Disclosures

None
Objectives

Review types of spine surgeries and indications for each

Summarize innovative modalities for perioperative pain control for patients undergoing neck and back surgery.

Review management of high-risk spine patients to minimize complications.

Discuss emerging technologies in the field of spine surgery.
Background
Back pain

10-30% Annual prevalence of low back pain in US
65-80% Lifetime prevalence of low back pain in US
5th most common reason for visiting a doctor
>$26 billion in direct health care costs
Leading contributor to disability and work days lost
Back pain

Axial
- Lumbosacral
- Lumbar or L1-5
- Sacral or S1 to sacroccygeal junction

Radicular
- Leg pain travels along a dermatomal distribution
- Due to nerve or dorsal root ganglion irritation

Referred
- Spreads remote from its source along non-dermatomal trajectory

Myelopathy
- Spinal cord injury due to compression

Urits et al 2019
Etiology

Facet-mediated
- Degeneration of the intervertebral discs
- Leads to lumbar facet degeneration

Discogenic
- Disc disruption
- Degradation of the disc

Spinal Stenosis
- Degenerative changes of the spine
- Decreases available space for neural and vascular structures

Urits et al 2019
Etiology

Persistent or recurring pain

– Post-laminectomy syndrome
  • Incidence 10-40%
  • Risk factors
    – Preop: anxiety, depression, poor coping, litigation, workers comp
    – Intraop: poor surgical technique, surgery at incorrect level, inability to achieve anticipated surgical goal
    – Postop: surgical complication, disease progression, epidural fibrosis, new instability, myofascial pain syndrome

Urits et al 2019
Multidisciplinary Approach to Treatment

Pharmacologic
- Acetaminophen
- NSAIDS
- Muscle relaxants
- Tramadol
- TCAs
- Serotonin Norepi re-uptake inhibitors
- Anti-epileptics

Psychological
- Cognitive Behavioral Therapy

Physical Therapy

Complementary and Alternative medicine

Minimally Invasive Procedures

Spinal cord stimulation

Urits et al 2019
Indications for surgery

Urgent evaluation
- Severe or progressing motor weakness
- Cauda equina syndrome

Elective
- Disabling symptoms
- Impaired quality of life
- No response to other interventions
Type of surgery indicated

Nonspecific low back pain
- Spinal fusion
- Lumbar disc replacement

Lumbar disc prolapse
- Discectomy
  - Open vs. Micro
Type of surgery indicated

Spinal stenosis or Spondylolisthesis
– Decompressive laminectomy, +/- fusion

Intractable low back pain
– Spinal cord stimulation
Spinal Fusion

Most common surgery for chronic non-specific low back pain

Goal:

– Restrict spinal motion
– Remove degenerated disc
– Fuse 2 or more vertebral bodies

With or without supplemental instrumentation

Associated with long-term degenerative changes in adjacent spine segments
Types of spinal fusion procedures

Interbody Fusion
- Anterior Lumbar (ALIF)
- Transforaminal Lumbar (TLIF)
- Direct Lateral/eXtreme Lateral (DLIF/XLIF)
- Posterior Lumbar (PLIF)

Posterolateral
Failed back surgery syndrome

Surgical end stage after one or several interventions

<table>
<thead>
<tr>
<th>Table 1. Summary of the etiologies of FBSS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Etiology of FBSS</strong></td>
</tr>
<tr>
<td>Preoperative</td>
</tr>
<tr>
<td>Patient-related factors: psychological, social</td>
</tr>
<tr>
<td>Surgery-related factors: poor candidate selection, revision surgery, improper planning</td>
</tr>
<tr>
<td>Operative</td>
</tr>
<tr>
<td>Inadequate decompression of lateral recesses and foramina</td>
</tr>
<tr>
<td>Instability with excessive decompression</td>
</tr>
<tr>
<td>Incorrect level surgery</td>
</tr>
<tr>
<td>Postoperative</td>
</tr>
<tr>
<td>Recurrent disc herniation</td>
</tr>
<tr>
<td>Adjacent segment disease</td>
</tr>
<tr>
<td>Sagittal balance-related problems</td>
</tr>
<tr>
<td>Pelvic incidence and lumbar lordosis mismatch</td>
</tr>
<tr>
<td>Battered root syndrome</td>
</tr>
<tr>
<td>Nerve root entrapment syndrome</td>
</tr>
</tbody>
</table>

FBSS, failed back surgery syndrome.

Daniell et al 2017, Sebaaly et al 2018
Fig. 3. Proposed algorithmic approach for FBSS. FBSS, failed back surgery syndrome; MRI, magnetic resonance imaging; CT, computed tomography; MPR, multiplanar reconstruction; OMM, optimal medical management.
Failed back surgery syndrome

Fig 1. The main causes of narcotic addiction (e.g., morphine) and strategies for the prevention and treatment of narcotic addiction in FBSS patients. (A) The possible mechanism for inducing narcotic addiction and preventive strategies during the induction process; (B) strategies for the prevention and treatment of narcotic addiction (e.g., MOR agonist: methadone; MOR antagonist: naltrexone). BBB: blood–brain barrier; FBSS: failed back surgery syndrome; MOR: mu opioid receptors; NMDAR: N-methyl-D-aspartate receptor.
Spinal cord stimulators

Placement of electrodes in the epidural space
Complex mechanism of action
  – Electric current
  – Sympatholytic and neuromodulatory

Implanted percutaneously or by laminectomy
Spinal Cord Stimulators

Indications

- FBBS
- CRPS
- Painful peripheral vascular disease
- Intractable angina
Spinal cord stimulators

Long-term outcomes of SCS in FBSS

Persistent low back pain:
  >50% pain relief compared to reoperation
  >60% substantial improvement in quality of life
  ~ 30% rate of complications

Persistent radicular pain:
  >50% pain relief compared to medical management

Nissen et al 2019; UpToDate 2019
Spinal Cord Stimulators

Anesthesia for patients with SCS

Electrosurgery
  Use bipolar if able
  Test for impedance, turn off, place grounding pad as from IPG as possible, turn back on post-op

Neuraxial
  Will be challenging – scarring in fibrous tissue

MRI
  Confirm compatibility
Perioperative Planning
Fig. 1. Components and workflow of a typical ERAS pathway. Copyright American Association of Nurse Anesthetists. Published with permission.
Preparation for surgery

ERAS Systematic review
  – Feasible
  – Shorter length of stay
  – Accelerated return to function
  – No increase in rates of complications or readmissions

Utilization of more minimally invasive techniques
Multi-modal analgesia
Early rehabilitation
Early enteral nutrition

Elsarrag et al 2019
Intraoperative planning

Opioid sparing, multi-modal analgesia
Normovolemia
Nausea/vomiting prophylaxis
Normothermia
Normoglycemia

Spine Team

Wilson et al 2019
Opioid sparing

Preoperative planning
  – Current opioid regimen
  – Pain pumps
  – Medical Marijuana
Pain Pumps

Intrathecal delivery

Morphine
Dilaudid
Baclofen
Ziconotide
Table 1. Physiological effects of marijuana

<table>
<thead>
<tr>
<th></th>
<th>Acute effects</th>
<th>Chronic effects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiovascular</strong></td>
<td>Tachycardia</td>
<td>Atheromatous disease</td>
</tr>
<tr>
<td></td>
<td>Vasodilation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Orthostasis</td>
<td></td>
</tr>
<tr>
<td><strong>Pulmonary</strong></td>
<td>Bronchodilation</td>
<td>Chronic bronchitis</td>
</tr>
<tr>
<td></td>
<td>Hyperreactivity</td>
<td>Emphysema</td>
</tr>
<tr>
<td></td>
<td>Airway edema</td>
<td></td>
</tr>
<tr>
<td><strong>Central nervous system</strong></td>
<td>Anxiolyis</td>
<td>Similar to acute effects but tolerance develops, requiring higher doses for similar effects</td>
</tr>
<tr>
<td></td>
<td>Anxiety</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paranoia/psychosis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Euphoria</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dizziness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Headache</td>
<td></td>
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<tr>
<td></td>
<td>Memory dysfunction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analgesia</td>
<td></td>
</tr>
<tr>
<td><strong>Gastrointestinal</strong></td>
<td>Antinausea</td>
<td>Hyperemesis</td>
</tr>
<tr>
<td></td>
<td>Increased appetite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abdominal pain</td>
<td></td>
</tr>
<tr>
<td><strong>Endocrine</strong></td>
<td>None</td>
<td>Gynecomastia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anovulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Galactorrhea</td>
</tr>
</tbody>
</table>
Table 3. Anesthetic considerations in patients consuming marijuana

<table>
<thead>
<tr>
<th>Period</th>
<th>Considerations</th>
</tr>
</thead>
</table>
| Preoperative | Elevated risk of myocardial infarction within 1 hour after use  
               | Airway hyperreactivity  
               | Anxiety/paranoia  
               | Psychosis  
               | Need to assess for other drugs |
| Intraoperative| Tolerance to induction agents  
               | Elevated bispectral index  
               | Unknown cross-tolerance to other anesthetic agents  
               | Elevated risk of myocardial infarction within 1 hour after use  
               | Airway hyperreactivity |
| Postoperative| Unknown cross-tolerance to analgesics  
               | Possible heightened pain perception  
               | Withdrawal |

Alexander et al 2019
Opioid sparing at Michigan

Protocol for Lumbar Fusion Surgery

Inclusion
- Non-traumatic low thoracic thru lumbar complex spine surgery
- 12 lead EKG within 90 days to assess Qtc
- 18-70yo

Exclusion
- Patients who are on a baseline opioid regimen of > 90 mg oral morphine equivalents per day
- Patients who are pregnant or breastfeeding
- Symptomatic heart failure (NYHA class II-IV)
- Pulmonary disease necessitating home oxygen therapy
- Patients with severe hepatic impairment or severe active liver disease (cirrhosis or hepatic failure)
- Clinically significant renal insufficiency (GFR < 60 ml/min)
- A history of recent falls and/or instability, Postural Orthostatic Tachycardia Syndrome (POTS), Menieres disease, or Benign Paroxysmal Positional Vertigo
- Supermorbid Obesity (BMI ≥ 50 kg/m²)
Opioid sparing at Michigan

Preoperative
Acetaminophen 1000 mg PO
Gabapentin 600 mg PO
Celecoxib 400 mg PO

Intraoperative
Methadone (dosed at induction):
- OPIOID NAÏVE: 0.15 mg/kg actual body weight IV (MAXIMUM 15 mg IV)
- OPIOID TOLERANT (regular use of opioids* in 6 weeks preceding surgery): 0.2 mg/kg actual body weight IV (MAXIMUM of 20 mg IV)
  Do not titrate other long acting opioids during the case (including morphine, hydromorphone, sufentanil or high-dose fentanyl)

Preoperative field block with 20 cc – 30 cc of 0.25% bupivacaine with 150 mcg clonidine
Remifentanil titrated to heart rate and blood pressure intraoperatively
(Consider) Ketamine 0.5 mg/kg bolus followed by 0.25 mg/kg/hr – MAX dose of 30 mg/hr, discontinued at surgical closure
Acetaminophen 1000 mg IV (only if 6+ hours after previous dose)
Opioid sparing at Michigan

**Postoperative**

Morphine PCA: 1 mg demand, 6 min lockout, 10 mg 1 hour max for 24 hours. *Continuous pulse oximetry is required for all PCA's at Michigan Medicine.*

Oral opioids after 24 hours: Recommend initial dose of oxycodone 5-10 mg PO q4hrs PRN as starting dose (may be titrated based on clinical assessment)

After 24 hours, plan to transition to clinically indicated dose of oral opioid

Acetaminophen 1000 mg PO q8hrs during inpatient stay

Gabapentin 300 mg PO BID POD 1 and 2

Celecoxib 200 mg PO daily on postop day 1 and 2

Magnesium Oxide 400 mg PO twice daily for 7 days postoperatively

Muscle relaxants prescribed at surgery's discretion. Please avoid benzodiazepines if possible given concurrent methadone use.
Opioid sparing at Michigan

Hold Methadone in Patients With:
- Known Hypersensitivity
- Prolonged QTc (mean QTc > 450 msec, women QTc > 470 msec)

Hold Celebrex in Patients With:
- Known hypersensitivity to Celecoxib, sulfonamides, other NSAIDs

Hold Ketamine in Patients With:
- Known Hypersensitivity
- Patients with a history of schizophrenia, psychosis or active suicidality
- Severe valvular (e.g. aortic, mitral) stenosis

Hold Tylenol in Patients With:
- Known Hypersensitivity

Hold Gabapentin in Patients with:
- Known hypersensitivity
Blocks

Preoperative
Paravertebral
Erector spinae
Intraoperative
Field block
Anesthetic maintenance

“Michigan” TIVA

½ MAC propofol; ½ MAC isoflurane

Additional Infusions

Dexmedetomidine
Ketamine
Lidocaine
Minimizing risk and complications
Tranexamic Acid

Pharmacology
- Synthetic lysine analog
- Reversibly blocks lysine binding sites on plasminogen
- Inhibits degradation of blood clot

Dosing
- Bolus: 10-40mg/kg
- Infusion: 1-4mg/kg/hr

Indications

Hariharan et al 2019
TXA: Metanalysis

7 articles (2 RCTs, 4 retrospective, 1 prospective cohort)

Safety
- Increase in odds of DVT/PE was not significant

Efficacy
- No significant difference in intraoperative blood loss
- Smaller total transfusion volume in TXA groups versus controls in 2 of the Observational studies
- No significant increase in odds of intraoperative transfusion

Hariharan et al 2019
#5 Bleeding During Spine Surgery

- Verify Diagnosis: Increase in Blood Loss, Hypotension, Tachycardia, Oliguria

**Stabilize Patient:**
- Control bleeding (surgical)
- Replace plasma volume
- Maintain BP with vasopressors as needed
- Verify blood product availability, consider MTP

**Drugs:**
- Tranexamic Acid: *Institutional protocols may vary and should be followed*
  - Low Dose: Load 1 mg/kg Infusion 1 mg/kg/hr
  - High Dose: Load 30 mg/kg Infusion 1-10 mg/kg/hr

**Treatment:**
- Confirm blood loss (suction canister, sponges, under drapes, etc.) and exclude other causes for hemodynamic problems
- Ensure adequate vascular access if not secured already, communicate with blood bank re need for blood products
- Consider use of red cell salvage techniques
- Check labs: (ABG, Hct/Hb, thromboelastography)
  - Correct deficiencies as indicated
  - Goal Hb >8.0 (may vary based on patient co-morbidities)
- Consider temporary wound packing until patient stabilized
- Restore plasma volume and temporize with vasopressors
- Ensure normothermia 36.0-37.9 °C
- Consider antifibrinolytics (Tranexamic Acid) and Factor VIIa

**Differential Diagnosis:**
- Overdose of anesthetic, pulmonary embolism, anaphylaxis, other forms of shock, or transfusion reaction.

**Common Causes:**
- Multilevel spine surgery, tumor resection, trauma, infection
- Revision surgery
- Patient age, obesity, known coagulation defects
POVL

Anterior ischemic optic neuropathy
Front of the optic nerve
Posterior ischemic optic neuropathy
portion of optic nerve behind the eye

<table>
<thead>
<tr>
<th>Anterior Ischemic Optic Neuropathy (AION)</th>
<th>Posterior Ischemic Optic Neuropathy (PION)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Onset of blindness is usually delayed from 48 hours to a week after surgery.²</td>
<td>Onset of symptoms are upon awakening (60%) and is not uncommon to have symptoms within 24 hours (40%)²</td>
</tr>
<tr>
<td>• Symptoms rarely occur upon awakening from anaesthesia.</td>
<td>• Binocular vision involvement is frequent (50-60%)²</td>
</tr>
<tr>
<td>• Usually painless.</td>
<td>• Optic disc appears normal at time of onset of symptoms</td>
</tr>
<tr>
<td>• Binocular vision involvement is frequent (50-60%)²</td>
<td>• Affects men more frequently (&gt;70%) than women</td>
</tr>
<tr>
<td>• Onsets of symptoms are accompanied by optic nerve oedema. Hemorrhagic spots may or may not be present on fundoscopy.</td>
<td>• Frequently encountered in lumbar spine surgery.²</td>
</tr>
</tbody>
</table>

Apfelbaum et al 2019
POVL

Preoperative Evaluation & Preparation

Intraoperative
- BP Management
- Management of blood loss and fluids
- Use of vasopressors
- Patient and head positioning
- Staging of procedures

Postoperative

Apfelbaum et al 2019
Post-op delirium

Spine surgery one of the most common procedures in elderly

Most common complication after complex spine surgery

<table>
<thead>
<tr>
<th>TABLE 3. Predictors of Postoperative Delirium by Multivariable Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predictor</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>ASA physical status ≥ 3</td>
</tr>
<tr>
<td>METs &lt; 4</td>
</tr>
<tr>
<td>Depression</td>
</tr>
<tr>
<td>Nonelective surgery</td>
</tr>
<tr>
<td>Invasiveness tier 3 or 4</td>
</tr>
<tr>
<td>BIS monitoring</td>
</tr>
<tr>
<td>Mean pain score postoperative day 1</td>
</tr>
</tbody>
</table>

ASA indicates American Society of Anesthesiologists physical status; BIS, Bispectral Index; CI, confidence interval; METs, metabolic equivalents of task; OR, odds ratio.

Susano et al 2019
Post-op delirium

<table>
<thead>
<tr>
<th>TABLE 4. Outcomes Associated With Postoperative Delirium (Univariate Analysis)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Postoperative Delirium Status (n [%])</strong></td>
</tr>
<tr>
<td>Postoperative Delirium Status (n [%])</td>
</tr>
<tr>
<td>(N = 715)</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>(N = 127 [17.8])</td>
</tr>
<tr>
<td>Other complications</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Hospital length of stay (N = 710)</td>
</tr>
<tr>
<td>Median (25th-75th)</td>
</tr>
<tr>
<td>Discharge to other place than home (N = 614)</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
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<tr>
<td>30-d readmission</td>
</tr>
<tr>
<td>No</td>
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<tr>
<td>Yes</td>
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<tr>
<td>30-d mortality</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

*The χ² tests were used.
†The Wilcoxon rank sum tests were used.
‡The Fisher exact tests were used.
Novel techniques
3D printing

Surgical planning
- 3D printing of vertebrae to study screw trajectory

Education

3D printed implants
- Porous cages – material that Improves fusion

Wu et al 2018
Endoscopic approaches

Lateral, transforaminal endoscopic approach for removal of herniated intervertebral disc material

Removes less facet

Goal to reduce need for fusion in future
Endoscopic approaches

Challenges

– Lateral, prone, sitting
– GA, MAC, spinal
– Increases in ICP due to water pressure
– Durotomies difficult to close
Additional novel techniques

Total Posterior Spine (TOPS) device
- Stabilize, but not fuse
- Maintain range of motion

Biologics
- Osteogenesis

Cortical trajectory screws
- Contact more cortical bone than cancellous
- Instead of pedicle

Facet cages
Conclusions

Back pain is common…and expensive…so is back surgery

Many different types of surgeries available, not always clear which will offer most benefit

Preparation is key to optimizing outcomes

Be aware of opportunities to improve outcomes and minimize risk

New procedures and technology are developing rapidly
Thank you!
Questions?
References


