Title: From Scoliosis to Cerebral Thrombosis…How Did We Get There?

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Goals:

1) Understand the role of intraoperative evoked potential monitoring for scoliosis surgery
2) Discuss the use of ketamine, dexmedetomidine, N_2O, and intrathecal morphine for scoliosis surgery
3) Recognize, diagnose, and know a differential diagnosis of "spinal" headache in children
4) Describe symptoms of cerebral thrombosis
5) Understand choices for treating spinal headaches and cerebral thromboses

Description:
A fourteen year old, 60kg female with a 70 degree idiopathic scoliosis curve was scheduled for posterior spinal fusion. Except for occasional back pain, the patient was healthy. She was taking birth control pills and had no previous surgery, known allergies, nor relevant family history. On long car rides she often became nauseated. The patient was premedicated with midazolam and transfered to the operating room. Fentanyl, ketamine, propofol, and ondansetron were given intravenously; lidocaine was sprayed on the supra and subglottic mucosa; arterial, peripheral, and central venous access was obtained; intrathecal morphine administered; motor evoked potential monitors applied; and the patient positioned prone. A continuous infusion of ketamine and dexmedetomidine was started with a 50% FiO_2 blend of N_2O/O_2. Prior to incision, somatosensory evoked potentials (SSEPs) were normal but no motor evoked potentials (MEPs) could be recorded from the lower extremities. Replacement of monitoring leads and module and cessation of N_2O and dexmedetomidine failed to result in acquistion of evoked potentials. The case was cancelled. Subsequently, a comprehensive neurologic exam was performed and a brain/complete spine MRI obtained. All studies were normal: no cause was identified for the persistent absence of lower extremity MEPs. The patient was discharged the following afternoon.

Two days after discharge, the patient was reexamined in neurology clinic because of a severe headache exacerbated when standing. Aspirin, caffine, and fluids were recommended. Nonetheless, the headache persisted and was diagnosed as a "spinal headache." Therefore, the patient was evaluated by the anesthesia pain service. Assuming the headache was from the dural puncture necessary for administration of intrathecal morphine, an epidural blood patch was injected at the lumbar 4-5 interspace. After the blood patch there was immediate improvement. After two days at

home, the patient again complained of headache. Three hours later she lost consciousness, convulsed, developed left sided weakness, and was emergently admitted to the hospital. A brain MRI revealed extensive cerebral venous thromboses involving the right transverse, right sigmoid, and superior sagittal sinuses. The patient was placed on enoxaparin. After a 5 day hospitalization, she returned home. Over the following months, the patient's neurologic exam normalized and sequential MRIs demonstrated decreasing size of the thromboses until there was near total resolution.

Case history:
A 14 year old, 60kg female, was scheduled for a posterior spinal fusion, T3 – L4 vertebral level. After intubation and prone positioning, motor evoked potentials (MEPs) could not be obtained from the lower extremities. Central venous, arterial, and large bore venous, 16 gauge, peripheral vascular access had been obtained after intravenous induction with fentanyl, 5 mcg/kg ; ketamine, 2 mg/kg; propofol, 2 mg/kg; and lidocaine, 60 mg supraglottic and intratracheal. After intubation, morphine, 5 mcg/kg, was administered intrathecal. Dexmedetomidine 0.5 mcg/kg/hr and ketamine 2 mg/kg/hr IV was started after prone positioning. The only inhalation agents were N_2O & O_2, @50% FiO_2.

Questions:
Should this case be cancelled? Is there a role for a "wake-up test?" What factors affect evoked potentials? Is there a "best" combination of anesthetic agents for spinal fusions? What vascular access is necessary? Is intrathecal morphine indicated? Isn't a narcotic and propofol infusion the best TIVA combination for spinal surgery? Should an anti-emetic(s) be given?

Case history (continued):
The case was cancelled. A neurologist was consulted and a comprehensive exam was performed. MRI of the brain and entire spine was obtained. All evaluations were interpreted as normal: no cause was identified for the absent lower extremity MEPs. The patient was scheduled the following month for follow-up evaluation in outpatient orthopedic and neurologic clinics. But two days following discharge, the patient was reexamined in the neurology clinic because of a severe headache exacerbated when standing. Aspirin, fluids, and caffeine were prescribed. Nonetheless, the headache persisted.

Questions:
If all the evaluations were normal, should the patient be rescheduled for a spinal fusion? What are the physical signs and symptoms of a spinal headache? How effective is treatment with fluids, aspirin and caffeine? How effective is a blood patch? When should a blood patch be prescribed? What are the side effects, complications, and risks of a blood patch? Are there other possible etiologies for the headache?

Case history (continued):
Assuming the headache was from the dural puncture necessary for the administration of intrathecal morphine, the patient received a blood patch. There was immediate improvement and nearly total resolution of her headache. Then after two days at home, she complained of a headache and had trouble seeing clearly. Three hours later she lost consciousness, collapsed, had a generalized seizure, and developed left-sided weakness. She was emergently admitted to the hospital.

Questions:
What are possible causes of this sudden deterioration? What would be a systematic approach to evaluate her status? Should any medications be given immediately? Should a lumbar puncture be part of her medical evaluation?

Case history (continued):
IV access was obtained, blood studies were sent, and an emergency head CT scan was obtained en route to the PICU. The interpretation of the CT scan was equivocal. The patient continued somnolent and the left-sided weakness persisted. She experienced another generalized seizure, vomited, and remained unresponsive. Lorazepam was administered to control the seizure. Subsequently, MRI, MRA, and MRV studies of the brain were performed. There were extensive cerebral venous thromboses (CVTs) involving the right transverse, right sigmoid, and superior sagittal sinuses. Fluids were administered to assure adequate hydration and anticoagulation with enoxaparin instituted. Once oriented and conscious she complained of headaches that persisted for the next three days. There were no further seizures. Follow-up cerebral venous studies demonstrated resolution of the thromboses over several months.

Questions:
What are the common causes of cerebral vein thromboses? What are the symptoms of CVTs? What are the diagnostic criteria and treatment options? Morbidity? Mortality? Is there a causal association between lumbar puncture and CVTs? Does intrathecal injection of chemotherapeutic agents protect against CVTs?

Discussion:
Orthopedic surgery for idiopathic and neuromuscular scoliosis is commonplace among pediatric medical centers. The operations are invasive, complex, and require extensive monitoring. Although there is no “one way” to provide anesthesia, there is one fundamental principle for providing optimal care: **the spinal cord must be protected from injury**.

To protect the spinal cord, the neurovascular integrity of the cord must be preserved. This requires monitoring of evoked potentials and careful selection of anesthetic agents to minimally affect cord physiology. All halogenated inhalation anesthetic agents cause significant dose-dependent depression of both SSEPs and MEPs, but <50% N_20 “does

not cause significant myogenic response amplitude depression"[Lotto] when used with a TIVA technique employing opioid, ketamine, dexmedetomidine, or low dose propofol.

Therefore, the use of any halogenated agent for scoliosis probably should be discouraged. Furthermore, although intravenous opioids, propofol, dexmedetomidine, and midazolam don't cause significant depression of evoked potentials, high doses and large boluses do depress wave amplitude. Yet one drug, ketamine, facilitates MEPs.[Erb] Despite it's association with dysphoric reactions, ketamine can be considered for spinal fusions, especially for patients with neuromuscular disorders that impair MEP amplitude. In addition, intrathecal morphine can help facilitate pain and patient management upon emergence and 18 hours thereafter. Intrathecal morphine has no depressant effect on evoked potentials and has been shown to decrease postoperative pain and opioid use.[Urban]

During spinal fusion surgery the role of the anesthesiologist is far more than just the selection of anesthetic agents. Numerous parameters anesthesiologists monitor affect the quality of evoked potentials: anemia, temperature, positioning, blood pressure, oxygenation, pH, and $ETCO_2$, are all a part of our purview as is the need for appropriate communication between anesthesiologist, intraoperative monitoring technician, surgeon, and nursing.

As noted above, intrathecal morphine augments pain control for spinal fusion patients and facilitates management of the patient during the first hours after surgery. Unfortunately, one of the complications of spinal drug administration is post-dural puncture headache (PDPH) which is usually bilateral, develops within 7 days of lumbar puncture (LP), is exacerbated with standing up, and improves with recumbency.[Janssens] Other symptoms may include nausea, vomiting, and neck pain. Ocular, vestibular, or cochlear symptoms also are common. Risk factors include female gender, age 20-40, use of a cutting needle, use of large bore spinal needles, and possibly orientation of needle to longitudinal dural fibers.

Treatment of PDPH is replete with suggestions: hydration, bed rest, caffeine, analgesics, abdominal binders, intramuscular adrenocorticotropic hormone, gabapentin, theophylline, hydrocortisone, sumatriptan, epidural saline, and epidural blood patch. Presently, gabapentin and theophylline are promising but not proven. Only an epidural blood patch is "proven." Therefore, if symptoms of PDPH persist after an epidural blood patch, further evaluation is paramont because the symptoms of PDPH can be similar to the symptoms of a CVT which include: severe headache often with vomiting, sleepiness, or changes in vision; loss of balance and falling; hemiplegia; and seizures. Brain MRI, MRV, and MRA is the most sensitive and reliable study for demonstrating cerebral vein thrombosis. Head CT scans are less reliable and may be normal in 30% of patients with CVT.

In children there are many causes of CVTs: dehydration, sinus infections, hematologic prothrombotic factors, congenital heart disease, immune disorders, cancer, trauma or surgery of the head and neck, and birth control pills. It is interesting to note that there are very few articles relating an association of lumbar puncture and CVT. The articles reviewed thusfar involve pregnant female patients, patients with multiple sclerosis, or patients receiving high dose corticosteroids. [Presicci] Presently, no reports describe a 1:1 corollation between lumbar puncture and CVT in children.

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