Spine Protocol
Anesthesia Protocol
University of Washington Medical Center
Department of Anesthesiology

Overview

The spectrum of spinal surgery at UWMC extends from minimally invasive blood-less procedures to complex, excessive blood-loss multiple-level operations, performed at any site in the spine from cervical to sacral. Spine procedures present particular challenges for the anesthesiologist. These include:

- Limitation on anesthetic choices imposed by the use of case specific spinal cord monitoring.
- Multilevel procedures and management of major blood loss.
- Hemodynamic stability and adequate hematocrit to avoid spinal cord ischemia.
- Airway management in patients at risk for cervical spine injury.
- Specific concerns in positioning and surgical approach.

Common Procedures and Indications

1) **Discectomy/Laminectomy**: partial or complete excision of an intervertebral disk.
   Indications: progressive neurological deterioration due to nerve compression caused by: spinal stenosis; herniated disc; spondylolisthesis.

2) **Spinal Fusion and Instrumentation**: a technique of stabilizing two or more vertebrae by bone grafting, followed by instrumentation with the aid of metal implants (screws, plates, wires, rods).
   Indications: spinal deformity (kyphosis, scoliosis); injury and instability (trauma, tumors); degenerative disc disease.
   Note: These may be complex and lengthy (8-12 hours) procedures when performed in the thoracic to lumbar levels, with major blood loss. Some patients may require ICU care and/or postoperative mechanical ventilation.

3) **Minimally Invasive Spine Surgery**: procedure performed through small incision, with the aid of endoscope or microscope.
   Indications: herniated disc; radiculopathy
Case classification by surgical complexity:

- **LEVEL A**: non-complex or minimally invasive procedure; estimated blood loss (EBL): 200-500 ml; monitoring: standard.
- **LEVEL B**: average procedure; less than 5 levels; EBL: 500-1000 ml; monitoring: standard plus arterial line, consider central venous pressure (CVP).
- **LEVEL C**: complex, prolonged procedure; more than 5 levels and/or re-do surgery; EBL > 1500 ml; monitoring: standard plus arterial line and central venous catheter (consider cordis)

**NOTE**: This stratification is only informative; the final decision how to prepare and monitor a patient should be made on a case by case basis, according to the ASA risk classification and IV access availability.

**Pre-Operative Assessment**

Routine and particular areas of interest:

1) **Neurological integrity**: check and document any pre-existing uni- or bilateral limb weakness, paresthesia, neck and back pain.

2) **Airway management and the cervical spine**: awake vs. asleep fiberoptic intubation vs. direct laryngoscopy

3) **Decision making depends on**:
   a) **Anticipated difficult intubation**
      - Risk factors: restriction of neck movement, presence of fixation device, history of difficult intubation.
      - Incidence: rheumatoid disease 48%; trauma 25%.
   b) **C-spine stability**. In patients with unrecognized cervical-spine instability, risk of neurologic injury with intubation is ≈ 10%. A preoperative consult with the surgeon is advisable for decision making in airway management.

4) **Surgical approach and positioning** will be discussed below.

**Spinal Cord Monitoring**

**Objective**: to reduce the risk of neural injury either from surgical trauma, operative positioning, or inadequate blood supply.

**General principle**: stimulation applied to specific neural tracts elicits electrical responses (evoked potentials) that can be measured, recorded, and interpreted by the neuromonitoring team.
The waveform consists of positive and negative deflections and is characterized by terms of amplitude, latency, and morphology.

Criteria for spinal cord compromise: reduction in amplitude greater than 50% or increase in latency of more than 10%.

**Monitoring Modalities**

1) **Somatosensory evoked potentials (SSEP)** assess the posterior sensory pathway from peripheral nerve through the brainstem and cortex.

2) **Motor evoked potential (MEP)** monitors the motor descending tracts by transcranial stimulation.

3) **Electromyograph (EMG)** monitors muscle activity during mechanical stimulation of different nerve roots (e.g., bladder and rectal sphincter).

4) Factors that affect SSEP/MEP monitoring:
   a) Technical factors: lead placement, stimulation modalities, electrical noise.
   b) Physiologic variables should be kept stable:
      Mean arterial pressure (MAP) no less than 70 mmHg or 25% below usual mean; pH, oxygenation, and ventilation within normal limits, normothermia. Note that hypothermia can reduce the amplitude and mimic ischemic changes.
   c) Anesthetic agents, in general, alter neuronal excitability and reduce evoked potentials (EP) amplitude, and latency changes in a dose-dependent manner.
      ▪ Inhalational agents suppress SSEPs at minimum alveolar concentration (MAC) >1. In contrast, MEPs are markedly depressed by even small concentrations of volatile anesthetics; therefore it is best to avoid volatile anesthetics when MEP are recorded.
      ▪ Opioids minimally affect recording.
- Bolus administration of hypnotic drugs or sudden increases in inhalation agent concentration can cause 10-20 min depression of EP responses. Therefore, a constant anesthetic level is highly recommended.
- Nitrous oxide reduces the amplitude of EP responses and potentiates depression of waveforms by volatile anesthetics. Therefore, it shouldn’t be added to volatile anesthetics for monitoring. While our center avoids use of nitrous oxide in SSEP monitoring, many centers around the U.S. use nitrous oxide in preference to volatile anesthetics. However, we typically choose a volatile anesthetic because they are better anesthetics and permit use of a higher inspired O2.

<table>
<thead>
<tr>
<th>Drugs</th>
<th>SSEP</th>
<th>MEP</th>
<th>EMG</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inhalational:</strong></td>
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<tr>
<td>Isoflurane, sevoflurane, desflurane</td>
<td>≤ 1 MAC*</td>
<td>NR</td>
<td>-</td>
<td>Add opioid infusion</td>
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<tr>
<td>Nitrous oxide</td>
<td>NR</td>
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<td><strong>Intravenous:</strong></td>
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<tr>
<td>Propofol</td>
<td>Yes (I+M)</td>
<td>Yes (I+M)</td>
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<td>Dose &lt; 150 µg/kg/min TIVA: basic component*</td>
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<tr>
<td>Barbiturate</td>
<td>Yes (I)</td>
<td>Yes (I)</td>
<td>-</td>
<td></td>
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<td>Etomidate</td>
<td>Yes (I+M)</td>
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<td>Limited: adrenocortical suppression</td>
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<td>Limited: dissociative effect</td>
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<tr>
<td>Opioids</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
<td>TIVA: basic component*, remifentanil is preferred</td>
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<tr>
<td>Neuromuscular blocking agents</td>
<td>Yes</td>
<td>Yes (I); NR (M)</td>
<td>NR</td>
<td>Use short- and intermediate-acting drugs</td>
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<td>Dexmedetomidine</td>
<td>Adjuvant to TIVA: 0.2-0.4 µg/kg/hr</td>
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</tbody>
</table>

MAC = minimum alveolar concentration; NR = not recommended at UWMC/HMC; I = induction; M = maintenance; TIVA = total intravenous anesthesia
* routinely used at UWMC

**How to manage intraoperative SSEP/MEP changes (imminent neurological compromise)**

- Rule out surgical factors: stop surgery; communicate with the surgeon and monitoring team.
- Rule out physiologic causes: Hypotension or hypothermia are the most common factors.
• MOST IMPORTANT: raise MAP to increase spinal cord perfusion even if MAP is within normal limits (some authors suggest 30-40% above baseline).
• Turn off inhalation agent and switch to total intravenous anesthesia (TIVA).
• Consider etomidate – it increases the amplitude of EP waveforms.
• Consider wake-up test.
• Consider steroid infusion.

### The Procedure

#### Antibiotics

For supine cases, start antibiotics after all lines/monitoring devices are placed. For prone cases, do not start antibiotics until the patient is turned prone. Otherwise the antibiotics will be administered too early.

#### Minimally Invasive Spine Surgery (Level A)

1) Procedure: endoscope and fluoroscope-guided microdiscectomy in outpatients.
2) Position: prone or kneeling with bolster or frame support. Cervical laminectomies are sitting.
3) Monitoring: standard ASA ± spinal cord monitoring.
4) Special considerations:
   a) Small skin incision, minimal fluid and blood loss, no Foley, and don’t overhydrate!
   b) If SSEP + EMG, avoid long-lasting muscle relaxants, otherwise consult the surgeon.
5) Note that cervical microdiscectomies do not have a significant risk of venous air embolism. Hence, a right atrial catheter is not indicated. Special monitors include a Precordial Doppler and possibly an arterial line if indicated by patient condition.

#### Cervical Spine Surgery

1) Positioning
   a) Supine for anterior cervical discectomy and/or fusion.
      • Head mildly extended in tong traction or pins (Mayfield tong or horseshoe headrest).
      • Cervical traction by surgeon request with 5-10 lbs of weight attached to the device or to a cervical strap placed behind the chin and around the occiput.
      • Shoulder roll.
      • Arms tucked at the sides.
      • Use extension lines.
      • Check if IVs and arterial line are free.
      • Check and pad pressure points.
b) **Prone** for posterior cervical laminectomy and/or fusion.
   - Head in pin fixation (Mayfield frame) or
   - Check and pad pressure points.
   - Check eyes and head every 15 minutes and chart on anesthetic record for medicolegal purposes.
   - Secure ETT, using “pink” tape, and support breathing tubes (risk of dislodgement and disconnection).

2) **Setup**: 2 x IV, e.g., 18-16G with extensions and T-connectors for fluid and drug infusions. Infusion pumps; blood warmer; fiberoptic bronchoscope if clinically indicated; wire-reinforced ETT optional, (reduces the risk of airway obstruction during intraoperative tracheal retraction); bite block mandatory if MEP monitoring is used.

3) **Monitoring**
   a) Standard ASA plus arterial line
   b) Foley catheter
   c) SSEP± MEP
   d) Bispectral Index (BIS) (needed when TIVA is planned)

4) **Induction**
   a) For patients with a stable neck, direct laryngoscopy and orotracheal intubation are acceptable. For patients with unstable spine or difficult airway, fiberoptic intubation is recommended.
   b) For surgery in prone position, start anesthesia supine on a stretcher, then after the ETT is secured, turn patient prone onto the OR table. Be sure IV catheters are taped well and pay attention as IVs may come out and monitors lost.
   c) Suitable drugs: IV propofol or etomidate or thiopental with opioid and a short- or intermediate-acting muscle relaxant. Avoid succinylcholine in patients with motor weakness due to risk of hyperkalemia.

5) **Maintenance goal**
   a) Hemodynamic stability with optimal oxygen delivery to the brain and spinal cord, MAP > 70 mmHg, normocapnia.
   b) Stable anesthetic regimen with minimal fluctuations in anesthetic depth to facilitate spinal cord monitoring.

   Examples of routine anesthetic regimens at UWMC:
   - SSEP + EMG: isoflurane or sevoflurane <1 MAC plus remifentanil or fentanyl infusion. EMG use requires avoidance of neuromuscular blocking agents for maintenance.
   - SSEP + MEP: TIVA propofol <150 µg/kg/min plus remifentanil infusion. Use BIS to guide propofol dosage for BIS level of 35-50.

   **Notes**: A good routine is to prepare the drugs during the set-up period, including T- connectors, and be ready to infuse through or immediately after induction. In order to avoid
undesired movement, a relatively high dose of opioids, e.g., remifentanil 0.2-0.5 µg/kg/min, needs to be administered.

6) **Emergence**: The goal is an awake, responsive patient to allow immediate postop neurologic evaluation.

7) **Blood replacement and fluid management**: Blood transfusion is rarely required. Avoid over hydration to reduce the risk of airway edema.

8) **Complications**
   a) Airway obstruction caused by airway edema or neck hematoma. Risk factors include surgery in prone position greater than 4-6 hours; re-operations; multiple cervical levels; combined anterior-posterior approaches; severe facial edema. If in doubt, perform a leak test prior to extubation; extubate using a tube exchanger, or keep patient intubated in head-up position until the edema resolves.
   b) Transient recurrent laryngeal palsy (6.4%) with the anterior cervical spine approach. The surgeon will ask you to deflate and reinflate the cuff after retractor placement to reduce the risk of recurrent laryngeal palsy, as excessive cuff pressures may be associated with ischemia of the recurrent laryngeal nerve during surgical trach.

**Thoracic and Lumbar Spine Surgery**

1) **Positioning**: Variable depends on the pathology and the level of spine to be operated.
   a) **Lateral decubitus** for anterior thoracolumbar spine reconstruction/fusion:
      - Indications: T4-L1 scoliosis/kyphosis, fractures, tumors.
      - Transthoracic one-lung ventilation and double lumen endotracheal tube may be required.
      - Check with surgeon.
   b) **Supine or partial decubitus** for the retro- or transperitoneal approach of the lumbo-sacral (L2-S1) spine (degenerative disc diseases, neoplasm).
   c) **Prone** for posterior thoracolumbar laminectomy/fusion/instrumentation.
   d) Combined, antero-posterior approaches are uncommon and need patient repositioning during the case. Most cases now are double staged.
      Jackson table or a Wilson frame is used to support the body and permit free abdominal movement. Head rests on a foam face pillow with cutout for eyes and nose. The arms are extended out and forward (don’t place IVs in the antecubital fossa due to risk of bending).
      - Check and pad pressure points
      - Check eyes, ears and nose are free of pressure and do not touch table
      - Check if abdomen hangs free to keep epidural pressure low
      - Check ETT and IV lines

2) **Monitoring**:
   a) **Standard ASA** for simple Level A cases.
b) 2 x large bore IVs, arterial line, double lumen CVP. Consider cordis or rapid infusion catheter when major bleeding is expected.

c) SSEP ± MEP (appears on the schedule or check with the surgeon)

d) BIS if TIVA used

3) Room Setup: Level B and C surgery:
   - Routine anesthesia drugs and phenylephrine infusion.
   - Steroids: Solu-Medrol (methylprednisolone) if requested by surgeon. Dose: Bolus 33 mg/kg over 1 hour; maintenance 5.4 mg/kg over the next 24 hours for spinal cord protection. If used for “protection” against ischemic optic neuropathy, discontinue at the end of the case. Note that there is no evidence that steroids are helpful to protect against ischemic optic neuropathy. Do not follow the UWMC insulin protocol if the patient is non-diabetic. IV bolus doses of insulin are usually adequate to treat hyperglycemia secondary to steroids in non-diabetic patients, and dextrose-containing intravenous solutions should be avoided.
   - Syringe pumps and/or Imed pump (TIVA, drugs).
   - T-connector and extension lines.
   - Hot-line, Bair-Hugger.
   - Alton-Dean pressure infuser.
   - Level One when massive blood loss is anticipated (e.g. multilevel posterior spine or neoplastic diseases).
   - Cell Saver if requested by surgeon (only 1 surgeon uses the cell saver).
   - Fluids: Plasmalyte (7-10L) and albumin 5% (500-1000ml). Avoid hetastarch - it inhibits release of Factor VIII and has been associated with bleeding. Normal saline in large quantities is associated with hyperchloremic metabolic acidosis.

4) Anesthesia Technique: follow the protocol described in the C-spine section.

5) Complications:
   a) Neurologic injury.
   b) Perioperative visual loss: 1-2/1000 cases; mechanism uncertain but may be related to venous congestion. Risk factors for ischemic optic neuropathy: prolonged surgery in prone position, and excessive blood loss. Note that pressure on the eyes causes central retinal artery occlusion, not ischemic optic neuropathy.
   c) Massive blood loss.
   d) Air and fat embolism – hemodynamic effects are worse if patient is hypovolemic. Air embolism may become manifested with increases in venous return and cardiac output with position change to supine at the end of the case. Keep ECG and A-line connected when turning.

6) Postop care: Some patients may require mechanical ventilation if there is massive blood loss (> 3000ml). However, a neuro “wake up” test should be performed and documented on the
anesthetic record at the end of the procedure, prior to sedating the patient and transporting to ICU. A wake up test at the end of surgery is important for both clinical care and medicolegal purposes. Most patients with less than 3000ml of blood loss, and younger patients with less than 5000ml, can be extubated in the OR or in PACU. A leak test should be performed. Patients without a leak can be positioned sitting for up to an hour before extubation to reduce airway edema. The reason to aim for extubation after the procedure is it permits followup neurological exams (e.g. epidural hematoma is a postop complication and is most rapidly detected in a responsive patient).

Transfusion Management

Significant blood loss > 2000ml should be anticipated when multilevel instrumentation or surgery for tumors is performed.

- Check blood availability in time; use the mobile refrigerator for storage. Order 1 pack apheresis platelets (not pooled platelets) and 6 units fresh frozen plasma (kept frozen) and 1 unit cryoprecipitate (kept frozen). At UWMC, these blood components can be stored at the Transfusion Services Lab until needed for transfusion to avoid charges to the patient if not used.
- Monitor continuously signs of ongoing blood loss: assess surgical field, suction canisters, and surgical sponges; look for signs of inadequate organ perfusion (BP, HR, urine output, CVP, acid-base balance); check hematocrit and coagulation parameters frequently.
- Transfusion trigger: Hct ≤ 30% in most patients. Note that it is very easy to underestimate the amount of blood loss, and hypovolemia should be treated with fluids, not phenylephrine. CVP tends to climb in the prone position over several hours.
- Blood component therapy (UWMC Transfusion practice protocol):
  - Platelets if the platelet count < 100,000
  - Fresh frozen plasma (FFP) if international normalized ratio (INR) > 1.5. Start thawing FFP if INR = 1.3 and ongoing blood loss.
  - Cryo if fibrinogen < 125mg/dl
  - Recombinant Factor VIIa has been used with massive blood loss and coagulopathy. FDA-approved.

Aprotonin

1) Mechanism of action: Aprotonin is a proteinase inhibitor, which modestly reduces blood loss by inhibition of multiple mediators (e.g., kallikrein, plasmin) of the systemic inflammatory response, fibrinolysis and thrombin generation.

2) Dosage: Note that aprotonin must be administered through a central line.
3) **Test dose:** Administer a test dose of 1ml (1.4mg or 10,000 KIU) of apronotin at least 10 minutes prior to the loading dose. When re-exposure to apronotin is less than 6 months, the incidence of hypersensitivity/anaphylactic reactions is 5%, whereas it is 1% with re-exposure of greater than 6 months.

4) **Dosage for spine surgery:** Loading dose of apronotin = 100ml (140mg or 1.0 million KIU), followed by continuous infusion of 25ml/hr of apronotin (35mg/hr or 250,000 KIU/hr). On occasion, the higher dose regimen may be used (load = 200ml, infusion is 50ml/hr). Note that the lower dose is as efficacious as high dose apronotin during CABG surgery in low-risk patients and the low dose is recommended for spine surgery.

5) **Toxicity:** Due to limited efficacy (reduction in blood loss by 1-2 units) and toxicity (myocardial infarction, renal failure, thrombosis), use of apronotin during spine surgery is not recommended for patients with cardiac, kidney, or cardiovascular disease. See FDA alert [http://www.fda.gov/medwatch/safety/2006/safety06.htm#trasylol](http://www.fda.gov/medwatch/safety/2006/safety06.htm#trasylol)

**Dexmedetomidine as Adjuvant to TIVA**

Dexmedetomidine is a selective alpha_2_ receptor agonist, marked as a sedative in the intensive care and the operating room.

- **Pharmacology:**
  - Affected receptors and responses:
    - Alpha_{2A}: location: brain-stem→ sympatholysis; sedation; anxiolysis
    - Alpha_{2B}: location: vascular smooth muscle→ vasoconstriction
    - Alpha_{2C}: location: spinal cord→ analgesia
  - Pharmacokinetics: Distribution half-life ~ 5-6 min; elimination half-life ~ 2 hours.
- **Clinical properties:**
  - Sedation and anxiolysis with no respiratory depression
  - Analgesia
  - Anesthetic sparing effect
  - Thermoregulation with reduction in shivering
- **Cardiovascular effects include dose-dependent blood pressure changes:**
  - At clinical doses (less than 10 µg/kg/hour), Alpha_{2A} receptors mediate a reduction in sympathetic outflow with enhanced vagal activity dominating and causing a moderate decrease in MAP and bradycardia.
  - At high doses and with rapid infusion, the Alpha_{2B} action dominates with vasoconstriction and increase in MAP.
**Dexmedetomidine for Spine with MEP monitoring**

Rationale for use is to reduce the dose of propofol (by 30-50%) and allow optimal anesthetic conditions for MEP monitoring.

- **Recommendations**
  - Use in combination with TIVA (propofol/remifentanil).
  - In case of bradycardia, give atropine. Treat hypotension with fluid bolus or vasopressor.
  - Stop dexmedetomidine if refractory bradycardia or hypotension occurs.
  - Dexmedetomidine is not recommended in patients with heart block. Note that dexmedetomidine can be used in patients on beta-blockers and on calcium-channel blockers.

- **Preparation and administration**
  - Dexmedetomidine is supplied as 2cc vial containing 200µg.
  - To prepare, combine 200µg with 48cc NS (4 µg/cc). You will need an infusion pump programmed to deliver in µg/kg/hour (not per minute!).
  - Loading dose: 0.5-1 µg/kg given over 20 min.
  - Maintenance: 0.2-0.4 µg/kg/hour (maximum 0.7 µg/kg/hour).

**References:**