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An approach to anaesthesia for scoliosis repair

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Background

Scoliosis is a condition that involves abnormal lateral curvature of the spine which may also involve rib cage deformity. It is described radiologically with a Cobb angle > 10°,[1] and can be classified by the shape of the deformity and by which part of the spinal column is involved. In addition to cosmetic consequences, severe disease also leads to chronic back pain and may impact cardiorespiratory function. Generally a Cobb angle > 45–50° requires surgery.[2]

Scoliosis can be classified aetiologically. Adolescent idiopathic scoliosis accounts for approximately 75% of cases[3] and occurs in 1–3% of the general population.[4] Of those patients only 0.1% will require surgery in order to improve function and cosmesis.[4] Surgery may involve a posterior approach, anterior approach or a combination of the two.[4]

Figure 1 shows aetiological classification of non-idiopathic scoliosis as described by Yong et al.[3]

In 2006, the Scoliosis Research Society Morbidity and Mortality Committee[5] reported a complication rate of 5.7%, which included pulmonary complications (except pulmonary embolus), wound infection, neurological, implant related, haematological and other medical complications.

Considering the complexity of the clinical profile of patients presenting for scoliosis repair surgery, as well as that of the procedure itself together with significant perioperative concerns, the importance of a multidisciplinary team approach should be emphasised. In addition to this, the enhanced recovery after surgery (ERAS) approach together with the development of a care bundle has been used within the spine surgery cohort.[6] Borden et al.[1] highlight specific factors that can reduce morbidity and mortality, reduce length of hospital stay and ultimately improve patient outcome (see Table I):

- reduction of infection
- preventing neurological injury
- reducing perioperative blood loss
- reducing other complications and
- optimising postoperative care.

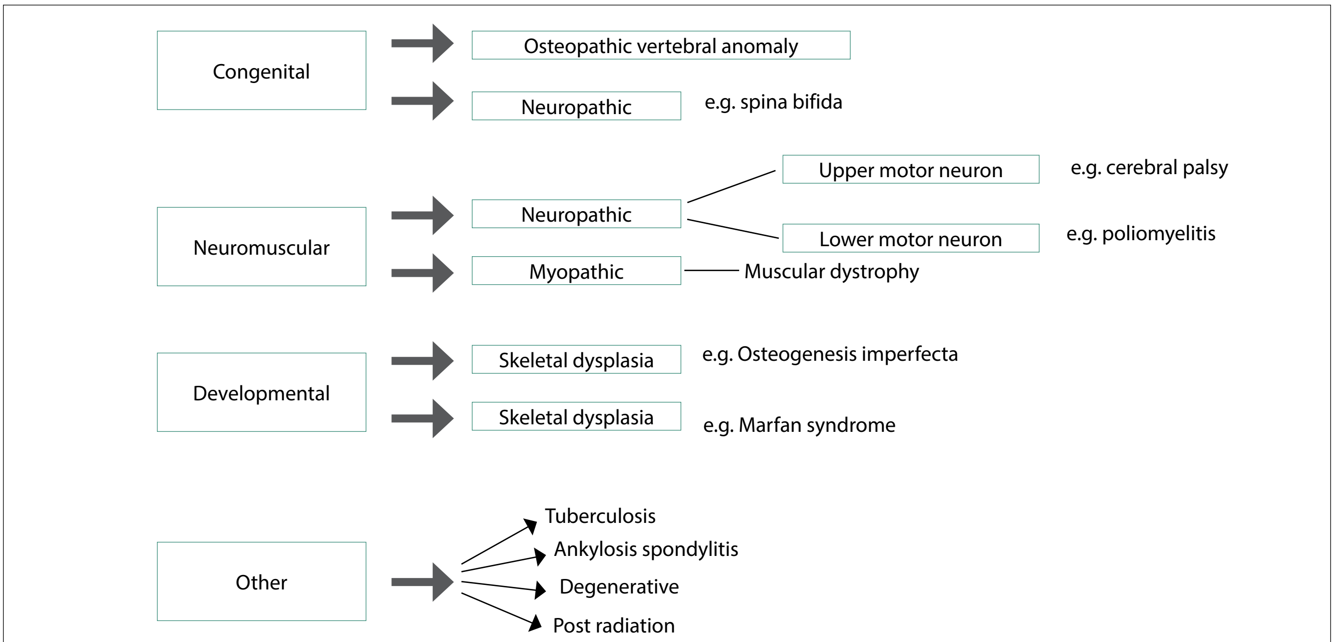

Figure 1: Aetiological classification of non-idiopathic scoliosis as described by Yong et al.

Table I: Details of interventions taken to address these factors are summarised[1]

Factors	Interventions
Reducing risk of infection	Multidisciplinary task team Preadmission bath with chlorhexidine Hair removal with clippers Optimisation of nutrition Preoperative information handout on SSI prevention Appropriate antibiotic prophylaxis including topical use of vancomycin Reduction in operation room traffic Wound irrigation with 2 litres of saline.
Preventing neurological injury and perioperative blindess	Careful positioning of patients with care of nerves at risk of pressure, or tension Padding of pressure points Avoid hypotension Replace fluid and blood losses appropriately Avoid direct pressure to eyes Intraoperative neuromonitoring combining SEPs and MEPs and EMG
Reducing perioperative blood loss	Controlled hypotension during incision (balanced with spinal cord perfusion) Antifibrinolytic agent (tranexamic acid). Appropriate cell salvage
Reducing postoperative complications	Identify patients at high risk for complications Postoperative care protocols Minimise perioperative blood loss Monitor for postoperative infection Prevention of ileus with bowel regimen Early mobilisation
Optimising postoperative care	Implementation multidisciplinary team approach Preoperative counselling to patient and family Early mobilisation Appropriate analgesia including patient-controlled analgesia Early removal of drains and catheters

It should be noted that conditions which can lead to non-idiopathic scoliosis have multiple anaesthetic implications in the perioperative period and should be managed as such. The more common conditions with their own significant perioperative concerns, include cerebral palsy, Duchene muscular dystrophy and mitochondrial diseases. These notes will discuss the assessment and management of adolescent idiopathic scoliosis

Preoperative assessment and management

A thorough preoperative assessment in the form of patient history, examination and investigations is imperative in these cases with the early involvement of a multidisciplinary team. Specific areas should be focused on:

1. Respiratory function assessment

A chest x-ray will allow for the assessment of the severity of the scoliosis as well as help to identify lung pathology. A Cobb angle > 65° is associated with deterioration in respiratory function.[2] The deformity of spinal column and chest wall can result in restrictive lung disease of varying severity. Symptoms include dyspnoea, secretions and cough. Pulmonary function testing can accurately diagnose and grade severity of restrictive lung disease (seen in Table II), with reduction in forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1) and total lung capacity (TLC) which all decrease with an unchanged FEV1/FVC ratio. Within the paediatric population it may be difficult to obtain an accurate lung function test, but the presence of an adequate cough may demonstrate sufficient lung function.

Table II: Severity of restrictive lung disease

Degree of disease	% of predicted FVC	% of predicted TLC
Mild	70%–lower limits of normal	70%–lower limits of normal
Moderate	60–69%	60–69%
Moderately severe	50–59%	
Severe	34–49%	< 50%
Very severe	< 34%	

Inability to cough and pooling of secretions can lead to lower respiratory tract infection, and although uncommon, airway inflammation with features of obstructive airway disease.[7] Signs of an upper or lower respiratory infection may require delay of surgery and medical optimisation.[2] In patients where scoliosis is secondary to comorbid disease, there may be advanced respiratory disease. An arterial blood gas may add value in assessment of function.

2. Cardiac function assessment

Patients with severe scoliosis with pulmonary disease may demonstrate features of pulmonary hypertension and right ventricular failure.[7] In addition mechanical effect of the scoliosis and chest wall deformity may restrict filling and reduce cardiac output.[7] History and examination as well as basic assessment of effort tolerance should address this together with an echocardiogram. Mitral valve prolapse is present in approximately 25% of patients with scoliosis.[2] Note that other comorbid disease may contribute to other cardiac pathology including cardiomyopathy.

3. *Investigations and optimisation*

Other important investigations include baseline haematological studies with the focus on optimisation of haematocrit. Baseline renal function and electrolytes should be checked. These should be normalised.

Optimisation of nutritional status together with multidisciplinary pre-habilitation of the patient is important to prepare for faster postoperative recovery.

4. *Multidisciplinary team approach and application of care plan*

Once the patient has been assessed, a multidisciplinary team should develop the perioperative plan including the application of an ERAS care bundle. This should also include the psychological preparation of the patient and their family for the surgery, and postoperative course. Young et al.[8] have developed an enhanced recovery care bundle for scoliosis repair focusing on analgesia, postoperative nausea and vomiting prophylaxis, bowel routine, and physiotherapy. Thorough informed consent should be taken.

Intraoperative considerations and management

1. *Positioning*

Positioning of the patient depends on the surgical approach. The majority of these cases involve posterior approach and prone positioning which has notable anaesthetic considerations. This can be complicated by the deformity itself requiring additional padding. Particular attention should address eye protection keeping in mind the risk of intraoperative visual loss, minimising abdominal pressure not only for improved ventilation but also to reduce pressure on epidural veins in order to reduce blood loss.

2. *Monitoring*

a. Standard ASA monitoring including urine output is used. Placement of central venous catheter together with arterial catheter is recommended. This will allow for regular arterial blood gas sampling. Fluid therapy should be goal-directed and cardiac output monitoring or the use of pulse contour analysis can aid in this management. It should be kept in mind that this monitoring may not be appropriate for the paediatric population, patients in the prone position and may also be affected by underlying cardiopulmonary disease.[2]

b. Scoliosis surgery requires intraoperative neuromonitoring. Electrophysiological monitors used include somatosensory-evoked potentials (SEPS) and motor-evoked potentials (MEPS).
   - SEPS involve stimulation of peripheral nerves, specifically ulnar, median and posterior tibial nerves. A signal is then generated and moves up the dorsal columns to produce a signal in the somatosensory cortex via the medulla and thalamus.[9]
   - MEPS are a measured muscular contraction produced by stimulation of the motor cortex via electrodes to the scalp.[9]
   - Evoked electromyography (EMG) of pedicle screws allows for evaluation of potential injury from incorrect screw placement.[1]

Anaesthetic factors that affect neuromonitoring include:

Spinal cord perfusion: reduced spinal cord perfusion (mean arterial pressure less than 60 mmHg) can reduce or result in complete loss of MEP responses. SEPs are not affected by hypoperfusion. Patients with scoliosis are at particular risk for ischaemic spinal cord injury and 1% will have a reduction of MEP signal due to hypotension.[9]

Ventilation: Hypoxia can reduce both MEPs and SEPs. Hypocapnia results in cerebral vasoconstriction this influencing SEP latencies.[9]

Anaesthetic agents: Volatile agents produce dose-related decreases in amplitude of MEPs. MEPs are also stopped with the use of neuromuscular blockade (NMB). It is accepted that an initial dose of a NMB agent will be metabolised before monitoring is required. Therefore a TIVA technique is the recommended anaesthetic technique for this procedure. Propofol has been shown to attenuate MEP signals and should be kept in mind. This affect can be mitigated with the use of Ketamine which increases SEP and MEP amplitudes. Benzodiazepines as well as opioids (including intrathecal opioids) have been shown to have minimal effect on signals. α2 agonists attenuate MEP amplitudes.[9]

Communication with surgeon and neurophysiologist allows for optimal monitoring and response to change in signals. Levin et al.[9] have discussed a checklist for reduction or loss of signal in spine surgery patients. This includes a pause in which the anaesthetist reports any change in monitoring or anaesthetic doses, and optimises oxygen delivery to the spinal cord; the surgeon will stop and assess the surgical field and the neurophysiologist will check and confirm neuromonitoring.[9]

c. Processed EEG monitoring is also recommended due to the nature of the anaesthetic technique targeting values between 40 and 60. It should be noted that the algorithms for BIS and Entropy have been developed using adult data which has been shown to correlate values in children over the age of one; however, the accuracy of this monitoring has many limitations.[10]

3. Anaesthetic technique

Due to the nature of the monitoring, a TIVA-based technique is recommended. This can be TIVA or TCI using appropriate models.

4. Blood loss and fluid management

Goal-directed fluid therapy using dynamic monitoring is recommended. Significant blood loss should be anticipated and blood conservation strategies should be used. Consider intraoperative haemodilution, use of cell salvage. Permissive hypotension may be considered, however this should be balanced with the risk of complications including ischaemic spinal cord injury, postoperative visual loss as well as risk of compromised organ perfusion.[2] Tranexamic acid is recommended with a loading dose of 20–30 mg/kg and an infusion of 10 mg/kg/hour. Appropriate transfusion triggers together with point-of-care testing should guide management.

5. Temperature

Hypothermia has many detrimental effects including contribution to bleeding and surgical site infection (SSI). Risks of hypothermia include: low ambient theatre temperature, large area of the patient exposed for surgery, long duration of procedure and positioning which may limit warming. This can be prevented by preoperative warming, the use of warmed fluids, airway humidification and external warming devices.[11]

6. Analgesia and PONV

Multimodal analgesia is recommended in the preoperative intraoperative and postoperative periods. The use of gabapentin in the preoperative period and continued use in the postoperative period has benefit.[8] Intrathecal morphine has been shown to reduce pain scores and allow for improved postoperative analgesia. Remifentanil infusions are used to reduce propofol requirements thus improving neuromonitoring. Hyperalgesia has been noted but various strategies can be used to mitigate this. Intravenous lignocaine and ketamine have been shown to reduce opioid requirements.[8] The use of α2 agonists help to reduce opioid requirements but can attenuate neuromonitoring signals.[9]

PONV prophylaxis is important for these cases, which have increased risk secondary to postoperative opioid use. Patient's risk of PONV should be assessed accurately and managed accordingly. Young et al.[8] incorporate prophylaxis into their care bundle and recommend the use of three agents: dexamethasone, odansetron and aprepitant (which is given preoperatively).

7. Prevention of surgical site infection (SSI)

Appropriate antibiotic prophylaxis should be given within 30 minutes of the incision. This should be conformed in the "time out" of the WHO checklist.[1] Borden et al.[1] recommend the use of cefazolin (20 mg/kg to a maximum of 2 g) and if there is a serious penicillin allergy, vancomycin (10 mg/kg) 150 minutes before incision. Redosing of antibiotics is considered in prolonged surgery and in patients with blood loss and transfusion. Vancomycin powder should be used in the surgical site and/or bone graft.[1]

Postoperative considerations

1. Postoperative complications

Postoperative pulmonary complications are more likely in patients with severe disease and reduced respiratory function. Depending on this, patients may require postoperative ventilation. Prevention and management include adequate analgesia, mobilisation and physiotherapy (including spirometry), reduction of secretions and atelectasis.

SSI is one of the most common complications of scoliosis surgery and has detrimental effects including increased duration of hospital stay, readmission, repeated procedures and increased cost. Close monitoring of wounds allows for early detection. Patients are also at risk of other infections (urinary tract or pulmonary).[1] Temperature spikes may be normal in the immediate postoperative period but temperature spikes on day three or four require investigation.[1]

Ileus is a common complication due to the nature of the surgery and opioid use in the perioperative period. This can be minimised with tailored bowel regimens and mobilisation.[1] Prevention and management of PONV is also important.[8]

2. Analgesia and PONV

Poor analgesia and PONV can result in delay to discharge and chronic pain and should be managed according to a care bundle. Multimodal analgesic regimens are recommended including paracetamol, NSAID (ketorolac), a basal opioid infusion and ketamine (if required) with supplemental patient-controlled analgesia or rescue opioid prescription, with the aim to transition to oral agents on postoperative day two.[8] Management of pruritis, constipation and PONV is recommended. Analgesia should be sufficient to allow for mobilisation and physiotherapy. Young et al.[8] describe a thorough evidence-based postoperative care plan and this could be adapted to other institutions.

Conclusion

Scoliosis repair is a complex procedure often performed in high-risk patients. It requires an in-depth multidisciplinary approach including thorough preoperative assessment and optimisation, in order for the provision of appropriate intraoperative management. This, together with a postoperative care bundle, will contribute to minimise complications, improve patient care in the acute postoperative period, reduce time to discharge and long-term patient outcome.

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