Title: Help! He was just awake, now he’s not! Acute Cerebral Herniation during pre-operative evaluation.

Moderators:
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Goals: Participants will:

1. Discuss cerebrovascular physiology in children.
2. Prepare a preoperative plan, monitoring techniques, anesthetic agents and management strategies to prevent secondary brain injury.
3. Discuss the signs and symptoms, differential diagnosis, and immediate treatment of acute cerebral herniation.
4. Discuss hyperosmolar therapies and hyperventilation strategies and their impact in the pediatric population with intracranial pathology.
5. Contrast different IV fluid therapies as well as establish blood transfusion thresholds in the pediatric neurosurgical patient.

Case History

A 6 year old presents to the ER with mild altered mental status after bumping heads with his brother while on a trampoline. The patient was mildly somnolent but otherwise neurologically intact. CT of his brain reveals a very large cystic tumor in the right frontal temporal region with moderate mass effect. He then undergoes MRI with sedation. Intermittent bradycardia was noted. The child recovers uneventfully, transfers to PICU, and is scheduled for resection via craniotomy the following morning.

Questions: Preoperative assessment and planning

What are the different types and locations of brain malignancies in children? What are the most common types and locations? What is the age distribution of tumor types in children? What are your concerns with intracranial space occupying lesions? How would the patient’s history and physical help with your assessment of ICP? When looking at the imaging results, what information is relevant to planning your anesthetic? What laboratory studies would you obtain? How would positioning affect your plans? What monitoring modalities and lines would you employ? Role for premedication?

Case History

You review all pertinent images and note a large L FRONTAL TUMOR with significant mass effect, midline shift and surrounding edema. Laboratory results are all normal except for a sodium of 132 mEq/L. The
nurse reports that the patient has been neurologically appropriate other than a mild headache, and has had a light meal since returning from the radiology suite. In addition, the nurse reports that the patient's blood pressure has been elevated ranging from 115 to 133 systolic and 70 to 85 diastolic, ECG monitoring has been mostly NSR with occasional PVCs. You enter the room and begin examining the patient and notice that the child now is unresponsive, has abnormal posturing to noxious stimulus to his fingernail bed and his right pupil is fixed and dilated.

Questions: Crisis Management

How does intracranial compliance differ between infants, children and adults? What are the components to ICP? What are the different types of neurologic herniation? How would you treat acute cerebral herniation and what are the mechanisms responsible for their effect? What drugs would you administer to secure the airway?

Case History

The head of the bed is immediately elevated and you begin to hyperventilate the patient by bag mask with 100% oxygen. This improves the patient's neurological exam though he remains somnolent. A modified rapid sequence intubation with IV lidocaine, propofol and rocuronium is performed in the PICU. His vital signs remain stable. A dose of Mannitol is administered (0.25g/kg). After successfully intubating the patient, you continue to hyperventilate the patient and rush him to the OR for emergent BIFRONTAL craniotomy.

Questions: Perioperative management

What is your anesthetic plan? What lines do you obtain and how do you monitor this patient? How do maintain anesthesia? Is one technique for maintenance of anesthesia superior to the rest? What are the effects of anesthetics on CMRO2, CBV, CBF and Flow – Metabolism coupling, Auto-regulation and CO2 responsiveness? How do you choose a hyperosmolar agent and how does it work? What type of fluids do you choose?

Case History

Upon entering the OR you continue to hyperventilate to target ETCO2 of 30mmHg, administer a repeat dose mannitol dose? and the patient is positioned and prepped for surgery while you obtain arterial access and an additional i.v. line. Blood gas analysis shows: pH 7.46, PaO2 412, PCO2 31. The surgeon performs a craniotomy and notices the dura appears very tight.

Questions: Perioperative management

What are the controversies surrounding hyperventilation? How does your anesthetic choice affect CO2 responsiveness and how low of a PaCO2 do you consider safe? What immediate options do you have to lower ICP prior to durotomy? What is your target MAP? If you choose to augment MAP, how will you do so and what are the effects on cerebral vascular resistance? Is there a role for mild or moderate hypothermia?

Case History

Durotomy is performed, the tumor is identified and resection commences. While the tumor is being resected, the patient becomes hypotensive. You begin to transfuse PRBCs and notice a lack of blood
pressure response to volume challenges. ETCO2 declines and hypotension worsens. You inform the surgeon to stop while you stabilize the patient for a suspected venous air embolism.

Questions: Crisis Management

What are your immediate treatment goals VAE? What else is in your differential? How would you evaluate? What is your goal HCT?

Case History

After a one-half blood volume resuscitation, hemodynamic stabilization, and full resection of the tumor, the surgeon begins to close.

Questions: Perioperative and postoperative management

How and when would you choose to normalize PaCO2? What would be your criteria for extubation for this patient? If you choose to extubate the patient, how will you do so? What problems would you anticipate in the post-operative course?

Discussion:

Acute herniation in a child with a frontal tumor presents with various challenges. Given the limited compliance of the cranial vault in children, small changes in intracranial volume lead to large changes in ICP in patients who already have considerable mass effect from malignancies with significant edema. Immediate attention to decreasing ICP must take precedence while awaiting definitive treatment. During acute herniation, understanding the impact of anesthetic agents, hyperosmolar therapies, as well as ventilation strategies on the components of intracranial pressure (CSF, Cerebral blood volume, interstitial fluid and cellular mass) help guide treatment with the goal of decreasing the extent of secondary injury.

Hyperosmolar therapies are cornerstone to decreasing ICP in acute herniation. The immediate effect following administration is due to an expansion of the intravascular compartment with a concomitant rise in CPP, as well as a decrease blood viscosity, both leading to increases cerebral oxygenation thereby causing reflex cerebral vasoconstriction via autoregulatory mechanisms (decreasing CBV). The more delayed effects are secondary to raising plasma osmolarity beyond the normal value 285-295 milli-osmoles per kg with shifting of parenchymal fluid to the intravascular plasma compartment. Overall, both mechanisms lead to a decrease in ICP. Of the available hyperosmolar therapies, Mannitol is the most used pharmacological agent in the perioperative setting, though hypertonic saline is increasingly being used as first or second line therapy. With regards to improving surgical conditions in elective craniotomies, recent studies have demonstrated equal efficacy between both therapies.

Hyperventilation leading to a rapid decline in PaCO2 decreases ICP via cerebral vasoconstriction. As a “bridging” measure in acute herniation, decreasing PaCO2 is clearly advantageous. Routine hyperventilation in elective intracranial surgery is controversial given the potential of decreasing cerebral blood flow below ischemic thresholds despite clearly improving surgical conditions both in patients anesthetized with either propofol or volatile based techniques. Mechanisms for cerebral vasoconstriction in the setting of acute hypocapnea are not clearly elucidated though there is experimental evidence that increases in CSF pH lead to increases in intracellular calcium concentration in cerebral smooth muscles resulting in increase vascular tone.
Anesthetic technique employed needs to be carefully considered given that the anesthetic agents used may have deleterious consequences and possibly worsen outcome. The anesthetic effects on CBV and ICP differ in patients with altered cerebral physiology. This is particularly evident in those with critical elevations in ICP. Modern volatile agents are proven to be safe when used in patients with normal to mildly decreased intracranial compliance, though when used in settings of critically low intracranial compliance, their vasodilatory effects may increase ICP, reducing CPP and raising likelihood of secondary injury. Though Intravenous agents and Volatile agents both reduce CMRO2, a propofol-based anesthetic has the advantage of consistently decreasing CBV and thus ICP.

Intracranial tumor resections present various challenges for the anesthesiologist. Though this discussion is very limited, other relevant topics is the use of therapeutic hypothermia both intraoperative and the postoperative settings, the effects of various vasoactive substances, the use of steroids, antiepileptic's and fluid management strategies. Refer to some of the references below for further reading.

References:

For some, the phrase “awake during surgery” conjures images of groggily coming to in the midst of highly complicated procedures, surgical tools buzzing away as you lie there in a frozen panic. But did you know there are surgeries during which patients are intentionally left awake? While the body areas being operated on are completely numbed and other precautions may be taken, some surgeries do not require patients to be put under general anesthesia. Patients who remain awake during surgery are given a front-row seat to the handiwork of some of our most talented medical professionals. But that’s not the only way to get an “in” to the OR! Working as a surgical technician can put you on the frontlines of leading medical procedures while aiding in the lifesaving process of surgery. From 1977 to 2002, he was Director of the Emergency Preparedness and Disaster Relief Coordination Program of the Pan American Health Organization, Regional Office for the Americas of the World Health Organization (PAHO/WHO). Beginning in 1976, he has travelled frequently to Haiti. Since his retirement from PAHO/WHO in 2002, Dr. de Ville de Goyet has conducted independent evaluations after most major disasters, including the Indian Ocean tsunami and the Bam and Kashmir earthquakes. Nutrition The levels of global acute malnutrition as well as those of stunting (chronic malnutrition) are high but markedly under those considered a humanitarian emergency. Expertise includes: Pharmacology Physiology Pre-operative evaluation and assessment Procedural Pain Management Emergency airway management Emergency hemodynamic stabilization Transfusion medicine. All this ranges from neonates to the elderly. Types of Surgery Valve repair/replacement Coronary artery bypass graft (CABG) Heart/Lung transplant Lung resection Aortic Aneurysm/dissection repair Endovascular stenting Left/Right ventricular assist devices Concerns: Pre-operative Severe CAD, valvular pathology, pulm HTN, aortic balloon pump Intra-op management Transesophageal Echocardiography Cardiopulmonary bypass Deep Hypothermic Circulatory Arrest Post-op management CTICU - Some institutions have anesthesiologist run ICU care. Though he did not know it, it was with him that I was going to stay. I had a letter of introduction to him in my pocket. I felt somewhat lonely when I landed and my bags were put beside me on the beach. Well, he was strolling about the town one day, when he happened to turn round and saw the Achinese walking quite quietly just behind him. It gave him a turn. It would give anyone a turn. “The Dutchman went straight back to his hotel, packed his things and took the next boat to Singapore. Of course he put up at the hotel where all the Dutch stay, and one day when he was having a drink in the courtyard in front of the hotel, the Achinese walked in, looked at him for a minute, and walked out again. The Dutchman told me he was just paralysed. This put him in a bad temper, and caused him to be very rude to his junior partner. The junior partner in turn was rude to the chief clerk; and so on all the way down to the office boy. 12 On Monday Tom’s boss suddenly asked for a report on the previous week’s figures. This was just as well, as if he said anything he would have been very rude. 16 Fortunately Ann, the typist, came to Tom’s assistance. Ann rather liked Tom. 21 All the roads were blocked by snow . . . meant that help could not reach us till the following spring. 22 You needn’t think you were unobserved! I saw . . . you did!