SNS Junior Resident Course

Simulation Description for Faculty – Day 2

Spine Skill Basics

Two 30-minute sessions: Residents will rotate through in groups of 4-6

Session 1 will be teaching Occipital Cervical with Medtronic equipment. Medtronic will send a rep and show occipital cervical under navigation and with sawbones.

Session 2 will be teaching Thoracolumbar with DePuy Synthes equipment [Viper Prime]. DePuy will be sending a rep and there will be sawbones available to teach placement of pedicle screws. Assume 2 screws placed per resident.

Prosection

For Day 2, you will be at the Prosection station—we will have 3 arms (shoulder to fingertip) that you will use throughout the day to show Peripheral Nerve. Residents will be rotating through in small groups every 20 minutes. We will have microsurgical instruments available.

Pain Pumps and Stimulators

For Day 2, you will be at the Pain Pumps and Stimulators station—Residents will rotate through in small groups every 20 minutes to learn about this procedure. A rep from Medtronic will be at this station demonstrating their equipment and supporting you.

Microscope Basics

For Day 2, you will be at the Microscope Basics station—Carl Zeiss Meditec will be sending their Pentero scope. Residents will rotate through in small groups every 20 minutes to learn the features of the scope and how it can be used to save information on cases. A rep from Zeiss will be at this station to provide a demo and to support you.

Endovascular Simulator: Diagnostic and Safety

For Day 2, you will at the Endovascular Simulator (Diagnostic and Safety)- Stryker will be sending their Simbionix Simulator to demonstrate endovascular access techniques and arch selection for cerebral diagnostic procedures. A rep from Stryker will be present to assist with the simulator.

Endovascular Simulator: Diagnostic Intervention

For Day 2, you will at the Endovascular Simulator (Diagnostic Intervention)- Stryker will be sending their Simbionix Simulator to demonstrate endovascular hemorrhagic and ischemic stroke interventions including thrombectomies, stenting and coiling. A rep from Stryker will be present to assist with the simulator.

Tumor Resection/Ultrasonic Aspiration

For Day 2 you will be at the Tumor Resection station. Integra will be sending their Cusa. Residents will rotate through in small groups every 24 minutes to learn the features of the Cusa and its use in the OR. Reps from Integra will be at this station supporting you and demonstrating the Cusa using meat and produce. You might be prepared with some case examples of tumor and ultrasonic aspiration.

Stereotactic Frame and Frameless Station

For Day 2 you will be at the Stereotactic Frame and Frameless Station. Integra will provide the stereotactic frame. You will teach residents how to properly place the frame. Stryker will provide navigation for frameless. You will teach residents its indications and use. Reps from each company will be on hand. Though this station is indicated as a 24-minute rotation, assume you'll need 12 minutes for each.

Gamma Knife Radiosurgery

For Day 2 you will be at the SRS station. Elekta will be providing a laptop preloaded with dosing, treatment plans and patient scenarios. Residents will rotate through in small groups every 24 minutes to learn about indications for SRS. A rep from Elekta will be on hand to support you.

Vessel Anastomosis Station

For Day 2 you will be at the Vessel Anastomosis station. Zimmer Biomet will be providing the anastomosis kits and Zeiss will provide some tabletop scopes, though residents are instructed to bring their loupes. Residents will rotate through every 60 minutes in a group of 8-10. A rep from Zimmer Biomet will be on hand to help with the set-up of materials. Residents will be directed to a vessel anastomosis power point on the SNS website to review in advance of the course.

Intraoperative Catastrophe Management

For Day 2, you will be one of 6 faculty at the hands-on Interoperative Catastrophe Management Simulation—there is nothing to prepare. The simulation goals are to experience a surgical emergency, manage a sagittal sinus injury with severe bleeding, and manage venous air embolism. Six residents will rotate through every 30 minutes with a faculty assigned to each of the six stations. You will be informed onsite on what you need to do by the 2 residents who created this simulation.

OR Crisis Management

For Day 2, you will be assigned to the OR Crisis Management Discussion—six residents will rotate through every 30 minutes. You will have them either before or after they complete the Intraoperative Catastrophe Management Simulation above. Please see below for guidelines.

SNS Resident Course II
OR CRISIS

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Scenario One: Patient comes out of 3-point pin fixation.

Despite appropriate placement of a patient in pins, scenarios can arise where the patient slips out of the pins. This could be due to an unexpected intraoperative wake up, a shifting of the patient with a change in table position and or failure of the fixation apparatus. As always, the best treatment is prevention. Pin fixation should be applied firmly and should be "stress tested" pre-operatively to be certain of adequate fixation. It is best to avoid pin fixation on sloping portions of the skull such as the posterior fossa or just lateral to the orbit. Pin fixation is usually lost during the portion of the operation that stresses the fixation most, scalp elevation and bone flap drilling. Counter-tension can be applied to lessen the pressure applied. Rarely, in patients with very thick skulls, the perforator can become stuck in the skull and removal of the perforator can pull the patient out of pin fixation. This can be anticipated and avoided in these cases by gently rotating the perforator bit just prior to completing the burr hole to create more room for perforator removal.

One can identify the problem by seeing, feeling, or hearing the head release from the pins. Gross loss of navigational accuracy may be another clue. When it is believed that there is loss of fixation, the operative intervention should be suspended. The OR team, especially anesthesia, should be notified. Adequate anesthetic levels should be verified: (IV lines carrying the anesthetic are intact, endotracheal tube connected, etc.). Simultaneous manual stabilization of the head on the field should occur to try to mitigate any further movement which could cause injury. Investigation of the orientation of the head to the pins under the drapes must now be accomplished. It is often beneficial to call a 3rd party into the room for this "under the drapes" maneuver so as to not deprive the operator of a primary assistant should continued intervention be necessary (i.e. control bleeding). Under the drapes, assessment should include the location of the individual pins as related to the anatomy (eye, ear canal) and injury (laceration, bleeding). Maintenance of a sterile field should be a critical priority at all times. If possible, removal of a free, potentially threatening pin should be undertaken. This is often the frontal pin which can oppose the eye. An evaluation of the position of the patient's head as it relates to finishing the

case, need for further manipulation of the table and risk of further head migration will need to be assessed by the operator. Considerations at this time include:

1) Proceed with the operation, with care not to further manipulate the head.
2) Exchange pin fixation for horseshoe rest.
3) Terminate the operation, close, undrape, reset the pins and begin again.
4) Terminate the operation.

Which of these scenarios one proceeds with depends on the nature of the case, the time-line of the case when the issue occurs and the condition of the patient.

Key points to review:

1) Recognize the event by sight, sound or movement under your hands.
2) Notify the surgical team if you think any fixation has deteriorated.
3) Communicate with the anesthesia team about the level of anesthetic: assure endotracheal tube and IV line integrity.
4) Ask for additional help to explore under the sterile field to evaluate stability of the patient's head and threat to critical anatomy.
5) Consider options to move forward with the operation or terminate.
6) Remember that navigation registration is no longer durable and that retractors fixed to the head holder may move.
7) Maintain a sterile field at all times.
8) After the operation, perform a critical analysis of the reason for loss of fixation: apparatus not performing appropriately, anatomy of the patient, insufficient fixation tension, location of fixation not adequately engaging the skull, lack of adequate fixation of the body to the table allowing for body shift, unexpected awakening from anesthetic due to loss of IV or endotracheal continuity with changes in patient positioning.

Scenario two: Uncontrolled/Unexpected Brain Swelling

In the course of intracranial surgery uncontrolled/unexpected brain swelling is one of the most worrisome and challenging surgical events. This problem can be divided into 2 primary categories: those events with known causes (acute ischemia due to compromise of a major artery/vein) and those events of unknown etiology. Differential diagnosis includes the following: contralateral epidural and/or subdural hematoma; acute hydrocephalus; venous congestion due to positioning, venous injury or obstruction; deep/intraventricular bleeding (i.e. aneurysm rupture or retraction and unobserved bleeding from a severed vessel); uncontrolled bleeding from coagulopathy, generalized seizure, insufficient ventilation, elevated airway pressure, uncontrolled hypertension, and insufficient anesthesia. The diagnosis and treatment varies with potential causes. A close working relationship with the anesthetic team is key since many of the causes and treatments are anesthesia related.

Initial treatment with hyperventilation, raising the head of the bed, diuretics, control of hypertension, paralytics, and metabolic suppression (i.e. pentobarbital) can buy initial time for diagnosis. Mild hypotension may help with initial management in severe cases, by must be weighed against potential exacerbation of ischemia. If the surgical pathology is exerting pressure, rapid decompression of the lesion (hematoma, tumor or cyst) should be started in parallel with the other maneuvers. Open adjacent cisterns to release CSF. If generalized seizure is considered, irrigation of the brain with ice-cold saline may rapidly abort the activity. A survey of the operative site may reveal an expanding parenchymal hematoma or a spreading subarachnoid hemorrhage at the edge or in the depth of the field. Intraoperative ultrasound can be diagnostic of deep hematoma and/or dilatation of ventricles. If dura is tented adjacent to a venous sinus, relaxation of the dura may improve venous drainage. In posterior fossa surgery in which communicating hydrocephalus may be precipitated, a prophylactic occipital burr hole should be considered.

In desperate times, with unknown pathology and limited diagnostic abilities, placement of an external ventricular drain may relieve pressure and be diagnostic. When all else fails, consideration should be made for extending the craniotomy to allow optimum decompression with dural relaxation and/or pathological brain resection. This can buy time allowing for emergent CT scanning. The ability to obtain and maintain hemostasis is critical, especially if coagulopathy or venous obstruction is being considered as the etiology for brain swelling. During closure, CT techs should be notified of the emergent need for the scan. If intraoperative CT is available, this could be employed prior to closure. While the patient is obtaining a CT scan the operating room should rapidly ready a room for re-opening or craniotomy extension. It is important that when this kind of event occurs, one considers calling for additional help. You cannot overestimate the benefit of another set of eyes, hands and an objective mind in managing these critical events.

Scenario three: Arrhythmia and/or hypotension

Cardiorespiratory instability is particularly dangerous during intracranial surgery. Firstly, the causes of instability related to brain exposure, manipulation and/or ischemia are particularly serious. Secondly, the consequence of instability for brain perfusion are very consequential. Thirdly, investigating and managing instability is particularly difficult with an open cranium and, mostly commonly, pin head fixation.

Neurosurgical patients are subject to the same general causes of intra-operative hypotension as others:

- Cardiogenic shock due to ischemia or volume overload.
- Hypovolemia due to bleeding.
- Sepsis.
- Drug or transfusion reaction or overdose.

- Arrhythmia due to metabolic or cardiac causes.
- Anesthetic complications such as malignant hypothermia.

Neurosurgical patients also suffer from additional etiologies of intra-operative hypotension:

- Arrhythmia due to direct irritation or injury to brainstem cardiorespiratory centers, as the result to surgical manipulation, ischemia, or mass effect (local or distant to the surgical field).
- Intra-operative status epilepticus, which may be masked in the presence of pharmacological paralysis (general anesthesia reduces but does not eliminate the risk of this complication, particularly in the setting of intra-operative cortical stimulation and/or resection).
- Venous air embolus, reducing central venous return and cardiac output.

Although intra-cranial causes of hypotension may be suggested by the clinical context, the differential diagnosis is broad and must always include the long list above of general systemic causes. Diagnosis of many of these causes is difficult in a draped patient (hiding, for example, the rash or petechiae associated with some drug or transfusion reactions or with coagulopathy). In other cases, the pattern of physiological abnormalities suggests a diagnosis, such as the combination of precipitous tachycardia, oxygen desaturation, hypotension, and drop in end-tidal CO2 (despite hypercapnia) in the case of venous air embolus.

Management of intra-operative hypotension during neurosurgical cases must be swift and effective to prevent brain ischemia and/or hypoperfusion. It is also critical to avoid the catastrophic occurrence of full cardiac arrest during open neurosurgery, which can result in severe brain swelling at the craniotomy site, compromise of the sterile field, and difficulties managing arrest due to limited access and pin head fixation. In lateral decubitus and particularly in prone surgery, managing arrest with an open craniotomy is particularly challenging and less likely to succeed.

Some of the best measures to manage hypotension and arrest in neurological surgery are prophylactic in very high risk cases. For certain type of skull base surgery, or surgery with the head above the heart (e.g. sitting position), placement of central venous access to both diagnose and treat venous air embolus (through withdrawal of atrial air) may be indicated. Very rarely, case setup and positioning to include availability of external or internal cardiac pacing may be useful, such as in the case of an ependymoma invading the lateral medulla on pre-operative imaging.

If intra-operative hypotension occurs, immediate and ongoing communication with anesthesia is paramount. The surgeon is responsible for investigating the surgical field to identify and treat any local cause, while the anesthesiologist must explore and respond to all general causes. Immediate exchange information about the surgical field and cardiorespiratory and ventilator parameters is crucial to the rapid diagnosis of many entities, such as venous air embolus. Finally, a joint decision to terminate ongoing surgery in very rare cases of ongoing instability may be necessary to ensure a patient's survival.