

This retrospective chart review is limited to patients under the care of a single orthopedic spine surgeon and two anesthesiologists. Data extracted was limited to what was recorded in the chart. The information collated is observational and cannot establish a definite cause-and-effect relationship. It is not intended to be recommendatory in terms of managing patients for MISST in the ambulatory setting.

CONCLUSION

Even in a developing country, MISST can be performed in an ambulatory setting with minimal complications, less unplanned hospital admissions and significant pain reduction. Transitioning MISST from inpatient to an ambulatory setting entails meticulous patient selection and education, close coordination between the anesthesia and spine surgical teams as well as provision of preventive multimodal analgesia. Prospective studies would further validate these results.

Statement of Authorship

All authors contributed in the conception and design of the study; data gathering and analysis; drafting, revising finalizing the manuscript; and approved the final version submitted.

Author Disclosure

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