Anesthesia Consideration for Posterior Stabilization Surgery

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ABSTRACT

Spinal surgery is often performed to address symptomatic compression of nerve roots or the spinal cord due to trauma or degenerative disorders. Posterior stabilization procedures present unique anesthetic challenges, particularly with the prone position commonly employed. General anesthesia remains the standard for lumbar spine surgery, although spinal anesthesia offers advantages for high-risk patients, such as reduced blood loss and fewer pulmonary complications.

This review outlines the critical anesthetic considerations across preoperative, intraoperative, and postoperative phases for posterior stabilization surgery. Preoperative evaluation includes assessments of airway, pulmonary and cardiovascular function, musculoskeletal and neuromuscular systems, laboratory testing, and potential autologous blood donation. Intraoperative management focuses on minimizing blood loss and maintaining hemodynamic stability, often incorporating blood conservation strategies like tranexamic acid. Pain management employs multimodal approaches to address severe postoperative pain, while complications from prone positioning, such as nerve injuries and hemodynamic instability, require vigilance.

Postoperative outcomes are influenced by complications, including neurological, cardiopulmonary, and structural issues, underscoring the importance of meticulous anesthetic planning and management throughout the perioperative period. This review highlights best practices and strategies to enhance safety and efficacy in posterior stabilization surgery.

Keywords: Anesthesia, Anesthesia Consideration, Posterior Stabilization Surgery

INTRODUCTIONS

Spinal surgery is typically performed to address symptomatic compression of the nerve roots or spinal cord due to trauma or degenerative disorders. While general anesthesia is commonly used for lumbar spinal surgery, spinal anesthesia is a viable alternative, particularly for high-risk patients who may not tolerate the complications of general anesthesia. Potential complications of general anesthesia in these patients include headaches, back pain, nausea, vomiting, dental injuries, sore throat, laryngeal injuries, anaphylaxis, cardiovascular collapse, respiratory depression, aspiration pneumonia, hypothermia, hypoxic brain damage, nerve injuries, embolism, and even death. Consequently, spinal anesthesia is often considered a safer option for high-risk individuals.[1-3]

Posterior stabilization surgery necessitates careful consideration of anesthesia with the patient positioned prone. Preoperative, intraoperative, and postoperative management is required for optimal outcomes. Several complications can arise during and after posterior stabilization procedures, making precise anesthetic management crucial to ensuring proper patient positioning throughout the surgery. This review aims to provide insights into the anesthetic considerations for posterior stabilization surgery.

DISCUSSION

Definition

Spinal surgery is commonly performed to address symptomatic compression of the nerve roots or spinal cord caused by trauma or degenerative disorders. This compression often results from intervertebral disc protrusion or osteophytic bone (spondylosis) into the spinal canal or foramen. Disc prolapse typically occurs at the lumbar or cervical spine, while spondylosis more often affects the lower cervical spine, particularly in older patients. Spinal surgery aims to correct deformities (e.g., scoliosis), decompress the spinal cord, stabilize the spine, or address tumors, vascular malformations, abscesses, or hematomas.[1]

Anesthesia in Posterior Reduction Surgery

General anesthesia is commonly used for lumbar spine surgery. Conscious patients under spinal anesthesia can also self-position to avoid injuries, making it a preferred choice for laminectomy. Spinal anesthesia is rarely used for posterior lumbar stabilization, even in high-risk patients, despite their often elderly status and pre-existing comorbidities.[9]

Positioning Patients for the Surgery

Surgical positioning balances patient tolerance and surgical access. Adjustments are often needed to accommodate patient physiology, as perioperative inflammatory responses can contribute to neuropathy. The body's compensatory mechanisms maintain blood pressure during positional changes, but anesthesia can blunt these responses, increasing the risk of hemodynamic instability, especially during sympathetic-triggering positions like sitting. Monitoring should continue during positional adjustments to prevent complications.[5]

1. Prone Positioning

The prone (ventral decubitus) position is used for procedures on the posterior skull, spine, buttocks, perirectal area, and lower extremities. General anesthesia often requires airway management before positioning. Moving an anesthetized patient to prone requires team coordination, with anesthesiologists managing airway security and monitoring.[5]

a. Full Prone

Elevating the torso prevents abdominal compression but may create head and limb perfusion gradients, leading to facial edema or optic neuropathy. Supports like gel pads or frames reduce abdominal pressure, though no device has proven superior. Compression stockings can prevent venous pooling.[5]

b. Jackknife Prone

This position flexes the thighs significantly to provide access to sacral, perianal, and perineal areas.[5]

c. Prone Kneeling

Used for lumbar and cervico-occipital surgeries, kneeling frames reduce abdominal pressure but may cause compartment syndrome or soft tissue injury in prolonged use.[5]

2. Complications of the Prone Position

Some of the complications of the prone positioning are:[5]

- **Eye Injuries:** Protect eyes with lubrication and ensure no pressure from supports or cables.
- **Vision Loss:** Associated with optic neuropathy, particularly in lengthy spine surgeries with blood loss or hypotension.
- **Nerve Injuries:** Excessive head rotation or improper limb support can impair perfusion or compress nerves.

- **Abdominal Compression:** Increases intra-abdominal pressure, impairing ventilation and venous return, which can worsen surgical site congestion.

Proper positioning, monitoring, and equipment selection are essential to minimize these risks.[5]

Preoperative Considerations

A comprehensive preoperative evaluation by an anesthesiologist is crucial to formulating an anesthesia plan, assessing pre-existing conditions, previous anesthesia complications, airway difficulties, and positioning concerns. Patients with limited mobility may require pharmacologic cardiovascular testing, and beta-blockers can reduce cardiac risks in select cases. Rheumatoid arthritis often impacts airway management due to cervical spine, temporomandibular joint, and laryngeal involvement, with chronic steroid therapy necessitating perioperative replacement. Medication reviews should ensure continuation of antihypertensives, chronic opioids, and antiplatelet therapy as needed. Physical exams must include airway assessment, cardiac and pulmonary auscultation, and documentation of neurological deficits. Routine lab tests and preoperative education on surgical and anesthesia plans are also essential.[2]

1. Airway Evaluation

Thoracic or upper cervical spine surgeries pose airway challenges, particularly in patients with osteoarthritis, rheumatoid arthritis, ankylosing spondylitis, neuromuscular disorders, or prior radiation to the head/neck.[2]

2. Pulmonary Evaluation

Significant spinal deformities can impair respiratory physiology, reduce vital and total lung capacity, and potentially lead to pulmonary hypertension and cor pulmonale. Tracheal or bronchial displacement may cause mechanical airway obstruction. Preoperative pulmonary assessments, including function tests, chest X-rays, and arterial blood gas analysis, are crucial for complex spine procedures.[2]

3. Cardiovascular Evaluation

Spine surgeries, often performed in the prone position, reduce cardiac index by 12-24% compared to supine positioning. Pre-existing cardiac dysfunction complicates management. Preoperative cardiac evaluations include at least an ECG, with echocardiography reserved for patients with poor exercise tolerance.[2]

4. Musculoskeletal Evaluation

Limited joint mobility in spine surgery patients complicates surgical positioning. Detailed skin assessments and documentation of bruising or other injuries are essential.[2]

5. Neuromuscular Evaluation

Documenting pre-existing motor and sensory deficits ensures accurate monitoring and diagnosis of new postoperative deficits. This is critical for selecting neuromuscular blocking agents and assessment sites.[2]

6. Laboratory Evaluation

Pre-existing comorbidities and surgical scope determine required preoperative labs. Baseline hemoglobin, platelet count, creatinine, electrolytes, and blood cross-matching may be necessary for extensive procedures involving more than two vertebral levels.[2]

7. Preoperative Autologous Blood Donation

Autologous blood donation may be considered for surgeries with anticipated blood loss exceeding 500-1000 mL. While effective for blood conservation in adolescent idiopathic scoliosis and shorter lumbar fusion procedures, studies suggest one-third of donated blood is unused, and patients remain at risk for allogeneic transfusion. No significant differences in perioperative infection or wound healing rates have been observed.[2]

Intaoperative Considerations

Spinal surgeries are often associated with significant blood loss, especially in complex, multi-level procedures or revisions, with potential loss up to 2.8L and an 81% transfusion rate if precautions are not taken. Blood conservation strategies, including the use of antifibrinolytic agents like tranexamic acid, aminocaproic acid, and aprotinin, are essential to reduce blood loss and transfusion needs. Factors such as prone positioning may increase intra-abdominal and intra-thoracic pressure, exacerbating surgical bleeding. Preoperative anemia management with iron supplements and erythropoietin reduces transfusion risks and hospital stays. Intraoperative strategies include cell salvage, patient warming, frequent hemoglobin monitoring, and volume resuscitation. Proactive blood loss and coagulopathy management are critical, with transfusion thresholds typically set at hemoglobin levels of 8 g/dL. Tranexamic acid, effective in reducing blood loss and transfusion needs, has varying dose regimens, commonly involving a loading dose of 10–30 mg/kg and maintenance infusion at 1–3 mg/kg/hr. Modern transfusion algorithms guided by viscoelastic hemostasis testing can optimize blood product use in massive bleeding scenarios, though benefits in routine spinal surgeries remain inconclusive. Maintaining fibrinogen levels with cryoprecipitate and platelet counts above 100,000/μL is

crucial for surgeries involving the spine or nervous system to minimize complications like epidural hematomas.[2,10]

Table 1. Blood Conservation Strategies in Spinal Surgeries[10]

	Intervention	Details	Summary of Evidence	Level of Evidence
Preoperative	Discontinuation of aspirin	Stoppage of 7 days before the surgery	Blood loss: no effect	3
	Erythropoetin	100-300 IU/kg/day SC 15 dose	Transfusion rate: 54-69% reduction	2
	Autologous predonation		Blood loss: no effect Transfusion rate: no effect Complication: increased major cardiac events	3
Intraoperative	Tranexamic acid	10-15 mg/kg bolus followed by infusion of 10 mg/kg/h	Blood loss: reduced Transfusion rate: reduced	1
	Epsilon aminocarpic acid	Bolus of 100 mg/kg, followed by a continuous infusion of 10 mg/kg/h	Blood loss: no effect Transfusion rate: conflicting result	2
	Recombinant activated factor VII	30-120 mg/kg x Q2h (up to three doses)	Blood loss: 56-84% reduction Transfusion rate: no increase in adverse event	2
	Magnesium sulfate	50 mg/kg over 10 min, followed by a continuous infusion of 20 mg/kg/h	Blood loss: reduced	2
	Controlled hypotension		No evidence to demonstrate effectiveness in adults Complications: may increase risk of organ ischemia and POVI	5
	Cell saver		Blood loss: 33% reduction Transfusion: no effect Cost effective in procedures with >3 spinal levels and expected blood loss of more than 500 ml	3

	Acute normovolemic hemodilusion	Harvest 1-2 units of blood and replaced with crystalloid (2-4 ml/ml of blood harvested)	Blood loss: not significant	3
	ROTEM-guided blood product management		Blood loss: no effect Transfusion: no effect on pRBC, reduced FFP, increased cryoprecipitate	3
	Staged operation	Staged operation (in 2 days)	Blood loss: no effect Complications: increased DVT, ARDS, and higher mortality	3

Pain Management

Complex spinal fusion surgeries often result in moderate to severe postoperative pain, with many patients already on significant preoperative opioid doses. Risk factors for postoperative pain include preoperative narcotic use, age, anxiety or depression, smoking, and surgical complexity. Reducing or eliminating opioids preoperatively can help, but over 50% of multilevel surgery patients still report inadequate pain relief. Severe pain can delay recovery and rehabilitation. Multimodal analgesia, including acetaminophen, NSAIDs (e.g., celecoxib), gabapentin, pregabalin, and ketamine, can reduce opioid use and improve pain management without increasing complications.[2,10]

Postoperative Complications

Failure of surgery in the thoracic spine, particularly at the T4 and T5 levels, can lead to serious complications, including:[2,10,11]

Neurological Complications

1. **Brown-Séquard Syndrome**: Damage to one side of the spinal cord may result in motor weakness on the affected side and sensory loss on the opposite side.
2. **Paraplegia**: Injury to the spinal cord at T4-T5 can cause complete paralysis of both lower limbs.
3. **Thoracic Myelopathy Syndrome**: Symptoms include localized pain, weakness, and sensory dysfunction due to spinal cord compression.

Cardiopulmonary Complications

1. The T4 and T5 segments are involved in autonomic nervous system innervation controlling cardiac and pulmonary functions. Failure may impair respiration, cause diaphragm dysfunction, or increase the risk of autonomic hypotension.

Structural Complications

1. **Spinal Instability**: Fusion failure or instrumentation issues can lead to chronic pain and structural deformities.
2. **Kyphosis**: Abnormal curvature due to spinal deformities may develop.

Other Complications

1. **Postoperative Infections**: Conditions like osteomyelitis or epidural abscess can worsen neurological damage.
2. **Epidural Hematoma**: May compress the spinal cord, causing acute symptoms such as severe pain and neurological deficits.

Special Considerations for Spinal Procedures

1. Minimally Invasive Posterior Lumbar Discectomy (Microdiscectomy)

Percutaneous discectomy, typically for contained disc herniations, uses a posterolateral approach under MAC with local anesthesia. Fluoroscopy and specialized tools guide herniated disc removal, avoiding nerve root anesthesia to allow patient feedback.[2]

Common Diagnoses: Chronic back pain; lumbar radiculopathy.[2]

2. Minimally Invasive Anterior Lumbar Fusion (Transpsoas Approach)

This approach requires neuromonitoring due to lumbar plexus variability. After general anesthesia, EMG responses ensure nerve safety. Patients are positioned laterally with fluoroscopy guiding access to the retroperitoneal space, avoiding the peritoneum and protecting intra-abdominal structures.[2]

Common Diagnoses: Chronic back pain; lumbar radiculopathy.[2]
Anesthesia: General anesthesia (TIVA preferred); avoid muscle relaxants except for intubation.[2]

3. Spinal Reconstruction and Fusion (Thoracic and Thoracolumbar)

Upper Thoracic Spine (T1–T3): Access involves clavicle, manubrium, and rib resections, with risks to major vessels, trachea, esophagus, and brachial plexus. Partial lung deflation and spinal cord monitoring are standard.[2]

Mid-Thoracic (T5–T10): Transthoracic approaches involve thoracotomy and rib resection. Risks include vascular, pulmonary, and thoracic duct injury. Lung deflation varies based on exposure.[2]

Lumbar Spine (L2–S1): Retroperitoneal approaches minimize bowel manipulation, reducing fluid and heat loss. Risks include major vessels, ureters, and sympathetic/presacral plexus. Common diagnosis are fractures, scoliosis, neoplasms, osteomyelitis, degenerative disc disease, or spinal instability.[2]

Reconstruction: Operative tables assist in alignment and stability testing of implants or grafts. Transperitoneal approaches for sacral access require laparotomy with similar risks to abdominal surgeries.[2]

CONCLUSION

Spinal surgery is most commonly performed to address symptomatic nerve root or spinal cord compression secondary to trauma or degenerative disorders. General anesthesia have been shown to be appropriate for lumbar spine surgeries and routinely used in most spinal practices.

Preoperative anesthetic considerations include airway evaluation, pulmonary and cardiovascular assessments, musculoskeletal and neuromuscular evaluations, laboratory tests, and preoperative autologous blood donation. Intraoperative considerations are primarily associated with significant blood loss and pain management.

Posterior stabilization surgeries typically use the prone position, which may lead to complications during and after the procedure. Postoperative complications are often related to neurological, cardiopulmonary, structural, and other issues.

CONFLICT OF INTEREST

There are no conflict of interest

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