Sudden Loss of SSEPs and Profound Hypotension in a child with Cerebral Palsy, Mental retardation undergoing Spinal Fusion for Significant Scoliosis with Controlled Hypotension and Anemia

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Goals
1. Understand the neuro-monitoring techniques and the benefit and limitations with our anesthetic agents.
2. Understand the risks and benefits of deliberate hypotension and its relationship with spinal cord ischemia.
3. Review the treatment modalities after an acute loss of neuro-monitoring.

Case
10 y.o. Male has cerebral palsy, mild mental retardation and seizure disorder. He has severe scoliosis 90-degree deformity from T3-8. He can communicate at a 4-year-old level; he is wheelchair bound, but can move all extremities well with no documented neurologic deficits. However, he is contracted in all the extremities. He is able to follow basic commands and participates minimally in ADLs. His scoliosis has been quickly progressive over the last year and he is having more pain. A posterior spinal fusion is planned from T1 – T12. Pulmonary function tests were attempted but not completed because of patient compliance and ECHO revealed no evidence of pulmonary hypertension but EKG should some right ventricular hypertrophy.

Standard ASA Monitors, 2 PIV, A-line, CVP, Foley, SSEPs and TcMEPs are selected as monitors for the case. Mixtures of O2/Air and propofol, ketamine, and remifentanil drips are used. His induction and start of surgery is uneventful. Gradual controlled hypotension is used with the goal of a MAP of 60mmHg. After several hours of surgical dissection and placement of pedicle screws, the HCT had gradually dropped from 32 to 26 with MAPs ranging form 55-59. PRBC are started. Surgical placement of rods and distraction begins. The MAPs start to decrease below 55mmHG; despite infusion of PRBCs and fluid bolus and no increase in blood loss; his MAPs trend down slowly. The left rod is placed and the right is being manipulated for placement. The neuro-monitoring reveals decrease in amplitude and latency of the SSEP in the lower but not upper extremities. MAPs are now in the low 50’s however the heart rate remains unchanged. The last Times was done 10 minutes prior to distraction. Surgery stopped and TcMEPs is run. It shows loss in lower extremities but not upper extremities.

Questions:
What are the risk factors and complications associated with neuromuscular scoliosis in spine surgery?

What is the best type of neuro-monitoring in spine surgery? How does choice in anesthetic affect neuro-monitoring?

What are the risk factors associated with the anesthetic plan for this patient particularly controlled hypotension and mild anemia?

The left rod is quickly removed without resolution of in SSEPs. Another PRBC are given with a fluid bolus; and a small dose of epinephrine is given along with the initiation of a dopamine drip to elevate the blood pressure of MAP above 65mmHG. ABG was done to see attempt to correct for abnormal oxygen or carbon dioxide tension, academia, or anemia. Despite all these interventions, the SSEPs and TcMEPs do not return in the lower extremities. And a Stagnara Wakeup Test is preformed. He awoke 10 minutes later abruptly. He becomes very agitated but is able to calm. He is unable to move legs on command. He is quickly re-anesthetized with a bolus of propofol. He coughs and the end-tidal CO2 turns to zero and the apnea alarm signals. A quick look under the drapes and under the table revealed either the ET tube had appeared to migrate out or appeared kinked. The surgeon decides to leaves him uncorrected and close the wound for formal neurological testing.
Questions:
What are the treatment modalities for addressing the neurologic event?

What are the options for re-intubating this patient in the prone position?

Is use of LMA a viable option for re-intubating in the prone position?

Discussion
Cerebral palsy and spinal fusion
In 1994 Kuban and Leviton defined cerebral palsy as static encephalopathy that may be defined as a non-progressive disorder of posture and movement. It is often associated with epilepsy and abnormalities of speech, vision, and intellect resulting from a defect or lesion of the developing brain. Gastroesophageal reflux disease (GERD), reactive airway disease (RAD) secondary to microaspirations, and seizures are very common in cerebral palsy. Scoliosis is also very common in this population leading to decrease in general health, ambulation, sitting, balance and transfers. This can lead to decubiti, restrictive lung disease, and pain. The goal of surgery is to provide stability; prevent further progression of disease; and to improve quality of life by improving sitting ability. Spinal fusion has a high satisfaction rate among caregivers. Therefore, complete assessments patient’s neurological, gastrointestinal, nutritional, pulmonary and cardiac system is warranted.

In the cerebral palsy population, scoliosis becomes more problematic before the age of 10. Curves more than 50% increase in the normal population by 1.4 degrees a year. In neuromuscular scoliosis the progression is more rapid and can include kyphosis.

Risk factors for spinal fusion
Complication rates are higher for the all neuromuscular scoliosis repairs. The most common involves the respiratory system. Most patients have some lung disease like RAD in addition to the restrictive lung disease secondary to the scoliosis, which makes postoperative intubation common.

Complication rates for neurologic injury during surgery is about 0.72 to 1.2% with roughly 30% of these recovering from the insult. As expected, there is a higher risk in patients with neuromuscular disease, like cerebral palsy, for neurologic injury.

Blood loss can be higher in patients with cerebral palsy, which is multifactorial in origin. Poor nutritional status, seizure medications like valproic acid, poor connective tissue function are factors that increase blood loss. CP patients tend to have high-normal coagulation profiles even before surgery and become coagulopathic earlier with less blood loss. In idiopathic scoliosis repairs, 25cc/kg of blood loss may be the norm; however in the neuromuscular scoliosis this can be quickly exceeded.

Neuro-Monitoring
Vauzelle and Stagnara first described the use of the Wake up test in 1973 to assess the integrity of the spinal cord. It is still used today. There are limitations to the wake up test. It requires a cooperative patient. It only assesses the motor pathways in one point in time. Neurologic insult can occur after patient is re-anesthetized. And it is not without complications. Some of those complications include dislodgement of vascular access, CVP, or ET Tubes; patients falling off table; dislodgement of surgical devices.

Somatosensory evoked potentials (SSEPs) have been one of the first and oldest types of neuro-monitoring used for scoliosis surgery. It measures the dorsal columns of the spinal cord therefore the integrity of the sensory pathway. If the amplitude of the signal was decreased by 50% or latency increased by 10%, this would be considered a significant event. However, because the blood supply of the dorsal columns differ from the motor tracts, SSEPs may not reveal event despite and ischemic event the motor tract, which is seen after surgery. While primarily the posterior spinal arteries supply the dorsal columns; the anterior spinal arteries supply the descending motor tracts.

To address the motor tracts, motor evoked potentials (MEPs) are used. Trancranial Motor Evoked potentials (TcMEPs) are a type of MEP that has emerged as a reliable technique for spinal surgery to test the functional integrity of the motor pathways. However unlike SSEPs, which can be run frequently, TcMEPs cause movement and delicate surgical manipulation cannot be performed.
SSEPs and MEPs are sensitive to volatile anesthetics and nitric oxide. They cause a decrease in amplitude and increase latency. Intravenous (IV) anesthetics do effect SSEPs but in varying degrees. Ketamine and opiates do not affect SSEPs and MEPs; midazolam and propofol decrease amplitude and increase latency of both but less than volatile agents. Muscle relaxants have no direct effect on SSEPs but provide a “quieter” background for monitoring. Although complete neuromuscular blockade is problematic for MEPs, 30% blockade can provide reliable data. Dexmedetomidine has been used successful in the TIVA technique for posterior spinal fusions however its effects on neuro-monitoring are still being debated particularly with TcMEPs. Newer stimulation techniques such as rapid trains of stimuli have produced MEPs resistant to effects of anesthetics.

As use of TcMEPs and SSEPs has increased, more recent reports have been published of TcMEPs or other forms of MEP changing without a change in SSEPs. Interventions like elevating blood pressure, reversing surgical correction, or correcting anemia returned MEPs back to baseline. In some reports when SSEPs did change, it lagged MEPs by 5 minutes. In neuromuscular scoliosis, some studies report unreliability of SSEP data; but TcMEPs or MEP can improve monitoring. Preoperative planning of the type of neuro-monitoring being used and tailoring the anesthetic to aid in early detections of ischemia is important. Awareness of the limitations of the monitoring should be taken into account.

**Hypotension and Anemia**

Mild hypotension is a very accepted and beneficial method to limit blood loss and aid in surgical exposure. However, acute or prolonged hypotension may put the blood supply to the cord at risk. There are watershed areas of the cord that receive blood from both the anterior and posterior circulations (e.g. the segments between T4-7) that may be at high risk of ischemia during low perfusions states. Just like the cerebral flow, the spinal cord flow depends on perfusion pressure (MAP-cerebrospinal fluid pressure) and does auto-regulate between MAPs of 60-150mmHG. And just like cerebral perfusion, blood flow is sensitive to oxygen and carbon dioxide tensions, pH, and temperature. Therefore, in low flow states, hypercapnia, oxygenation and mild decrease in temperature may increase flow and decrease demand thereby decreasing damage caused by ischemia.

Besides changes in neuro-monitoring, urine output decreases and EKG changes can be helpful in determining adequate oxygen carrying capacity by low hemoglobin and/or low perfusion state because of deliberate hypotension.

Therefore in the setting of mild hypotension and anemia, vigilant monitoring; normal carbon dioxide tension; and adequate carrying capacity is imperative to prevent ischemia to the spinal cord during surgical distraction. The delicate dance of providing deliberate hypotension (to aid in surgical hemostasis and dissection) has to be carefully balanced by the providing enough oxygen to the spinal cord particularly during periods when circulation to the spinal cord is dynamic.

**Treatment options**

Methylprednisone is a medication synonymous with spinal cord injury. However most of the data collected is secondary to trauma where the injury may be multifactorial. In the posterior spinal fusions arena where the most likely cause of injury is ischemia, providing adequate profusion pressure and enough oxygen carrying capacity or undoing the surgical correction are far more useful than giving a drug which inhibits posttraumatic lipid peroxidation and inflammation. High dose methylprednisone also has its adverse events like sepsis, GI hemorrhage, wound infections, pulmonary embolism, and acute corticosteroid myopathy. Further studies of the efficacy of its use in the surgical setting particularly in spine cases where ischemia is more likely the problem need to be explored.

Most instances where SSEP or MEP were lost, increasing perfusion pressure, increasing oxygen tensions or surgical manipulation is more likely to return SSEPs or MEPs back to baseline since the injury was ischemic in origin.

**Extubation of a patient in the prone position.**

There are many different techniques described in the literature to approach the accidental extubation of a patient in the prone position. Besides the obvious quick turn to the supine position, there have been other techniques described. These include using a flexible fiberoptic to visualize and reintubate; using a tube exchanger if the tube is kinked; using a Berman intubating airway to stent the kinked portion of the tube; and finally use of an LMA and/or intubating LMA.

Because of the limited pulmonary reserve in patients with scoliosis, quick evaluations and decisions need to be made. CP patients may have TMJ restriction and poor dentition, which can complicate intubation. In the neuromuscular scoliosis
patient, airway issues on induction may limit options in the prone position. Proper planning with surgeon and staff can prevent catastrophic events particularly during critical times like the Stagnara Wake up test.

References