



Spine Surgeries: Challenging Aspects and Implications for Anaesthesia

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Abstract

Anaesthesia for spine surgery presents diverse challenges for the anaesthesiologist. The various indications for spine surgery include trauma induced spinal instability, tumour or vascular malformation, congenital structural deformity, infections and discogenic or facetogenic pain. The pre-anaesthetic evaluation should be meticulous and is very important to know the degree of neurological damage and to anticipate the intraoperative concerns related to the approach, positioning and monitoring of neurologic functions of spinal cord. The anaesthetic technique should be tailored to best suit the type of intraoperative neurologic monitoring technique used. The control of postoperative pain is also a challenging task for the anaesthesiologist and a multimodal approach involving systemic analgesics in combination with regional techniques can be helpful.

Keywords

Anaesthesia; Postoperative care; Somatosensory evoked potentials; Spine surgery

Introduction

Advancements in anaesthetic techniques and drugs have been necessitated by the ever increasing complicated surgical procedures. This is highlighted by the fact that a considerable development in the surgical techniques of spine surgery and advancements in intensive care practices has led to an increase in the number of patients presenting for a spectrum of spine surgeries. Invariably, these patients have multiple co-morbid problems and pose significant challenges to the attending anaesthesiologist. The goals of anaesthesia in these surgeries are to provide optimal surgical conditions with maintenance of adequate oxygenation and also to facilitate the intraoperative spinal cord monitoring. The main indications of surgery in pathological conditions of spine can be enumerated as:

- Neurological dysfunction e.g. compression
- Structural instability e.g. abnormal displacement
- Pathologic lesions e.g. tumour or infections
- Deformity e.g. hereditary or acquired
- Pain e.g. discogenic or facetogenic

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The site of surgery can range from cervical to lumbosacral region and the procedures may involve minimally invasive microdiscectomy to prolonged surgeries involving multiple spinal levels. The approaches may be anterior, posterior or combined and may involve repositioning of the patients intraoperatively and possible chances of major blood loss.

Indications of spine surgeries

Elective spine surgery may be carried out for a number of spine pathologies:

Scoliosis: It involves a lateral and rotational deformity of spine with an incidence of about 4% [1]. Most of these cases have idiopathic etiology (70%) while others are divided into congenital and acquired aetiologies. The acquired aetiologies include but are not limited to myopathies, poliomyelitis, neurofibromatosis, rheumatoid arthritis, Marfan's syndrome, osteoporosis, Paget's disease, trauma, infections and primary and metastatic tumours. The indication of surgery is mainly related to the severity of spinal deformity which is indicated by the Cobb's angle such that an angle exceeding 50 degrees in thoracic and 40 degrees in lumbar region usually require surgical correction. The main aim of surgery is to reduce the respiratory and cardiovascular complications associated with the deformity. The feared complications if untreated usually occur by fourth or fifth decade of life may result in mortality due to pulmonary hypertension, right ventricular failure or respiratory failure [2]. The anaesthetic implications will be dealt in detail in subsequent sections.

Muscle disorders: The most important muscular disorders with spinal involvement are cerebral palsy and Duchenne muscular dystrophy. Duchenne muscular dystrophy is a sex linked recessive condition with an incidence of 1 in 3300 male births. The pathological condition is the lack of a cytoskeletal protein termed 'Dystrophin' with the involvement of skeletal, cardiac and smooth muscles. These patients present between the ages of 2 and 6 years with progressive weakness of proximal muscle groups with one third of the patients developing intellectual impairment [3]. The occurrence of cardiac complications such as dilated cardiomyopathy, mitral valve incompetency, dysrhythmia and conduction abnormalities, and remains high (50-70%). Surgery is primarily carried out to improve the quality of life, to stall the progression of respiratory compromise and to possibly increase the life expectancy.

The major anaesthetic implication in patients with muscular disorders is development of severe hyperkalemia with the use of depolarizing muscle relaxant like suxamethonium.

Malignancy: There is an increasing trend towards resorting to surgery in patients with primary malignancy of spine or secondary metastatic disease of spine mainly aiming at relief of pain, excision of lesion so as to prevent further neurological damage and stabilization of the spine. These patients have myriad problems attributing to malignancy itself or its effects e.g. infections, pleural effusions, effects of chemotherapeutic drugs on lungs and myocardium, nutritional derangements like malnutrition, hypoalbuminemia etc [4]. The various paraneoplastic syndromes associated with carcinomas of lung, prostate, pancreas may present as hypercalcemia, hyponatremia

and syndrome of inappropriate secretion of antidiuretic hormone (SIADH) and bear important anaesthetic implications. These patients often are on chronic pain therapy with opioids and other drugs and thus have increased intraoperative requirements of analgesics.

Spinal trauma: Patients of polytrauma often have severe spinal injuries which require urgent surgical stabilization with the patient in 'spinal shock'. The severity of clinical disease is represented by the level of spinal injury as physiological sympathectomy occurs below the level of spinal injury leading to arteriolar and venular dilatation which results in hypotension. This state starts immediately after injury and can continue upto 3 weeks. The spinal injuries at or above the level of T6 usually result in more profound hypotension as the sympathetic supply to splanchnic circulation is lost. Also, a higher injury leads to interruption of cardiac sympathetic supply (T2- T6) with an intact cranial parasympathetic supply leading to severe bradycardia [5].

Spinal hypotension usually does not respond to intravenous fluid administration and vasopressors are required to correct the hypotension. However, other causes of hypotension should always be excluded before instituting the treatment. Positive pressure ventilation may worsen the hypotension due to absence of compensatory increase in systemic vascular resistance below the level of spinal injury.

Cervical injuries (C4-C8) can cause paralysis of intercostal muscles and abdominal muscles leading to ineffective coughing, paradoxical movement of ribs during spontaneous respiration, a 50% reduction in vital capacity, 85% reduction in functional residual capacity and loss of active expiration. All these can significantly increase the chances of postoperative pulmonary complications. These patients are prone for development of venous thromboembolism and have abnormal thermoregulation.

These patients have propensity to develop 'autonomic dysreflexia' after 3 to 6 weeks of spinal trauma especially injuries above T7 level. It is manifested by extreme autonomic responses to stimulation of nerves below the injury level resulting in tachycardia, hypertension and cardiovascular derangements.

Central cord syndrome: A clinical syndrome in which there is disproportionately more motor impairment of upper than of the lower extremities, bladder dysfunction, usually urinary retention and varying degree of sensory loss below the level of lesion. It resulted from hyperextension injury with cord compression and injury to the central portion of spinal cord and associated neural spinal tracts. It is often seen in elderly population with spondyloticstenosed spinal canal sustaining a hyperextension injury and also seen in younger population where the etiology is mainly the bony instability caused by severe trauma to the vertebral column [6]. The other pathogenesis may be due to arterial ischemia, isolated injury to decussating corticospinal tracts in brainstem and central intraparenchymal spinal cord hematoma. The preoperative evaluation in these patients should focus on documentation of extent of neurologic damage and if cervical spinal cord is involved, these patients may pose difficulty in intubation for the fear of aggravation of the pathology. Surgical decompression is usually employed in younger population while medical treatment may be tried in elderly in early stages. The intra and postoperative management is similar to any other spinal cord surgery.

Preoperative assessment

Pre-anaesthetic evaluation of patients undergoing spinal surgery is most important and should involve assessment of respiratory, cardiovascular and neurological assessment together with the type of spine surgery and position involved. There should be a thorough discussion with the surgeon about the type of spine surgery and the anticipated blood loss. Risk and safety concerns in anaesthesia practice assume huge significance in complicated surgeries such as spine surgeries [7].

Airway assessment: Airway assessment is especially important in surgery of upper thoracic and cervical spine. A careful assessment of stability of cervical spine should be assessed which can be defined as ability of spine to resist displacement under physiological loads causing neurological injury. Apart from stability, other assessment tools like Mallampatti classification, range of neck movements, mouth opening etc. should also be assessed.

In addition to the clinical assessment, radiological screening of spine should also be done by taking anterior and lateral flexion/extension films of the spine involved along with computed tomography and if required magnetic resonance imaging of the spine. Inherited disorders like Duchenne muscular dystrophy may present with tongue hypertrophy, radiotherapy to head and neck with resulting fibrosis can pose difficulty in laryngoscopy and intubation and so a careful preoperative plan should be formulated for awake or asleep intubation of the patient. A similar more challenging scenario can be encountered during management of morbidly obese patient. Besides patho-physiologic abnormalities due to morbid obesity, positioning issues will be of paramount importance during surgical procedures [8].

Respiratory system assessment: Patients presenting for spine surgery, especially those having high thoracic and cervical involvement, often have impaired pulmonary functions with repeated chest infections and many of them may be mechanically ventilated preoperatively. Patients having scoliosis have restricted pulmonary disease with reduced vital capacity and total lung capacity and the severity often depends upon the angle of Cobb, the number of vertebrae involved, the cephalad position of curve and loss of normal thoracic kyphosis. The abnormality in arterial blood gas is usually reduced oxygen tension with normal carbon dioxide levels indicating a ventilation perfusion mismatch. Preoperatively, all the reversible conditions should be corrected like control of chest infection by appropriate antibiotics and optimisation of chest conditions by use of chest physiotherapy and bronchodilators.

The extent of improvement in pulmonary functions following a corrective surgery in patients with scoliosis has been studied and has yielded mixed results. The studies show that thoracic scoliosis surgeries result in only mild improvement in pulmonary functions at two years postoperatively if the approach used is anterior or combined but a significant improvement in pulmonary functions has been observed at two years postoperatively with only the posterior approach [9,10].

The patients at a high risk of postoperative ventilation include those having vital capacity 30-35% lower than predicted, on mechanical ventilation preoperatively and those requiring continuous nasal positive airway pressures at night.

Cardiovascular evaluation: Cardiovascular system may be

involved due to direct effect of the spinal deformity or due to the pre-existing underlying cardiac disease. The patients with long standing scoliosis may have cor pulmonale secondary to the chronic hypoxia and pulmonary hypertension. Cardiac dysfunction may also result from the underlying systemic pathology like rheumatoid arthritis, muscular dystrophy etc. These patients should be evaluated preoperatively with electrocardiogram and echocardiogram to assess left ventricular function and severity of pulmonary hypertension. The functional assessment of cardiovascular functions can be done by dobutamine stress echocardiogram as most of these patients are bed ridden.

Endocrinological evaluation: It is generally felt among anaesthesia fraternity that endocrine evaluation during pre-operative period should be given more weightage owing to an ever increasing number of endocrinopathies in surgical patients. Diabetes has engulfed the entire globe and has emerged as one of the most significant epidemic of modern times. As such, diabeto-anaesthesia is also emerging as a new sub-speciality of endocrine anaesthesia [11]. Besides diabetes, thyroid, parathyroid, pheochromocytoma, pituitary lesions, craniopharyngioma and many other endocrinological disorders may be associated in patients with spine pathology [12-16]. A good co-ordination between anaesthesiologist and the endocrinologist is highly essential in this subset of population. Patients with co-existent endocrinopathies should ideally be kept in the intensive care during post-operative period as these patients are the potential candidates for possible development of emergency endocrinological clinical situations [17].

Neurological evaluation: The patients with spinal pathology or spinal trauma usually presents with varied degree of neurological impairment ranging from weakness and atrophy of specific muscle group to paraplegia and quadriplegia. The degree of neurologic impairment should be assessed thoroughly preoperatively and should appropriately documented as further neurologic deterioration can take place during endotracheal intubation and positioning and presence of bulbar involvement preoperatively can be a risk factor for postoperative aspiration.

Hematologic evaluation: Routine hematologic examination should be performed preoperatively involving complete hemogram, serum electrolytes and renal function tests (as these patients are often catheterized for long time). These patients may be on chronic therapy with non-steroidal anti-inflammatory drugs (NSAID's) and thromboprophylaxis for deep vein thrombosis, so a coagulation profile is important preoperatively.

Anaesthetic concerns are exaggerated in patients suffering from acquired immunodeficiency syndrome (AIDS) and a meticulous approach is warranted in such patients considering the various pathophysiological alterations [18].

Renal functions: Renal function assessment can be immensely helpful as such surgeries are known to get prolonged and potential possibilities of renal compromise do exist mainly because of positioning issue. However, during pre-operative period, formulation of appropriate peri-operative renal protection strategies is generally recommended [19].

Premedication

It depends upon neurological deficit and hemodynamic stability of the patient. Preoperative bronchodilators and antibiotics are

continued to optimise pulmonary status. The usual premedication drugs used in spine surgery are antisialogogues like glycopyrrolate (100-400 ug intravenously or intramuscularly) and aspiration prophylaxis with proton pump inhibitors or histamine-2 receptor antagonists as these patients are at high risk for aspiration of gastric contents [20].

Intraoperative management

Anaesthesia induction: Inhalational or intravenous induction of anaesthesia is usually guided by the condition of the patient preoperatively, stability of cervical spine and concerns of deterioration of neurological injury. Intravenous induction usually suffices in patients with stable hemodynamic parameters and in whom stability of cervical spine is not a concern. Total intravenous anaesthesia (TIVA) has been hugely successful in establishing and delivering day care anaesthesia services especially for short surgical procedures related to spine [21].

Attenuation of stress response to laryngoscopy, intubation and skin incision is generally desired by anaesthesia fraternity. Advent of dexmedetomidine has brought a revolutionary phase in current anaesthesia practice as pre-operative administration helps in attenuation of stress response to laryngoscopy and intubation. Peri-operative dexmedetomidine not only augments sedation and analgesia but also provides marked peri-operative haemodynamic stability and abolition of shivering episodes significantly [22,23]. The use of depolarizing muscle relaxants such as succinylcholine in patients with muscular dystrophies and paralyzing spinal cord lesions has been implicated in causing cardiac arrest secondary to severe hyperkalemia. This has been explained by the phenomenon of proliferation of extrajunctional acetylcholine receptors in the denervated muscle groups causing sudden surge in intravascular levels of potassium resulting in cardiac arrest. The time interval between denervation and risk of fatal hyperkalemic response has been shown to extend from 48 hours to about 9 months post injury and use of succinylcholine should be avoided during this period [24].

The effect of anaesthesia induction using intravenous or inhalational agents on cortical somatosensory potentials and transcranial motor evoked potentials is only a reduction in amplitude of these responses at induction with no effect on intraoperative use of these monitoring techniques [25].

Intubation: The decision for the method of intubation is made preoperatively by careful assessment of the patient's condition. Awake intubation is usually indicated in patients with documented unstable cervical spine, presence of neck stabilisation devices (halo traction) and with delayed gastric emptying time, all of which makes the maintenance of airway difficult in unconscious patient.

Although the controversy exists that the direct laryngoscopy may worsen neurological injury in an unstable cervical spine but the contribution of other factors like hypotension and patient positioning is equally important [26]. The direct laryngoscopy with manual inline stabilization of spine may be an acceptable option if the intubation can be performed without significant neck flexion but in cases of fixed flexion deformity of cervical or upper thoracic spine, micrognathia, limited mouth opening and unstable cervical spine, the use of fiberoptic laryngoscopy is preferable. Various studies have been performed comparing Macintosh laryngoscopy with Bullard laryngoscope, bag mask ventilation, oesophageal combitube,

laryngeal mask airway, intubating laryngeal mask airway and fibreoptic guided nasal or oral intubation with respect to movement of cervical spine and have found different results with fibreoptic intubation being the one producing least movement of cervical spine. The use of intubating laryngeal mask airway has been described in successful intubation in patients with unstable cervical spine with or without the use of fibreoptic bronchoscope [27-29]. Recently, studies have been performed with the use of Glidescope (videolaryngoscope) in unstable cervical spine and most of these studies have found it to be an attractive alternative to the fibreoptic bronchoscope especially if the availability is under question [30,31]. The patients undergoing cervical spine surgery by anterior approach involve four or more cervical spinal levels with surgery lasting for more than ten hours with significant blood loss, may develop postoperative airway and neck edema leading to airway compromise [32,33] (Figure 1).

A double lumen endobronchial tube may be required in surgery of thoracic spine when anterior approach is used to deflate one lung so as to facilitate the exposure of thoracic spine.

Maintenance of Anaesthesia

The main aim of maintenance of anaesthesia is to provide a stable anaesthetic depth with stable hemodynamic parameters so that the intraoperative monitoring of somatosensory and motor evoked potentials can be performed reliably. The use of 60% nitrous oxide in oxygen with less than 0.5 MAC of isoflurane usually is compatible with the neurologic monitoring but an intravenous technique may be required in some cases.

Intraoperative monitoring

The standard monitoring as specified by American Society of

Anaesthesiologist (ASA) is mandatory for all cases which include electrocardiography, non-invasive blood pressure, pulse oximetry, capnography and temperature. The use of special monitoring like invasive blood pressure, central venous pressure and urine output, may be dictated by the duration of procedure, anticipated large fluid shifts, risk of venous air embolism, complicated medical history of patient, preoperative hemodynamic instability (spinal shock) and special anaesthetic techniques contemplated like induced hypotension and endoscopic surgery. Pulmonary artery catheter may be required in patients with severe cardiac or pulmonary diseases. It has been observed that in prone position, the central venous pressure may not correctly reflect the right and left ventricular end-diastolic volume and may show falsely high values. This is due to raised intrathoracic pressure with reduced ventricular compliance and compression of inferior vena cava in prone position [34].

Fluid management

The two main goals of fluid management in neurosurgical patients are maintenance of normovolemia and avoid reduction in serum osmolarity. The maintenance of normovolemia is common to all surgeries and in particular to neurosurgery, normovolemia maintains the mean arterial pressure which is essential. The lowering of serum osmolarity results in development of edema in brain which is not desirable. Thus use of hypoosmolar fluids like dextrose in water, results in extra load of free water lowering the serum osmolarity. The ideal fluid thus may be isotonic saline which is slight hyperosmolar (308 mOsm/L) and thus does not add to free water load. The lactated Ringer solution is also reasonable to be used for replacement of third space and blood losses but if large quantities are required then it may have propensity to lower serum osmolarity and thus cause cerebral edema.

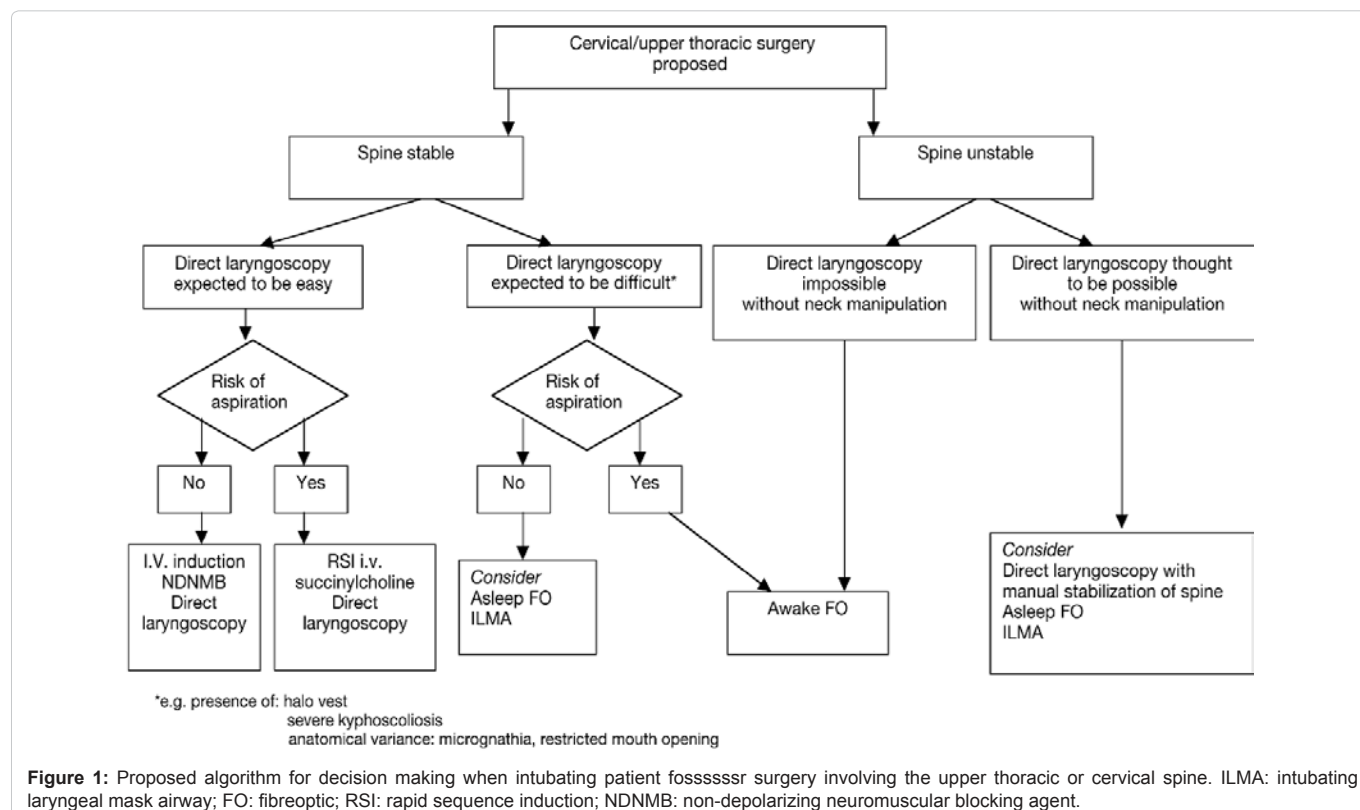


Figure 1: Proposed algorithm for decision making when intubating patient for surgery involving the upper thoracic or cervical spine. ILMA: intubating laryngeal mask airway; FO: fibreoptic; RSI: rapid sequence induction; NDNMB: non-depolarizing neuromuscular blocking agent.

The use of colloids over crystalloids has always been controversial. It has been postulated that if colloids are used beyond their allowable limit they can affect the coagulation and their use has been documented in resuscitation from massive blood loss due to multiple trauma but should be used within the allowable limits. The use of hypertonic fluids has recently been investigated in the setting of neurosurgery and it has been found that these may be beneficial. But sustained rise in serum osmolarity may have potential to cause rebound swelling of brain [35].

Positioning

While the prone position is the most commonly used position for spine surgeries but other positions like lateral decubitus, sitting and combined supine and lateral positions are frequently used. While positioning, special consideration should be given to the proper padding of pressure sensitive areas like bony prominences, eyes and peripheral nerves. The venous pressures at the surgical site are kept low to reduce the intraoperative bleeding by reverse Trendelenberg tilt and keeping the abdomen free in prone position [36]. If the double-lumen endobronchial tube is used, its position should be rechecked after positioning of the patient by using fibreoptic bronchoscope. In certain instances, ventilation obstruction has been observed during prolonged spinal surgeries which can be due to kinking of endotracheal tube (if reinforced tube is not used), secretions or malfunctioning of breathing circuit equipment [37].

Cervical spine surgeries may be performed in supine or prone position depending on the type of surgery and patient positioning should be such that to prevent undue pressure over eyes, face and skin over maxilla. Venous air embolism may be a risk in these patients as the operative site may be above the level of heart and careful vigilance for this required intraoperatively.

Specific neurologic monitoring

Specific monitoring of spinal cord functions may be required intraoperatively in surgeries where the integrity of spinal cord may be affected like in spinal fusion surgery, deformity correction surgery where distractive forces are applied and in removal of spinal cord tumours and vascular lesions. Newer modalities like bi-spectral index system (BIS) have become available which can measure the electroencephalographic activity during the surgical procedure and can help in maintaining adequate depth of anaesthesia [38]. The studies have shown that incidence of neurologic injury can be reduced significantly if intraoperative spinal cord monitoring is employed. The surgery can lead to dysfunction of sensory or motor functions of spinal cord which can be detected early by these monitoring techniques and corrective measures can be taken by the surgeons intraoperatively. The knowledge of the intraoperative tests of neurologic functions employed is important for the anaesthetist as the various anaesthetic techniques can influence the interpretation of these tests. The various monitoring tests used are:

Ankle clonus test

This was the first test used for testing the integrity of spinal cord. It tests the repeated rhythmic movements of foot brought about by stretch reflex called as clonus, by forceful dorsiflexion of foot. In healthy individual during emergence from anaesthesia, due to inhibition of descending inhibitory pathways from higher centers under anaesthesia, this test shows presence of clonus. In the presence of breach in the integrity of spinal cord due to surgery, this clonus

test may be absent. But false positive results may be obtained if the anaesthetic depth is inadequate or too much and it does not rule out injury to other parts of spinal cord [39].

Stagnara wake-up test

This test evaluates the integrity of motor pathways of the spinal cord by directing the patient intraoperatively to voluntarily move upper or lower limbs after the neuromuscular blockade is reversed and the plane of anaesthesia is lightened. It does not evaluate the integrity of sensory pathways. The anaesthetic technique has to be tailored in a fashion so as to allow for waking up of the patient but at the same time any agitation leading to extubation should be prevented and sensation of pain should also be avoided.

Various anaesthetic techniques have been employed e.g. volatile based anaesthesia, propofol infusion based, midazolam based anaesthetic technique with antagonism by flumazenil etc. and all have resulted in mixed responses. Recently, use of remifentanyl infusion based anaesthetic technique has been studied has been found to be effective in performance of wake up test [40]. The various disadvantages of this test involves cooperation of the patient under anaesthesia, chances of accidental extubation on waking up and non-reliability of this test in detecting the neurological damage occurring sometime after the surgical manipulation as it does not allow for continued monitoring of spinal cord functions.

Somatosensory evoked potentials (SSEP)

It involves electrical stimulation of a peripheral mixed nerve (posterior tibial, sural or peroneal nerve) and recording of the evoked potential at a distant site cephalad to the site of surgery. The electrical stimulus is applied alternatively to the lower limbs as a square wave at the rate of 3-7 Hz with the intensity between 25-40 mA ranges. The recording electrodes are placed over the somatosensory cortex on scalp or over the spinous processes of the cervical vertebrae. After obtaining the baseline values, a stable plane of anaesthesia is established and intraoperatively the integrity of somatosensory pathways is monitored by comparing the changes in amplitude and latency period of the evoked potentials with the baseline. A significant response is considered as a 50% reduction in amplitude and a 10% reduction in latency period. SSEP monitoring helps in detecting the change in integrity of the dorsomedial tract in the posterior part of spinal cord which is supplied by posterior spinal artery, so it does not detect any changes in the motor pathways which occupy mainly the anterior part of the spinal cord.

Anaesthetic agents can have significant effect on the pattern of SSEP's. Inhalational agents along with nitrous oxide can decrease the amplitude and prolong the latent period of SSEP's in a dose-dependent manner. [41] However, an anaesthetic containing 60% nitrous oxide combined with 0.5 MAC isoflurane is considered compatible with SSEP monitoring [42]. Studies comparing use of propofol and midazolam infusion together with the use of sufentanyl showed preservation of amplitude of cortical SSEP's throughout the surgery [43]. Intravenous agents also affect the interpretation of SSEP's but to a lesser degree as compared to inhalational agents. A propofol infusion based anaesthetic regimen is considered to be compatible with effective monitoring of SSEP's. However, the use of nitrous oxide has been questioned by various studies which showed increased risk of wound infection, severe vomiting, atelectasis, pneumonia and adverse cardiac events in patients at low cardiac

risk associated with the use of nitrous oxide in general anaesthetic (ENIGMA trial) [44].

The amplitude of SSEP's is also reduced by intravenous opioids but to a lesser degree while neuromuscular blockers have no effect on monitoring of SSEP [45]. The induced hypotension used in spinal surgery can also affect the SSEP's which is usually employed to reduce intraoperative blood loss but it has been shown that this effect is more pronounced if the mean arterial blood pressure is allowed to fall beyond 60 mmHg [46].

SSEP monitoring is considered to be a fairly reliable technique with acceptable sensitivity and specificity in detecting intraoperative neurological damage during spinal surgery.

Motor evoked potentials (MEP)

It involves stimulation of the spinal cord or motor cortex cephalad to the site of surgery and recording the evoked potentials in motor tracts of spinal cord or the muscle distal to the site of surgery. Any damage to motor tracts by surgery results in reduction in amplitude and prolongation of latency of evoked potentials. Myogenic responses are obtained by summation of electromyographic responses of muscles stimulated and are influenced by the degree of neuromuscular blockade which should be continuously monitored. Neurogenic responses are obtained from the peripheral nerve stimulated and are not influenced by neuromuscular blockade and are more reliable.

Both the intravenous and inhalational anaesthetic agents can cause dose-dependent reduction in amplitude of mainly the cortical evoked potentials with less effect on spinal evoked responses. Intravenous opioids also can affect the amplitude of evoked responses. It is generally employed that an anaesthetic technique based on propofol infusion and fentanyl or remifentanyl can provide reliable monitoring of motor evoked potentials in majority of the patients [25].

Postoperative care: These patients have high propensity for postoperative complications due to the preoperative neurological dysfunction, prolonged surgery involving significant blood loss and prolonged durations of anaesthesia. Early regaining of consciousness in postoperative period is usually required for immediate neurological assessment by surgeons. The various postoperative concerns include:

Postoperative ventilation: The proposed indications for continuing postoperative mechanical ventilation in these patients include presence of preoperative neuromuscular disorder, severe restrictive pulmonary disease, congenital cardiac abnormality, morbid obesity, prolonged surgical procedure, significant blood loss more than 30 ml/kg and invasion of thoracic cavity needing intercostal tube drainage [47].

Postoperative analgesia: Adequate control of postoperative pain is a challenge in these patients as a large incision is usually present with lot of bone manipulation. A multi-modal approach involving parenteral analgesics combined with regional techniques is usually recommended.

Intravenous route of analgesia is the conventional route used extensively and two major class of drugs are used i.e. opioids and non-steroidal anti-inflammatory drugs (NSAID's). Opioids are more potent but are associated with significant side-effects and on the other hand NSAID's are less potent but in combination with opioids can result in adequate control of postoperative pain. Recently, use of cyclooxygenase-2 inhibitors with less side-effect has been utilized for

control of postoperative pain following spine surgery [48]. The use of systemic analgesics by patient controlled analgesia techniques have resulted more favourable control of postoperative pain.

Use of local anaesthetics alone or in combination with opioids through an epidural catheter placed after the surgery by the surgeon has shown to be equally effective in control of postoperative pain after major spinal surgery compared to systemic analgesics delivered through patient controlled analgesia [49,50]. But the concerns of infection due to indwelling catheter, difficulty in neurological assessment and development of epidural abscess and hematoma, have resulted in protracted use of this technique.

The use of intrathecal instillation of opioids in spine surgeries at the time of wound closure also can result in good quality of analgesia for upto 24 hours if the dose used is such that it does not cause side-effects like respiratory depression, pruritus etc [51].

Postoperative complications: The early postoperative complications following major spinal surgery include fluid deficit, neurological dysfunction, dural injury leading to leakage of cerebrospinal fluid, nausea and vomiting, atelectasis, pneumonia, urinary retention and venous thrombosis [52]. Post-operative nausea and vomiting (PONV) can be abolished successfully to a large extent by use of long acting 5HT3 antagonists like Palonosetron half an hour before the end of surgical procedure [53]. The incidence of thromboembolic complications following major spinal injury has been found to range between 0.395 to 15.5% suggesting importances of instituting prophylaxis against thromboembolism [54]. The early complications related to anterior cervical approaches include dysphagia, hoarseness and airway edema leading to obstruction and hypoxia.

The late complications include wound infection, spinal instability, pseudoarthrosis, epidural fibrosis and rarely arachnoiditis [55].

Another important complication related to spine surgery especially in prone position is perioperative vision loss which is of great medico legal importance. The most common cause remains to be perioperative ischemic optic neuropathy while central retinal artery and vein occlusion and occipital lobe infarction are other less common causes. The risk factors are prolonged surgery, hypotension and anaemia and it is an untreatable cause of perioperative vision loss. The patient should be made aware of this rare complication of spine surgery preoperatively to prevent any medico legal issues [56]. According to the American Society of Anaesthesiologist closed claims report, which examined 80 patients with ischemic optic neuropathy following spinal fusion surgery and compared them with 315 control subjects, the independent risk factors were male sex, obesity, Wilson frame use, longer anaesthetic duration, greater estimated blood loss and lower percent colloid administration [57].

Conclusion

Spinal surgery presents a wide range of challenges to the surgeon as well as the anaesthesiologist. The perioperative morbidity has been reduced by advancement in Intraoperative monitoring of neurological functions which may be affected by the type of spinal surgery. The anaesthesiologist plays a dominant role in facilitating the Intraoperative neurologic monitoring and in managing the postoperative pain relief which may be challenging in these patients. A detailed preanaesthetic evaluation, Intraoperative anaesthetic

technique facilitating neurologic monitoring and good postoperative pain relief are main anaesthetic concerns in spine surgery.

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