Surgical Treatment of Seizures in Children

Kristina "Kristi" Rae Hughes, CST, MHA

The modern era of epilepsy surgery began in 1886, at the National Hospital for Paralysed and Epileptic in London (Meador, Loring, & Flanigin, 1989). Sir Victor Horsley was the first to successful perform a craniotomy for focal seizures secondary to a depressed skull fracture (Meador, Loring, & Flanigin, 1989). The enhanced modern interventions are a result of these earlier dated techniques and the beginning of the collaboration between epilepsy surgery and neuroscience.

Surgical interventions may be a last resort for children with epilepsy. While there are many pharmaceutical advancements that have been made, surgical intervention may be necessary to improve the patient's quality of life. New antiepileptic drugs (AEDs), introduced since 1993, provide more diverse options in the treatment of epilepsy (Hwang & Kim, 2008). Even with these drugs being developed and improved over time, more than 25% of patients remain resistant to even the most advanced drug therapies (Hwang & Kim, 2008). A patient is a candidate for surgical intervention when there is inadequate seizure control despite appropriate medical therapy with at least two AEDs in maximally tolerated doses for 18 months to 2 years, or adequate seizure control with unacceptable drug related side effects (Go & Snead, 2008).

In addition to pharmaceutical advancements, there are improvements that have been made in surgical treatment in patients with epilepsy. Historically, surgical treatment involves an open craniot-

LEARNING OBJECTIVES

- Compare and contrast the various surgical techniques/approaches for treatment
- Understand relevant anatomy and pathophysiology related to seizure activity/epilepsy
- Recall and understand the key concepts and procedural steps for the Certified Surgical Technologist (CST)
- Review the most common equipment and supplies used for an open craniotomy for focal cortical resection
- Evaluate important post-operative considerations and potential complications

omy with resection of the portion of the brain contributing to the seizure activity. Currently, more frequently occurring surgical advancements include, but are not limited to, the use of:

1. Stereotactic magnetic resonance imaging (MRI) guided laser ablation of the epileptogenic foci
2. Deep brain stimulation (DBS)
3. Vagus nerve stimulation (VNS) techniques.

While using small incisions and burr holes, stereotactic magnetic resonance imaging or MRI-guided laser ablation involves using small applicators that work in conjunction with optical fibers, laser energy, and magnetic resonance (MR) thermal imaging to ablate targeted brain tissue (Willie, et al., 2014). Similarly, DBS is a therapy applied to drug-resistant forms of epilepsy for which resective surgery cannot be applied (Kahane & Depaulis, 2010). DBS is a surgical procedure that involves implanting electrodes into certain areas of the brain. The electrodes then produce electrical impulses that help aid in regulating abnormal brain impulses. These electrical impulses delivered are controlled by a generator that is placed in a "pocket" underneath the skin, usually in the superior chest. Last, VNS prevents seizures by sending mild pulses of electrical energy to the brain by way of electrodes (a wire like device) that is wrapped around the vagus nerve, located laterally to the midline of the neck. Like DBS, there is a kidney shaped battery/generator that is tunneled and secured in a "pocket" on the patient's chest. Like other common surgical advancements, these techniques are considered minimally invasive epilepsy surgeries (MIES), in comparison to the traditional open craniotomy approach.

PROCEDURAL STEPS FOR AN OPEN CRANIOTOMY RESECTION

Anatomical Considerations

The anatomical structures in this article will be descriptive of the anatomy for a traditional open craniotomy for a focal cortical resection. There are various anatomical possibilities depending upon the specific approach for each patient, the diseased or epileptic portion of the brain must be considered. The anatomical description below is generalized to describe basic anatomy related to an open craniotomy.

Prior to epilepsy surgery, patients undergo a series of neurodiagnostic tests to pinpoint the area of the brain that is contributing to the seizure activity. This portion of the brain is often referred to as the sick or diseased portion of the brain. Along with an MRI, a detailed neurodiagnostic report called an electroencephalography (EEG) will help guide the surgeon to the area where the incision must be made, anatomically.

Patient Positioning, Prepping and Draping

Once the patient has been moved to the operating room table, the patient remains in the supine position for the placement of their endotracheal tube, intravenous and arterial access, Foley catheter, and other patient monitoring devices. Once the patient is ready to be positioned, the surgeon will carefully place the Mayfield skull clamp system onto the patient. Careful consideration is taken in deciding whether pediatric or adult skull clamp pins are used – depending upon patient age and size. Once the Mayfield skull clamp system is secured, the patient is then moved toward the head of the OR table so that the head is fully suspended in the Mayfield headrest system, with consideration of the operative side being positioned and exposed appropriately. During this time, the surgeon is using caution in stabilizing the head and neck, while anesthesia carefully monitors the patient's airway. Appropriate positioning devices and padding are placed to reduce the risk of intraoperative pressure sores. Once the patient is positioned steps are taken to set up MRI and navigation techniques being used. Typically, this process involves integrating navigation software with the patient's MRI, to improve accuracy.

Prior to prepping, the surgical time out is performed. Before the site can be surgically prepped, a non-sterile preparation may take place. Depending on where the incision is going to be made, the patient's hair may need to be shaved and secured. A skin marker is used to mark the incision. The surgeon, resident, or circulating nurse prep the surgical site with chlorhexidine-gluconate and alcohol or povidone-iodine scrub/paint and alcohol. Once the prep is dry, the patient is draped by the surgeon and CST using sterile towels or surgical utility drapes, a skin stapler, antimicrobial incise drape, split drape, and ¾ drape. The CST secures suction tubing x2, bipolar and monopolar cautery, navigation stylet, drill cord, and possibly the cavitronic ultrasonic surgical aspirator (CUSA) to the drape.

Surgical Procedure Steps

Exposure. Prior to incision, the surgeon injects local anesthetic to the site. An incision is made using a #10 or #15 blade over the area of interest. Electrocautery is used to cauterize bleeding scalp vessels. To establish hemostasis, Raney clips may be applied. Bipolar cautery is used to cauterize delicate tissues and vessels. Raney clips are applied to the scalp to provide hemostasis. In younger children, electrocautery may be used to provide hemostasis to the scalp (rather than the application of Raney clips) to prevent damage to the scalp edges. A periosteal elevator is used to elevate the scalp flap and careful consideration is taken to ensure that the periosteum remains intact. Two rolled Raytec sponges are used to elevate the scalp flap. A moistened lap sponge is placed over the galea prior to the flap being secured. This keeps the area moist and helps protect the surface during the procedure. The scalp flap is secured and retracted using blunt lone star fishhooks. The distal end of the lone star fishhooks is secured, using a hemostat, to a Kerlix that has a non-sterile portion that has been secured to the end of the bed with the sterile portion being taught and aiding in retraction towards the patient's head. Care is taken to ensure that minimal pressure is being applied to the patient to prevent unnecessary pressure sores. Cautery is used to remove periosteum from the areas of the bone where the craniotomy will be performed. Burr holes are made into the bone using a Midas rex drill with an M-8 burr or a perforator. The sizes range from 10-13mm for pediatric patients. Warm saline irrigation and a 10fr Frazier suction tip are used while the drill is in use to remove bone dust, aid in visualization, and keep the drill from becoming too warm. Once the burr holes have been placed, a Kerrison rongeur may be used to widen the burr hole or remove fragments of bone. Next, a Penfield #1 dissector is used to ensure that the bone flap is free from the dura. Next, a router (or saw) will be used to connect the burr hole portions to remove a portion of the skull, most commonly referred to as the "bone flap." When the bone flap is being removed, care is taken to ensure that the dura remains intact. Care must be taken by the surgeon during exposure to ensure that emissary veins are avoided. These veins provide a strong venous connection to intracranial structures. During all steps, the Certified Surgical Technologist (CST) must be vigilant and alert to signs of bleeding, having hemostatic agents such as bone wax, Floseal, gelfoam, and cottonoids ready for immediate use.

Dural Opening. Once the bone flap is removed and hemostasis has been achieved, the dura is opened. The CST must have stiles or Geralds with teeth, Woodson elevator, bipolar forceps, and tenotomy scissors ready. The dura is carefully opened, and 4-0 nylon sutures are used to delicately retract the edges of the dura to provide adequate exposure of the brain.

Mapping. Once the brain is exposed, intraoperative monitoring is performed called electrocorticography (ECOG) (Al-Otaibi, Baeesa, Parrent, Girvin, & Steven, 2012). During this process sterile monitoring electrodes are placed directly onto the surface of the brain. The CST carefully passes off one end of the electrode to be attached to the neurodiagnostic machine. The end of the electrode on the brain is marked with numbers that correspond with readings being recorded on the neurodiagnostic machine. The CST prepares a collagen sponge by moistening it. This sponge is laid on top of the electrodes to increase the contact/connection between the surface of the brain and the electrode. This "mapping" enables the team to accurately locate the portion of the epileptic portion of brain that needs to be resected. The CST must also be vigilant to ensure that the electrodes are secure and other sterile team members do not interrupt the placement of the electrodes. During the use of ECOG monitoring, cold irrigation must be available. One major risk of intraoperative stimulation mapping is the production of stimulation-evoked seizures (Sartorius & Berger, 1998). Cold irrigation solution applied directly to the irritated cortex during intraoperative brain mapping procedures may rapidly and reliably terminate these simple partial seizures (Sartorius & Berger, 1998). Once the area of the brain that needs to be resected has been confirmed, the resection of the epileptic portion of the brain begins.

Historically, surgical treatment involves an open craniotomy with resection of the portion of the brain contributing to the seizure activity. Currently, more frequently occurring surgical advancements include, but are not limited to, the use of:

1. Stereotactic magnetic resonance imaging (MRI) guided laser ablation of the epileptogenic foci
2. Deep brain stimulation (DBS)
3. Vagus nerve stimulation (VNS) techniques.

Resection of epileptic brain. The CST will have bipolar cautery, micro-crossover scissors, and 5-7fr tear drop suctions available. During the resection, disposable nonstick bipolar tips are used to decrease residue build up and are easy to clean during the procedure. These bipolar tips aid in the delicate resection process to decrease blood loss, which can occur at a faster rate in pediatric patients, due to their size. Once the epileptic portion of the brain has been resected and sent to pediatric neuropathology for review, the ECOG monitoring electrodes are placed on the surface of the brain for a post-resection reading/mapping.

Wound closure. The wound is irrigated using saline irrigation and the dura is closed using interrupted 4-0 nylon sutures. Prior to the last interrupted stitch in the dura, the cavity is filled with saline. Following the final dural stitch, the surgeon typically irrigates to look for any dural leaks. If needed, a dural matrix product may be applied. The bone flap is secured using various titanium plates and screws. The CST must ensure that the implanted plates and screws are appropriately documented by the circulating nurse. The remainder of the surgical wound is closed with either 2-0 or 3-0 absorbable multifilament synthetic suture followed by an absorbable monofilament suture for the skin, to size. Depending upon the patient's age, surgical skin glue may be applied or antibiotic ointment, non-adherent dressing, and 2" soft cloth surgical tape.

POST-OPERATIVE

Following surgery, the patient is transferred to the post-anesthesia care unit where the patient's vital signs are monitored. Depending upon the patient's progress during surgery, they may be transferred to the pediatric intensive care unit (PICU) or to the neurosurgery floor where they will continue to be monitored by neuro healthcare professionals. During this time, medications may be given to help control symptoms associated with the procedure such as surgical site pain, headaches, and nausea.

COMPLICATIONS AND CONSIDERATIONS

In addition to common surgical complications such as bleeding, risk of infection, and reactions to anesthetic mechanisms, specific risks associated with having a craniotomy and resective brain surgery arise. Some of these complications may include stroke, permanent brain damage, brain swelling requiring an additional craniotomy, and a CSF leak, requiring surgical repair (Mayfield Brain & Spine, 2019).

More specific complications related to the resection of epileptic brain tissue include memory and language deficits after a temporal lobectomy is performed, reduced visual field, partial or one-sided paralysis (specific to hemispherectomy) (Mayfield Brain & Spine, 2019). Early and effective epilepsy surgery does not guarantee cognitive recovery in young children, but it can be considered as a "bonus" in some specific circumstances (Roulet-Perez, et al., 2010).

ABOUT THE AUTHOR

Kristina "Kristi" Hughes, CST, has been a surgical technologist for over 13 years since obtaining her associates of applied science in surgical technology. She has been a member of a pediatric neurosurgery team at a hospital close to her hometown. While employed at the hospital, Kristina completed her bachelor's and master's degrees in healthcare administration. She has also been in higher education for over 9 years, instructing and mentoring future surgical technologists. She is a working mom and wife that strives to promote and educate people on the importance of the surgical technologist in the operating room for delivering safe and quality patient care.

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1. **More frequently occurring surgical advancements for treatment of seizures in children include all the following except:**
   a. Stereotactic magnetic resonance imaging (MRI) guided laser ablation of the epileptogenic foci
   b. Traditional Open Craniotomy
   c. Deep brain stimulation (DBS)
   d. Vagus nerve stimulation (VNS) techniques

2. **Sir Victor Horsley was the first to successfully perform a craniotomy for focal seizures secondary to a depressed skull fracture.**
   a. True
   b. False

3. **A _______ elevator is used to elevate the scalp flap and careful consideration is taken to ensure that the _______ remains intact.**
   a. Freer and muscle
   b. Periosteal and periosteum
   c. Penfield and fascia
   d. Woodson and periosteum

4. **For pediatric patients, a common perforator size is:**
   a. 14-16 mm
   b. 10-13 mm
   c. 6-8 mm
   d. 2-5 mm

5. **All the following are hemostatic agents that should be ready for immediate use, except for:**
   a. Bone wax
   b. Floseal
   c. Gelfoam
   d. ESU

6. **The CST prepares a collagen sponge called ______ by moistening it.**
   a. Avitene
   b. Bicol
   c. Grafton
   d. None of the above

7. **During the use of ECOG monitoring, the CST must have cold irrigation available for use.**
   a. True
   b. False

8. **To aid in the resection of epileptic brain tissue, _______ tips are used to decrease residue build up, aid in the delicate resection process, and decrease blood loss.**
   a. ESU Needle
   b. Disposable non-stick bipolar
   c. Guarded ESU
   d. Non-bayonet

9. **The bone flap is commonly secured with titanium ______ and ________.**
   a. Screws and nylon suture
   b. Plates and synthetic non-absorbable suture
   c. Plates and screws
   d. None of the above

10. **The following are possible surgical complications associated with resective brain surgery:**
    a. Memory loss
    b. Language deficits
    c. Reduced visual field
    d. All of the above

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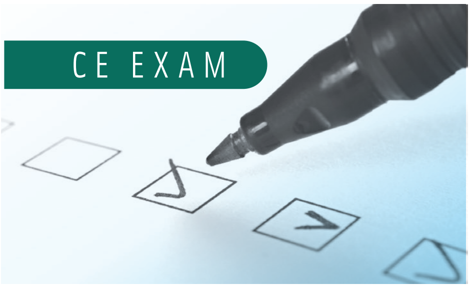

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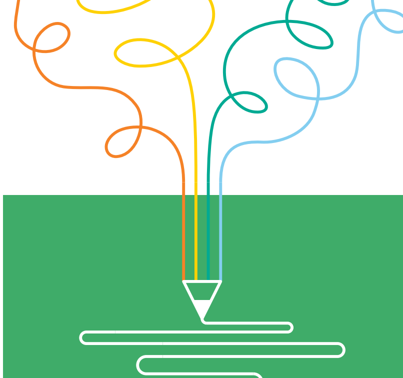

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