ANESTHESIA FOR SPINE SURGERY

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Introduction

Patient presenting for surgical procedures of the spine are a diverse population undergoing a wide variety of operative procedures and present diverse challenge to the anesthesiologists. The anesthetic management depends on the operative site, spine pathology, surgical approach and the anesthesiologists experience & expertise.

General Indications for Spine Surgery

One of the most difficult jobs of a spine surgeon is deciding when surgical intervention is appropriate. There are five basic reasons to offer surgical treatment to patients with spinal disorders.

- Neurological dysfunction (compression)
- Structural instability (abnormal displacement)
- Pathologic lesions (such as a tumor or infection)
- Deformity (abnormal alignment)
- Pain (spinal column/discogenic/facetogenic)

Placing the patient in one or more of these categories allows the spinal surgeon to organize his/her thoughts. In general, nonoperative treatment should be considered first prior to surgical intervention.

Surgical Procedures

1. Conventional Open procedures
2. Microdiscectomy can be performed to decompress nerve roots affected by simple pathology; bone is not usually removed
3. Endoscopic spinal surgeries: For a long time, the spine did not benefit from Minimum-access techniques but this situation was changed when, in 1991, Obenchain performed a **laparoscopic** L5-S1 discectomy, followed, in 1992, by Thomas Zdeblick's L5-S1 fusion by laparoscopic placement of an interbody cage. In 1994, Rosenthal et al reported the first excision of a herniated thoracic disc by **thoracoscopic surgery**. At the same time, Le Huec and Husson performed the first **endoscopic retroperitoneal approach to the lumbar spine**. Together, these three techniques provide access to the thoracic and lumbar spine in its entirety.

Thoracoscopic approaches to the spine are beneficial primarily in patients with lateral and anterior pathology and require "one lung ventilation". Both double lumen endotracheal tube and endobronchial blocker has been used successfully

in these patients. On occasion, the surgical goals can be accomplished by simply decreasing tidal volume via jet ventilation or traditional ventilation with temporary decrease of tidal volume during critical points in the procedure. Potential complications of a thoracoscopy include intercostal neuralgia, atelectasis, pneumothorax, hemothorax, chylothorax, pneumonia, infection, hardware–related complications, excessive epidural blood loss, major vessel injury, penetration of the diaphragm, pulmonary lacerations, etc. Conversion to open thoracotomy is always a possibility and should be included on the informed consent.

Laparoscopic procedures were used in lumbar spine diseases in both posterior and anterior approaches. Anesthetic consideration for these procedures is similar to those for any laparoscopic procedure and is related to CO_2 insufflations. In addition, the bifurcation of venacava and aorta occurs near the L 4-5 interspace. The most common reason for conversion to an open procedure was excessive bleeding either from the vena cava or segmental vein injury[1].While there is considerably less experience with endoscopic approach to cervical spine, early data suggest that endoscopy may offer advantages for certain procedures[2] .The possible complications using a retroperitoneal approach in endoscopic surgery are femoral neuralgia, psoas haematoma, and "Coincidental" lumbar sympathectomy.

The use of endoscopes allows surgical procedures to be performed through small incisions which may minimize postoperative pain, decrease length of hospital stay, facilitate recovery times, hasten return to work, and decrease costs of medical care [1,3,4,].

4. Spine surgery using intraoperative neuronavigation in combination with intraoperative computed tomography is of benefit to the patient. Problems encountered during the procedure were patient positioning, limited patient access, long tubing, and therefore the need for adequate monitoring[5] Utilization of intraoperative MRI during spine procedures has recently been reported with potential advantages of improved localization of pathology and ability to access adequacy of surgical correction suggested[6]. If this technique gains in popularity it will require careful planning of operating rooms and equipment needs.

Anesthetic Technique

Although General EndoTracheal Anesthesia (GETA) is the preferred technique for all spine surgeries, both Spinal and Epidural anesthesia have been successfully used for simple lumbar disc excision[7].Studies suggest that spinal anesthesia may be associated with a decreased blood loss, decreased early postoperative pain, lower incidence of nausea and vomiting, and a decreased incidence of deep vein thrombosis[8]. With proper patient selection, failure rate requiring conversion GETA is rare[7]. Although rarely used, but cervical spine surgery can be performed using local anesthesia[9]. Adequate local anesthesia is very difficult if not impossible to obtain, requiring a depth of sedation that most are uncomfortable with in the prone position.

Anesthetic Considerations

A. Preoperative evaluation and anesthetic management of patients for spine surgery must take into account the medical condition as well as the surgical procedures including the duration and surgical approach. The factors that need to be evaluated are
   1. Airway Evaluation: It should include Mallampatti classification, various radiological predictors of difficult intubation and range of motion of the neck with attention given to elicitation of pain or other neurological symptoms during manipulation.
   2. Pulmonary Evaluation: Patient at risk of pulmonary dysfunction during spinal surgery includes those undergoing corrective surgeries (eg. Scoliosis), old age (patient with degenerative spine diseases), suffering from acute fracture of cervical spine (C-spine) and patient requiring special anesthetic technique like one lung ventilation.

Depending on the situation and type of procedure, the patient is subjected to various clinical and laboratory test ranging from bed side pulmonary function evaluation to pulmonary function text, chest radiograph, etc.

   3. Cardiac Evaluation: Cardiac function may be compromised by under lying medical conditions, neuromuscular disorder rheumatoid arthritis and high cervical cord injury. Patient with C-spine injury and associated spinal cord trauma may exhibit profound vasodilatation with bradycardia because of loss of regulatory sympathetic tone. Generally this condition treated effectively with intravenous fluid and atropine.
   4. Neurologic Evaluation: It is not very uncommon that patient suffering from spine pathology may present from spine pathology may present with various grader of neurologic deficits ranging from weakness and atrophy of specific muscle groups to paraplegia and quadriplegia. A thorough neurological examination and careful documentation of preexisting neurological deficit is essential. The extent of neurological dysfunction may dictate intubation technique and choice of anesthetic agents.

Magnetic resonance imaging (MRI) has replaced myelography as the primary diagnostic test because it distinguishes disc from tumor from cyst. Emergency CAT scan is invaluable in assessing patient with acute neck injury and suspected cervical fracture but some time even neck X-Ray(AP and lateral view) is of immense help where the above sophisticated investigation are not available.

   5. Hematological Evaluation: Many patients with spine pathology will have been taking some NSAIDs for pain relief. So a proper coagulation profile has to be ordered and the NSAIDs should be stopped at least 10days before elective surgeries.

6. Premedication: Depends on the haemodynamic stability and neurological status of the patient

B. Monitoring
   1. Standard Monitoring: As specified by American Society of Anesthesiologists (ECG, NIBP, Pulse oximetry, Capnometry, Temperature).
   2. Special Monitoring: Invasive blood pressure, central venous pressure , urine output are monitored in patients undergoing lengthy procedures that have potential for large volume shift, risk of venous air embolism and patients who have complicated medical history, haemodynamic instability (spinal shock) or in procedures where special anesthetic techniques are planned like deliberate hypotension, endoscopic surgeries. Placement of a Swan Ganz catheter may be required for patients with severe cardiac or respiratory disease.
   3. Specific monitoring: Neurologic monitoring is necessary during operative procedures that may compromise the integrity of the spinal cord. Patients undergoing procedures such as spinal fusion and removal of spinal cord tumors and vascular lesion are at more risk. The basic methods used to asses the spinal cord function or nerve root injury are somatosensory evoked potential (SSEP), motor evoked potential (MEP), Wake up test, and electro myographic monitoring (EMG).

SSEPs are the modality with the longest history of intraoperative use with more recent introduction of MEPs. Intermittent wake up testing is an adjunct technique and remains the most reliable assessment of intact spine for several reasons. The reasons are anesthetic agents may suppress SSEP signals[10], certain patient condition such as neuromuscular degeneration may make SSEP impossible to obtain and isolated anterior spinal injury may go undetected with SSEP.

SSEP monitoring during scoliosis repair is considered an indicated technique by the scoliosis research society and is felt to result in a lower risk of intraoperative neurologic injury [11]. SSEP monitoring of other spine procedures in patients felt to be at high risk for neurologic injury is felt by some to decrease risk of neurologic injury but is not utilized consistently in all centers.

In one centre SSEP changes occurred in 2 – 10% of patient monitored during spine surgery leading to interventions in 50 -80% of patients with SSEP changes. The highest incidence of changes occurred during spine tumor resection and highest intervention rate during scoliosis repair[12]. In a retrospective study SSEP monitoring was found to have a sensitivity of 57% and a specificity of 95% with a false negative rate of 1.1 %[13]. As experience has increased with motor evoked potentials they have been shown effective monitors for high risk spine surgery occasionally detecting isolated motor injury in the presence of normal SSEP monitoring [14].

EMGs which are increasingly used to monitor nerve root injury can be ablated with complete neuro muscular relaxation. However partial relaxation monitored with peripheral nerve stimulator can be used to provide clinical relaxation and maintain the integrity of EMGs.

C. Positioning: A major problem during spinal surgery is the maintenance of basic cardiovascular monitoring techniques during positioning of the patient. This period may represent a stress to circulatory integrity and it is very difficult to prevent an almost total monitoring "blackout" as anesthetized patients are turned from the supine to prone position, which is the most frequently used position in spine surgery. The problems of surgery and anesthesia in prone position are cited in table I.

While positioning particular attention should be focused on positioning of the neck, arms and eyes to protect pressure sensitive areas. Patients who have a lateral approach to the spine may be positioned in the lateral decubitus position (if not supine) and requires a heightened level of sensitivity to positioning. Regardless of how well a patient is positioned at the start of a procedure on going vigilance with regard to position is essential because a patient's situation may change after movement during wakeup test or manipulation of the operating table. The use of sitting position may facilitate good surgical vision by elimination pooling of blood in the operative field but is associated with a number of complications including venous air embolisms(VAE), adverse position related haemodynamic changes and position related nerve injuries.

D. Induction: Any standard technique is acceptable; consider using a wire reinforced tube to avoid tube kinking and occlusion while tuning the patient from supine to prone position. It also allows maximal banding to remove it from surgical field and prevent compression from "Dingman retractor" during cervical surgical procedures. Due care should be given to stabilize the neck during endotracheal intubation by any of the method as described in table II.

E. Airway Management: Patients undergoing cervical spine procedure require special consideration for airway management. Patients with C-spine disease have a high incidence of difficult intubation. In a prospective study of patients undergoing elective cervical spine procedures 20% were found to have grade 3 or 4 glottic visualization (view of epiglottis only or unable to view epiglottis) at direct laryngoscopy. Patients with rheumatoid disease had higher incidence of difficult intubation (48%) followed by patients suffering from cervical fracture or tumor (23%, 24%).The other risk factor that has been reported as predictor of difficult intubation include upper vs. lower C-spine disease and presence of external or internal fixation devices[15].

The risk of neurologic injury is more when endotracheal intubation has been attempted in patients suffering from C-spine disease[16, 17]. Various studies have been made for evaluating the optimal techniques for intubating patients at risk for cervical spine injury[18-28]. In the presence of a recognized unstable C-spine a variety of intubation techniques in experienced hand have consistently been shown to be safe and not associated with increased risk of neurologic injury. But till now no single technique has been proved to be superior to other [16, 17, 25, 27]. Results of studies of cervical motion and intubation characteristics of different intubation maneuvers suggest potential advantage with fiberoptic bronchoscopy, use of Bullard laryngoscope, use of intubation guides, and use of inline stabilization for decreasing C-spine motion doing intubation. Use of rigid color is of no benefit during airway management [18-24] .Table II summarizes result from studies evaluating C-spine motion and intubation characteristics with different intubation tool.

Both awake intubation and intubation after general anesthesia have been used safely and studies could not demonstrate the safety of one above the others[16,17,27]. Awake intubation offers several advantages including maintenance of normal muscle which has been suggested but not proven to splint an unstable spinal column, and the ability to perform a neurologic examination following intubation (and positioning if indicated).

However awake intubation always necessitate a cooperative patient and it can be very stressful in planning airway management of patients undergoing C-spine surgery. Awareness of the risk of spinal cord injury with laryngoscopy, recognizing the increased probability of encountering a difficult airway, and attention to minimizing motion of the C-spine are more important to success than of a particular technique in patients with a recognized unstable C-spine. Intubation is associated with a 1.3% incidence of neurologic deterioration which is similar to the rate of neurologic deterioration in similar patients that do not undergo intubation. In patients with unrecognized C-spine instability, risk of neurologic deterioration with intubation is around 10%[29] compared to only 1.3% in patients with recognized C-spine instability which is almost equal to the incidence of neurologic deterioration in patient who does not under go intubation[27]. Positioning the patent with C-spine disease may be associated with the risk of neurologic injury and in some situations may be done with neurologic monitoring either of the awake patient or with electro physiologic monitoring. Patients undergoing multiple levels anterior C-spine procedures may be at risk of post operative neck and airway edema causing airway compromise. The various predictor for this are operative time more than10hrs, requirement for more than 4 unit transfusion, obesity, reoperations and operation of 4 or more cervical spine level or involving C2 [30,31]

F. Maintenance: A standard N_2O- Opioid based technique with neuromuscular blocking agent and low dose inhalational agent supplementation is desirable.

The maintenance dose of anesthetics is altered as many of the patients with spinal cord injuries and neurological deficits may have altered pharmacokinetics due to muscle wasting, increased volume of distribution and decreased serum albumin [32].

Patient felt to be at high risk for neurologic injury intraoperatively may be managed with either induced hypertension or maintenance of systemic blood pressure with in 10-20% of pre operative values. This is most often utilized in patients with anatomic compromise of the spinal canal in the cervical and thoracic region and / or preoperative neurologic abnormalities. Some centers utilize neurologic monitoring during placements of patients in the operative position to prevent position related injury. This is most commonly utilized in patients with either spinal column instability or anatomic compromise of the spinal canal as in severe cervical stenosis with myelopathy.

The type, duration, and extent of surgery may guide the approach to fluid administration and replacement. It is well agreed that dextrose containing solution should be avoided because of risk of worsening neurosurgical outcome in the presence of hyperglycemia during spinal cord ischemia [33].

G. Transfusion Management: Transfusion management during spine surgery has changed over the last decade. Surgical procedures involving significant bone work at multiple levels may be associated with large intraoperative blood loss and a higher requirement for transfusion of blood and blood products. Strategies that reduce or remove the risk of allogeneic transfusion include preoperative autologous donation (PAD), acute normovolemic hemodilution (ANH), perioperative cell salvage techniques (PCS), deliberate hypotension, and pharmacologic interventions[34,35,36]**.** Each has been shown to be similarly effective when used alone to decrease requirement for transfusion of homologous blood products during major spine procedures as compared to routine transfusion without use of any autologous blood products. But when a combined strategies are used it was found that the combination of strategies decreased the quantity not only of allogeneic red cells transfused, but also of other blood products in those patients undergoing reconstructive spinal surgery[37]. Although induced hypotension is most commonly employed to minimize blood loss during procedure involving multiple levels of spine, but its efficacy has not been consistently demonstrated[38,39]. Operative position which prevent abdominal compression (Jackson table and frame supported kneeling position) have been reported to result in less blood loss and lower rate of transfusion requirement as compared to position in which some degree of abdominal compression may occur(prone or Bolster or Wilson frame) [36].

H. Extubation: The timing of extubation is an important consideration. This decision is based on many factors that include issues such as the complexity and extent of the surgery, operative time, patient's co-existing diseases, blood loss/transfusions, and complications that occurred during

or immediately after the surgery. Some select patients may require postoperative care in an intensive care setting. If there is any question about adequacy of the airway after ETT removal, a conservative approach to extubation should be employed[29]. It is desirable to leave the ETT in place until patient is fully awake, responding to command and able to manage his/her own airway. In few cases it is prudent to leave the ETT in place and spray lidocaine 4%, 4ml down the trachea to prevent or minimize coughing or bucking on the ETT for about 15-30 minutes. One should also consider inserting an airway exchange catheter (AEC) through the ETT before its removal. This AEC will provide a conduit for immediate reinsertion of an ETT if airway obstruction from early or delayed swelling, bleeding, or haematoma formation should occur.

I. Postoperative care**:** Postoperative care is individualized for each patient. The preoperative status, surgical procedures, intraoperative complications and pain tolerance are to be considered in planning the postoperative management. Most spinal surgery is painful and good postoperative analgesia is important. Local anesthetic and Opioid drugs can be instilled into the epidural space before closing. More usually, however, a regimen including patient-controlled analgesia (PCA) combined with regular oral/rectal analgesics is successful.

Postoperative complications

In the early post-operative phase, potential complications of spinal surgery include fluid volume deficit, neurologic injury or deficit, dural tear with cerebral spinal fluid leakage, anemia, urinary retention, ileus, atelectasis/pneumonia, and venous thrombosis[40,41,42]. Complications specific to anterior cervical procedures include dysphagia, hoarseness, and airway obstruction from edema [43, 44]. Later complications of spinal surgical procedures include skin breakdown, wound infection, spinal instability (after wide lumbar decompressive procedures not accompanied by fusion), hardware failure, pseudarthrosis, epidural fibrosis, transitional Syndrome and more rarely, arachnoiditis[40,45].

In recent years, perioperative vision loss in patients undergoing spine surgery has become an issue of increasing concern to physicians, patients, and medico legal experts. Perioperative ischemic optic neuropathy (POION) is the most common causes of postoperative vision loss. Other less common causes of postoperative vision loss include central retinal artery or vein occlusion and occipital lobe infarct. While corneal abrasion is the most common eye injury after spine surgery, it rarely leads to permanent vision problems. POION is a rare (incidence 0.028 %.) but potentially devastating and untreatable complication of spine surgery particularly that performed with the patient in the prone position. Anemia, hypotension, long duration of surgery and significant intraoperative hydration may all be risk factors for this condition. All patients undergoing spine surgery should be informed about the low but definite risk of this condition, and every attempt should be made during surgery to maintain stable hemoglobin and mean arterial pressure and to avoid over hydration [46].

Conclusion

Patient undergoing spine surgery present diverse challenge to the anesthesiologist. Optimal management depends on the anesthesiologist understanding the pathologic process and the risk and need of the operative procedure.

Table I
Problems associated with "prone" position.

Potential problems	Comments
Eyes	
Corneal abrasion	Ensures eyes taped shut
Optic neuropathy	Increased intraocular pressure Decrease perfusion pressure Reduce risk by avoiding compression to the eyes, hypotension, low hematocrit
Retinal artery occlusion	Avoid pressure on the eyes
Head and Neck	
Venous and Lymphatic obstruction	Careful positioning to minimize venous obstruction
Skull fixation	Insertion of pins into skull can result in a hypertensive response that is difficult to control
Abdominal compression	
Impaired ventilation	Avoid abdominal compression as far as possible
Decreased cardiac output	Bean bag mattress or pillow are better than the supportive frames or knee-chest position
Damage to major vessel	
Aorta and Venacava	Accidental damage following perforation of anterior longitudinal ligament produces major bleeding into wound. Present with acute reduction of blood pressure and electromechanical dissociation arrest High mortality
Iliac vessel	Less acute presentation. High degree of suspicion to avoid delayed diagnosis

Table II:
Intubation techniques, Cervical spine motion and Intubating conditions

Methods	C-spine motion	Intubation difficulty	Time required
Rigid collar	0	↑	
Inline stabilization	↓	0-↑	↑
Axial traction	↑		
Blind nasal intubation	↓	↑	↑
Retrograde Intubation	↓	↑	↑
Bullard vs. conventional laryngoscope	↓	↓	↑
Miller vs. Macintosh laryngoscope	0	0	0
McCoy vs. conventional laryngoscope	↓	↑	↑
Lighted stylet vs. FOB†		0-↑	↓
ILMA‡ vs. FOB	0	↑	↑
Augustine guide vs. FOB		↑	↓

† Fibreoptic bronchoscopy
‡ Intubating laryngeal mask airway

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