Title: Repairing a broken back in someone with a broken heart: Anesthetic implications of posterior spinal fusion in a child with an AICD

Objectives:

• Present an anesthetic plan for an adolescent who is scheduled for extensive prone spine surgery, who has an AICD/pacemaker and will require intraoperative neuromonitoring
• Review the importance of communication with cardiology/electrophysiology team regarding appropriate measures to take with AICD/PPM pre-, intra-, and postoperatively
• Discuss the impact of volatile anesthetic agents on different modalities of intraoperative neurophysiologic monitoring
• Devise a strategy for anesthetic management when the neurophysiologic signals are lost intraoperatively
• Devise a plan to deal with intraoperative ventricular dysrhythmias in a prone patient with a disabled AICD
• Review the physiologic and potentially pathologic consequences of patient positioning for combined anterior and posterior spine surgery
• Describe appropriate postoperative consultation and care for the patient with nerve injury secondary to intraoperative positioning

Case History/Preoperative Course:

A 13-year-old female with kyphoscoliosis presents for posterior spine decompression with instrumentation fusion with autologous bone graft. Past medical history includes sudden pulseless arrest 1 year prior with consequent AICD placement for pre-excitation
pathway, obesity, and back pain. No other previous surgeries. Laboratory tests are within normal limits. She weighs 88 kg, with a height of 150 cm. Preoperative vitals are: HR 80 bpm and BP 125/72 mmHg. The patient donated 2 units of autologous blood prior to surgery. The last hemoglobin 4 days before surgery was 11.2 g/dL. At the preanesthetic visit, the patient and her parents were curious as to “what can go wrong” during this procedure.

Questions:

1. What risks and possible complications should be disclosed to the patient and her parents?
2. The surgeon did not order an electrocardiogram before surgery. Would you proceed without a baseline EKG?
3. The parents are asking about options for post-operative pain control. Is continuous epidural an option? What about single shot intrathecal morphine?
4. The parents are concerned that the AICD is disabled intraoperatively and want to know how we plan to protect their daughter from another potentially fatal rhythm intraoperatively. What would your plan entail?
5. There is a new neurophysiologist and he is questioning the ability to perform TcMEP in someone with potentially an underlying rhythm issue.
6. Does this patient require any further investigations such as echocardiogram and pulmonary function tests?
7. Is her obesity a significant concern?
8. The surgeon indicates that the blood loss will be significant and is asking about all options that can minimize blood loss.
9. The surgeon told the parents about using cell saver during surgery and they are asking you not to give any homologous blood transfusion. How do you respond?
10. The new neurophysiologist is asking you not to use any inhalational anesthetic agent, nitrous oxide or muscle relaxant because they will affect his neurophysiologic monitoring of the patient. How do you handle this request?
11. You decide to use total intravenous anesthesia (TIVA) for anesthesia maintenance. What anesthetic agents will you choose?
12. The neurophysiologist is asking what agents you chose for TIVA. What are the effects of high doses of propofol, remifentanil, morphine, and alpha 2 agonists on both SSEP and MEP? How do you answer this question?
13. What monitors would you use intraoperatively?
14. The orthopedic surgeon is notifying you preoperatively to get prepared for an intraoperative wake up test in addition to utilizing neuromonitoring. Does this impact your selection of anesthetic technique? How do you prepare the patient psychologically for this test?
15. Can the position of the patient be monitored throughout the case? How can you utilize the neurophysiologist, who is asking you many questions, to help you to provide proper positioning by monitoring nerves and plexus?
**Intraoperative Course:**

The patient is turned to prone position. The estimated blood loss now is 3.5 liters. You have replaced with the 2 autologous units, one unit of homologous blood, 1L of albumin and 3200 mL of LR. Her blood pressure is 92/68 mmHg and her hemoglobin is 8.7 gm/dL. The surgeon is getting upset because of blood loss and is asking you to help him with controlled hypotension.

**Questions Continued:**

16. Would you agree with him? Is controlled hypotension appropriate in this setting?
17. If you do, what agents will you use to decrease blood pressure and why?
18. In spine surgery with increased difficulty with hemostasis, do you have to recheck patient position? What would you look for?
19. You gave more blood and colloid but the patient is oliguric now. Would you give more fluids to increase urine output?
20. What is the likely diagnosis?

Blood loss is controlled now and the surgeon started to smile again and telling jokes. After the surgeon placed all the screws, the neurophysiologist tells you that there is moderate attenuation of the transcranial motor evoked potential amplitude. The surgeon loosened all the screws, but the neurophysiologist is still not happy as the motor evoked potential signal is still attenuated.

**Questions Continued:**

21. The surgeon and neurophysiologist are asking if any anesthetic agent you are using could be the reason for this problem. What is the most appropriate response?
22. What you should do once you have any problem with neuromonitoring in spine surgery?
23. The surgeon is telling you that it could be a false positive test and he wants you to do an intraoperative wake up test. How should you reply?
24. Would you give steroids now or wait for the wake up test response?

**Postoperative Course:**

You increased the mean arterial pressure and perform the wake up test. The patient did not have any motor deficit and the surgeon is satisfied with the response. At the end of the procedure, the patient recovers but has a very swollen face. In the intensive care
unit after you signed off to the ICU team, the patient tells that she is not able to feel her right hand and it is numb.

Questions Continued:

25. Why her face is so swollen?
26. How do you approach post operative nerve injury problem?
27. What would you tell the parents about the numbness?
28. When do you call risk management?

Discussion:
While the list of potential problems that may arise when anesthetizing a patient for complex spinal surgery can be daunting, anesthetists must be prepared to manage all issues and complications that may arise. This includes, but is not limited to, excessive blood loss, spinal cord injury, loss of motor function, and peripheral nerve injury.

Surgery to correct scoliosis is often associated with substantial blood loss during the intraoperative period. The extent of blood loss is associated with the number of spinal levels fused, the patient’s weight, surgery involving tumors, raised intra-abdominal pressure in the prone position, and the length of time required for instrumentation. While many of these contributing factors can not be controlled, a concerted effort should be made to control moderating variables impacting intraoperative blood loss. Patient positioning is one such example. Should the vena cava become obstructed when in prone position, blood returning from the lower extremities may be diverted into channels within the vertebral venous system. Likewise, any rise in intra-abdominal pressure impacting the inferior vena cava will ultimately divert blood to the vertebral venous plexus resulting in excessive blood loss. Therefore, it is imperative that patients undergoing posterior spinal fusion in the prone position maintain a free abdomen to keep epidural venous pressure low. To achieve this, patients are often supported on a Wilson frame or a raised mattress with a hole for the abdomen. Proper positioning is essential, however, ad studies have demonstrated that minor changes in poisoning when on the Wilson frame can reduce blood loss per vertebral level by approximately 50%. While in the prone position, pressure points must be well padded and the eyes should be protected. Frequent inspection of the eyes and nose should continue throughout the surgical procedure.

To minimize deleterious effects of the prone position, operative time should be as short as possible and staging of procedures may be considered. Studies investigating the safety of staged versus continuous posterior spinal fusion report that a continuous procedure is faster, there is less blood loss, fewer days are spent in the hospital, and better correction of the spinal deformity is achieved when compared to staged procedures. Furthermore, complications are less frequent and less severe in patients
undergoing a continuous procedure when compared to those undergoing a staged procedure.

Regardless of approach, blood loss can be significant whether it be from altered blood flow patterns, accelerated fibrinolysis, or oozing from large areas of exposed cancellous bone. Different strategies have been employed to reduce intraoperative blood loss including changes in surgical techniques, controlled hypotension, and administration of anti-fibrinolytic agents. Moderate hypotension, typically achieved via a reduction in systolic blood pressure 20 mmHg from baseline or lowering the mean arterial pressure to 65 mmHg in normotensive patients, has been shown to decrease blood loss and reduce transfusion requirements. Induced hypotension, however, is not without risk and may lead to spinal cord ischemia and neurologic deficits such as permanent vision loss. Factors associated with increased risk for spinal cord injury include intraoperative mean arterial pressure less than 60 mmHg, rapid decrease in blood pressure and anemia. Accordingly, invasive blood pressure monitoring is advised to allow for accurate assessment of blood pressure and frequent measurement of hemoglobin levels. Several drugs that modulate the coagulation cascade can also be used to decrease minimize blood loss, such as tranexamic acid, aprotinin, and aminocaproic acid. Tranexamic acid is a synthetic antifibrinolytic drug that has been reported to significantly reduce transfusion requirements, especially in patients with neuromuscular scoliosis. Further efforts aimed at decreasing administration of homologous blood products often include intraoperative blood salvage, preoperative autologous donation, and acute normovolemic hemodilution.

Iatrogenic spinal cord injury during thoracic spine surgery often occurs as a result of mechanical injury, ischemia, or secondary to direct drug effect. Mechanical injury can result from direct spinal cord contusion or concussion during placement and/or adjustment of instrumentation. Ischemic injury usually results from inadequate spinal cord perfusion secondary to vascular compromise or hypotension. Intraoperative spinal cord monitoring has the potential to reduce the incidence of motor deficit or paraplegia following surgery to correct scoliosis. There are four main methods of intraoperative monitoring routinely employed: the ankle clonus test, Stagnara wake up test, SSEP monitoring and the use of MEP. The wake up test is a valid measure of motor function only at the precise moment in time the test is instituted, as it does not allow continuous intraoperative monitoring of motor pathways. Subsequently SSEP and MEP are routinely utilized to provide continuous assessment of spinal cord function throughout the surgical procedure. Given reports in the literature of postoperative paralysis despite normal intraoperative SSEPs, transcranial electric motor evoked potentials (TceMEP) has been increasingly utilized to reduce the risk of spinal cord injury during corrective spine surgery. Since inhalational anesthetic agents considerably depress TceMEP amplitude and latency in a dose dependent manner, TIVA techniques with propofol as a central component have been advocated to optimize TceMEP monitoring during spine surgery.
The effects of opioid analgesics on SSEP and TceMEP are less than any other anesthetic agents, making opioids as important components of TIVA for neurophysiological monitoring as well.

Regardless of approach to spinal monitoring, anesthetists should remain cognizant of the fact that the onset of a change in electrophysiological recordings and permanent neurological injury can occur more than 20 minutes after the last corrective force is applied to the spine. Acute, complete loss of SSEP or MEP in the absence of technical or anesthesia-related explanation represents neurological catastrophe. Should this occur, the mean arterial blood pressure should be raised to at least 90 mmHg to increase spinal cord perfusion pressure. If there is no evidence of improvement within 15 minutes following elevation of the mean arterial pressure, the surgical correction should be reversed. Furthermore, while steroid therapy remains controversial, administration is recommended at this time to compensate for potential spinal cord edema which may exacerbate spinal cord injury during the immediate postoperative period.

Nerve injury while under anesthesia is a significant source of morbidity for patients. The mechanisms for most injuries, particularly those of the ulnar nerve, are not apparent. Perhaps more troubling is that ulnar nerve neuropathy can occur despite conventional methods of positioning and padding. Certain patient populations may be more susceptible to such injuries. These patients typically have a history of preexisting subclinical neuropathy that is aggravated during surgical correction of scoliosis. Intraoperative brachial plexus monitoring by the neurophysiologists should allow for early identification and prevention of peripheral nerve injury. If peripheral nerve injury is suspected, EMG should be performed immediately as it may help determine whether or not the neuropathy was present preoperatively as signs of denervation secondary to acute injury do not appear until 18-21 days after the event. Currently, there is no reliable treatment of ulnar nerve palsy and treatment is often limited to physiotherapy to prevent excessive muscle atrophy. It remains difficult to predict which patients will demonstrate significant postoperative improvement.

In summary, multiple issues need to be considered when caring for the patient undergoing complex spinal surgery. Although blood loss can be minimized with careful positioning, good surgical technique, moderate hypotension, and the use of antifibrinolytic agents, spinal cord or peripheral nerve injury may still occur. Knowledge of signs of spinal cord injury coupled with an understanding of appropriate treatment protocols may decrease the incidence of permanent derangement in patients undergoing complex spinal surgery.
References:


