Chapter 7
Brain Code (Adult)

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Case Outline

Learning Objectives

1. Discuss anesthetic management of stroke code.
2. Describe signs and symptoms of elevated intracranial pressure.
3. Discuss acute management of elevated intracranial pressure.

Simulator Environment

1. Location: interventional radiology suite of an adult hospital.
2. Manikin setup:
   (a) Age: adult
   (b) Lines: 1 x 20 Gauge (G) peripheral intravenous (PIV) line, radial arterial line, foley catheter
   (c) Monitors: non-invasive blood pressure (NIBP) cuff, 5-lead electrocardiogram (EKG), pulse oximeter
3. Medications available: normal saline, propofol, etomidate, succinylcholine, rocuronium, epinephrine, albuterol, fentanyl, midazolam, calcium chloride, hypertonic saline, mannitol.

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4. Equipment available
   (a) Airway equipment: ventilator, face mask, laryngoscope and cuffed and uncuffed endotracheal tubes (ETTs) of various sizes, stylet, oral airway, nasal trumpet, laryngeal mask airway (LMA), suction, fiberoptic bronchoscope, video laryngoscope.
   (b) Monitors: pulse oximeter, blood pressure cuff, 5-lead EKG.
   (c) Lines: arterial line kit, central line kit, PIV kits
   (d) Crash cart with defibrillator
   (e) Paperwork: pre-operative anesthesia history and physical

Actors

1. Scrub tech
   (a) The scrub tech is busy opening trays.
2. Circulator nurse
   (a) The nurse is busy charting.
3. Neuro-interventional radiologist
   (a) The neuro-interventional radiology (Neuro-IR) team is focused on locating and removing the clot.

Case Narrative

1. Scenario background given to participants:
   (a) You are the anesthesiologist taking care of a 70-year-old man with poorly controlled type 2 diabetes mellitus (T2DM) and severe gastroesophageal reflux disease (GERD). He was found down in the parking lot of a grocery store and on exam was found to have dysarthria, dysphagia, facial droop, and hemiparesis. Computed tomography (CT) scan of the head confirmed acute ischemic middle cerebral artery (MCA) stroke.
   (b) He is currently in the interventional radiology suite undergoing diagnostic cerebral angiogram and clot removal under monitored anesthesia care (MAC)/sedation with propofol infusion for maintenance of anesthesia.

(c) Medications: insulin, metformin, gabapentin.
(d) Preoperative labs: potassium (K) 4.9, hemoglobin (Hb) 11.5, bicarbonate (HCO_3) 30.

2. Phase 1: coughing, vomiting and nonresponsiveness

(a) The patient is initially doing well, calm, breathing spontaneously on simple face mask. The surgeons are advancing their catheter towards the clot when suddenly the patient starts coughing and moving. The patient is unable to remain still despite verbal instructions from the staff. He then turns his head and throws up. He becomes nonresponsive, hypoventilating, and is no longer following commands.
(b) The learner should move to the head of the bed and recognize the hypoventilation and acute change in neurologic status. The learner should move to intubate as soon as possible to protect against aspiration.

3. Phase 2: intracranial bleed leading to elevated intracranial pressure

(a) The blood pressure will acutely increase to systolic blood pressure (SBP) 190 s and the heart rate will slow down to the 40s–50s. The surgeon will now report that on angiogram, there was an accidental rupture of a major cerebral artery that must have occurred while the patient was coughing.
(b) The learner should recognize an acute intracranial bleed now resulting in elevated intracranial pressure, and should activate a brain code. They should recommend the following steps:

(i) The surgeon will remove the catheter and hold pressure at the groin site.
(ii) Brain code will be activated to alert pharmacy and neurology.
(iii) Administer mannitol or hypertonic saline loading dose/infusion.
(iv) Hyperventilate the patient.
(v) Alert the operating room and prepare for possible surgical decompression – Burr holes, craniotomy for clot evacuation.
(vi) Ask the surgeons to consider emergent external ventricular drain (EVD) placement for intracranial pressure (ICP) treatment and monitoring.
(vii) Elevate head of bed.
(viii) Manage hemodynamics: maintain goal cerebral perfusion pressure (CPP) >60 while also controlling hypertension to avoid hematoma expansion.

Scoring Rubric

Table 7.1 Scoring rubric for case scenario on Brain Code

Topic: Brain Code		
Participant Name:		
Evaluator Name:		
Score:		
	Completed	Not Completed
Aspiration		
Recognizes acute change in mental status		
Relocates self to head of bed to assess patient's mental status and respiratory status		
Suctions oropharynx		
Administers supplemental oxygen: Switches simple face mask to circuit mask for better seal		
Intubates patient in a timely fashion to protect against aspiration		
Elevated intracranial pressure		
Identifies hemodynamic instability: Hypertension and bradycardia that occurred acutely		
Recognizes hemodynamic signs of intracranial hypertension		
Calls for help		
Activates brain code to alert pharmacy and neurosurgery		
Hyperventilates the patient with 100% fraction of inspired oxygen (FiO_2)		
Administers mannitol or hypertonic saline		
Establishes large-bore peripheral intravenous (PIV) access		
Places arterial line		
Orders PRBCs to be crossmatched		
Requests the operating room be alerted and prepared for possible surgical decompression		
Elevates the head of bed when possible		
Maintains adequate cerebral perfusion pressure		
Weighs risk of hypertension in causing further hematoma expansion		
Discusses with surgeon possible emergent decompressive procedures to be done prior to the operating room (OR): External ventricular drain (EVD) placement, Burr holes		

Summary of Clinical Teaching Points

What are the pros and cons of doing a diagnostic cerebral angiogram and intervention under general anesthesia with an endotracheal tube (GETA) versus monitored anesthesia care (MAC)/sedation?

Table 7.2 Comparison of pros and cons of general anesthesia versus sedation for stroke intervention

	General Anesthesia and Endotracheal Intubation (GETA)	Monitored Anesthesia Care (MAC)/Sedation
Pros	Airway protection High aspiration risk (especially if neurologic deficits include dysphagia, dysarthria, facial droop, depressed mental status) Avoid intraoperative emergency conversion to a general anesthetic if complication occurs Avoids pain, anxiety, agitation Avoids patient movement that could lead to unintentional vessel perforation / dissection	Enables providers to track changes in neurologic exam in timely fashion. Enables early detection of exacerbated, new, or resolved neurologic deficits Improves early detection of iatrogenic intracerebral hemorrhage
Cons	Unable to track changes in mental status or neurologic exam May cause hemodynamic instability especially with induction May involve ventilation-associated complications Delays time to extubation and post-operative repeat neurological exam	Sedation may exacerbate altered mental status due to stroke, increasing aspiration risk with an unprotected airway If patient becomes disoriented or disinhibited, patient may move and disrupt surgical field

What are the signs and symptoms of intracranial hypertension? [1–4]

- Presentation
  - Headache
  - Decreased consciousness
  - Vomiting
  - Cushing triad: hypertension, bradycardia, respiratory arrest
  - Dilated pupil on ipsilateral side of hemorrhage
  - Cranial nerve palsies III, IV, VI – double vision, ptosis
- When to call a brain code
  - Signs of herniation
  - Intracranial pressure >20 cm H_2O for >3 minutes

How do you manage intracranial hypertension? [1–4]

- Activate hospital Brain Code to alert Pharmacy and Neurology
- Administer mannitol or hypertonic saline loading dose or infusion.
- Hyperventilate the patient.
- Operative management
  - Alert the operating room and prepare for possible surgical decompression – Burr holes, craniotomy for clot evacuation.

  - Ask the surgeons to consider emergent external ventricular drain (EVD) placement for intracranial pressure (ICP) treatment and monitoring.

- Elevated head of bed.
- Manage hemodynamics: goal cerebral perfusion pressure (CPP) >60 mmHg, intracranial pressure (ICP) <20 mmHg.
  - If someone is herniating, do not use antihypertensives to lower blood pressure – generally need a higher mean arterial pressure (MAP) in the setting of higher ICP to maintain CPP.
  - Also avoid overshooting MAP, which will skyrocket cerebral blood flow (CBF) and exacerbate ICP.
- Ensure adequate oxygenation.
- Consider antiepileptics.
- Consider antipyretics.
- Avoid hyperglycemia.

How do you manage intracranial hemorrhage? [1–4]

Table 7.3 Comparison of hypertonic saline versus mannitol for management of intracranial hypertension

	Hypertonic Saline (3% NaCl)	Mannitol
Indications	Cerebral edema Elevated intracranial pressure Hyponatremic seizures	Cerebral edema Elevated intracranial pressure
Mechanism of action	Increases serum sodium Creates osmotic gradient Induces shift of fluid from intracellular to extracelluar space Increases effective circulating volume Osmolarity of 1026 mEq/L	Increases plasma osmolarity and draws water from brain cells into vasculature leading to diuresis Osmolarity of 1098 mEq/L
Dosing	Cerebral edema: 3–5 cc/kg over 10–20 minutes 3 cc/kg will increase serum sodium by 2–3 mmol/L, maybe greater if large diuresis occurs	Start with 0.5–1 gram/kg, maximum 2 grams/kg Give slowly over 30 minutes Too fast: Dramatic electrolyte derangements Too slow: Equilibrates, doesn't change plasma osmolarity to drive diuresis

Table 7.3 (continued)

	Hypertonic Saline (3% NaCl)	Mannitol
Nuances	As effective as mannitol for treatment of elevated ICP Less "rebound" ICP No obligatory osmotic diuresis (plasma volume is preserved/expanded) Reno-protective Monitoring osmolality: Use serum sodium	May be nephrotoxic More readily available in the operating room Monitoring osmolality: Infer osmolar gap Metabolic derangements: Metabolic acidosis because dilution of serum bicarbonate; hypokalemia or hyperkalemia; dilutional hyponatremia Caution in patients who cannot tolerate significant increases in intravascular volume (e.g. congestive heart failure). May need to provide inotropic support or preempt with furosemide to offload increased venous return to heart Caution in patients who are already hypovolemic. Goal is to create a gradient, not to dehydrate the patient

- Immediate control of blood pressure within 10 minutes
  - Goal is to prevent hematoma from expanding
  - Goal systolic blood pressure (SPB) <150 mmHg
  - Antihypertensives: nicardipine, labetalol, hydralazine
- Immediate reversal of coagulopathy

How do you decide whether to use hypertonic saline or mannitol to treat intracranial hypertension? [1–4]

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