An Eye Opening Experience: Hardware Removal Resulting in Fixed and Dilated Pupils and an Emergency Craniotomy

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Objectives:

1. Review the anatomy, location, and function of osteointegrated hearing devices, including the Vistafix system.
2. Discuss the differential diagnosis and implications of unanticipated "Fixed and Dilated" pupils.
3. Review the anesthetic goals to treat elevated intracranial pressure.
4. Discuss the various imaging modalities that can identify stroke, intracranial/ vascular hemorrhage, and mass effect and determine which is best for each problem.
5. Discuss some approaches to address conflicts in the workplace during a high stress situation.

Stem Case

You are scheduled to remove an osseointegrated hearing implant on a 4-year-old girl. She was born with congenital aural atresia, microtia, conductive hearing loss, and had previously received bilateral osseointegrated hearing aids. After a fall, she developed cellulitis over the left implant and reported pain at the site for the past 6 months. The site periodically exudes pus that her pediatrician has been treating with oral antibiotics. During her follow-up visit with the ENT (otolaryngology) surgeon, the device is noted to be dislodged and she is scheduled for hardware removal to allow the site to heal.

What is an "osseointegrated hearing device", where is it located, and how does it work? What is a Vistafix? Do you anticipate any complications from its removal?

Past Medical History (Hx) – Your patient was born full term without complications. She had an URI (upper respiratory infection) within the last week and has a hx of asthma, for which she is treated intermittently with albuterol. She also has a hx of eczema and seasonal allergies.

Vital Signs: HR 74, BP 106/67, SpO2 99 on RA, T 36.8, and RR 24, Wt. 18 Kg

Is there any additional information you would like before your proceed?

She is NPO appropriate and was given 9 mg of oral midazolam in the pre-operative holding area. She remains highly anxious and her anxiety seems to be increasing as it gets closer to the operating room (OR) start time.

Your surgeon informs you that this will be a brief and minor surgery but that he will require the bed to be turned 180 degrees and may need a small drill to remove the implant. He reminds you the device is already displaced.

How would you choose to induce this patient and how would you maintain her anesthetic? Are there any special considerations you may have for this procedure? Do you intubate?

The induction of anesthesia is uneventful and you leave your resident in the room and attend to the induction of another patient. Thirty minutes later the surgeon calls you back into the room to inform you that when he pulled the device from the skull, he encountered some brisk bleeding, but was able to achieve hemostasis. The surgeon initially felt the bleeding originated from the bone. When it did not subside after the application of bone wax, he realized the device had eroded through the skull and had adhered to a small vessel on the dura, which tore with the removal of the device.

Your patient is currently anesthetized with Sevoflurane and received 2 mg of morphine upon induction. The BP is appropriate under anesthesia for this age group but you note that the HR was 180 with Induction/intubation and settled under anesthesia in the 120's. Over the next 30 min the HR trends up to the 150's. The patient has received a 20 ml/kg bolus of fluid and your resident gives some additional morphine. EtCO2 is in the normal range.

Does this change your anesthetic plan? Do you extubate? Do you keep the child overnight although she was scheduled to go home?

Your ENT surgeon "curbsides" a neurosurgeon who recommends your patient be monitored overnight for any neurologic changes. The surgery is completed and the patient is extubated after meeting extubation criteria. The patient's pupils are equal and reactive in the OR. In the PACU you place monitors and give the nurse a handoff report. While you are completing your paperwork the nurse asks you to come in and examine the patient's eyes. Both pupils are "fixed and dilated."

What is your differential diagnosis for "fixed and dilated pupils"? What is your response? Do you have to presume the worst?

You initiate hyperventilation, call for some mannitol and furosemide, and alert the OR front desk. After transferring the patient back to the operating room, intubating, and treating the presumed increased intracranial pressure, your neurosurgeon opens the cranium and informs you he can't find any source of

bleeding. He then asks you if you are sure of the "fixed and dilated" finding and strongly suggests that you were wrong in your diagnosis.

What is your next course of action for this patient? What is your response to the surgeon's frustration?

The pupils are now reacting normally; the surgeon closes the cranium and elects to send your patient to the MRI scanner. He wants her awake and extubated for neuro-checks.

Which imaging modality would you choose to evaluate her brain? What do you choose as your anesthetic for the MRI? Do you extubate her prior to the MRI? Where would you take her to recover from the MRI sedation?

The MRI demonstrates bleeding at the base of the skull and a new stroke. She is taken back to the operating room for a repeat craniotomy and decompression.

Discussion:

This case will review implantable hearing devices, the differential diagnosis for "fixed and dilated pupils", the treatment of elevated ICP and the various imaging modalities for the brain, as well as the anesthetic goals for a craniotomy after an unexpected intracranial hemorrhage. The participants will also address the conflicts arising from differences in opinion concerning the diagnosis of a patient and how to resolve them while keeping the patient's best interests in mind.

Implantable hearing devices:

Bone anchored hearing aids (BAHA) works on a principle of efficient coupling of the sound processor to the underlying bone through a small connector across the skin, and an implant that directly bonds with the underlying bone – an osseointegrated implant. Hearing is achieved by conduction of sound via bone directly to the cochlea. It is suited for patients with absent ear canals, as in our case, and conductive hearing loss not amenable to other hearing aids. The Vistafix combines a BAHA with a prosthetic ear.

Differential Diagnosis of Fixed and Dilated Pupils

The pupils are dilated by sympathetic stimulation and constricted via parasympathetic stimulation. Inhibition of either one has the opposite effect. The resting pupil size is the result of external factors (light, medication, etc.) and the balance of sympathetic and parasympathetic input. With regard to the parasympathetic pathways, approximately 10% of the afferent fibers travel via the optic nerve and optic chiasm to the lateral geniculate bodies and relay to the periaqueductal grey matter and then to both Edinger-Westphal nuclei. Preganglionic efferent parasympathetic nerves are carried in the dorso-medial part of the oculomotor nerves and relay to the ciliary ganglion in the posterior

orbit. The understanding of the microanatomy of these pathways is of great practical importance, as the external or peripherally placed pupillary fibers are vulnerable to direct pressure, and they are usually unaffected in infarction of the nerve trunk (which may occur in diabetes). The ciliary ganglion gives origin to 8 -10 short ciliary nerves that pass around the eye to reach the constrictor muscles of the pupil. The first neuron of the sympathetic innervation arises in the hypothalamus. Its subsequent course is predominantly ipsilateral through the brain stem, to the lateral gray matter of the thoracic spinal cord. It then travels via the superior cervical ganglion, carotid blood vessels, third cranial nerve, and nasociliary branch of the trigeminal nerve to reach the dilator muscle of the pupil as the long ciliary nerves. From the level of the cavernous sinus outwards, the parasympathetic and sympathetic nerve fibers freely mix with each other, and in the third and fifth cranial nerves [(6)].

Once detected, the clinical significance of fixed and dilated pupils must be determined. In the conscious patient, they are less predictive of a dangerous underlying cause, but can be indicative of it. Broadly the differential diagnosis for fixed and dilated pupils can be divided in parasympathetic, sympathetic, and miscellaneous causes. The parasympathetic causes include parasympatholytic medications, cranial Nerve III palsy secondary to Guillain Barre or Botulism, raised intracranial pressures(ICP), CNS Diseases such as Diabetes, Encephalitis, Multiple Sclerosis, and venoms from the Puffer Fish, Snakes or Spiders. The sympathetic causes include sympathomimetic medications or a Pheochromocytoma. The miscellaneous causes include cardiac arrest, Cyanide/Methanol/Propranolol/Barbiturate poisoning, hypothermia, deep anesthesia, and a high spinal. In our case the differential included deep anesthesia and elevated ICP.

Treatment of increased ICP:

Traditionally, administration of mannitol, furosemide, and hyperventilation were the mainstay of the acute treatment of elevated intracranial pressure. A recent study, by Colton, et.al., though, revealed that mannitol resulted only in a minor decrease in ICP, with a rebound after approximately an hour, whereas Hypertonic Saline led to the largest decrease in ICP. Hyperventilation is able to decrease ICP acutely, but compromises cerebral perfusion at the same time, and should therefore only be used with caution and in extreme situations where brain stem herniation is imminent. Identification of the cause of the increased ICP is key to a successful treatment.

CT (computer tomography) versus MRI (magnetic resonance imaging) for the evaluation of intracranial processes

A CT can rapidly diagnose intracranial hemorrhage, edema, and midline shift. Conventional MRI when compared with CT has a higher sensitivity, specificity, better correlation with outcome, and especially in childhood – a lack of radiation. MRI is also now recommended as an imaging modality for the

evaluation of brain ischemia. In cases were time is of the essence, a CT should probably be the imaging modality of choice.

Anesthetic goals for a craniotomy for intracranial hemorrhage:

The goal for the anesthetic management in these situations can be summarized as brain protection. In order to prevent brainstem herniation in cases of increased ICP secondary to hemorrhage or other causes, a further raise of ICP has to be prevented. In cases of increased ICP, the most critical parts during the anesthetic are the induction/intubation and acute increases in surgical stimulation. Adequate anesthetic depth and blunting of airway reflexes will mitigate any elevation of ICP in these situations. This has to be balanced with maintenance of adequate cerebral perfusion pressure to prevent further brain tissue loss and worsening neurological outcome. Additional brain protection may be achieved by moderate hypothermia and the use of barbiturates.

Conflict in the Operating Room

Conflict is a common occurrence during the course of one's day in the operating room and occurs 50% to 78% of the time according to different studies[4]. The conflict can range from minor disagreements to significant disruptive clashes of opinion. The operating room is a unique environment where two physicians of equal standing are responsible for the same patient. In addition there are teams of nurses and technicians, patients, and families that all have interrelated roles. A conflict can occur between any of these participants. While the goal should always be the best care for the patient, each team member has different tasks and roles, different experiences, and possibly different beliefs and all these factors may result in conflicting goals when taking care of the patient. In addition, the OR environment can mean high stakes and possible life and death decisions which can add to the stress of the conflict. Miscommunication, a lack of information, or incorrect information can be a significant source of conflicts in the OR.

Resolution of conflicts can generally take 5 different forms: 1. Avoidance when the conflict is inappropriate for that time or possibly too large or difficult to be dealt with immediately. The conflict will usually need to be dealt with in the future. 2. Yielding or Accommodation when the conflict seems insignificant or the person realizes they are in error. 3. Compromise is when each party must give some ground to gain part of their goals. It is sometimes referred to as shared pain and gain. [4] 4. Collaboration is generally the most time consuming but also can be the most rewarding, with all parties invested in the solution to the conflict. Collaboration has the potential for long-term change and has been referred to as a "win-win" solution. 5. The final conflict resolution type can be referred to as forcing or competition. This style of conflict resolution has the potential to create larger conflicts with the person you are in conflict with. This style can be used if the issue is so important that you must "win" or if the other person is not willing to give any ground.[4]

All these conflict resolution styles have their usefulness, consequences, and more appropriate time of use. For example, during an OR fire the conflict between the nurse and scrub tech over who is responsible for filling the basin with water should be ignored to appropriately treat the patient. Another example is during a code, forcing the respiratory therapist to step aside after three failed attempts to intubate is the appropriate course of action. Being aware of these different styles of conflict resolution will allow you to manage your work conflicts with greater insight and potentially defuse some of the stress associated with these workplace conflicts.

In summary, even minor procedures such as hardware removal have the potential to inflict injury to our patients and the anesthesiologist must remain vigilant and prepared to treat potential complications. Conflict is also a part of our work environment with both the potential to harm our patient or better the patient's outcome. Understanding the conflict and the styles of conflict resolution provides an opportunity to decrease the stress associated with these conflicts and allows everyone to focus on patient care.

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