A Case of Scoliosis Repair: Pathophysiology, Special Considerations, and Intraoperative Management

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Outline

- Case presentation
- Overview of diagnostic/treatment considerations
- Intraoperative management
Case Report: C.C.
Identification

- 12 yo male with complex medical history
- Scheduled for posterior spinal instrumentation and fusion with multiple vertebrectomies
Past Medical History

- Midthoracic Myelomeningocele - repaired as an infant in Mexico
  - paralysis to T6
- Chiari II malformation
- Hydrocephalus, s/p VP Shunt placement
- Developmental Delay
- Scoliosis
Past Medical History

- Failure to Thrive
- Seizures
Past Surgical History

- Per mother’s report, has had over 30 surgeries:
- Repair of midthoracic myelomeningocele
- VP Shunt, s/p multiple revisions
- Urostomy
- Ventral hernia repair
- Bilat ear tubes
- G-tube placement
Birth/Developmental History

- Born at 32 wks
- Wheelchair dependent
  - Cannot stand
- Urostomy - incontinent of urine
- Incontinent of stool
- Sensory level approximately at umbilicus
Family History

- Negative for any bleeding problems
- Negative for any problems with anesthesia
Medications

- Phenobarbital 15mg per G-tube bid
- Nitrofurantoin 3mg per G-tube bid
Vital Signs:
- T - 36.8 C
- HR - 90
- BP - 122/85
- RR - 20
- SpO2 - 99% on RA
Physical Exam

- Weight 20.3 Kg
- General - seated in wheelchair, NAD, interactive and pleasant
- HEENT - Macrocephalic with multiple surgical scars over scalp
- Airway - MP 1, good thyromental distance, good mandibular mobility, short, stiff neck
Physical Exam

- Pulmonary - severe scoliosis, BS decreased over R, o/w clear
- CV - RRR, no m/r/g
- Abdomen - G-Tube. Normal bowel sounds
- Musculoskeletal - very pronounced scoliotic curve. Curve is rigid and does not move with bending
- Neuro - No sensation below umbilicus. No lower extremity motor function
The Cobb Angle
Labs

- Chem 7 - wnl
- CBC - Hct 43
- Coags - wnl
Operation

Consisted of:
- Vertebrectomy T12-L1
- Spinal cord excision below T12
- Posterior spinal instrumentation and fusion T1-S1
Intraoperative Course

- Intubated easily with 5.0 cuffed ETT and MAC blade
- 3 PIV’s total: 1x22G, 2x20G
- Radial A-line
- RIJ 5Fr double lumen central catheter
Intraoperative Course

- Amicar bolus 75mg/kg, drip at 75 mg/kg/hr
- Lungs with reasonable compliance (!) and no difficulties with gas exchange
- Stable hemodynamics (when surgical losses properly attended to)
- Stable UOP
- Persistent and significant bleeding from bony surgical sites
Intraoperative Course

Operative course stable (with some effort), with no unexpected complications until......
Guess What’s Missing..........

* The spinal cord was incised and excised below T12
Intraoperative Course

- Acute spinal shock manifested as sudden hypotension, unresponsive to fluids
- Neosynephrine bolused frequently, while drip prepared
  - Dose ranged from 0.1 - 2 mcg/kg/min
- Vasopressin drip started
  - Dose ranged from 0.2 - 1.2 units/hr
  - Usual shock dose 10-50 mU/kg/hr
Intraoperative Course

- Volatiles reduced, and midazolam bolused to ensure amnesia
- Despite mild, persistent hypotension (MAPs in 50s, with visits to the 40s), sufficient end-organ oxygen delivery maintained as evidenced by continued UOP > 0.5 cc/kg/hr and lack of a base deficit on ABG
Intraoperative Course

Case ended smoothly, secondary to consistent leg work
- 1200 cc crystalloids
- 250cc colloids
- 6 units PRBC, 2 units FFP, 1 unit Platlets
- Aforementioned pressors, plus boluses
Brief Post-Op Course

- Pt admitted to PICU on 0.5 mcg/kg/min Neosynephrine and 1 unit/hr Vasopressin
- Hct 30 with Coags wnl
- Pressors off by next morning
- Extubated that same day to NC
- Discharged home after 5 days
Bilateral lung Fields visible!
Scoliosis: An Overview
Outline

- Definition
- Etiology
- Associated co-morbidities
- Conservative treatment
- Indications for surgery
- Predictors of complications
Definition

- A lateral spinal curvature of >10°
- ~2% of children affected at some stage of life
- ~10% of affected patients will require corrective surgery
Plain Radiographs of the Spine in Two Children With Idiopathic Scoliosis

The Cobb Angle

- Line across top of cephalad and bottom of caudad vertebrae that are maximally displaced
- Perpendiculars from these two lines are intersected
- Angle between perpendicularrs = Cobb Angle
Idiopathic Scoliosis

- Most common ~70% of all cases
- Infantile, juvenile, or adolescent forms
- Exact cause unknown, but many contributing factors identified
  - Collagen abnormalities
  - Abnormal growth
  - Hormonal abnormalities
  - Possible genetic basis with incomplete penetrance may explain female predominance

Other Etiologies

- Congenital
  - Osteogenic - vertebral anomalies
  - Neuropathic - tethered cord, myelomeningocele
- Neuromuscular
  - Neuropathic - cerebral palsy, polio
  - Myopathic - Duchenne muscular dystrophy
- Developmental Dysplasia
- Neurofibromatosis
- Tumor-associated
  - Vertebral/Intraspinal
- Infection
Pulmonary Comorbidities

- Restrictive lung pattern
- Decrease in lung volumes
  - Vital capacity ↓ most significant
  - FRC, TLC, IC, ERV also ↓
- Impaired respiratory muscle function
  - Chest wall deformity = inspiratory muscles working at mechanical disadvantage
- Arterial hypoxemia from V/Q mismatch
Pulmonary Comorbidities

- Slope of ventilatory response to CO$_2$ may be decreased
- Higher respiratory rates and lower tidal volumes minimize work of breathing
- Pulmonary compromise increases with curve progression
Cardiac Comorbidities

- Chronic hypoxemia $\rightarrow$ HPV
  - Pulmonary Hypertension
- RVH $\rightarrow$ RV failure
- MVP common among scoliosis patients
- Scoliosis associated with congenital heart disease (no specific lesion)
Significant curve progression may eventually lead to intolerable cardiopulmonary compromise.

Treatment is either conservative (aimed at slowing/stopping curve progression) or surgical.
Examples of Braces Used in Scoliosis Treatment

Conservative Management

- Bracing is the mainstay of treatment
- Goal = slow or prevent curve progression via external forces guiding growth of spine
- Curve correction with bracing is not commonly observed
Indications for Bracing

- Curve of 25-45° in patient going through a rapid growth period (Risser 0-1 years)
- Some patients with smaller curves showing recent progression

Characteristics Predicting Failure of Bracing Treatment

- Overweight
- High thoracic curve (above T8)
- Lordotic thoracic spine
- Within a year of skeletal maturity
- 1-year post-menarche
- Treatment non-compliance

Indications for Surgical Treatment

- Cobb Angle >50º
- Cobb Angle >40º in skeletally immature patient
- Progression of scoliosis in spite of bracing
- “Unacceptable” (cosmetically or functionally) deformity
Risk Factors for Postoperative Complications

- **Etiology of scoliosis**
  - Neuromuscular pts have higher surgical complication rates (17.9%) vs congenital (10.6%) or idiopathic scoliosis (6.3%) - higher mortality, increased LOS, increased costs
  - Respiratory, cardiac, transfusion-related complications predominate
- **Anticonvulsant use**
  - VPA, phenytoin, phenobarbital associated with greater EBL, more transfusions

Erickson MA and Baulesh DM. Curr Opin Pediatr 2011.
Risk Factors for Postoperative Complications

- **Pulmonary status**
  - Poor baseline function predicts complications/need for postop ventilation
  - Frequent PNA, inability to handle secretions, prolonged desaturation during sleep, lung damage/fibrosis are red flags preoperatively

- **Cardiac status**
  - Be mindful of congenital heart disease and pulmonary hypertension
Risk Factors for Postoperative Complications

- Nutritional status
  - Delayed wound healing and greater susceptibility to infection
- Immune status
  - Increased infection risk if compromised
- Social considerations
  - Postoperative care needs can be intense so suitability of home environment/caregivers must be assessed

Erickson MA and Baulesh DM. Curr Opin Pediatr 2011.
Surgical Considerations

- Bigger surgery = more complications
- Anterior posterior spinal fusion associated with longer operative times, more EBL, more transfusion, more pulmonary complications than anterior or posterior fusion alone
- Rule of 6
  - if operative time is longer than 6h, or if more than 6 levels fused, complication risk is higher

Erickson MA and Baulesh DM. Curr Opin Pediatr 2011.
Summary

- Definition and Etiology
- Cobb Angle
- Comorbidities
- Bracing
- Risk factors for complications
References


http://www.pediatriceducation.org/2006/12/11/
Outline

- Airway management
- Access and monitors
- Prone positioning
- Anesthesia and neurophysiologic monitoring
- Transfusion management
- Postoperative pain management
- Management of spinal shock
Airway evaluation

- Assessment of cervical spine stability (Chiari II malformation)
  - Flexion of the neck may cause compression of the medulla
- Assessment of any coexisting craniofacial abnormalities
- Implications for mask ventilation and intubation:
  - Is the patient is a difficult airway?
  - What is the primary plan for airway management?
  - What are the backup plans in case the primary plan fails?
Positioning during induction

- Patient positioning during induction and airway management:
  - can the patient be laid supine? (severe kyphosis/meningomyelocele)
  - lateral or semi-lateral induction and airway management may be necessary
Access and monitors

- **Access**
  - in addition to large bore peripheral access, consider central access for patients with anticipated increased bleeding risk

- **Monitoring**
  - In addition to standard ASA monitors, CVP as a monitor for trending volume status
  - Arterial line as a close monitor of hemodynamic changes with the ability to sample blood gases for Hct, assessment of acid base status, etc.
Intraoperative prone positioning \(^1,2\)

- Sources of morbidity in the prone position
  - Facial compression, ocular injury -> loss of vision/blindness
  - Neck/cord injury from excessive extension or flexion
  - Inadequate intraabominal excursion leading to impaired ventilation and increased venous pressure (more bleeding)
  - Brachial plexus injury from excessive extension (greater than 90 degrees)
  - Femoral nerve injury from compression by bolsters
- Tape ETT securely
- Frequent checks of eyes, face, airway, and neck positioning
Intraoperative management

- If the airway is unexpectedly lost in the prone position, what is the plan for reacquiring airway control?
  - Plan for supporting oxygenation and ventilation in the prone position
  - Expeditious turning of patient to supine position (proximity of OR stretcher)
  - Plan for reintubation
Intraoperative anesthetic management

- Stable, balanced anesthetic consisting of volatiles and intravenous infusions to provide satisfactory and consistent conditions for neurophysiologic monitoring
- Avoid large boluses or sudden changes in anesthetic
- Communication with neurophysiologist
- Backup anesthetic plans in the event of hemodynamic instability (conversion to more cardiostable medications i.e. ketamine)
Anesthetic effects on SSEPs and MEPs

- All anesthetics affect spinal monitoring to varying degrees
- Nitrous oxide decreases SSEP amplitude without an increase in latency
- Volatiles anesthetics cause dose dependent decrease in amplitude and increase in latency
- Hypoxia, hypotension, hypothermia, and hematocrit below 15% also affect both SSEPs and MEPs
Abnormal SSEPs and MEPs

What if SSEPs and MEPs become abnormal during surgery?
- Ensure adequate oxygenation, ventilation, and hemodynamics (adequate spinal cord perfusion)
- Communication with surgeon as to possible surgical causes (instrumentation?)
Risk factors associated with increased perioperative and postoperative complications

- Neuromuscular disease
- Genetic syndromes
- Traumatic nerve/muscle injuries
- Seizure disorders
- Decreased cognitive ability
- Poor pulmonary status
- Restrictive lung disease
- Frequent pneumonias
- Sleep apnea
- Malnutrition
- Cardiac disease
- Immune compromised
- Social status
- Ambulatory status
- Increasing complexity of surgical procedure
Risk factors associated with increased perioperative and postoperative complications

- Pediatric patients with secondary scoliosis tend to have greater blood loss than those with idiopathic scoliosis.
- The exact reasons are unknown and are still under investigation but platelet dysfunction, poor vascular response, increased bleeding time, and fibrinolysis are some of the proposed reasons.
Transfusion management

- Blood loss is estimated to be in the range of 15-25 mL/kg in scoliosis surgery involving instrumentation\(^2\)
- For a 20 kg patient, blood loss can be estimated to be 300-500 mL
- Patient’s estimated blood volume (EBV) assuming an average of 70 mL/kg is 1400 mL
- Estimated allowable blood loss (ABL) is calculated as follows:
  \[
  \text{ABL} = \text{EBV} \times \frac{[\text{Hct (initial)} - \text{Hct (final lowest acceptable)}]}{\text{Hct (initial)}}
  \]
● Given a starting Hct of 43 and assuming a lowest acceptable Hct of 20, the allowable blood loss would be:
  - ABL = 1400 mL \((43-20)/43\) = 750 mL
Given the anticipated large bleeding from a long complicated multilevel repair as well as patient risk factors, what evidence based interventions can minimize blood loss?
- Minimize intraabdominal pressure to prevent further engorgement of the vertebral venous plexus and venous bleeding
- Isovolemic hemodilution
- Intraoperative blood salvage
- Deliberate hypotension
- *Antifibrinolytic drugs*
Antifibrinolytic therapy\textsuperscript{5,6}

- Antifibrinolytic drugs have been shown to reduce blood loss and the amount of transfusion in children undergoing scoliosis repair.
- In a meta analysis of 6 randomized prospective controlled double blinded trials evaluating the use of antifibrinolytics versus control:
  - The amount of blood loss in the antifibrinolytic group was \textit{decreased by 426.53 mL} (95% CI -602.51 to -250.56).
  - The amount of blood transfused in the antifibrinolytic group was \textit{decreased by 327.41 mL} (95% CI -469.04 to -185.78).
  - The risk of being transfused with homologous blood was 13% lower in the antifibrinolytic group (95% CI 0.67 to 1.12).
  - The risk of being transfused with allogeneic blood was 29% lower in the antifibrinolytic group (95% CI -47% to -10%).
- There were no mortalities in either the treatment or control groups
- Aprotinin, tranexamic acid, and aminocaproic acid seem to be similarly effective with excellent safety profile (no evidence of hypercoagulability or thrombotic complications)
- High dose aminocaproic acid was used in the studies: 100 mg/kg bolus administered as an infusion over 15 to 20 minutes followed by a continuous infusion of 10 mg/kg throughout the remainder of the procedure
- No comparisons of antifibrinolytics head to head
- No comparisons of different doses
Given the large surgical incision and musculoskeletal work over many levels, what are the best evidence based interventions for postoperative pain control?
Epidural anesthesia superior to IV PCA in pediatric scoliosis surgery

In a meta analysis of four randomized prospective controlled trials evaluating PCEA vs. IV narcotic PCA in adolescent patients undergoing scoliosis repair, epidural anesthesia was shown to provide superior postoperative analgesia at 24, 48, and 72 hours.

Patients randomized to the epidural group underwent placement by the surgeon under direct visualization prior to closure.

The treatment group received epidural analgesia in the form of a continuous infusion of local anesthetic with or without an opioid in addition to parenteral opioids.

The control group received parenteral opioids only.
- Blinding was not possible because placement of a sham epidural is associated with morbidity.
- Visual analog scale pain scores in the PCEA group were found to be lower at 24, 48, and 72 hrs:
  - VAS pain scores were 15 points lower at 24 hours (p=0.03)
  - VAS pain scores were 10.1 points lower at 48 hrs (p=0.03)
  - VAS pain scores were 11.5 points lower at 72 hrs (p=0.02)
- Patient satisfaction was higher by 1.7 on a 0-10 scale in the two studies that assessed it (p<0.0001)
- Some but not all studies showed decreased nausea, pruritis, and number of rescue analgesics in epi grp.
- Some but not studies demonstrated shorter time to return of bowel function in the epidural group.
Management of spinal shock\textsuperscript{8,9}

- Ensure adequate tissue perfusion with volume resuscitation
- Favorable outcomes reported in uncontrolled studies using fluid resuscitation and vasopressive medications to maintain a minimum mean ABP of 85 mmHg during the 1st week following spinal cord injury in adults
- Assess for bradycardia and arrhythmias associated with neurogenic shock and treat appropriately
- To counter the loss of sympathetic tone and provide chronotropic support, vasopressors with both alpha and beta adrenergic actions are recommended unless contraindicated
References

3. Miller, R. Miller’s Anesthesia, 6th ed. 2005
