The NSICU Resident Handbook

The Neurology/Neurosurgery Intensive Care Unit
Virginia Commonwealth University Health System
Richmond, VA.
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Welcome to the NSICU. Your rotation can be a very challenging experience. Even residents with prior critical care experience will find neurologically ill patients to be quite different from patients in medical and surgical intensive care units. Our patients have unique issues, which need to be addressed; and approaches to management are often significantly different.

This handbook has been written to make your life easier during this rotation. It will provide a brief overview of how the NSICU is run, your responsibilities as a resident; and it should help you manage most of the common problems that you might encounter during your rotation.

This book is designed to be more of a practical problem solving and management tool rather than educational in nature.

Doses of commonly used drugs are included. In some instances, we use drugs for non-FDA approved indications as well as doses higher than the dose recommended by the drug manufacturer; however, caution should be exercised in these circumstances.

This book is a work in progress; so feel free to give us any suggestions you might have on improving this book in order to make it more useful to your colleagues.

**Frequently used abbreviations:**

- **AMS** - Altered Mental Status
- **CPP** - Cerebral Perfusion Pressure
- **DDAVP** - desmopressin acetate
- **EDH** - Epidural Hematoma
- **ETCO₂** - end-tidal CO₂
- **ETT** - endotracheal tube
- **EVD** - external ventricular drain
- **FVC** - forced vital capacity
- **GBS** - Guillain-Barre syndrome
- **GCS** - Glasgow Coma Scale
- **ICH** - Intracerebral hemorrhage
- **ICP** - Intracranial pressure
- **IVH** - Intraventricular hemorrhage
- **LOC** - level of consciousness
- **MTS** - Mid-America Transplant Services
- **NIF** - negative inspiratory force
- **NIHSS** - National Institute of Health Stroke Scale
- **SAH** - subarachnoid hemorrhage
- **SCI** - spinal cord injury
- **SDH** - Subdural Hematoma
- **TBI** - traumatic brain injury
- **tPA** - tissue Plasminogen Activator
- **UOP** - urinary output
RESIDENT RESPONSIBILITIES

Since patients are not assigned to any particular resident, it is important that ALL residents be aware of the history, examination findings, labs values, medications and plans for the day on ALL patients.

Sign outs should be accurate and thorough; all goals should be reviewed.

When on Service:

- Examine your patient and review all labs, goals from the previous day and medications before ICU rounds.

- Write transfer orders before 10:00 AM. All other orders should be written while on rounds.

- Present pertinent findings on rounds (see below) and be prepared to discuss further plan of care for each system. Know what drugs the patients are on and why. Evaluate all medications every day and see if any of them can be discontinued (including PRN). For antibiotics, know the organism, current day and expected duration of therapy. For Antiepileptics know the indication, dration, level, and type of AED.

- Take care of the routine ICU work for the day on all patients including:
  - Schedule test and follow up on test results;
  - Enter orders (including cosigning all verbal and telephone orders within 24 hours) and restraint orders on rounds;
  - Call consults and make a note of their recommendations;
  - Ensure that the plans are carried out and test results are available before evening rounds;

- Perform procedures with the help of the fellow/attending.

- Find out about expected admissions from the Neurology and Neurosurgery Resident.

- Evaluate all patients on admissions to the ICU; discuss orders with the appropriate primary service.

- Present all admissions to the fellow/attending.

- Do not hesitate to call the fellow/attending if you have a question, or if you are unsure about management of a patient.

- Notify the fellow/attending of any major change in a patient’s status, even if you are comfortable managing it.

- Review midnight CXR on intubated patients and labs on all patients before Neurosurgery rounds (available by 3-5 am); reorder if studies are missing.
REASONS TO CALL THE FELLOW/ATTENDING

- All admissions.
- Prior to calling consults.
- Significant neurologic changes, unexpected ICP elevation, need for urgent CT scan, results of urgent and postoperative CT scans, seizure.
- Hypotension requiring pressors, arrhythmias, elevated trotopin, transfusion of blood products.
- Prior to intubation or starting BiPAP.
- Before starting antibiotics.
- Before starting hypotonic fluids (e.g. D5W, \(1/2\) NS).
- Unplanned or major procedures (unexpected trips to OR, EVD, central lines, chest tubes).
- Anything you are unsure of at any time.

TYPICAL WORKDAY

- Neurosurgery rounds (weekdays) 5:30 AM
- Evaluate your patients and prepare notes for rounds 8:00 AM
- Attending rounds 8:30-11:00 AM
- Work rounds 11:30-4:30 PM
- Evening rounds for the late call resident (with the NSICU fellow or attending) 5:00-6:00 PM

PRESENTING CASES ON ROUNDS

We like the following format, especially for patients with altered sensorium:

- Diagnosis, including post bleed day for patients with SAH or ICH and post operation day (major operations).
- Important goals from previous day and following-up.
- Important events over the last 24 hours.

- Mental status:
  - Level of sensorium described as:
    - GCS
    - Awake and alert, spontaneously opens eyes
    - Sleepy or drowsy, open eyes to voice
    - Lethargic, opens eyes to pain
    - Comatose, no response to any stimuli
  - Whether the patient regards the examiner
  - Whether the patient follows commands
  - Orientation, if it can be tested (not on aphasic pts)
• Cranial nerves:
  o Pupil size, symmetry and reaction to light
  o Ocular movements (do not perform doll’s eyes maneuver on patient in a cervical collar)
  o Corneal reflex of patient is not awake
  o Facial symmetry (smile or grimace)
  o Cough

• Movement of each limb (best response):
  o Follows commands – grade strength (from 1 to 5)
  o Localizes (central stimuli)
  o Withdraws (peripheral stimuli)
  o Flexes
  o Extends
  o No response

• Pertinent finding on examination of the heart, lungs, abdomen and extremities

**DOCUMENTATION**

1) **Writing progress notes (electronic)**
   o **Cerner** – Documentation on all patients is to be entered using the Cerner electronic documentation system. These notes are to be entered each day on each patient under Power Notes. The template for these can be found under “NSICU Progress Note”

2) **Writing orders**

   All ICU orders are to be placed in Cerner. You should make every attempt to write orders that are non-emergent on ICU rounds and not before.

   • **Medications:** drugs should have only one route listed (not PO/PT/IV). Range orders for PRN doses (e.g. 1-4 mg) are not allowed; ranges for time intervals (e.g. q8-12h) are not allowed.
   • **Infusions:** all drugs ordered as infusion should include a starting dose, the expected goal of treatment, a maximum dose and parameters for which you wish to be notified (Example: start dopamine at 5 mcg/kg/min, titrate to keep MAP at 120-130, max dose 20 mcg/kg/min, notify HO for heart rate >120).
   • **Verbal and telephone orders:** all verbal and telephonic orders by anyone must be cosigned within 24 hours with a legible name, beeper number, date and time.
   • **Restraints:** All new restraint orders should be written to start at the time that the restraint was first applied and end no greater than 24 hours later.

3) **Admission orders**

   • A Neurosurgery or Neurology team member writes the admissions orders for all patients admitted by their services. The orders are then reviewed by the NSICU resident admitting the patient ASAP, so that there can be communication between services in a timely fashion.
This process ensures that all teams are familiar with the care plan. Feel free to ask the ICU fellow/attending any questions, make appropriate changes and communicate them.

- Medicine reconciliation must be done in Cerner.

4) **Transfer orders**

- Transfers should be discussed before ICU rounds and noted. These orders should be written before AM rounds, so the patient can leave the NSICU as soon as a floor bed becomes available. Transfer orders are usually written by the primary team and not by the ICU team. However, physical transfer should occur after the ICU attending has reviewed to ensure no ICU issues remain outstanding.

**STANDARD OPERATING PROCEDURES (SOP)**

**Electrolyte replacement (per ICU careset):** the nurse will replace abnormal low values of K, Mg and PO₄ automatically when a low value is noted. There are exceptions to this rule (e.g. high creatinine), and you will have to enter a specific order. Low PO₄ is replaced with NaPO₄ or KPO₄. If the patient is severely hypernatremic, order an equal amount of KPO₄ (unless renal failure).

- **IV fluids:**
  - The preferred initial fluid is normal saline at 1.5-2 ml/kg with KCI (if appropriate). The nurses will add D5 per SOP if the patient is NPO.
  - Patients receiving hypertonic saline (2% or higher) cannot be transferred to the floor.

**GENERAL GUIDELINES FOR LABORATORY EVALUATION**

- **Admission labs:** each patient should have a CBC, CMP, Mg, PO₄, PT/PTT/INR, urinalysis, ECG, CXR. Anticonvulsants trough levels should be drawn approximately 24 hours after the loading dose, prior to the scheduled dose.

- **Daily labs:**
  - **Most patients:** CBC, BMP
  - **Ventilated patient:** need daily ABG, this may change as the patient stabilizes.
  - **Patients on mannitol:** Mg and PO₄ (due to osmotic diuresis, can develop hypomagnesaemia and hypophosphatemia); once or twice daily osmolality and BMP (refer to Mannitol section).
  - **Patients given large amounts of fluids** (SAH patients with cerebral salt wasting may be on 300-800 ml/hr) – Mg and PO₄ should be measured daily.

- **Sunday labs:**
  - All patients – CMP, Mg, PO₄ and anticonvulsant trough levels (when appropriate), Prealbumin

- **X-Rays:**
  - Intubated patients should have daily CXR to check ETT placement. This may change as the patient stabilizes or has a tracheotomy.
o All IJ or subclavian line attempts should have a CXR immediately to exclude pneumothorax and to confirm positioning.
o Dobhoff tube placement is confirmed by x-ray.
• Surveillance cultures should be done every 48 hours in TBI patients with induced hypothermia.
• Surveillance LE dopplers should be done approximately every 7-10 days.
COMMUNICATION

Communication is one of the most difficult and most important aspects of your experience in the NSICU.

- It is essential to keep the NSICU fellow/attending up-to-date regarding patients (see above).
- The primary service and the ICU team provide care concurrently; therefore, good communication is essential. Any significant change in a patient’s neurologic or medical condition must be communicated to the primary service in a timely fashion.
  - For Neurosurgery patients, contact the junior Neurosurgery resident.
  - For Neurology patients, the senior resident should be contacted.
- Similarly, the primary service is expected to discuss plans for the patient each morning with the ICU team.
- If the primary team enters an order that does not seem appropriate, discuss your concerns with them; if you are not satisfied with the response, contact the NSICU attending.
- Always remember to inform the patient’s family about any significant changes in the patient’s condition.

CONSULTS

- Ideally, consults should be obtained to provide expertise or perform a procedure that is not otherwise available.
- Consults may, however, be obtained in order to ensure that someone will follow a particular issue once the patient leaves the NSICU.
- Consults should not be obtained without first checking with the primary service and the NSICU fellow/attending.
- Consultants leave recommendations; they do not dictate management. Before instituting a consultant’s recommendation, make certain that they integrate well into the overall care plan, otherwise discuss with the NSICU fellow/attending.
- Consultants, while not the primary team, have been called at our behest and should be treated with respect and dignity. If the primary or ICU team chooses not to follow the recommendations of the consultant team, the reasons why their recommendations or plans may be deviated from should be communicated in an effective and respectful fashion whenever possible.
NEUROLOGIC AND NEUROSURGICAL CONDITIONS

POSTOPERATIVE PATIENTS

All postoperative patients

- Meet the patient on arrival to the unit and obtain report from the delivering anesthesiologist and/or nurse.
- Neurologic exam – compare to preoperative exams. If the postoperative exam is worse, notify the ICU fellow/attending and the neurosurgical resident immediately.
- The notes on new patients from the OR should include a summary note of operating room events (you should also review the anesthesia OR sheet):
  - Volume status before, during and after the procedure. Blood loss is replaced with equal volume of PRBC’s or triple volume of isotonic crystalloids. If I>>O and UOP is adequate, reduce IV fluids.
  - Hemodynamic alterations and baseline BP.
  - Complications- surgical or anesthetic
  - Was intubation difficult?
- Respiratory status:
  For intubated patients discern reason patient was not extubated in the PACU;
    - Wean from IMV to CPAP (5 – 10) as LOC improves, so the patient is ready for extubation in the morning;
    - Goal RSBI <105 and 2 hour tube comp trial w/ leak test *at 6a
    - *leak test done by RT: A/C mode imv 6, set vt, cuff dropped, RT documents returned vt for 6 breaths. Leak >20% is passing.
    - Use end-tidal CO₂ and pulse oximetry to guide weaning instead of serial ABG’s.
- Invasive lines and reasons for placement.
- Medications:
  - Pain control: make sure adequate analgesics (and sedation if intubated) are ordered.
  - Is patient is on phenytoin? Level?
  - Were other medications administered? (i.e. rFVIIa, mannitol)
  - Reversal of anesthetic and paralytics.
- Drains:
  - Where? Working? Output?
- Special nursing care – is the spine stable? Can the patient be ambulated?
- Address surgical questions to Neurosurgery resident and critical care issues to the ICU fellow/attending.
- Postoperative note should be short and concise. Document brief pertinent PMH, OR events, fluid balance issues, current status and a plan.
- Most patients will receive 24 hrs of prophylactic antibiotics (cefazolin or vancomycin).
- If there is any change in the patient neurologic’s status, notify Neurosurgery immediately.
SPECIFIC OPERATIONS

Endovascular procedures (coiling, stenting, glue, etc.):
- High doses of heparin used in these procedures often cause PTT to be “supratherapeutic”. Before resuming heparin, check PTT immediately on arrival to the ICU. Before resuming heparin, also check with the primary service for specific parameters.
- Check the femoral puncture site, distal pulses and blood pressure. Note significant hemodynamic changes. Check CBC if necessary, consider retroperitoneal hematoma if there is a major drop in Hb/Hct.
- Find out when the sheath will be removed.
- Any significant change in the patient’s condition should be brought to the attention of the Neuroradiology/Neurosurgery attending as well.

CAROTID ENDARTERECTOMY

Surgical site complications:
- Check the neck for tracheal deviation. Disruption of the arteriotomy closure can produce a focal hematoma and compromise the airway. Do not forget to protect the airway, intubate if necessary. If this rare but serious event occurs, call Neurosurgery immediately to open the site to relieve the compression. For a high-risk patient, have equipment (suture or staple removal kit) at the bedside.
- Check the cranial nerves for Horner’s syndrome, facial, hypoglossal and recurrent laryngeal nerve injury.

Cardiovascular complications:
- Acute MI is the most common complication of this procedure. Check EKG and troponin q8h for 24 hrs.
- Carotid sinus hypersensitivity may cause hypotension and bradycardia, treat with fluids and pressors if necessary.
- Hypotension can lead to carotid occlusion; keep BP at patient’s normal using vasopressor as needed. Wean pressors overnight.
- If the patient is hypertensive, use short acting agents. Remember, for patient with long-standing hypertension, higher BP may be normal, target their usual “normal” numbers.

Cerebral complications:
- Find out if any intraoperative complications took place (prolonged clamping, occlusion, ruptures, etc.).
- New neurologic deficit can be due to intra/postoperative embolus, carotid occlusion or ICH. Call Neurosurgery JAR immediately. Do not lower BP. Arrange for CT and/or angiography.
• Hyperperfusion – restoration of blood flow to the vessels with lost autoregulation may result in headache or eye pain and very rarely intracranial hemorrhage.

Anticoagulation is administered at the discretion of the neurosurgeon. The Neurosurgery resident should evaluate the patient before the first dose of heparin is given.

**POSTERIOR FOSSA CRANIOTOMIES**

Surgery in the posterior fossa warrants special post-operative considerations. Assessments should pay special consideration to: a) respiratory rate and pattern, b) the presence of or development of hypertension, and c) evidence of CSF leak.

The posterior fossa is a small compartment and even modest amounts of mass effect can cause serious complications through transmission of forces directly to the brainstem. Mass lesions can also quickly cause obstructive hydrocephalus. Increased pressure in the posterior fossa is usually heralded by sudden increases in BP or changes in respiratory pattern. Pupillary reflexes, level of consciousness, and ICP are not affected until late. As a result, sudden hypertension should trigger consideration of such a complication rather than simply initiating efforts to lower the blood pressure.

**CLINICAL PROTOCOLS**

It is difficult to establish definitive patient care recommendations, and treatment must be individually based. This document strives to combine physician based best care practices with currently available evidence-based literature to provide general treatment recommendations for NSICU patients.

**TUMOR RESECTION**

**Key Summary Points**

- Note location and extent of resection.
- Identify the location of drains and special care needed.
- Check anticonvulsant trough level, if applicable.
- Make sure patients are on steroids.
- Transsphenoidal surgery (pituitary tumor resection) may produce diabetes insipidus (DI) manifesting by large urine output (>300 ml/hr) with dilute urine (specific gravity <1.003) and rising serum sodium.
- If DI is suspected, rule out other causes of diuresis first (I>>O, mannitol/diuretics, hyperglycemia). Check BMP for hypernatremia.
- If DI is confirmed, UOP should be replaced with iso-osmotic or hypotonic fluids. Call before treating with hypotonic fluids or DDAVP.
Post-operative Management

1. **Respiratory management:**
   a. Maintain SaO2 ≥ 95% with supplemental O2 as needed.

2. **Neurological examinations:** hourly with vital signs.
   a. May initiate a sleep protocol of limited exams between the hours of midnight and 5 am if the patient has had a stable exam.

3. **Post-operative imaging:**
   a. MRI is the follow-up imaging of choice.
      i. Obtain within 48 hours of surgery unless done during surgery.
      ii. If able to get within 1st 24 hours, a CT is not needed unless there is a deterioration in the patient’s neurological status. If that occurs, emergent CT imaging is required.
   b. If MRI is unable to be obtained in the 1st 24 hours after surgery, the patient will need a post-operative CT. Imaging should be reviewed prior to transfer out of unit.

4. **Steroid Management:**
   a. General post-operative dose: dexamethasone *4 mg IV or PO every 6 hours*.
   b. Tapering protocol is attending based, present options:
      i. Taper off over 5 days unless significant edema noted on peri-operative scans, if so wean off over 2 weeks.
      ii. Discuss taper plan with attending, options will include no taper, a slow taper to 2-4 mg bid, or a rapid taper. If on long term dexamethasone prior to admission, taper to home dose.

5. **Seizure management:** (known seizures or prophylactic therapy)
   a. Maintain anticonvulsant(s) patient was started on prior to or during surgery.
   b. If patient is unable to take oral meds, use lorazepam (Ativan) 1 – 2 mg every 6 hours or IV phenytoin as bridging therapy until able to take oral agent.

   Anticonvulsant regimen can be individualized based on clinical situation. Common regimens are:
      i. Phenytoin at 5 mg/kg/d divided every 12 hours. Goal therapeutic range: free phenytoin = 1 – 2 mg/L or total phenytoin = 10 – 20 mg/L. Post-op levels should be maintained at the higher end of therapeutic range.
      ii. Levetiracetam 500 mg - 1000 mg every 12 hours**(Drug of choice for chemotherapy)
   c. Follow free levels in all patients, especially those with low albumin or renal insufficiency. Be aware that total phenytoin levels can vary based on albumin level and renal function (elevated BUN).
   d. If recurrent seizures develop, or multiple anticonvulsants are needed for seizure control, request Neurology consult to assist with seizure management (after discussion with Neurosurgery team and NSICU)
   e. Duration of therapy will be determined by the neurosurgical attending.
      i. In general, all patients will be discharged on an anticonvulsant with long-term use being determined at time of post-operative follow-up in clinic.
      ii. If anticonvulsant use is unquestionably empiric, then certain patients may require only 7 days of therapy.
      iii. See seizure prophylaxis guideline (Appendix L)

6. **Wound Care:**
   a. Chlorhexidine is used for wound cleaning.
b. Maintain a protective covering over any posterior incision. Do not allow tracheostomy tape to lie over wound.

**Acoustic neuromas**
1. No AEDs are indicated.
2. No steroids are necessary unless there is evidence of intra-operative facial nerve injury. In that situation, dexamethasone 4 mg every 6 hours.
3. No post-op MRI needed, but a post-op CT is needed.

**Pituitary tumor**
1. No AEDs
2. No dexamethasone
3. No post-op scan unless clinical change
4. Hydrocortisone replacement: 100 mg in OR, then 50 mg IV/PO q 8-12 hrs x 3 doses, then 25 mg IV/PO q 8 hrs x 3 doses, then 20 mg PO q 12, then 20 mg at 8AM and 10 mg at 5pm until seen in follow-up. We taper to po HC pretty fast per endocrinology; maintenance dose is HC 20mg am, 10mg pm.
5. Fluids – use NS unless sodium >/= 145, then change to ½ NS. Replace UOP cc for cc and closely follow fluid balance. (refer to DI protocol)
6. No blowing nose, no using straws
7. Nasal packs stay in three days
8. Draw BMP every 6 hours for the first 24 hours, then every 8 hours for the next 24 hours (if stable the day prior).

**EPILEPSY SURGERY**
- Patients who undergo surgery for seizure monitoring (grid and strip placement) may have focal seizures, which should not be treated. If the patient has a generalize seizure or frequent focal seizures, talk to the Epilepsy fellow/attending before treating with benzodiazepines. The patient should stay on their home medications until transfer to the EMU (having unmonitored seizures does not help in the management of these patients).
  - Upon arrival to the ICU, attempts should be made to “make up” any doses of AED’s the patient may have missed in surgery.
  - Patients should get a CT scan before being transferred to the EMU
- For patient after resective surgery for epilepsy (e.g. amygdalohippocampectomy) continue their pre-operative anticonvulsants. Seizures in these patients are not expected, and they should be brought to the attention of the Neurosurgery resident, ICU fellow/attending.
- Prophylactic antibiotics (cefazolin 1gm IV every 8 h) after grid placed until OR.

**DEEP BRAIN STIMULATION:**
- DBS patients do not require seizure prophylaxis before surgery.
- These patients generally do not come to the ICU after surgery.
- DBS patients do not require seizure prophylaxis before surgery.
- These patients generally do not come to the ICU after surgery. The normal procedure is to get a CT immediately after lead placement – if there is not hematoma and their blood pressure is under control they are transferred to the floor.
- Patient having undergone DBS will come to the ICU for one of two primary reasons:
Intracranial Hematomas: ICH’s can be caused by placing of the DBS leads. This may become apparent at this time of placement or it may be seen on the intraoperative CT scan. In either case, the patient is immediately given Factor VII and aggressive measures are taken to control blood pressure. Other management strategies (craniotomy, EVD, observation) are specific to the actual clinical scenario and will be directed by the Neurosurgery Attending.

Uncontrolled Blood Pressure: After stabilization in the PACU after surgery, patients that still require intravenous medications to control their blood pressure (SBP< 155-160) will come to the ICU for continued stabilization and blood pressure control. The patients are often on several medications to control their specific movement disorder. These medications are purposely held on the morning of surgery in order to unmask the true nature of the movement disorder and thus optimize results of lead placement. As a result, patients can sometimes develop hypertension during surgery and/or in the PACU. Oftentimes it is resolved with administration of their normal medication regimen. If they still require a drip (Nipride is preferred in most) to keep SBP<160, then they are taken to the ICU.

SPINAL CORD OPERATIONS AND INJURY

- Operations involving the vertebral bodies often result in significant blood loss and secondary coagulation abnormalities. Follow CBC, PT/PTT and treat when necessary.
- Fluids shifts are common. Watch for hemodynamic instability and pulmonary edema. Use UOP as the most reliable guide to intravascular volume. If I>>O and UOP is good, minimize or stop IV fluids.
- Some patients may be at risk for cord ischemia, the neurosurgeons may request keeping MAP>80 mmHg; discuss with the fellow/attending first. Current guidelines state MAP >85-90 for 1st 7 days after acute SCI.
- If the patient remains intubated due to postoperative edema, leave the patient intubated overnight. Sedate adequately (you do not have to monitor LOC closely). Elevate the head of the bed to let the gravity help reduce the swelling. With the help of RT check for an air leak* around the ETT if surgery was prolonged and /or airway edema expected. *leak test explanation on page 12
- IF PATIENT IS A CERVICAL CORD INJURY, WITH DEFICITS, THERE IS A SPECIFIC MODE OF VENTILATION AND WEANING FOR THESE PATIENTS. PLEASE SEE APPENDIX H.

Neuroprotection:
For those presenting within 8 hours of injury, infusion of methylprednisolone for 24 hours may improve functional outcome. Q4h accuchecks should be ordered for these patients.

Cardiovascular:
- Injury to the sympathetic chain (high thoracic (T6 or above) or cervical lesions) may cause hypotension and bradycardia due to vasodilatation and loss of ability to improve cardiac contractility.
• Treat hypotension with fluids (be careful not to put the patient in CHF) and vasopressors. Dopamine is preferred since it also increases heart rate. Even low doses are effective in raising BP. Avoid phenylephrine (might exacerbate bradycardia). The appropriate BP goal is not clear; initially keep MAP at 70-80 or SBP > 90 mm Hg.
• Avoid medications that decrease BP/HR.

Respiratory:
**CONTACT RT SUPERVISOR (beeper 6258) FOR ANY NEW CERVICAL SPINE INJURY PATIENT SO SCI PROTOCOL CAN BE INITIATED (see appendix H)**

• Patients can develop respiratory failure due to a variety of reasons:
  o With lesions above C3, diaphragmatic function is lost and most patient need mechanical ventilation immediately.
  o With lesions between C3 and C5, diaphragmatic function is partly preserved. Supine position may be better for breathing in these patients. Most of them will also need mechanical ventilation.
  o With lower cervical and thoracic lesions, though diaphragmatic function is preserved, paralysis of the intercostal or abdominal muscles can cause progressive atelectasis due to a poor cough.
• Refer to the respiratory issues section for recognition of respiratory failure due to neuromuscular weakness.
• Caution should be used in interpreting ABG’s. Unopposed parasympathetic tone in cervical and upper thoracic injuries results in vagal innervation and activation of primary pulmonary receptors producing hypocapnia, dyspnea, and tachypnea (and not the typical carotid chemoreceptor response to hypoxemia). This hypocapnia, in this patient population, can be misinterpreted as adequate pulmonary reserve when in actuality it may be a portent of impending respiratory failure. Therefore, carefully evaluation ABG results with respiratory rate and effort in unintubated patients. Supine position may be better for breathing in these patients. Most of them will also need mechanical ventilation. DO NOT use full face mask ventilation or full face mask BiPAP on these patients due to the risk of aspiration and inability of patient to remove the full face mask. Use Biap with a nasal mask only.

GI:
Ileus and constipation are frequent problems. Begin scheduled docusate, bisacodyl and senna per bowel protocol. Continue stress ulcer prophylaxis until no longer mechanically ventilated.

DVT prophylaxis:
- Many patients with SCI eventually develop DVT. Consequently, mechanical prophylaxis measures should be initiated immediately upon admission consisting of sequential compression devices (SCD’s) and thigh-high compression stockings.
  Pharmacologic prophylaxis, Enoxaparin (Lovenox) 30 mg q12 hrs, should be delayed if the patient is scheduled to have surgery within 24 hours of injury. If operative intervention will be delayed more then 24 hours, then enoxaparin can be started within 24 hours of admission and then suspended 12 hours before any operation.
- Surveillance Dopplers are done every 7-10 days.
SUBARACHNOID HEMORRHAGE

GENERAL OVERVIEW

- **Pain management:** pain should be adequately treated. Frontline therapy should be with fioricet. Addition of scheduled ibuprofen (up to 800mg tid for short periods) may be used in patients with pain refractory to fioricet. Narcotics should be used sparingly and the decision to use them should be made on a case by case basis.
- **Lines:** All subarachnoid hemorrhage patients should receive an arterial line and a central venous line.
- **Blood pressure control:** with an unprotected (not clipped or coiled) aneurysm, keep BP less than systolic of 140. Treat hypertension with labetalol. If ineffective or HR<65, consider hydralazine boluses or nicardipine infusion. Higher BP is usually allowed after the aneurysm has been treated (“protected”) – permissive hypertension with SBP 160-180 is typical after intervention.
- **Seizure prophylaxis:** use PO/NG phenytoin or levetiracetam 500mg twice daily for 7 days. If patient had a new seizure, continue indefinitely. If history of epilepsy, discuss medications with the ICU fellow/attending (refer to drugs, drips and doses section).
- **Nimodipine** is given 60 mg q4h PO or PT for 21 days for neuroprotection to all patients. If BP drops with each dose, change to 30 mg q2h.
- **Fluids:** maintain euvoolemia with isotonic fluids. Hypovolemia increases risk of symptomatic vasospasm and should be avoided. Do not use hypotonic fluids; they exacerbate hyponatremia, which these patients are prone to develop. Follow I&O and daily weight closely.
- **Steroids:** Not routinely utilized.
- **Angiography:** keep the patient NPO and hydrate adequately to help eliminate contrast and protect the kidneys. Patients with preexisting renal disease (Cr>1.2), DM, on nephrotoxic meds (mannitol, NSAIDs, sulfa drugs, aminoglycosides) and elderly population (>75 yrs) should be pretreated with bicarbonate drip and acetylcysteine (refer to drugs, drips and doses section).

**Neurologic complications:**

- **Hydrocephalus:** usually occurs in the first few hours (may occur later) and causes a decline in LOC. It may develop even in the absence of intraventricular blood. If in doubt, get a head CT. treatment is usually by external ventricular drainage (EVD).
- **Re-bleeding:** usually manifests as a sudden dramatic change in neurologic status of high bloody CSF output via EVD. Consider intubation and mannitol; notify Neurosurgery. Get a stat head CT.
- **Cerebral edema:** occasionally patients have either diffuse swelling or retraction edema after surgery. These are treated with mannitol or hypertonic saline.
- **Vasospasm:**
  - Clinically manifests as a change in mental status (confusion, lethargy or agitation) and/or focal motor signs usually on post bleed 5 days through 14 (can occur from day 4 to 21). Symptoms typically wax and wane.
The diagnosis is confirmed by CT angiography or catheter angiography, but treatment should be initiated on suspicion even prior to confirmation of the diagnosis. Vasodilatation and angioplasty are often performed during angiography.

The standard treatment (after aneurysm repair) is hemodynamic augmentation – increasing MAP by 15-20% with vasopressors. BP could be raised further if no neurologic improvement seen. Watch cardiovascular status carefully. Pulmonary artery catheter is sometimes inserted to tailor therapy. Antihypertensive medications are usually stopped.

**Cardiac complications:**

- These patients can have early cardiac dysfunction with EKG changes mimicking acute MI; get serial EKG’s and troponin; if abnormal, get an echocardiogram. Begin metoprolol 12.5 BID and titrate to keep HR < 80, provided hypotension does not occur. Cardiac function usually improves over a few days.
- In rare cases, a picture of “stunned myocardium” develops with severe pump failure, poor cardiac output, pulmonary edema and hypotension.
- Patients over 50 years of age with a Fisher grade above 2 and cardiac risk factors should get an echocardiogram on admission.

**Fluid and electrolyte disturbances:**

- **Hypovolemia** – many SAH patients have a spontaneous diuresis and become hypovolemic unless you keep up with fluids. Increasing maintenance rate is more effective than using boluses. Watch I&O and weight carefully beginning day 4 after SAH.
- **Hyponatremia** is frequent due to cerebral salt wasting and /or SIADH. Limit hypotonic (including oral) fluids, but maintain euvolemia. Treatment of hyponatremia with 3% hypertonic saline or fludicortisone is occasionally needed.
- **Do not let patient in vasospasm be hypovolemic.**

**Pulmonary complications:**

- Pulmonary edema and aspiration pneumonia (cardiogenic and neurogenic) are the most common pulmonary manifestations.

**I. Assessment**

**A. Clinical assessment includes:**

World Federation Neurological Surgeons Score (WFNS); cranial nerve exam (pupillary response, extraocular movements, facial symmetry, corneal and gag reflexes); motor strength; motor tone; sensory assessment; and vital signs. Note any seizure activity.

Older assessment scores: Hunt & Hess Score, Fisher CT Grade

**B. Diagnostic assessment of subarachnoid hemorrhage may include:**

1. Brain imaging: CT, MRI
2. Cerebral vascular imaging: angiogram, CTA, MRA
3. Neuro- monitoring options:
   - Intracranial pressure (ICP); LICOX Brain tissue oxygen (PbtO2); EEG
4. Neurovascular monitoring options:
   - Transcranial Dopplers (TCDs); Cerebral blood flow

**C. WFNS assessment:**

1. GCS = 15 with no motor deficit
2. GCS = 13 – 14 with no motor deficit
3. GCS = 13 – 14 with a motor deficit
4. GCS = 7 – 12 with or without a motor deficit
5. GCS = 3-6

II. Initial Management before Aneurysm is secured

A. ICU admission

Implement initial general resuscitation protocols. Appropriate interventions include:

2. Airway Management:
   a. Supplemental O₂ to maintain Sats>95%
   b. Call anesthesia (beeper 1475) for intubation for WFNS = 5 or an inability to protect airway:
      Use RSI Protocol.
   c. Titrate ventilator to maintain PaO₂ ≥100 mm Hg, and PaCO₂ 38 – 44 mm Hg
   d. Use ETCO₂ and pulse ox to monitor status rather than serial ABGs.
   e. Do not ett circumvent the patient’s neck.

3. Circulation
   a. Establish minimum of 2 large bore IVs
   b. Place NG/Foley if indicated.
   c. Draw initial assessment labs (CBC, renal profile, & Coags).
   d. Place central intravenous catheter and arterial line during initial care.

4. Diagnosis: Arrange for appropriate diagnostic imaging.

5. Hemodynamic management:
   a. Avoid hypotension and hypertension (ie, goal SBP 90 – 140 mm Hg).
   b. Goal MAP ≤ 70 mm Hg.

6. Sedatives and analgesics as indicated for diagnostic procedures. Preferred agents based on desired goal:
   a. For Sedation: use propofol
   b. For Analgesia: use fentanyl

7. Management options for signs of intracranial hypertension or herniation.
   a. Hyperventilation (temporary) PCO₂ 35±2. Only to be done if ordered by Chief or Attending (every 1 mmHg change in PCO₂ changes CBF by 4%)
   b. Mannitol 0.25 – 1 gram/kg
   c. 3% NaCl 250mL bolus (or 4 mL/kg)
   d. 7.5% NaCl 2 mL/kg bolus
   e. Consider placement of ICP monitor/ventriculostomy
      a. Preferred device: ventriculostomy. If in ED, transfer to ICU or OR for placement.

8. Management options for signs of hydrocephalus or intraventricular hemorrhage.
   a. Insert ventriculostomy. If in ED, transfer to ICU or OR for placement.
   b. Keep ventriculostomy to open to drain at 10 – 20 mm Hg
   c. Monitor intracranial pressure (ICP) every hour, goal ICP ≤ 20 mm Hg.

9. Seizure prophylaxis
   a. Fosphenytoin at 20 mg/kg loading dose, then 3 - 5 mg/kg/d maintenance dose divided every 8 – 12 hours.
   b. May use phenytoin when taking adequate po.
   c. Other antiepileptics may be indicated based on clinical situation.

B. Intensive Care Unit: Pre-operatively

1. Review all initial care needs from section II. A.
   a. Place Arterial line/Central lines if not done.
   b. Initiate analgesia/sedation, monitor for effects on MAP.

2. Respiratory management
a. Maintain SaO2 ≥ 95% with supplemental O2 as needed
b. If intubated, goal PaCO2 = 38 – 44 mm Hg.
c. If intubated use ETCO2 and pulse ox to monitor status instead of serial ABGs
d. If PbtO2 monitor placed, titrate ventilator to maintain PbtO2 ≥ 15 mm Hg.

3. Neurological examinations: hourly with vital signs and CVP.

4. Hemodynamic management:
   a. Maintain MAP ≤ 70 mm Hg with antihypertensive agents until etiology of SAH determined and causative aneurysm is secured.
   b. Administer fluids to keep CVP 4 – 8 mm Hg. Avoid hypervolemia, fluid balance goal is a range of 0 – 500 ml positive every 24 hours.
   c. Fluid choice: Normal Saline with or without 20 meg KCl

5. Ventriculostomy / ICP management:
   a. Keep ventriculostomy to open to drain at 10 – 20 mm Hg
   b. Monitor ICP every hour, goal ICP ≤ 20 mm Hg.
   c. Neurosurgical house officer to be notified for ICP elevation.
   d. Management options for signs of intracranial hypertension or herniation.
      i. Hyperventilation (temporary) 35+/−2(temporary)
      ii. Mannitol 0.25 – 1 gram/kg
      iii. 3% NaCl 250mg bolus

6. Seizure prophylaxis:
   a. Fosphenytoin at 20 mg/kg loading dose if not done on admission. May use phenytoin if taking adequate po.
   b. Phenytoin maintenance dose at 3 - 5 mg/kg/d divided every 8 – 12 hours.
   c. Other antiepileptics may be indicated based on clinical situation.

7. General Care Issues:
   a. Glucose: Initiate treatment for hyperglycemia. (See appendix P for VCUHS critical care continuous infusion of insulin policy); usual BG goal of < 150 mg/dL (avoid hypoglycemia)
   b. Sodium: Maintain in normal range (135 – 146 mEg/L).
   c. Magnesium: Maintain ≥ 1.8 mg/dL.
   d. Hematologic: Reverse coagulopathy (FFP/Cryoprecipitate/Platelets/vitamin K).
   e. Temperature: Goal is normothermia. Culture per NSICU protocol for fever ≥ 101.5 F

8. Special Orders (Non-study patients)
   a. Magnesium drip x14 days per protocol (12.5g continuous IV infusion per 24 hours)
   b. Addition of statin x14 days per protocol (typically pravastatin 40mg qday)


III. ICU Care after aneurysm is secured
A. General management.
   7. Hemodynamic management
      a. **Do not initiate vasospasm treatment empirically.** Vasospasm treatment is based on the clinical exam, TCD results and radiographic findings.
      b. Maintain MAP 70 - 100 mm Hg. Typically initiate permissive hypertension with SBP 160-180 after securing aneurysm. Track medication effects on MAP.
      c. Closely monitor fluid status to avoid both hyper and hypovolemia
         (Refer to Table 1)
         i. Daily body weights and fluid balance calculations with a goal range of 0 – 500 ml positive every 24 hours.
ii. Administer fluids to keep CVP 4 – 8 mm Hg.
iii. Fluid choice: Normal Saline with or without 20 meg KCl

8. Respiratory management:
   a. Maintain SaO2 ≥ 95% with supplemental O2 as needed
   b. If intubated, goal PaCO2 = 38 – 44 mm Hg.
   c. If PbtO2 monitor placed, titrate ventilator to maintain PbtO2 ≥ 20 mm Hg

   a. May initiate a sleep protocol of limited exams between the hours of midnight and 5 am if the patient has had a stable exam ≥ 48 hours.

10. Ventriculostomy / ICP management:
    a. Keep ventriculostomy open to drain at 10 – 20 mm Hg
    b. Monitor ICP every hour, goal ICP ≤ 20 mm Hg.
    c. Neurosurgical house officer to be notified for ICP elevation.
    d. Management of ICP elevations: refer to ICP management algorithm in TBI guideline.
    e. Management of herniation: hyperventilation; mannitol 0.5 – 1.4 gm.kg; 3% NaCl bolus (250ml)

11. Seizure prophylaxis:
    a. Maintenance phenytoin at 3 - 5 mg/kg/d divided every 8 – 12 hours for 7 days.
    b. Goal therapeutic range: total phenytoin = 10 –20 mg/L, free phenytoin = 1 – 2 mg/L.
    c. Follow free levels only in patients with low albumin or renal insufficiency.
    d. Other antiepileptics may be indicated based on clinical situation.

12. Corticosteroids: There is no indication for corticosteroids after aneurysmal clipping.

13. TCDs:
    a. Baseline at day 1 – 3 post-hemorrhage.
    b. Surveillance every other day minimally between days 3 – 14 post hemorrhage.

14. General Care Issues:
    a. Glucose: Treat hyperglycemia. Goal glucose = < 150 mg/dL (avoid hypoglycemia).
    b. Sodium: Maintain in normal range (135 – 146 mEq/L). 
    c. Magnesium: Maintain ≥ 1.8 mg/dL.
    d. Temperature: Goal is normothermia. Culture per NSICU protocol for fever ≥ 101.5 F
    e. Nutrition: address by 24 – 48 hours after admission.
B. Vasospasm Treatment Algorithms.

See separate algorithm sheets for specific management guidelines. The algorithms are based on the neurological exam.

1. Aneurysmal Subarachnoid Hemorrhage With Stable Neurologic Exam
   a. Algorithm # 1
   b. Treatment will be guided by TCD data, including Lindegaard Index

2. Aneurysmal Subarachnoid Hemorrhage With New Neurologic Deficit
   a. Algorithm # 2
   b. Consider full differential (Table 2 below)

3. Specific Vasospasm Management Issues: Refer to tables in vasospasm management algorithm
   a. General Assessment of Volume (Table 1)
   b. Options to increase volume (Table 3)
   c. Options to increase blood pressure (Table 4)
   d. Options to increase cardiac index (Table 5)

Reference Tables for SAH

<table>
<thead>
<tr>
<th>Table 1: General Assessment of Volume Status</th>
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<tr>
<td>Physical exam</td>
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<tr>
<td>Daily fluid balance</td>
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<tr>
<td>Urine studies</td>
</tr>
<tr>
<td>Serum studies</td>
</tr>
<tr>
<td>CXR</td>
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<tr>
<td>Cardiopulmonary status</td>
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<thead>
<tr>
<th>Table 2: Differential and preliminary diagnostic work-up for a new neurological deficit in patients with aneurysmal subarachnoid hemorrhage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differential diagnosis</td>
</tr>
<tr>
<td>Re-bleed/new infarct/acute HCP</td>
</tr>
<tr>
<td>Vasospasm</td>
</tr>
<tr>
<td>↑ ICP</td>
</tr>
<tr>
<td>Seizure</td>
</tr>
<tr>
<td>Metabolic abnormality</td>
</tr>
<tr>
<td>Hypotension</td>
</tr>
<tr>
<td>Infection</td>
</tr>
<tr>
<td>Medication overdose</td>
</tr>
<tr>
<td>Hyper/hypothermia</td>
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<tr>
<td>Hyper/hypoglycemia</td>
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<tr>
<td>Respiratory issues (hypoxia, Hyper/hypocarbia)</td>
</tr>
</tbody>
</table>
### Table 3: Options to increase volume

<table>
<thead>
<tr>
<th>Agent</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>NS</td>
<td>500-1000 ml</td>
</tr>
<tr>
<td>5% Albumin</td>
<td>250-500 ml</td>
</tr>
<tr>
<td>3% saline (if Na low)</td>
<td>250 ml</td>
</tr>
<tr>
<td>Blood (if HCT &lt;25)</td>
<td>1 – 2 units PRBC</td>
</tr>
</tbody>
</table>

### Table 4: Options to increase blood pressure

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid bolus</td>
<td>Refer to table 3 for recommendation</td>
</tr>
<tr>
<td>Review medications</td>
<td>Eliminate or decrease those that lower BP</td>
</tr>
<tr>
<td></td>
<td>Sedation / analgesia: propofol, fentanyl</td>
</tr>
<tr>
<td></td>
<td>Calcium channel blockers: nimodipine; Beta-blockers</td>
</tr>
<tr>
<td></td>
<td>Antiepileptics: phenytoin</td>
</tr>
<tr>
<td>Vasopressors</td>
<td>Phenylephrine</td>
</tr>
<tr>
<td></td>
<td>Norepinephrine</td>
</tr>
<tr>
<td></td>
<td>Vasopressin if serum sodium normal (not more than 0.04 units/min)</td>
</tr>
</tbody>
</table>

### Table 5: Options to increase cardiac index

- Dobutamine
- Norepinephrine
- Milrinone (long T½)
- Dopamine
HEAD INJURY

GENERAL OVERVIEW

Note patient’s initial **Glasgow Coma Scale** (best function) – see appendix C.

- **Initial resuscitation:**
  - The main goal of TBI management is to control ICP and preserve adequate perfusion to the brain measured by cerebral perfusion pressure (CPP=MAP-ICP). Target MAP > 90 (if an ICP monitor is not yet placed) or CPP 60 - 70 mm Hg.
  - Give mannitol if there are signs of herniation or progressive neurologic deterioration (pupillary asymmetry, lateralizing motor exam). Expect osmotic diuresis with mannitol administration; adjust IV fluids to maintain euvoolemia.
  - Use **hyperventilation** only in the cases of:
    - Signs of herniation or progressive neurologic deterioration (pupillary asymmetry, lateralizing motor exam)
    - Acute neurologic deterioration;
    - Plateau waves (spontaneous or stimulus induced sustained elevation in ICP).
    - >24-48 hours after injury.
  - Neurophysiologic Monitoring: All severe TBI’s should have an ICP monitor (EVD first choice), an brain tissue oxygen monitor, a central line, an arterial line, and an end tidal CO₂ monitor.

- **ICP and CPP monitoring** is indicated in:
  - **NOTE:** At VCUHS, the preferred ICP monitor is an external ventricular drain (EVD), with placement of a fiberoptic parenchymal monitor only if unable to successfully pass an EVD.
  - Patients with **GCS<9** and an abnormal CT scan.
  - Patients with a **normal CT scan** and **two of three features**:
    - Age>40
    - Posturing
    - Systolic BP <90 mm Hg
  - Place an arterial line in all severe TBI’s to facilitate CPP monitoring.

- **Treatment of elevated ICP:**
  - Elevate head of bed above to 30 degrees
  - Ensure that the cervical collar is not too tight compressing the jugular veins.
  - Ensure adequate analgesia (morphine or fentanyl).
  - Ensure adequate **sedation** (propofol)
  - **Drain CSF** from ventriculostomy (if present).
  - Give **mannitol** 0.25-1 gm/kg PRN q4-6hrs for ICP sustained >20-25 mm Hg for 5 minutes. Hypertonic saline 23.4% (30-60 mL), 3% (4 ml/kg), or 7.5% (2 ml/kg) via central line are alternatives (refer to mannitol section).
    - Alternatively, mannitol can be given in a non-weight-based fashion, either 50g or 100g (half a bag or a full bag).

- **Treatment of low CPP:**
  Keep the patient euvolemic. Use vasopressors if necessary to keep CPP 60-70.

- **Seizure prophylaxis:**
  Load with fosphenytoin and continue seizure prophylaxis for 7 days.
Only treat for longer if patient has seized.

I. Assessment
A. Clinical assessment includes: Glasgow Coma Scale; level of consciousness; cranial nerve exam (pupillary response, extraocular movements, facial symmetry, corneal and gag reflexes); motor strength; motor tone; sensory assessment; and vital signs. Note any seizure activity.

B. Diagnostic assessment of brain injury may include:
   1. Brain imaging: CT, MRI, MRS
   2. Cerebral vascular imaging: CTA, MRA, MRV, angio
   3. Intracranial pressure (ICP) Monitor
   4. LICOX Brain tissue oxygen monitor (PbtO2)
   5. EEG
   6. Transcranial Dopplers

C. Definition of severe head injury includes: GCS-3 – 8 with or without an abnormality noted on a CT scan of the brain.

<table>
<thead>
<tr>
<th>Table 1: Glasgow Coma Score</th>
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<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td><strong>Eye</strong></td>
</tr>
<tr>
<td><strong>Verbal</strong></td>
</tr>
<tr>
<td><strong>Motor</strong></td>
</tr>
</tbody>
</table>

II. Initial Management Intensive Care Unit:
The first week focuses on preventing secondary injury and optimizing survival.

1. Review all initial care needs from section II. A.
   a. Insert ICP monitor/ventriculostomy and PbtO2 catheter as indicated per II.A.7.b.
   b. Place Arterial line/Central lines if not done.
   c. Initiate analgesia/sedation, monitor for effects on MAP.

2. Respiratory management
   a. Initial goal PaCO2 = 40 +/- 2 mm Hg.
   b. If PbtO2 monitor placed, titrate ventilator to maintain PbtO2 > 15-20 mm Hg.

3. Sedatives and analgesics may be indicated, monitor for their effects on ICP / CPP. Preferred agents based on desired goal:
   a. For Sedation: use propofol
   b. For Analgesia: use morphine or fentanyl

4. Neurological examinations:
   a. Pupils and GCS will be checked hourly with vitals.
   b. While neuromonitoring devices are in place (ie, ICP monitor, Licox, etc) once neuromonitoring devices are removed, exams will be performed hourly unless otherwise specified.

5. Ventriculostomy / ICP management:
   a. If ICP ≥ 20 mm Hg for 5 minutes, if possible drain CSF until comes down to 10 mmHg.
   b. Keep ventriculostomy to monitor, goal ICP ≤ 20 mm Hg. If there is a significant amount of traumatic subarachnoid (SAH) or intraventricular hemorrhage (IVH), consider:
      1) Keeping ventriculostomy open to drain at 20 mm Hg and monitor ICP every hour (MUST be diligent about checking ICP at least once/hour if EVD open to drain)
      2) Placement of an intraparenchymal ICP monitor, in addition to an EVD, for continuous monitoring
3) TCD’s can be considered if there is significant traumatic SAH and there is concern for vasospasm.

c. Neurosurgical house officer to be notified for ICP elevation. Refer to Section III for ICP management algorithm.

d. Management options for signs of acute herniation.
   i. Hyperventilation (temporary) to PCO2 35-38; only if >24 hours since injury.
   ii. Mannitol, either weight-based at 0.25 – 1 gram/kg or non-weight-based with half or full bags of mannitol administered (50 or 100g).
   iii. 3% NaCl 4 mL/kg is typical first option with alternatives being 7.5% 2 mL/kg or 23.4% 30-60 mL bolus

6. Hemodynamic management:
   a. Monitor MAP, CPP and CVP hourly.
   b. Maintain CPP > 60 mm Hg with fluids/vasopressors, Add vasopressors as indicated.
   c. Administer fluids to keep CVP 4 – 8 mm Hg. Avoid hypervolemia. Goal is euvoemlia.
      1) Fluid choice: Normal Saline with or without 20 meq KCl
      2) Blood products as indicated. If PbtO2 monitor placed, maintain Hgb > 8 – 10 based on PbtO2 measures.

7. Seizure prophylaxis:
   d. Fosphenytoin at 20 mg/kg loading dose if not done on admission.
   e. Phenytoin maintenance dose at 5 mg/kg/d divided every 12 hours for 7 days when taking adequate po.
   f. Other antiepileptics may be indicated based on clinical situation.
   g. If a patient is determined to have a seizure then ensure the AED is maintained and not stopped after 7 days.

8. General Care Issues:
   a. Glucose: Initiate treatment for hyperglycemia. Goal glucose = < 150 mg/dL (avoid hyperglycemia); see Appendix P for VCUHS continuous infusion of insulin in critical care policy.
   b. Sodium: Maintain in normal range (135 – 146 mEg/L) initially. This goal may change is HTS started for ICP control.
   c. Magnesium: Maintain > 1.8 mg/dL.
   d. Hematologic: Reverse coagulopathy (FFP/Cryoprecipitate/Platelets/vitamin K/Factor VII). For INR >1.4
   e. Temperature: Goal is normothermia. Culture per NSICU protocol for fever ≥ 101.5 F every 48 h
      1) If Tylenol does not defervesce patient within 2-4 hours, start surface cooling to achieve normothermia.
   f. Nutrition: address within first 24 hours after admission, with enteral nutrition being at goal by 72 hours.
   g. DVT prophylaxis and surveillance per NSICU protocol in non-ambulatory patients.
      1) Mechanical prophylaxis immediately upon admission.
      2) Pharmacologic prophylaxis 24 hours after admission or stabilization of hematoma by CT. Options are subcutaneous unfractionated heparin or enoxaparin.
         - Initiate evaluation for heparin induced thrombocytopenia if platelet count decreases to 50% of its admission value after initiation of heparin.

9. Prepare for any Neurosurgical procedures: consider craniectomy for mass lesions or refractory ICP.

    Treatment Goals: ICP < 20 mm Hg; CPP > 60 mm Hg; PbtO2 > 20 mm Hg (treat if ≤ 15mmHg)
III. ICP Treatment Algorithm. Initiate treatments in a stepwise fashion for ICP control.

General caveat: CT Scan early and often for poorly controlled ICP.

1. Mechanical measures: head of bed at 30°, head neutral, check cervical collar for excessive tightness.
2. Sedation / Analgesia, titrate for effect
   a. Sedation agents: propofol (maximum 80 mcg/kg/min)
   b. Analgesia agents: morphine (maximum 10 mg/hr, fentanyl (maximum 150 mcg/hr,
   c. Monitor for effect on CPP
3. Initial CSF Drainage: drain CSF to bring ICP from 20 mmHg to 10 mmHg (“pop 20 down to 10”) if ICP ≥ 20 for 5 minutes, or if significant traumatic SAH/IVH components open ventriculostomy to drain at 10 – 20 mm Hg. Confirm presence of intraparenchymal monitor for continuous ICP monitoring.
4. Hyperosmotic therapy. Choose one agent and continue that agent alone until treatment fails, at that time consider the other agent as alternative osmotic therapy.
   a. 3% NaCl infusion for goal Na⁺ of 145 – 155 mEq/L
   b. Mannitol boluses of 0.25 – 1.0 gram/kg. Do not give if serum Osm ≥ 320
5. Neuromuscular paralysis and heavy sedation
   a. TOF 2/4 to ensure pulmonary cilia can still function.
6. Mild hyperventilation for goal PaCO2 = 35 – 40 mm Hg. A PbtO2 monitor should be in place if hyperventilation is to be initiated, particulary in the first 24-48 hours after injury.
7. Hypothermia
8. Moderate hyperventilation for goal PaCO2 = 35 - 38 mm Hg if PbtO2 monitor.
9. Maximal level interventions:
   a. Decompression
   b. Barbiturate coma with EEG for burst suppression monitoring
   c. Trial of alternative osmotic therapy. (ie, mannitol if on HTS OR HTS if on mannitol)
10. Options to consider at any point:
    a. Vasopressors to maintain CPP > 60 mm Hg if fluids at goal.
    b. Darken room, minimize stimulation, treat symptoms of withdrawal or anxiety
Supplement analgesia / sedation with longer acting enteral agents.
Dysautonomia following Traumatic Brain Injury

AKA "Sympathetic Storming", Autonomic Dysfunction Syndrome (ADS), and more recently, Paroxysmal Autonomic Instability with Dystonia (PAID). ADS/PAID is similar to other conditions of autonomic dysregulation and has been noted in cases of TBI, hydrocephalus, tumors, SAH, and ICH.

Dysautonomia after TBI is a well recognized, but incompletely understood, syndrome that occurs after some head injuries. It is characterized by episodic hypertension, tachypnea, fever, diaphoresis, dystonia, and posturing. These events can be triggered by only minor environmental stimulants (so called “allodynic tendency”) and symptoms can persist for months or years after injury. Any combination of this constellation of symptoms are often referred to as "storming". They are most commonly noted in TBI’s combining complex focal injuries and DAI.

Initially, explanations regarding the etiology of storming centered on presumed epileptogenic activity. However, most theories now favor a disconnection, or a pathologic interruption with subsequent imbalance, between the inhibitory and excitatory pathways within the mesencephalon, diencephalon, and the spinal cord – so called Disconnection Theories. Even among Disconnection Theories, explanations vary widely and can involve several neurotransmitters. Examples include a loss of GABA inhibition of cortical neurons to a more recent theory called the Excitatory: Inhibitory Ratio (EIR) Model. The EIR Model suggests “causative brainstem/diencephalic centers are inhibitory in nature, with traumatic damage releasing excitatory spinal cord processes. There is continued suggestion that Dysautonomia is more closely associated with damage to mesencephalic structures rather than diencephalic damage.

**Signs/Symptoms:**
- Episodic hypertension, tachypnea, fever, tachypnea, pupillary dilation, diaphoresis, dystonia, and posturing (extensor).

**Frequency:**
As many as 15-33% of patients develop ADS after TBI, with incidence increasing with increasing severity of injury.

**Diagnosis:**
A diagnosis of exclusion in the initial stages of the syndrome, although there has been some radiographic association with DAI and brainstem injury – making MRI a useful test when clinically appropriate.

**Differential:**
- Neuroleptic malignant syndrome: Unlikely in most cases of TBI as neuroleptics are generally contraindicated in this population. However, if the patient was on a dopaminergic medication prior to injury, and that medication is withheld upon admission, this condition should be considered.
  - Reglan can also precipitate this condition.
- Serotonin syndrome:
- Malignant hyperthermia: Consider after post-op patients, especially if given succinylcholine.
- Thyroid storm: more likely with trauma to the neck.
- Infection: consider this, as tachycardia, fever, and hypertension are the most common presenting signs of ADS.
WORKUP CONSIDERATIONS:
1. CBC with diff
2. Blood cultures
3. Sputum cultures and gram stain
4. Urine cultures and urinalysis
5. Plasma catecholamine levels of clinical interest, but may not help in diagnosis
6. Thyroid panel to rule out thyroid storm
7. Comprehensive Metabolic Panel:
8. Plasma creatine kinase and troponin levels: to rule out AMI, neuroleptic malignant syndrome, and serotonin syndrome
9. CXR
10. Dopplers to rule out DVT
11. ECG: to rule out AMI
12. HCT: to rule out abscess, encephalitis, or hydrocephalus
13. LP: to rule out meningitis

TREATMENT:
The specifics concerning the evidence favoring one Disconnection Theory over another are beyond the scope of this document. That said, as the syndrome remains an area of active research, there is no definitive treatment paradigm. There is a wide array of neurotransmitters involved in autonomic control; therefore, there is an equally wide array of medications used in the management of ADS. These pharmacologic strategies are outlined below:

1. Intravenous Morphine: Will control pain and attenuate sympathetic outflow.
   a. The most common initial drug given at VCUHS for storming.
   b. Used as maintenance treatment and for breakthrough paroxysms
   c. Appears to work in dose-dependent fashion
   d. DOSE: Start with 4mg i.v and titrate up as needed and as tolerated
      i. DOSE: 0.1mg/kg iv/im/sc (typically, a trial of 4mg IV is used to gauge effectiveness when ADS is suspected or for a breakthrough paroxysm)
      ii. Maintenance: 5-20 mg/70kg q4h
2. Dopamine Agonists:
   a. Bromocriptine: A dopaminergic agent used to decrease frequency of paroxysms and has also been used effectively to reduce temperature and diaphoretic lability.
      i. DOSE: 1.25mg PO BID with meals; increase by 2.5 mg/day q2-4 weeks as needed
3. Beta-Blockers (Propanolol, Labetelol): Due to the increased sympathetic tone in ADS, both alpha agonists and beta-blockers have been used in treatment.
   a. Used primarily to reduce the severity of paroxysms and the tachycardia associated with ADS
   b. Labetelol: an alpha-1, beta-1, beta-2 blocker is more effective than metoprolol
   c. Propanolol: has no alpha activity but is still useful in treating ADS, particularly the HTN and hemodynamic abnormalities
      i. Crosses BBB and blocks 5HT1A receptors, which may explains some of its efficacy
      ii. DOSE: 40-80mg PO BID initially, increase to 160-320 mg/day as needed
   d. As usual, use beta-blockers with caution in patients with diabetes and asthma
4. Muscle Relaxants:
a. **Dantrolene**: Best used to treat *extensor posturing*
   i. **DOSE**: Begin with 25mg PO QD; increase to 25mg BID/QID; then increase by 25mg increments to as high as 100mg BID/QID prn

5. **Clonidine**: An alpha-2 agonists that acts centrally (blocking stimulatory adrenergic influences of the hypothalamus and rostral ventrolateral medulla and activating the sympathoinhibitory brainstem center) and peripherally
   a. Theoretically useful, but clinically has not been as effective as hope to treat the *hypertension and tachycardia* associated with ADS
   b. Shown to be useful in normalizing plasma epinephrine levels and reducing norepinephrine levels – therefore treating HTN.
   c. Can cause sedation and rebound hypertension
   d. **DOSE**: 0.1 mg every 8 hours, titrate up to effect

6. **Baclofen**: A GABA B agonist used to treat the *spasticity* associated with ADS.
   a. **DOSE**: 10 mg every 6 hours titrate to max of 80 mg/day

7. **Benzodiazepines**: Versed has been used with some attenuation of symptoms in the ICU setting. Consider 5mg IV to start.

8. **Gabapentin**: A newer agent used in the pharmacologic management of ADS. Decreases severity and frequency of paroxysms while also decreasing the amount of other medications needed.
   a. **DOSE**: 900-1800mg PO in divided doses; not to exceed 3600mg/day

In addition:

9. **Aggressively treat fever**: this will prevent further secondary injury

**Keep Hydrated**: Fever and dystonia can cause severe dehydration and rhabdomyolysis.
CLINICAL DECISION MAKING WITH LICOX MONITORING:

- When a monitoring trigger has been met, get an ABG and pay particular attention to BP, oxygen saturation, and the most recent hemoglobin and PCO₂ while awaiting the result.
- Ask about the most recent FiO₂ challenge to assess validity of the result.
- There will be four clinical scenarios/events that we will encounter in patients with Licox monitors.
  1. **TYPE 1**: ICP<20, P₇₅O₂ >15
  2. **TYPE 2**: ICP>20, P₇₅O₂ >15
  3. **TYPE 3**: ICP<20, P₇₅O₂ <15
  4. **TYPE 4**: ICP>20, P₇₅O₂ <15

**TYPE 1 EVENTS: ICP<20, P₇₅O₂ >15**
- No changes necessary, these are our ideal goals.

**TYPE 2 EVENTS: ICP>20, P₇₅O₂ >15**
- Treat as our standard Severe TBI Protocol dictates; recall the tiered approach to management of elevated ICP.
  1) Intubation with Normocarbic Ventilation (PaCO₂ of 35-45)
     a. Mild-moderate sedation with propofol and morphine
  2) Optimize positioning and controlled ventilation (PaCO₂ of 35-45)
     b. Hyperventilation to a PaCO₂ of 32-35 only if necessary AND guided by P₇₅O₂ monitor (NOT prophylactically)
  3) Ventriculostomy with drainage
  4) Hyperosmolar therapy
  5) Heavy sedation and neuromuscular paralysis
  6) Hypothermia (therapeutic, not prophylactic)
  7) Surgical Decompression
  8) Barbituate Coma

**TYPE 3 EVENTS: ICP<20, P₇₅O₂ <8**
  1) Tier 1 Options:
     i) Lower HOB to 0°
     ii) Adjust ventilator to increase PaO₂ (↑FiO₂ or ↑PEEP)
     iii) Increase PCO₂ to 45-50
     iv) Transfuse to hemoglobin >10
  2) Tier 2 Options:
     i) Increase CPP >60 (fluid bolus or pressors)
     ii) Optimize hemodynamics (increase CVP)
     iii) Use Swan to measure wedge pressure
     iv) Decrease ICP to <10 (CSF drainage, more sedation)
**TYPE 4 EVENTS: ICP>20, P_bO_2 <15**

1) **Tier 1:**
   i) Elevate HOB to 30°
   ii) Adjust ventilator to increase PaO_2 (↑FiO_2 or ↑PEEP)
   iii) CSF drainage
   iv) Hyperosmolar therapy
   v) Transfuse to keep hemoglobin >8
   vi) Sedate
   vii) Paralyze

   *** Do not hyperventilate ***

2) **Tier 2:**
   i) Hyperosmolar therapy
   ii) Increase CPP >60
   iii) Repeat CT to see if there are any changes
   iv) Surgery if indicated

3) **Tier 3:**
   i) Decompressive Craniectomy
   ii) Barbituate coma
INTRACEREBRAL HEMORRHAGE

- In all patients admitted with intracerebral hemorrhage (ICH), the following questions should be answered:
  - Does the patient require intubation?
  - What are patient’s BP goals/treatment thresholds?
  - What is the patient’s coagulation status and have they been taking oral anticoagulant?
  - Does the patient need emergent surgery?

- Important things to note on the CT scan include size of the hemorrhage, degree of mass affect, intraventricular extension, hydrocephalus, compression of the cisterns.

- Initial management:
  - Correct existing coagulopathy rapidly (see pp 42-43).
  - Monitor I&O very closely when using FFP. Be proactive with diuretics. Use IV vitamin K with FFP once.
  - Recombinant factor VIIa administration may be considered in the following instances (discuss with the attending first):
    - Coagulaopathic patient with CHF/pulmonary edema;
    - Rapid correction of anticoagulation (actively bleeding or awaiting an emergent surgical procedure) is needed (refer to Transfusion section)
  - For patient admitted to the Neurology service, a routine Neurosurgery consult is neither necessary nor appropriate. If you feel the patient is a candidate for surgery of ventriculostomy, then a consult should be obtained.
  - Gently lower blood pressure if there are signs of cardiac distress (active CHF, EKG/troponin changes, chest pain). Do not decrease MAP below 110 in previously hypertensive patients due to risk of hypoperfusion. The value of routine lowering of elevated BP is unknown. It is usually not harmful to reduce by 15% below admission level, no lower than MAP of 110 or SBP to 140-160. Consider withdrawal as an additional cause of high BP/HR and treat as necessary.
  - The preferred agent is labetalol; high doses may be needed due to sympathetic activation. If 2-3 doses are ineffective or patient is bradycardic, use nicardipine or nitroprusside drip.
  - If the hemorrhage location suggests an underlying ruptured aneurysm or an AVM, discuss ordering angiography with the primary service first.
  - If the patient is intubated for airway protection, wean the ventilator settings rapidly to the minimum support needed for comfortable breathing.
  - Start DVT prophylaxis with heparin 5000 units SC q8-12 hrs 24-48 hours after presentation.
  - AED X7 days for lobar hemorrhage (not necessary for basal ganglia/cerebellar hemorrhage)

- INTRAVENTRICULAR HEMORRHAGE: A special clinical challenge with increased mortality and morbidity. When the blood in the ventricles precludes CSF drainage via an EVD, thus making intracranial hypertension difficult to control, one can consider administering intrathecal rt-PA.
  - Dose is 1 mg rt-PA q8 hours until the blood in the 4th ventricles clears
  - MUST GET CONSENT FROM FAMILY BEFORE INITIATING THIS PROTOCOL.
ACUTE ISCHEMIC STROKE

 Patients are usually admitted to the ICU for:

- 24 hours observation after receiving tPA.
- Neurologic deterioration after large hemispheric stroke.
- Observation for hydrocephalus or brainstem compression after cerebellar infarct.
- Brainstem stroke with compromised airway – may need intubation (see respiratory issues section for recognition and management of bulbar weakness).
- Cardiac ischemia, arrhythmias or severe hypertension.

Ischemic stroke patients (NOT receiving tPA) should be started on enoxaparin (Lovenox) 40 mg SC daily or heparin 5000 units q8h for DVT prophylaxis immediately unless there is a clear contraindication. Those, who have received tPA, should be started on enoxaparin or heparin 24 hours after tPA dose (unless symptomatic deterioration from hemorrhagic transformation).

MANAGEMENT OF A PATIENT WHO HAS RECEIVED tPA

 Neurologic checks q15 min during infusion of tPA, q30 min for next 6 hours, q60 min for next 16 hours.

- No heparin or antiplatelet therapy for 24 hours.
- No Foley, NGT or central lines within 30 min of tPA.
- The primary service decides if a follow-up CT scan is needed and which secondary prevention medicines to start after 24 hours.
- Keep systolic BP<180 mm Hg and diastolic BP<105 mm Hg. Labetalol is the drug of choice. Use nicardipine or nitroprusside drip in cases of bradycardia or poor response to labetalol. May begin oral anti-hypertensive medications after 24 hours. Monitor patient for changes in mental status due to hypoperfusion.
- Obtain a stat head CT for a new severe headache, acute BP elevation, nausea/vomiting, worsening neurologic status (intubate before CT if the airway is compromised)
- In case of developing intracerebral hematoma, draw blood for CBC, fibrinogen, PT/PTT, type and screen. May need to transfuse FFP. Platelets, cryoprecipitate or RBC’s if indicated. Consider Neurosurgery consult after discussing with the Neurology chief resident/private attending and the ICU fellow/attending.
MANAGEMENT OF NEUROLOGIC DETERIORATION AFTER LARGE HEMISPHERIC STROKE

- Address advance directive/DNR status.
- Consider intubation if GCS <9, bulbar dysfunction or poor cough. Take measures not to further increase ICP during intubation (refer to respiratory failure section).
- Use empiric mannitol (0.25-1 g/kg) and/or hyperventilate (goal pCO₂ of ~30) while getting ready for head CT.
- Do not lower blood pressure (keep MAP>90), treat hypotension associated with clinical deterioration aggressively with vasopressors. Use caution in patients with cardiac distress.
- ICP monitor not indicated.
- Options for further management include treatment with osmotic therapy or hemicraniectomy (discuss with the primary service prior to calling Neurosurgery).

Guidelines for Decompressive Hemicraniectomy following Malignant MCA Infarction

Eligibility criteria for early decompression (ie, presentation triggers to consider decompression)

Inclusion criteria
- Age 18–60 years, > 60 years may be considered based on the absence of co-morbidities and level of function
- Clinical deficits suggestive of infarction in the territory of the MCA with a score on the National Institutes of Health stroke scale (NIHSS) >12 for dominant hemisphere, > 10 for non-dominant.
- Decrease in the level of consciousness to a score of 1 (ie, not alert, but arousable with minimal stimulation) or greater on item 1a of the NIHSS.
- Signs on CT or MRI of an infarct involving at least 50% of the MCA territory.

Exclusion criteria

Absolute contraindications
- Pre-stroke score on the mRS ≥ 3
- Two fixed dilated pupils
- GCS ≤ 4 without improvement in the first 24 hours.
- Space-occupying hemorrhagic transformation of the infarct (≥ parenchymal hemorrhage grade 2)
- Life expectancy <3 years
- Known irreversible coagulopathy or systemic bleeding disorder

Relative contraindications
- Complete ICA distribution ischemia on affected side
- Contralateral ischemia or other brain lesion that could affect outcome
- Other serious illness that could affect outcome
Criteria to perform early decompression (ie, triggers for decompression)

Inclusion criteria

- Inclusions as above, in addition:
- Any one of the following:
  1. Clinical deterioration in neurological exam not explained by medications or other medical conditions. This includes any subtle decrease in the level of arousal.
  2. Head CT showing a ≥ 4 mm increase in midline shift.
- Agreement of available family after a thorough discussion explaining the role of a life saving, not stroke reversal, procedure. Information about quality of life must be presented in an objective fashion.
- Minimum of 6 hours has passed since any thrombolytic therapy.

Exclusion criteria

- Above exclusion should be re-assessed
- Acute development of a co-morbidity that could affect outcome.
- Contraindication for anesthesia

CEREBELLAR INFARCT

- Patients may worsen due to hydrocephalus or direct brainstem compression (often manifesting as horizontal gaze palsy or new facial droop). Consider mannitol and head CT at the earliest sign of deterioration.
- Can develop acute respiratory arrest; consider intubation prior to head CT.
- Neurosurgery should be involved if ventriculostomy or resection of the cerebellum is considered by the primary service.
- Can develop brady- or tachycardia, hypo- or hypertension due to the brainstem compression. Do not treat hypertension, correct hypotension. Use atropine for symptomatic bradycardia, an external pacemaker may be needed.

NEUROMUSCULAR DISEASE

- Patients with myasthenia gravis and Guillain-Barre syndrome (GBS) are usually admitted to the ICU because of the potential for respiratory difficulties.
- GBS patients also may demonstrate life-threatening dysautonomia (wide fluctuations of the heart rate and BP). Avoid treating it because the swings are too rapid.
- These patients are usually dehydrated on admission.
- Initial assessment included checking respiratory rate, oxygen saturation, the ability to cough and manage oral secretions. Asks the patient about subjective dyspnea.
- Monitor NIF (more reliable) and FCV q4-12 hrs while awake (normal NIF >50-100, FCV -40-70 ml/kg). Use a mask in the patients with facial weakness. Proper seal is essential. If there is a discrepancy between the numbers and clinical condition, treat the patient, not the numbers.
- Having the patient count out loud as long as they can on a single breath is an easy and consistent means of monitoring vital capacity (normal = 20)
• Decisions regarding intubation should be made based on clinical criteria. Patients should be intubated before their blood gases deteriorate.
• Using BiPAP sometimes prevents intubation (discuss with fellow/attending first).
• Intubate patient if:
  o FCV drops below 18 ml/kg and/or NIF below 25
  o Cough is extremely weak or absent
  o Unable to count to 10 on a single breath
• Succinylcholine is contraindicated due to a risk of fatal hyperkalemia in myasthenics; use vecuronium if needed.
• Patients with neuromuscular disease should be switched rapidly from IMV to pressure support ventilation. The amount of pressure support should be adjusted to achieve a comfortable respiratory rate and reasonable spontaneous tidal volumes (5-8 ml/kg of IBW).
• Consider holding pyridostigmine (Mestinon) while patients with myasthenia gravis are intubated.

### STATUS EPILEPTICUS

If no allergy or specific contraindications give:
• Lorazepam (Ativan) 4 mg IV (up to 0.1 mg/kg) and
• Phenytoin IV load according to body weight (15-20 mg/kg) no faster than 50 mg/min (may cause arrhythmias and hypotension). Make sure the complete loading dose was administered between the ER and the ICU.
• If seizures persist, additional phenytoin 5-10 mg/kg should be given. Check free phenytoin levels post load and aim for a high therapeutic range (1.5-2.5 mg/L) – order a free trough level approximately 24 hours later, then again on day 3 and at steady state (approximately day 5-7).
• Hypotension may be seen with all anticonvulsants. Place an arterial line if necessary. Be proactive, use pressors as needed to keep an adequate MAP.
• If seizures persist, intubation is usually required.
• The choice of the third drug should be made in conjunction with the primary service. These are usually given to achieve burst-suppression pattern on EEG or seizure control. The most frequently used are:
  o Propofol: 5 mcg/kg/min titrated to burst suppression
  o Phenobarbital: 20 mg/kg load, no faster than 50-100 mg/min; may repeat 10 mg/kg if seizures continue (total of 30 mg/kg) – monitor respiratory status and load in divided doses if patient is not mechanically ventilated.
  o Midazolam (Versed): 0.2 mg/kg IV bolus load, then 10-40 mg/hr infusion.
  o Pentobarbital: 10 mg/kg over 1 to 2 hours until no seizure EEG evidence of seizure, repeat bolus of 5-10 mg/kg over 1-2 hours if then maintenance drip of 1-5 mg/kg/hr.
• All patients placed on continuous infusions (Midazolam, pentobarbital) should have continuous EEG monitoring. Call to get it set up early (while the drip is being prepared), especially after hours when a tech has to be called in.
• Consider adding valproic acid: 25 mg/kg IV loading dose (the correct loading dose is not established yet).
• Proceed directly to anesthesia with propofol or midazolam if:
  o Extreme hyperthermia
  o Seizure duration of > 60-90 minutes
CNS INFECTIONS

PROPHYLACTIC ANTIBIOTICS:
- Postoperative after craniotomy – cefazolin (Ancel) or vancomycin* (if penicillin allergy) for 24 hrs.
- External ventricular/subdural/lumbar drains – cefazolin or vancomycin* as long as the catheter is present.
- ICP monitor – no antibiotics or one of cefazolin just before the insertion.
- CSF leak – no antibiotics.

VENTRICULITIS:
- Frequently asymptomatic. Diagnosis is based on CSF studies from EVD (collected by Neurosurgery).
- Cell counts on bloody CSF are almost impossible to interpret – low glucose, positive gram stain and culture are most reliable.
- An appropriate initial treatment regimen is cefepime* 2g IV q8hr and vancomycin* 20 mg/kg IV q12hr.
- Target vancomycin trough of 15-20 mg/L for CNS infections.

BACTERIAL MENINGITIS:
- Empiric coverage: ceftriaxone 2g IV q12hr and vancomycin* 20 mg/kg IV q12hr.
- Patients with suspected bacterial meningitis should be immediately started on dexamethasone 4 mg q6hr (this should be continued for 4 days if S. pneumoniae isolated). First dose should be given prior to antibiotics.
- May consider ampicillin 2g IV q4hr (in cases of elderly [>50 years old], alcoholics or immunocompromised patients) – discuss with the primary service.
- If N. meningitis or H. influenzae are possible causative organisms, keep the patient in respiratory isolation for 24 hrs after effective therapy initiated. Consider giving ciprofloxacin 500 mg single dose PO for the family members and health care workers exposed to those with meningococcal meningitis for prophylaxis.

ANTIBIOTICS

The injudicious use of antibiotics leads to resistance and is strongly discouraged. Use the most efficacious, least expensive option.

- Postoperative: Most patients receive 24 hrs of antibiotics after surgery (cefazolin or vancomycin*).
- Neurologic considerations:
  - Ciprofloxacin (all quinolones), carbapenems and high dose penicillin’s lower seizure threshold.
  - Ceftriaxone, ceftazidime and cefepime penetrate the blood brain barrier most effectively.
Doses:

Acyclovir*:
- Meningitis: 10 mg/kg IV q8 hrs
- Tracheitis: 400-800 mg q4 hrs

Amphotericin:
- Meningitis (Candida, Cryptococcus): 5 mg/kg/day lipid formulation
- Fungal UTI: 50 mg CBI X 3 days

Ampicillin:
- Enterococcus UTI: 0.5-1g IV q6 hrs (or amoxicillin)
- Meningitis: 2g IV q4 hrs

Cefazolin (Ancef):
- 1g IV q8 hrs

Cefepime*:
- Pneumonia 1-2 g IV q8-12 hrs
- Meningitis: 2g IV q8 hrs

Ceftazidime*:
- Meningitis: 2g IV q8h

Ceftriaxone:
- Pneumonia: 1g IV qd
- Meningitis: 2g IV q12 hrs

Clindamycin:
- 600 mg IV q8 hrs

Fluconazole:
- Invasive candidiasis: 6mg/kg/day
- UTI: 200 mg PO/NG once, then 100 mg PO/NG qd for 4 days

Gentamicin*:
- 5-7 mg/kg/d, check trough concentrations. Consult PharmD for further dosing

Metronidazole**(Flagyl):
- 500 mg IV/NG q 6-8 hrs for CNS abscess
- 500 mg NG/PO q 8 hrs for C.diff colitis

Imipenem:
- Resistant infections: 500 mg IV q 6 h

Meropenem*:
- Meningitis: 2g IV q 8 hrs

Nacillin:
- Meningitis: 2g IV q 4 hrs

Trimethoprim/ sulfamethoxazole (Bactrim)*:
- UTI: 20 ml NG or 1 DS tab q12 hrs
- Stenotrophomonas pneumonia: 15-20 mg/kg/day in 4 divided IV doses

Vancomycin*:
- 15-20 mg/kg q12 hrs. If treating pneumonia or CNS infections, target trough of 15-20 mg/L.

*: Dosage adjustment needed for renal dysfunction
**: Dosage adjustment needed for severe hepatic dysfunction
BRAIN DEATH

**Brain death** is an irreversible loss of all functions of the brain determined by:

- Clinical assessment – absence of function of all part of the brain (no response to stimulation, no brainstem reflexes, no breathing, no movement).
- If you cannot complete the clinical exam, a cerebral perfusion study should be obtained (demonstrates lack of blood flow to the brain).

- Clinical brain death determination consists of two steps. The VCUHS policy requires a senior staff member of Neurology or Neurosurgery services (attending, fellow or chief resident) makes the final declaration of brain death.

- **First step.** When the patient loses all neurologic function (including breathing over the set rate), a NNICU resident performs neurologic exam and documents findings in the chart. *Remember in order to undergo the exam, the patient must be warm (>36°C) and have a SBP > 90 mm Hg (use vasopressors if needed).*

- Consider conditions that may produce encephalopathy and mimic brain death including sedatives, severe metabolic disturbances (obtain CMP and drug screen if appropriate).

- Document the following:
  - Date and time of examination
  - Temperature and blood pressure
  - Response to painful stimulus (should include pressure on the supraorbital notch or TMJ)
  - Pupil size and reaction
  - Oculovestibular reflex (cold calorics) – head of bed up at 30°, ~50 ml of ice cold water instilled in each ear slowly, observation of the eye movements for 3 min.
  - Corneal reflex
  - Cough and gag

- **Second step.** Another neurologic exam followed by apnea testing is performed by a senior staff member of Neurology or Neurosurgery. Apnea test ensures lack of responsiveness of the brain to hypercarbia (pCO₂ ≥ 60) and respiratory acidosis (pH ≤ 7.3). If no respiratory effort is detected, criteria for death have been met; the patient is declared brain dead. See Appendix E for apnea testing.

**Clinical pearls:**

- Prevent/treat hypothermia by using warming blankets and Cool Guard if necessary.
- Watch for diabetes insipidus (DI) – hypernatremia and large volumes of dilute urine not due to mannitol/diuretics. Treat DI with DDAVP; replace urinary loss with hypotonic fluids (redose DDAVP when UOP exceeds ~300 ml/hr again).
- Treat hypotension. The patient may have DI and be dry. The patient may be bleeding. Brainstem dysfunction leads to vasodilatation.
- Vasopressors should be used on this setting independent of code status, since the goal is to have an adequate BP to perform a brain dearth evaluation and preserve the organs for donation.
- Remember to correct acidosis (Vasopressors are less effective when pH is low).
GENERAL ICU ISSUES

DVT PROPHYLAXIS:
Spinal Cord Injury and Ischemic Stroke:
1) Immediate mechanical prophylaxis (TED hose and sequential compression devices)
2) SCI: Enoxaparin 30mg q12; ischemic stroke: enoxaparin 40mg day
   a) Delay starting pharmacologic prophylaxis if surgery is expected within 24 hours
   b) Otherwise, begin pharmacologic prophylaxis within 24 hours of admission.

All others:
1) Immediate mechanical prophylaxis (TED hose and sequential compression devices)
2) UFH 5000 units q8-12
   a) Delay starting pharmacologic prophylaxis if surgery is expected within 24 hours
Otherwise, begin pharmacologic prophylaxis within 24 hours of admission.
   • All ischemic stroke patients (except after tPA) should be started on enoxaparin 40 mg SC
daily or heparin 5000 units every 8 h immediately (hold for 24 hours in patients who received
TPA).

Fluid management:
The management of fluids in NSICU patients is relatively straightforward if the following questions
are considered:
   • Is the patient currently hypovolemic, hypervolemic or euvoicemic?
   • Is your therapeutic goal to have the patient hypovolemic, hypervolemic or euvoicemic?
   • How essential is it to maintain the patient’s volume status in the desired range?

Clinical pearls:
• Clues about volume status include: UOP and specific gravity; change in BUN, creatinine,
   hematocrit or body weight; fluid balance over the past several days; CVP or wedge pressure.
• Look at the fluids status over the past several days.
• In general patients with cerebral edema should be maintained in a somewhat hypovolemic
   state.
• SAH patients can develop a spontaneous diuresis leading to significant hypovolemia. Patients
   with or at risk for vasospasm be kept in a euvoicemic or mildly hypovolemic state.
• If you are getting consistently behind on the patient’s fluid balance, increasing the fluid rate
   is more effective than giving a bolus.
• In patients who are hemodynamically or neurologically unstable, frequent monitoring of the
   volume status and adjustment of fluids may be necessary.
• In stable patients, volume status assessment should be made once a day during rounds. When
   checking I&O, pay attention to timing of mannitol administration, since mannitol-induced
   diuresis may affect the overall picture.

Hypertension:
• Due to the nature of acute neurologic illnesses, hypertension is generally well tolerated in the
   NSICU, with the exception of a recently ruptured unprotected aneurysm.
• Lowering blood pressure too quickly (over minutes rather than days) may lead to
   hypoperfusion in a neurologic patient with chronic hypertension.
**Hypotension:**
- Confirm hypotension by re-checking blood pressure.
- Hypotension may exacerbate CNS injury; **initiate treatment to raise BP while determining the cause.**
- For mild hypotension, consider starting a fluid bolus; for severe hypotension (generally MAP<50-60 mm Hg in a previously normotensive patient) start a wide open 0.9% NaCl bolus (500-1000 ml) and pressors simultaneously.
  - Dopamine (5-20 mcg/kg/min) or norepinephrine is preferred in patients with SCI and/or bradycardia.
  - Phenylephrine (25-200mcg/min) is chosen in cases of tachycardia unless cardiac function is poor.
  - Norepinephrine (Levophed) is preferred in patients with heart failure and sepsis. Vasopressin can be used as an adjunct in cases of refractory sepsis as well, but has been out-of-favor due to possibility of increasing the ICP in patients with head injuries.
- Dopamine infusion is immediately available, while norepinephrine and phenylephrine need to be made.
- Place an arterial line as soon as possible. Patients on vasopressors should have a central line as well.
- **Common causes of hypotension in our patients are:**
  - Excess sedation
  - Drugs such as nimodipine, ACE inhibitors, IV phenytoin
  - Sepsis and fever
  - Brain death/herniation
  - Autonomic abnormalities in SCI and GBS (especially during plasmapheresis)
  - Hypovolemia
  - Impaired function of the carotid sinus baroreceptors after endarterectomy
- **Uncommon but important causes of hypotension in our patients are:**
  - Pulmonary embolism
  - Retroperitoneal hematoma due to angiography or attempted femoral line placement
  - Tension pneumothorax in mechanically ventilated patients or after subclavian/jugular line placement
  - Internal bleeding (chest or abdomen) or bleeding into the soft tissue in a trauma patient
  - Myocardial infarction
  - GI bleed
  - Transfusion reactions/anaphylaxis
- **While evaluating the cause of hypotension, history and examination should be directed towards looking for these causes.**
- Ask the nurse about drugs the patient received, examine for groin hematoma, listen for unequal breath sounds, guaiac NG aspirate and stool.
- Investigations should include a stat CBC, type and screen, BMP, ABG, troponin, EKG, CXR.

**Bradycardia:**
- **Common causes of bradycardia in our patients are:**
  - Raised ICP
  - Spinal cord injury with unopposed vagal action
  - Pressure on the baroreceptors from carotid stent/endarterectomy
Medicines: IV phenytoin, beta-blockers, phenylephrine, non-dihydropyridine calcium channel blockers, clonidine

- Asymptomatic sinus bradycardia does not need treatment. Keep atropine at bedside, get an EKG. Cardiology consult is warranted for complete heart block and Mobitz II 2\textsuperscript{o} heart block.
- For symptomatic bradycardia (chest pain, pulmonary edema, hypotension, acute MI, altered sensorium), start transcutaneous pacing, call stat cardiology consult.

Tachycardia:

- Sinus tachycardia should not be treated with beta-blockers unless there is myocardial ischemia. Find and treat the cause.
- Sinus tachycardia is commonly seen in our patients due to:
  - Fever
  - Hypovolemia
  - Anxiety and pain
  - Sympathetic activation in TBI, SAH, ICH (e.g. “storming”)
  - Dysautonomia with GBS
  - Pulmonary embolism/MI
  - Sepsis
- SVT with heart rate of > 150 with mental status changes, chest pain, pulmonary edema, MI or hypotension need immediately cardioversion under sedation and analgesia (do not sedate if profound hypotension).
- Paroxysmal SVT:
  - Try vagal maneuvers (endotracheal suctioning in intubated patients is useful)
  - If sustained, the following drugs may be used:
    - Adenosine
    - Verapamil or diltiazem
    - Metoprolol
    - Other options include amiodarone IV, diltiazem or esmolol infusion
- Atrial flutter or fibrillation with RVR
  - New onset, check O\textsubscript{2} saturation, EKG and troponin; order TSH and echocardiogram for a.m. If clinical scenario appropriate, consider PE protocol CT. Use usual precautions to prevent contrast-induced nephropathy.
  - IV amiodarone is used in new onset (<48 hrs) atrial fibrillation per ACLS protocol.
    - (150 mg IV over 10 minutes, followed by Amiodarone drip at 1 mg/kg/hr x 6 h, then 0.5 mg/kg/hr x 18 h)
    - Diltiazem or beta-blockers for rate control. Digoxin may be used when hypotension is of concern (recent cerebral infarct) or in CHF.
- Wide complex tachycardia
  - Briefs runs of unsustained ventricular tachycardia are not uncommon in ICU patients. Evaluate further and treat if there is poor cardiac function EF.
  - Check and replete Mg and K, consider getting an echocardiogram.
  - Treat with amiodarone, lidocaine or procainamide per ACLS protocol.
TRANSFUSIONS AND COAGULOPATHY

Blood:
- There is convincing evidence that liberal blood transfusions in ICU not only do not improve outcome, but also may increase mortality rates.
- Transfusions are not recommended for patients with hemoglobin > 7 unless is acute ischemic heart disease (target Hb of 10), a significant ongoing bleeding or, at times, in severe vasospasm.
- Most frequent causes of anemia are hemodilution, GI bleeding, femoral or retroperitoneal hematoma post angiography/line placement; hemolysis is very rare.

Platelets:
- Prophylactic transfusions may be appropriate for patients with platelet counts <10,000/ml.
- Platelet count > 50,000/ml is recommended for patients undergoing minor surgical procedures.
- For major or neurosurgical procedures, 100,000/ml is the usual threshold. This also usually applies to the patients with active intracranial hemorrhage.
- Neurosurgery may request platelet transfusions prior to surgery for patients on ASA or clopidogrel (regardless of platelet count).
- Remember to discuss thresholds with the primary service and the ICU fellow/attending prior to transfusions.

Fresh frozen plasma:
- For anticoagulated patients with active bleeding or requiring neurosurgical procedures, initial recommended dose of FFP is 15-20 ml/kg. Each bag/unit of FFP is approximately 300-350 ml.
- The desired INR goal needs to be clarified with the primary or service performing surgery. An INR goal of < 1.5 is usually reasonable for a patient with an active ICH or requiring an emergent procedure.
- Patients with poor cardiac function/pulmonary edema may require IV furosemide.

Recombinant factor VIIa: See VCU guidelines in Appendix R
- Recombinant factor VIIa (rFVIIa may be used as a second line agent - off-label use) for correction of coaglopathy in patients with acute hemorrhages.
- Unless the patient requires urgent surgery, IV vitamin K and FFP should be given first. If these agents are ineffective, or the patient does not tolerate the large volume of fluid (CHF), add rFVIIa. The other circumstances would be an urgent surgery or EVD placement.
- Do not routinely use for spontaneous ICH. Use with caution in patients with an increased risk for arterial thrombosis (recent active cardiac or cerebral ischemia)
- Dosing:
  - Factor VIIa should always be given with IV vitamin K 10mg and 15-20 ml/kg of FFP. It is very short acting.
  - Elevated INR requiring rapid reversal: 1 mg vial IV (~20 mcg/kg for a 70-kg patient).
**Vitamin K:**
- The full effect of vitamin K in reducing INR takes up to 24 hrs regardless of doses.
- IM administration may cause a hematoma. Avoid SC dosing; absorption is incomplete and erratic. (i.e. always give vitamin K by the IV route in patients with active bleeds)

**HEPARIN-INDUCED THROMBOCYTOPENIA**

Heparin-induced thrombocytopenia (HIT) is a hypercoagulable state resulting from a hypersensitivity reaction to unfractionated heparin (UFH) and low-molecular-weight heparin (LMWH). This contributes to a life-threatening and limb-threatening situation with great potential for thrombosis. Further complicating the matter is that the alternative anti-coagulants used to combat the thrombotic consequences of HIT cannot be reversed. The challenge then becomes a careful balancing of both risks, thrombosis and bleeding.

HIT is mediated by an IgG antibody that reacts with platelet factor 4 (PF4)/heparin complex \( \Rightarrow \) Once formed, this PF4/heparin/IgG complex binds to platelets via their Fc\( \gamma \)IIa receptors (thus crosslinking the receptors) and induce strong intravascular platelet activation \( \Rightarrow \) this results in the following platelet and blood coagulation activation events:
- a) platelet granule and microparticle release
- b) platelet aggregation
- c) thrombus formation
- d) in addition to platelet activating function, HIT antibodies also activate endothelial cells and monocytes, inducing tissue factor expression, thrombin generation and fibrin clot formation

**FREQUENCY:**
2) Occurs in 0.5-5.0% of patients receiving UFH
3) Some evidence suggests that post-surgical patients have an increased tendency to produce the HIT antibody as well as develop HIT.
4) LMWH is less antigenic than UFH
5) Fondaparinux is a synthetic drug that seems to only very rarely cause HIT (as it only weakly binds PF4 and does not cross-react with the antibody).

**CLINICAL FEATURES:**
1. *Thrombocytopenia or Relative Thrombocytopenia:* Thrombocytopenia is defined by a count <100-150. Relative thrombocytopenia is a substantial decrease in platelet count (40-50% decrease). Platelet count usually falls to \( \sim 50 \times 10^9/l \), but not to extreme lows seen in other immune drug-induced thrombocytopenia’s. If platelet count falls below 15 it is not likely to be HIT.
   a. Typically occurs 4-14 days after commencement of heparin – but can occur day 1 if a patient had been sensitized to heparin at some point in the previous 4 weeks. In any case, HIT usually happens in patients with recent previous exposure to heparin
   b. Rarely, thrombocytopenia can occur after cessation of heparin (“delayed-onset HIT”)
   c. Note that platelet counts often drop after surgery (POD’s #1-4), masking the development of HIT. In these cases, one may see a biphasic response with an initial fall in POD #1-4, a rise on days #4-6, and then the subsequent HIT-related fall.
2. *HIT-Related Thromboses:* Half of those with thrombocytopenia (relative or absolute) will also have thromboses.
   a. Can be arterial or venous, but venous more common
   b. In the ICU setting, thrombocytopenia can be common, therefore a new symptomatic thrombosis may be your best clue that a patient has HIT.
3. Skin Lesions:
   a. These can occur at sites of heparin injections in some patients with anti-PF4/heparin antibodies even in the absence of thrombocytopenia.

**DIAGNOSIS:** Need both clinical symptoms and confirmatory laboratory analysis.

Clinical triggers to suspect HIT:
   a) Thrombocytopenia (Platelet count <100 or a drop of >40%) occurring 4-14 days after initiation of heparin.
   b) The presence of thromboses will support the diagnosis but it is not essential
   c) Other causes of thrombocytopenia should be excluded (Differential includes: Sepsis and DIC, bleeding, hemodilution, intravascular devices, massive PE, drug-induced thrombocytopenia, pseudothrombocytopenia, liver disease, antiphospholipid antibody syndrome with thrombocytopenia, posttransfusion purpura)
   d) After cessation of heparin, resolution of thrombocytopenia will further support the diagnosis of HIT.

Laboratory: Centers on the detection of the HIT antibody. There is no national or international standard for testing. That said, there are two general types of tests available:
   a) **Immunoassays:** Detect the presence of anti-PF4/heparin antibodies, most commonly via ELISA or particle gel immunoassay. At VCUHS we start with:  
      1. Hep-Ind PLT Ab (ELISA)
   
   b) **Functional Assays:** Not directed at detecting HIT antibodies, but instead toward platelet activation and thus a hypercoagulable state. These tests detect platelet activation when patient serum/plasma is incubated with normal platelets and heparin. Examples include i) platelet aggregometry (PAT), ii) heparin-induced platelet aggregation (HIPA), and iii) $^{14}$C-serotonin release (SRA). At VCUHS we have:
      1. Platelet Aggregation
      2. Platelet Functional Assay
      3. (SRA or Serotonin Release Assay) Depending on the level of suspicion and the results of the Hep-Ind PLT Ab test, one can order an SRA (but this test takes longer).

Ideally, both the functional and immunoassays should be positive. The immunoassays typically have very good negative-predictive value. A positive result from one of the functional assays may carry more clinical significance.

**MANAGEMENT:**
Clinical triggers to assess for HIT include:
   1. Thrombocytopenia (Platelet count <100 or a drop of >40%) occurring 4-14 days after initiation of heparin.
   2. The presence of thromboses will support the diagnosis but it is not essential

Steps to take when a trigger is met:
1) **Immediately suspend UFH or LMWH** – this includes heparin used to flush catheters and i.v. lines.
2) **Start an alternate anticoagulant** (lepirudin or agratobran).
   - There is no need to wait for laboratory results to initiate this step.
   - Consulting hematology is recommended to help guide therapy in proven cases of HIT.
- Again, remember that HIT is a hypercoagulable state brought on by anticoagulants – so now initiating an alternative anti-coagulant strategy is crucial.

- Without treatment, 25-50% of HIT patients with thrombocytopenia alone will develop thrombosis.

- The alternative anticoagulant can be ceased when the platelet count returns to baseline (and there is no indication of overt thrombosis)

- Which alternative medication to use? There has been no prospective RCT comparing the three most common agents. Considerations:
  
  i) Only argatroban and lepirudin are on formulary at VCUHS (as well as bivalirudin). Danaparoid is not available in the US.

  ii) Danaparoid has at least one RCT demonstrating its efficacy. Argatroban and lepirudin have been shown to be effective as well, but via prospective historical controlled cohort studies.

  - However, danaparoid has been shown in vitro to also cross react with the HIT antibody (5% of cases); however, this is much more rare in vivo.

  - Neither argatroban nor lepirudin cross-react with HIT antibody. Both are direct thrombin inhibitors (DTI’s).

  - Danaparoid does not cross the placental barrier, so it is considered by some to be the drug of choice in pregnant patients.

  iii) The kidneys excrete danaparoid and lepirudin, while the liver metabolizes argatroban. Clearly, if the patient has either renal or liver failure, that would effect choice of medication.

  iv) Argatroban dose: Initial bolus of 0.5 microgram/kg/min with maintenance adjusted to keep aPTT between 45 – 75

  v) Lepirudin dose: I.V. bolus of 0.4mg/kg followed by an infusion of 0.15 mg/kg/hr (can be reduced to 0.2 and 0.1 in patients without thrombosis). Also, follow effect with serial aPTT’s.

  vi) Bivalirudin: Another DTI. Can be considered in patients with both hepatic and renal dysfunction. Inactivated by plasma enzymes.

  vii) None of the three have antidotes to reverse the anticoagulation

3) **Order appropriate labwork and diagnostic tests:** Start with 1) Hep-Ind PLT Ab, 2) Platelet Aggregation, and 3) Platelet Functional Assay.

  i) If Hep-Ind PLT Ab is positive, or clinical scenario dictates, one can also order a SRA.

  ii) Consider coagulation tests to detect DIC

  iii) Consider labwork to evaluate renal and liver functions

  iv) If clinically indicated, consider Dopplers, Chest CT, or angiogram depending on the specific clinical concerns for thromboses.

4) Vitamin K Antagonists (VKA’s)

  a) In patients with significant thrombosis, start a vitamin K antagonist (such as Coumadin) – but only after the platelet count returns to baseline, as these drugs can deplete plasma proteins C and S and cause a temporary procoagulant state.

  b) They are **contraindicated in acute HIT**

  c) Should only be started after acute phase of HIT has passed, platelet count has recovered, in low doses, and in conjunction with an alternative anti-coagulant to overlap a minimum of 5 days.

  d) Once started, Coumadin should be continued for 6-12 months.
RESPIRATORY ISSUES

COMMON REASONS FOR RESPIRATORY FAILURE:

Inability to protect the airway/manage secretions

Causes:
- Decreased level of sensorium (GCS<9)
- Bulbar palsy: brainstem stroke or hemorrhage, myasthenia gravis, GBS, SCI.

Recognition of bulbar palsy:
- Poor cough; presence/absence of gag is not useful
- Dysarthria; impaired palate elevation
- Pooling of secretions in the back of the throat
- Sturdor (snoring)

Management:
- Intubate patients with GCS<9
- Measures to manage borderline airways status:
  - Sit patient up, hourly spirometry
  - For thin secretions, try glycopyrrolate (Robinul) 0.1-0.2 mg IV (0.5-2 mg per NGT)
  - Oral/nasal airway and frequent nasotracheal suctioning with a rubber catheter
  - Soft cervical collar with a pillow below the occiput (works by maintaining “sniffing position”)
  - BiPAP (make sure the patient is not likely to vomit or having increased residuals). Usual initial settings are IPAP of 10, EPAP of 5, with an oxygen bleed-in to chief the desired SaO₂ Titrate as needed.

Respiratory muscle weakness

Causes:
- GBS, myasthenia gravis
- Spinal cord injury

Recognition:
- Anxiety, tachycardia, diaphoresis
- Rapid shallow breathing
- Poor cough, pooling of secretions
- Unable to count to 20 on a single breath
- Paradoxical breathing, use of the accessory muscles
- Dips in O₂ saturation, CO₂ retention
- FCV < 15 ml/kg, NIF < 25

Management:
• Intubated if the patient has symptoms or signs of worsening respiratory failure; do not wait for or depend on ABG results. Remember, NIF and FVC are unreliable with facial weakness unless a facemask is used.
• If the nurse thinks that the patient should be intubated, he/she is probably right. If the patient thinks he needs to be intubated, he/she is definitely right.
• Patients with cervical cord lesions (with incomplete diaphragmatic paralysis) may breathe better supine instead of being propped up.
• If a patient with spinal cord injury needs to be intubated, do the following:
  o Call a neurosurgeon to be at bedside for inline traction.
  o If a patient is in a halo, have someone who knows how to take it off and has the tools at bedside.
  o Tell Anesthesiology or ENT to bring an attending along with a fiberoptic scope for patients with cervical spine lesions.
  o **Avoid succinylcholine** if injury is >48 hrs old.
  o Call the airway team early for patients in a halo if intubation seems to be difficult.
  o **BE VERY VIGILANT AND ACT EARLY IF YOU NEED TO INTUBATE A PATIENT IN A HALO. HAVE A NEUROSURGERY RESIDENT AT BEDSIDE.**

Lung problems:

Usual culprits:
• Mucous plug with atelectasis/lobar collapse.
• Pulmonary edema (cardiogenic and neurogenic)
• Bronchospasm
• Pulmonary embolism
• Aspiration pneumonitis/pneumonia
• Pneumothorax etc.

Intubation in the NSICU:

Do:
• Mask ventilate the patient with an oral or nasal airways in place.
• If the ICU fellow/attending is not available, ask the nurse/unit clerk to call Anesthesiology.
• Ask the nurse/unit clerk to call the respiratory therapist.
• Make sure the stomach is empty (suction NG tube).
• Have the nurse prepare two IV lines without infusion pump to push medications.
• Keep suction ready.
• Make sure O₂ saturation monitor is working and is on the hand opposite BP cuff.
• Clamp ventriculostomy catheter when the patient’s head is lowered or raised.
• For patients with raised or suspected increased ICP use the following prior to intubation:
  o Etomidate 0.2 mg/kg (10-20 mg) IV push, may repeat every 5-10 min as needed for adequate sedation
  o Lidocaine 50-100 mg IV for persistent cough
In severe cases, consider mannitol 0.25-1 g/kg IV bolus.
- Sedate patient adequately during and after intubation.
- Give a fluid bolus and/or vasopressor for hypotension; it is usually transient.

**Do not:**
- Do not try to intubate without expert help being available except in dire emergency. Most patients can be safely ventilated with an Ambu bag.
- Do not hesitate to call the airway team for a surgical airway if necessary.

**Ventilator settings:**
- Preferred mode of ventilation is CPAP with pressure support (PS) or SIMV with PS
- For SIMV/PS usual settings are:
  - Tidal volume: 8-10 ml/kg
  - Rate: 10-14 (to keep CO₂ normal)
  - PS: 10 mm Hg
  - PEEP: 5 mm Hg
  - FiO₂: 40%
- For CPAP/PS setting are:
  - PS: 5-20 (small ETT needs more PS), titrate to get spontaneous TV 5-8 ml/kg and RR < 20-25.
  - PEEP: 5
  - FiO₂: 40%
- Patients with ARDS need smaller TV (5-8 ml/kg) and higher PEEP (10-20)
- Call respiratory therapy for all vent changes
- For intubated postoperative patients, try to wean to CPAP by next morning (if they cannot be extubated right away)
- **Ways to improve oxygenation:**
  - Increase FiO₂
  - Increase PEEP
  - Increase I:E ratio by:
    - Decrease flow rate to 40-80 L/min
    - Adding inspiratory pause (0.2-0.5 sec)
  - Sedation and paralysis
- **Ways to improve ventilation (lower CO₂):**
  - Increase tidal volume
  - Increase rate
- Call the fellow/attending for any complex management such as pressure control ventilation or anything you are unsure or uncomfortable with.

**Extubation:**

**Three criteria:**
- Patient should be weaned:
  - Hemodynamically stable and clinically improving (better than at the time of intubation)
  - Acceptable ABG on **minimal** ventilator settings (e.g. FiO₂ ≤ 5, PEEP ≤ 5, pressure support ≤ 10)
- Minute ventilation <20 L/min
- Alert
- Able to handle secretions:
  - Good cough
  - Secretions not excessive (suctioning less than every 2 hrs)

Do:
- Sit patient up.
- Get O₂ supply setup (mask, tent, cannula).
- Make sure the nurse is ready.
- Suction NG tube.
- Suction ETT.
- Call a respiratory therapist to bedside.
- Perform an occlusion test on patients who have been intubated for a long time or at risk of airway edema (post surgery in prone position). This entails deflating the ETT cuff and observing chest wall movements and listening for breath sounds or cough while ETT is manually occluded (the patient can breath around the tube).
- For those who fail occlusion test, order Solumedrol 40 mg IV and repeat the test in 12-24 hrs.
- For post Extubation stridor, consider 0.5-1 ml racemic epinephrine nebs (monitor for tachycardia). Use of 80-20 Helium-O₂ mixture may help to avoid reintubation (FiO₂ of He-O₂ is equal to room air, so additional O₂ may be needed). Try humidified oxygen while He-O₂ is being set up.

TROUBLESHOOTING RESPIRATORY DISTRESS/ OXYGENATION PROBLEMS ON VENTILATION

- Step 1: Look for self-extubation or disconnection from the ventilator and take steps to correct it. Raise FiO₂.
- Step 2: if a patient is in distress or O₂ comes up saturation is low, check the waveform. If accurate, disconnect from the ventilator and bag the patient until SaO₂ comes up. A patient, whose BP drops with each bagged breath, possibly has tension pneumothorax.
- Step 3: problem solving:
  - Examine the patient:
    - Palpate for deviated trachea (pneumothorax or collapse)
    - Listen for asymmetrical breath sounds (right mainstem intubation/collapse/pneumothorax
    - Listen for wheezes and rales
    - Listen for stridor
  - Look at the ETT and ventilator tubing:
    - ETT to far in or out – reposition the tube
    - Patient biting the ETT – sedate the patient, insert an oral airway
    - Plugging with secretions – suction, may need to change the in-line filter
    - Air leak due to a deflated cuff or a cuff leak – instill more air, put a stopcock at the end of the pilot balloon, increase tidal volume by 50-100%
    - If the ETT is too high, it may also present as a cuff leak
  - Look at the alarms on the ventilator (see below)
• Get ABG and stat CXR
• Consider auto peep, especially if there is hypotension associated with the respiratory decline

• Step 4:
  Management of common causes of acute tachypnea/desturation:
  o Mucous plug usually responds to lavage, bagging and suctioning (if fails, bronchoscopy).
  o Bronchospasm usually responds to bronchodilators. Repeat albuterol until wheezes clear (be cautious in patients with cardiac ischemia). Consider sedation, decreasing tidal volume and IV steroids.
  o Anxiety – decreasing ETCO₂ is a clue. Try sedating the patient.
  o Pulmonary edema – diuretics, higher PEEP.
  o Pneumothorax: call Thoracic Surgery for chest tube.

Intractable hypotension, O₂ desaturation and asymmetric breath sounds are indicative of tension pneumothorax. This is an emergency. Insert a wide bore needle in the second intercostal space in the midclavicular line on the suspicious side if diagnosis/definitive treatment is likely to be delayed.

Ventilator alarms:

Pressure alarms:
• High peak pressure (normal 20-30 cm H₂O)
  o Increased resistance to air flow: biting tube, bronchospam, secretions – treat the cause
  o Decreased lung compliance: pneumothorax, pulmonary edema, pneumonia, ARDS – treat the cause
  o Asynchrony: cough/gag, “fighting the vent”: try sedation, changing flow rate, try CPAP
• Low inspiratory pressure/low PEEP
  o Disconnection
  o Cuff leak
• Low O₂ pressure/low air pressure: outlet disconnection/failure – call respiratory therapy

Volume alarms:
• Low exhaled volume
  o Disconnection or leak
  o Spontaneously breathing patient is tiring on pressure support
  o Change in compliance on pressure control
  o High pressure alarm leading to dumping of TV
• High exhaled volume
  o Increased RR or TV: anxiety, pain, fever, pulmonary embolism, acidosis, hypoxemia
  o Inappropriate ventilator settings
  o Self-cycling

Apnea (usual max apnea interval is set at 22 sec):
• Sedation (patient on CPAP given sedatives), tiring
• Respiratory arrest, disconnection, blocked tube (ETCO₂ rises)
• Cheyne-Strokes respiration
• Too much PS leads to higher tidal volumes and low respiratory rate. ETCO₂ does not rise. With lower PS, TV will fall and respiratory rate will increase. **DO NOT add a mandatory rate, decrease PS.**
• Patient is hypocapnic/alkalotic and needs to reaccumulate CO₂ to trigger breathing.
Relative contraindications

1. Hemodynamic instability
   a. SBP < 90
   b. On > 1 vasopressor to maintain SBP > 90
2. Elevated/Uncontrolled Intracranial Hypertension
3. Hypoxemic Respiratory Failure
   a. Peep > 5 to maintain SpO2 > 90%
   b. FiO2 > 0.6 to maintain SpO2 > 90%
4. No spontaneous respirations
5. Neurodegenerative disease
   a. Guillain-Barre
   b. Myasthenia Gravis
6. Cervical Spinal cord injury
7. On neuromuscular Blockade

Weaning/Extubation Protocol

A. Daily request if any contraindications to weaning
B. If no contraindications wean as tolerated
C. Daily Extubation Screen
   a. Sedation vacation
   b. Tube-comp trial for 30min
   c. Secretions: How frequent is suctioning
      i. Heavy → every 2 hours or greater
      ii. Mod → 2-4 hours
      iii. Light → greater than 4 hours
D. Extubation Parameters
   a. P/F ratio greater than 200 yes/no
   b. GCS ≥ 8 yes/no
   c. RSBI < 105 yes/no
   d. Heavy Secretions yes/no
E. If Extubation Criteria met. Inform MD about extubation
   a. If no, document reason and return to “C” and address everyday
NOTE:
1. Clinical assessment must be performed by two physicians, one of whom must be a licensed neurologist.
2. Either physician A or B must be a licensed physician, not necessarily a specialist.
3. Brain death certification constitutes pronouncement of death, and is a medical act. Ventilator support will be withdrawn, unless organ donation is considered.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Dr. A</th>
<th>Date:</th>
<th>Time:</th>
<th>Dr. B</th>
<th>Date:</th>
<th>Time:</th>
</tr>
</thead>
</table>
A. Preconditions:<br>1. Is the cause of brain damage known?               | YES   |       |       | YES   |       |       |
2. Has CNS depressant drugs been excluded:<br>(Ethanol, barbiturates, benzodiazepines, muscle relaxants)<br>(Toxicology screen, if indicated; therapeutic levels are not a contradiction)<br>3. Is hypothermia excluded?<br>4. Are endocrine causes excluded? |       |       |       |       |       |       |
B. Clinical Assessment:<br>1. Both pupils fixed to light<br>2. No response to intense central pain<br>3. Absent corneal/larval reflexes<br>4. Absent cough/gag reflex<br>5. Absent oculocephalic response, or<br>6. Absent ice-water ocular caloric response, each ear |       |       |       |       |       |       |
C. Apnea Test:<br>See reverse side of this form for Apnea Test Guidelines and to record results.
D. Optional Tests: (Not Required)<br>1. EEG is isoelectric?<br>2. Absent cerebral blood flow? |       |       |       |       |       |       |
E. Certification:<br>Clinical Criteria and Apnea Testing are sufficient to certify death.<br>Physician A: ____________________________

Signature

Physician B: ____________________________

Signature

Brain death information has been reviewed in detail with the attending neuroscience physician, Dr.

Who concurs that brain death has occurred. Date: ____________ Time: ____________

Form: H-MR-501 (1/04) MEDICAL RECORD COPY
1. Respiratory therapist verifies physician order for apnea test.

2. Pre-conditions are met:
   - Normothermia (temperature ≥ 35°)
   - Systolic Blood pressure ≥ 90mmHg
   - Euvolemia (+ fluid balance for past 6 hours)
   - Eupnea (PCO2 ≥ 40 mmHg)
   - Patients with C-spine injury or CO2 retention (sleep apnea, COPD) should be diagnosed by cerebral blood flow studies.

3. Obtain baseline values and alert ABG lab that apnea testing for brain death testing is beginning.
   - ABG: pH __________ PaO2 __________ PaCO2 __________ HCO3 __________ O2 sat __________
   - Vital signs: HR ___ BP ___ Temp. ___ Pulse ox ___

4. Respiratory therapist puts patient on 100% oxygen for 10 minutes before beginning testing.

5. Equipment needed:
   - Manual resuscitation bag with 100% oxygen source.
   - Suction catheter (French diameter) sized no greater than double the size of the artificial airway (ex: 14 Fr. catheter for 7.0 Endotracheal tube or tracheostomy)
   - Tape

6. Procedure:
   - Place tape over suction engagement port of catheter to divert oxygen to patient’s lower airway
   - Remove patient from ventilator. Starting time: ___
   - Attach prepared catheter to 10 lpm O2 source and place catheter in artificial airway (tip placed just above the carina)
   - Draw ABG at 5 minutes: actual time drawn ___
     - ABG: pH __________ PaO2 __________ PaCO2 __________ HCO3 __________ O2 sat __________
     - Vital signs: HR ___ BP ___ Temp. ___ Pulse ox ___
   - Draw ABG at 10 minutes: actual time drawn ___
     - ABG: pH __________ PaO2 __________ PaCO2 __________ HCO3 __________ O2 sat __________
     - Vital signs: HR ___ BP ___ Temp. ___ Pulse ox ___

7. Monitor for:
   - Spontaneous respirations or respiratory effort yes ___ no ___
   - Cardiac ectopy yes ___ no ___
   - Pulse oximetry ≤ 90 % yes ___ no ___
   - Systolic blood pressure ≤ 90mmHg yes ___ no ___

Stop test and draw an ABG if “yes” is checked at any time. Hyperventilate and consider optional confirmatory test.

8. The test may be extended to 12-15 minutes and a third ABG drawn if PaCO2 does not reach 60mmHg, if the patient remains stable.

9. Hyperventilate and place patient back on ventilator @100% oxygen for 15 minutes at end of test

The Apnea Test is considered positive (supports the diagnosis of brain death) if the PaCO2 is ≥ 60mmHg or (20mmHg above baseline) while the patient shows no respiratory effort.

Comments:_________________________  Physician:_________________________

Registered Nurse: ______________________  Date of test: ______________________

Respiratory Therapist: ____________________  Completion time of test: ____________________

Form H-MR-501 (10/04)  MEDICAL RECORDS COPY
<table>
<thead>
<tr>
<th>Screen # 1: Intubation Day</th>
<th>#</th>
<th>#</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete # 1-7 5 am Q day</td>
<td>Date: Time:</td>
<td>Date: Time:</td>
<td>Date: Time:</td>
</tr>
<tr>
<td>1. Hemodynamically stable?</td>
<td>YES or NO</td>
<td>YES or NO</td>
<td>YES or NO</td>
</tr>
<tr>
<td>2. Off vasopressors?</td>
<td>YES or NO</td>
<td>YES or NO</td>
<td>YES or NO</td>
</tr>
<tr>
<td>3. PaO2/FiO2 ratio &gt; or = 150 OR SaO2 95% or &gt; or FiO2 of 0.50 or less</td>
<td>PaO2</td>
<td>PaO2</td>
<td>PaO2</td>
</tr>
<tr>
<td></td>
<td>FiO2=</td>
<td>FiO2=</td>
<td>FiO2=</td>
</tr>
<tr>
<td>4. PEEP set at 8 cm H2O or less? (Refers to low PEEP if in Bi level mode)</td>
<td>YES or NO</td>
<td>YES or NO</td>
<td>YES or NO</td>
</tr>
<tr>
<td>5. PSV set at 15 cm or less?</td>
<td>YES or NO</td>
<td>YES or NO</td>
<td>YES or NO</td>
</tr>
<tr>
<td>6. RASS -2 or higher</td>
<td>YES or NO</td>
<td>YES or NO</td>
<td>YES or NO</td>
</tr>
<tr>
<td>if &quot;NO&quot;, is IV sedation present? YES or NO</td>
<td>YES or NO</td>
<td>YES or NO</td>
<td>YES or NO</td>
</tr>
<tr>
<td>7. Nursing concerns (secretions, adequate cough, AMS, other?)</td>
<td>YES or NO</td>
<td>YES or NO</td>
<td>YES or NO</td>
</tr>
</tbody>
</table>

If NO to any question: STOP! Otherwise ALWAYS proceed to Screen #2

<table>
<thead>
<tr>
<th>Screen #2: Rapid Shallow Breathing Index: Place patient in “Spontaneous” mode at 100% Tube Comp. Start measurement 1 minute after setup. Record results below:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory rate/tidal volume ratio (f/Vt) of 105 or less (Vt in liters)</td>
</tr>
<tr>
<td>f/ Vt:</td>
</tr>
<tr>
<td>Tent meets criteria for Spontaneous breathing Trial (SBT)</td>
</tr>
</tbody>
</table>

Proceed to Spontaneous Breathing Trial (SBT)

SBT: Spontaneous breathing for 120 minutes through ventilator on 100% Tube Comp or 5 cm H2O PEEP.

If YES, MD contact time:

SBT: Time started: Time ended: Time started: Time ended:

Reason for NO SBT if criteria met

SBT results Pass or Fail Pass or Fail Pass or Fail

When SBT complete, place on minimal ventilator settings necessary for patient comfort.

**Terminated due to**
- RR > 35 breaths/min for 5 min or more
- SaO2 < 90%
- HR > 140/min or sustained increase of 20% above baseline
- Systolic BP > 180 mm Hg or < 90 mm Hg
- Increased anxiety

**SBT FAILURE X 3 DAYS**

Auditory leak? Yes or No Yes or No Yes or No

If auditory leak, record 6 raw volume leaks to calculate % leak

Leak: A/C, Vt 10 ml/Kg, cuff deflated, Vt vol. Lost* Leak: % Leak: Leak: % Leak: Leak: % Leak:

**MD must be contacted and present prior to extubation (Please note MD and time contacted)**

MD: Time: MD: Time: MD: Time:

Reason for NOT extubating if all criteria met Yes or No Yes or No Yes or No
FEVER IN THE ICU

- Fever is very common in the NSICU. The source of fever often cannot be determined. Temperature dysregulation due to the underlying lesion is a diagnosis of exclusion. Evaluation for infectious causes is nearly always in order.
- The orders guide the nurses to obtain urinalysis, urine, sputum and blood cultures when the patient’s temperature is >38.6°C, once every 48-72 hrs. A CXR should not be ordered on every ICU patient; order it if needed.
- Blood cultures are drawn into two sets (aerobic and anaerobic) from separate peripheral sites. Blood cultures are not drawn from indwelling lines unless they just have been placed.
- Routine changes of intravascular catheters are not recommended except for Cool Line catheters (see below).
- Catheter tips should not be routinely cultured.

Common causes of fever:

- **Infectious causes:**
  - Intravascular catheter (phlebitis, bacteremia, septicemia, fungemia, endocarditis)
  - EVD-related (ventriculitis)
  - Meningitis
  - Respiratory tract infection (bacterial and fungal)
  - Wound infection
  - Intra-abdominal (acalculous cholecystitis, diverticulitis, *C. difficile* colitis)
- **Noninfectious causes:**
  - Drugs (phenytoin, glycopyrrolate, vancomycin)
  - Venous thrombosis, pulmonary embolism
  - Withdrawal syndromes
  - Vasospasm in subarachnoid hemorrhage
  - Central/peripheral temperature dysregulation (Dysautonomia)
  - SAH, TBI, ICH, SCI, intraventricular dysregulation
  - Pancreatitis

Clinical assessment:

- Examine the patient specifically looking at:
  - Vascular catheter insertion sites
  - Evidence of a rash
  - Nuchal rigidity/AMS
  - Calf tenderness of leg swelling
  - Lung sounds and secretions
  - Abdominal examination
  - A new murmur
- Order CXR, if has not been done recently
- Testing of CSF from an EVD is sometimes indicated. The Neurosurgery service will obtain CSF from the catheter.
- If the patient has diarrhea, check stool for *C. difficile* toxin daily for three days.
If no source is apparent on the initial workup, you may consider:
  o Abdominal US for cholecystitis (especially if LFCT’s are abnormal)
  o Abdominal CT for evidence of an intraabdominal source of infection
  o Lower extremity Dopplers for DVT (or upper if appropriate)
  o Lumbar puncture (patients with CSF leak or recent craniotomy)

Consider discontinuing medications that are possible culprits, especially phenytoin.

An IV line inserted > 48 hrs ago with signs of local infection and/or bacteremia should be removed.

The extent of fever workup depends on patient’s clinical picture and your level of suspicion for infectious etiology.

Empiric broad-spectrum antibiotics may be warranted for febrile hypotensive patients while awaiting workup results. A combination of vancomycin* and cefepime* is a reasonable starting point.

Specific scenarios:

**Positive blood cultures**:

Positive blood culture deserves immediately assessment. Repeat cultures should be sent regardless of antimicrobial treatment prior to initiation.

  o Isolation of gram-negative bacilli from blood cultures usually represents true bacteremia or septicemia. Initiate therapy before the organism has been identified. Cefepime is a good choice.
  o Gram-positive cocci are usually *S. epidermidis, S. aureus* or *Enterococcus* spp. pending appreciation, empiric therapy with vancomycin* is usually appropriate depending on clinical picture. Intravascular catheters should be changed after 24 hrs of antimicrobial treatment.
  o *S. epidermidis* may represent contamination (if it grows from only one site) or true bacteremia. Shunt infections are also commonly due to *S. epidermidis*. Antibiotic therapy should be stopped if repeat cultures are negative.

**VAP** is associated with a high mortality. It usually occurs >48 hrs after intubation. Pneumonia is diagnosed based on a combination of fever, a new persistent infiltrate on CXR, purulent secretions and the results of sputum culture. Organisms isolated from sputum containing a large number of epithelial cells and few PMN leukocytes, may represent oral flora and not true pathogens. The usual pathogens are *S. aureus* (possibly ORSA), *P. aeruginosa* and Gram-negative enteric flora. If VAP is suspected, start empiric therapy with vancomycin* and cefepime* until the pathogen is identified.

**Aspiration. Prophylactic antibiotics are not recommended** for patients with a suspected or witnessed aspiration or in patients, who develop aspiration pneumonitis (fever, leukocytosis or a pulmonary infiltrate shortly after aspiration). If patient has small bowel obstruction, or is stress ulcer prophylaxis with gastric pH>5-7 or aspiration pneumonitis does not resolve in 48 hrs, start piperacillin/tazobactam. For those patients, who have been in a health care facility for a prolonged period, use cefepime instead. **Anaerobic coverage** is required only for patients with severe periodontal disease or alcoholisms.

**UTI**: bacteriuria without pyuria does not require antibiotics. All isolates of >100K colonies should be treated. Usual duration of treatment for catheter-associated UTI is 5-7 days.

  o Patients with UTI due to especially virulent strains (*P. aeruginosa, Acinetobacter spp, and S. aureus*) with colony counts of >10K should be treated
  o Do not use broad-spectrum antibiotics (levofloxacin or ciprofloxacin) unless treating resistant organisms.
  o Empiric coverage should be:
    ▪ Ampicillin or vancomycin* for isolates with Gram-positive cocci
- Bactrim* or gentamicin* for isolates with Gram-negative rods
  - Options for treating Candida with pyuria include:
    - Changing the catheter
    - Fluconazole 200 mg single dose followed by 100 mg daily for 4 days

- **CNS infections** are discussed in the section on neurologic and neurosurgical conditions.
- **Persistent fever:** hyperthermia could exacerbate neurologic damage. Aggressive fever control is especially important during the ongoing risk of CNS injury (vasospasm after SAH).
  - Febrile patients with an **acute** CNS injury are initially treated with acetaminophen as needed. Those requiring repeated doses should be placed on schedule acetaminophen 650 mg q4hrs (decrease dose or avoid in cases of active liver disease).
  - For persistent fever, add ibuprofen 400 mg q4hrs, both drugs given simultaneously. Exercise caution when administer ibuprofen to patients with intracranial hemorrhage, severe coagulopathy, renal disease and active peptic ulcers or neurosurgery patients. For all patients on scheduled antipyretics especially cultures, CXR and testing CSF (when appropriate).
PROCEDURES

GENERAL PRINCIPLES:
An assent from the patient/family is obtained (except emergencies) for central lines, EVD placement, Swan-Ganz catheterization, cardioversion, and lumbar puncture.

- **STERILE CONDITIONS ARE ESSENTIAL:**
  - Wash hands
  - Wear a sterile gown, hat and mask for all central line placements
  - Prep the skin widely. Use Chlorhexidine for all procedures except LP’s (betadine should be used)
  - Drape widely with sterile sheets (full body drape)
  - Time out

- **SEDATION AND ANALGESIA:**
  - Provide adequate sedation and analgesia for all procedures. Sedate intubated patients to the point of immobility.
  - **Always use short-acting drugs.** Commonly used drugs are fentanyl (25-100 mcg IV) for analgesia/sedation and midazolam (1-4 mg IV) for sedation/amnesia.
  - Watch blood pressure and respiratory status very closely. Monitor ETCO₂/minimally ventilated patients on CPAP and consider placing them on SIMV if ETCO₂ rises until sedation wears out.

- Write a procedure note in Cerner including:
  - Indication for the procedure
  - Documentation of sterile technique
  - Type of sedation and analgesia used
  - A brief description of the procedure
  - Any complications noted
  - If a CXR was ordered and the results of it
  - If the fellow/attending supervised the procedure

- **ARTERIAL LINES:**
  - Ensure that the nurse has the pressure monitoring system ready before placing the line.
  - **Should be done as a sterile procedure (gown, gloves, hat, mask, proper hand washing technique).**
  - Radial artery is the preferred site. Use the 20G radial artery catheter. Suture the catheter securely to the skin. Agitated patients should have the catheter placed somewhat more proximally.
  - For femoral artery approach, use a single lumen central venous catheter. Your insertion site should be 2 cm below the inguinal ligament.
  - **DO NOT DILATE THE ARTERY.**

Central lines (see Appendix F for subclavian line guidelines):
- Do not attempt subclavian or internal jugular lines unless the fellow/attending has approved you to perform these procedures independently. Place a femoral line instead.
- Subclavian triple lumen catheters (TLC) are preferred. Internal jugular and femoral lines are the subsequent choices.
• For patients with increased ICP, consider pretreating with mild transient hyperventilation (pCO₂ 35-38) or mannitol 0.25-1g/kg IV.
• If the patient has an EVD, it should be clamped.
• Remember to unclamp it once finished procedure.
• If you placed a line into the subclavian artery, DO NOT REMOVE THE CATHETER and call a stat Vascular Surgery consult.
• If replacing lines, do not remove the old line until good positioning and lack of complications confirmed by CXR.
• If replacing TLC with a Swan-Ganz introducer sheath (Cordis), use a long guidewire available in the line cart. The guidewire in the Cordis introducer kit is not long enough for this procedure.

Lumbar puncture:
• The kits are located in the clean utility room. If the patient has a ventriculostomy, remember to clamp it when placing the patient flat; unclamp when done. Remember to measure and document opening pressure (lying position).

Intubation:
• Residents should not attempt intubation unless supervised by Anesthesiology/ENT, ICU fellow/attending except for life-threatening situations.
• Call Anesthesiology/ENT for all intubations at night unless it is a safe mask ventilated with an oral or nasal airway in place until experience help arrives.
• Refer to the Respiratory issues section for guidelines.
DRUGS, DRIPS AND DOSES

NERVOUS SYSTEM

Sedatives, anxiolytics, antipsychotics, paralytics:

Before sedating a patient, the following issues should be considered:

- What is the goal of sedation? Is it to prevent the patient from pulling out the lines, for ICP control or to facilitate performing a procedure?
- For how long will the patient need to be sedated?
- How worried are you about a neurologic deterioration that would be difficult to detect due to sedation?
- How likely is it that pain is contributing to the patient’s agitation?

Commonly used agents:

- **Propofol** is routinely used in our unit (5-80 mcg/kg/min, titrate by 5mcg/kg/min every 5 minutes) It is an ultra-short acting sedative agent, clears rapidly following short infusions. It may produce hypotension (especially with boluses, so avoid this practice). Monitor triglycerides and adjust caloric intake as necessary when using infusions, 1ml provides 1.1 kcal.
- **Opioids:** fentanyl is shorter-acting and less likely to produce hypotension than morphine. In rare cases, it may elevate ICP. It is well absorbed from IM injections. For more sustained analgesic effect, use morphine. Some patients may require large doses, and it is important to assess whether the patient is receiving adequate relief of pain. These agents decrease GI motility. All patients on large doses of narcotics should be prescribed bowel stimulants unless contraindicated.
- **Benzodiazepines** reduce anxiety and in larger doses produce sedation; they are well absorbed from IM injections. They have no analgesics properties. (Do not use in TBI patients unless for EtOH withdrawal.)
  - **Midazolam** – short acting (1-2 hrs) a more rapid onset
  - **Lorazepam** – longer acting (4-6 hrs), intermediate onset.
  These two agents are preferred for a sedating infusion.
- **Antipsychotics** such as Haldol, haloperidol may be used for delirium but may lower the seizure threshold. Check EKG frequently and stop these agents if QTc is >480 msec. K and Mg levels must be kept normal to avoid lethal arrhythmias.
- **Trazodone** (an antidepressant) may sometimes be used for agitated and aggressive behavior in patients with TBI.
- **Rocuronium** can be safely used for intubation including the patients with diseases of the neuromuscular junction.
- **Vecuronium** may be used for long-term postintubation paralysis (e.g. patients with ARDS)
- **Cisatracurium** may be preferred if organ dysfunction because its metabolized independent of organs by plasma esterases

Typical scenarios:

- Severe TBI, intubated, elevated ICP – continuous infusion propofol, morphine or fentanyl. (Do not use benzodiazepines except for EtOH withdrawal.)
- Postoperative patient who must remain intubated overnight – use intermittent boluses of morphine or midazolam. Be sure to stop them early in the morning to get the patient ready for extubation.
- CT scan, MRI procedures – bolus of fentanyl and/or midazolam.
- Difficulties oxygenating a patient with ARDS – benzodiazepine drip and neuromuscular blockade.

**Clinical pearls:**
- If recommended doses do not achieve your goal, stop and consider why. Is the IV line working? Is the infusion pump programmed correctly? Some patients need larger doses. Increase the dose to get the desired effect as long as you are not producing undesirable side effects.
- **Empiric treatment of alcohol withdrawal** should be used sparingly. Use of sedatives can potentially lead to oversedation and failure to recognize a neurologic deterioration. Clonidine can dramatically lower blood pressure and should be used cautiously. In most cases, it is the best to monitor the patient for signs of withdrawal. Use PRN benzodiazepines to treat.
- If the patient is requiring frequent doses, an infusion would be easier for the nurses and therefore for you.
- Opioids and benzodiazepines when used together are synergetic. Ensure that analgesia has been achieved when sedating patients. When using these two classes of drugs together, prescribe a fixed rate of one and titrate the other to the desired RASS score (see Appendix B).
- Monitor for hypotension and respiratory depression at all times when using these agents. Look for rises in ETCO₂ and consider SIMV in mechanically ventilated spontaneously breathing (on CPAP) patients.
- Benzodiazepines can be reversed with flumazenil. Do not use in patients with seizures or alcohol withdrawal.
- Opioids can be reversed with naloxone.

**Doses:**
- Common PRN doses (the NSICU nurses are very careful to avoid oversedation, so give wide dose range and short intervals. This allow flexibility in administration):
  - **Midazolam** IV: 1-5 mg IV q30 min
  - **Lorazepam** IV: 2-5 mg IV q30 min, PO: 1-10 mg/day in 2-4 div doses
  - **Morphine** IV: 1-5 mg q30 min
  - **Fentanyl** IV: 25-100 mcg q30 min
  - **Haloperidol** IV: 2.5 – 5mg every 4 hours
  - **Ziprasidone (Geodon)** IM: 10-20 mg IM q2hrs PRN for agitation (max 40 mg/day)
  - **Quetiapine** PO: 25 mg every 12 h. Max 800 mg/day
  - **Risperidone** PO: 1-2 mg every 12 h. Max 16 mg/day
  - **Trazodone** 100 mg PO/NG at bedtime, increase by 50 mg every 3 days, max 400 mg
  - **Flumazenil** 0.2 mg, repeat if needed
  - **Naloxone** 0.4 mg, repeat if needed
  - **Rocuronium** 0.6 mg/kg
- Whenever an order is written for an infusion of sedative medications, a target RASS scale must be specified. In most cases, it is appropriate to specify a RASS of -1 to -2 (refer to Appendix B). Common starting doses are:
- **Propofol**: 5-80 mcg/kg/min, titrate slowly
- **Morphine**: 4-10 mg/hr
- **Fentanyl**: 25-200 mcg/hr
- **Midazolam**: 2-5 mg/hr
- **Lorazepam**: 1-10 mg/hr
- **Vecuronium**: 0.1 mg/kg bolus, followed by 1 mcg/kg/min infusion, titrate to 1-2 twitches on a train of four.
ANTICONVULSANTS

Levetiracetam (Levetiracetam):
- Starting dose 500 mg PO/NG/IV q12hrs. Routinely used for 7 days in SAH patients without witnessed seizure.

Fosphenytoin:
- **Loading dose** (20 mg/kg), can repeat 10 mg/kg for status epilepticus. For IV loading, use a slow infusion (max: 150 mg/min); check level 24 hrs after the loading dose is completed, recheck in 2 days. (Levels can be checked 6-8 hrs after an oral load.)
- **Maintenance dose** (5 mg/kg/day)
  - IV – 2-3 divided doses (usual dose 200 mg q12 hrs)
  - PO (Phenytoin) – extended release capsules (usual dose 200 mg q12hrs)
  - NG – 30% higher dose than PO; q12 hrs; (usual dose 300 mg q12 hrs)
- Repeat drug level in 2-3 days. If low, consider reloading and **increasing the maintenance dose**.
- Therapeutic range for total phenytoin level is 10-20 mg/L, for free phenytoin level 1-2 mg/L.

Valproic acid:
- Loading dose: 25 mg/kg IV.
- Maintenance dose (20-60 mg/kg/day) given IV/PO/NG in 2-4 divided doses.
- Follow platelet count and LFT’s, NH3; Target levels of 50-150.

Lorazepam:
- 2-4 mg IV may repeat to a total of 0.1 mg/kg.

STEROIDS

Dexamethasone:
- 2-10 mg IV/PO/NG q 6-12 hrs.

Methylprednisolone:
- For spinal cord injury: 30mg/kg IV bolus, then infusion at 5.4 mg/kg/hr for 24 hrs.
- For post-extubation stridor prevent: 20 mg IV q 4 hrs x 4 doses starting at 8PM night before planned extubation.

MANNITOL AND HYPERTONIC SALINE (23.4%)
- Mannitol is a safe and effective means of lowering ICP and reducing cerebral edema in almost any setting.
- In a rapidly deterioration patient with cerebral edema, an IV bolus of 0.25 - 1 g/kg should be given immediately while evaluating and stabilizing the patient.
- If mannitol is used for ICP control (ICP monitor placed), it should be administered PRN rather than scheduled. If the patient requires regular doses, order scheduled mannitol at 0.25-1 g/kg q3-6 hrs.
- If mannitol is not cleared between doses, it can lead to worse cerebral edema. Use the osmotic gap (measured – calculated osmolality = (Na x 2) + (BUN/2.8) + (glucose/18).
- In cases of a rising osmotic gap (>18-20) indicating retained mannitol, use a lower dose or a wider interval, or switch to hypertonic saline (see below).
- Patients on standing doses of mannitol should have a daily Mg, PO4 and measured osmolality checked. For those receiving higher doses, q12 hrs osmolality is required.
- While treated with mannitol for cerebral edema, keep patient’s fluid balance even to slightly negative.
- Use caution when administering mannitol to patients with creatinine may be an indicator of renal failure. Stop mannitol.
- If the patient does not tolerate mannitol or is hemodynamically unstable, consider hypertonic saline (3% 4ml/kg, 7.5% 2ml/kg, or 30-60 ml of 23.4% saline).
- 0.686 ml of 23.4% saline is equiosmolar to 1 g of mannitol. Hypertonic saline should ALWAYS be given through a central line.

Nimopidine:
- 60 mg PO/NG q4h for 21 days vasospasm in ALL patients with SAH.

Vasopressin:
- 5-10 units IV for diabetes insipidus. Repeat as needed when UOP rises.

DDVAP:
- IV: 1 – 2 mcg as needed for UOP>300 q6-12 hrs, urine SG<1.003.
- PO: 0.1-1.2 mg/day in 2-3 divided doses

Pyridostigmine (Mestinon):
- 30-60 mg q4-6 hrs.

CARDIOVASCULAR SYSTEM

Vasopressors and inotropes:
- Whenever possible, all Vasopressors and inotropes should be administered through a central line. An arterial line is usually required for continuous blood pressure monitoring. If the lines are not present, the infusion should be started via a peripheral line in order to stabilize the patient while central and arterial lines are being placed.
- When beginning any vasopressors the infusion should be increased rapidly, (double the dose every 2-5 min) in order to achieve a predefined target blood pressure.
- Usual doses are (variable dose range, titrate to effect):
  - Dopamine 1-20 mcg/kg/min
  - Norepinephrine 2-80 mcg/min
  - Phenylephrine 10-200 mcg/min
orders should be written to titrate the drip to a MAP goal with an upper and lower limit. Specify a starting dose and a high dose for notification (e.g. “start dopamine at 5 mcg/kg/min, titrate to keep MAP 110 to 120, call HO if dose is above 20 mcg/kg/min”).

- Dobutamine is not a vasopressor and orders should be written for fixed dose with the physician making changes as indicated. The usual dose is 2-20 mcg/kg/min.

**ANTIARRHYMICS**

**Amiodarone:**
- IV load: 150 mg over 10 min, then 1 mg/min for 6 hrs, then 0.5 mg/min for 18 hrs. May repeat bolus if a fib reappears during the infusion.

**Digoxin**: 
- IV load: 0.5-1 mg (give 1/2 a dose initially, then two 1/4 doses 6 hrs apart).
- Maintenance:
  - IV 0.125-0.25 mg qd.
  - PO 0.125-0.5 mg qd.

**Diltiazem:**
- IV load: 0.25 mg/kg, may repeat 0.35 mg/kg IV after 15 min. IV infusion: 5-15 mg/h.
- Oral dose (mg/day = {IV rate (mg/h) x 3 + 3} x 10 (usually 30-60 mg q6 hrs immediately release).

**Esmolol:**
- IV infusion: 25-300 mcg/kg/min.

**Metoprolol:**
- IV load: 5 mg IV 3 doses 2 min apart.
- Maintenance: 100-200 mg/day PO in 2-4 divided doses.

**ANTITHROMBOTICS**

**Clopidogrel (Plavix):** 75 mg PO daily.
**ASA:** 325 mg PO daily.

**ANTIHYPERTENSIVES**

**Labetalol:**
- 10-20 mg IV q 10 min.

**Nicardipine:**
- IV infusion starting at 5 mg/h; increase by 2.5 mg/h q15 min to a max of 15 mg/h. Once BP controlled for 2 hrs, decrease dose to 2.5 mg/h
Hydralazine:
- 10-20 mg IV q6 hrs.

**Nitroprusside**
- 0.25 mcg/kg/min – 10 mcg/kg/min, titrate by 0.25 mcg/kg/min to avoid abrupt changes in BP/ICP. Avoid in patients with renal dysfunction.

**BICARBONATE DRIP AND ACETYLCYSTEINE**
- Used to reduce the incidence of contrast-induced nephropathy in patients at risk, including those with renal insufficiency [Cr>1.2], above 75 yrs of age or diabetics.
- One liter D5W mixed with 3 ampules of sodium bicarbonate should be given at 3 ml/kg for 1h prior to the contrasted study, then 1 ml/kg/hr during the procedure and for 6 hrs afterwards.
- Acetylcysteine (mucomyst) 20% solution PO/PT q12 hrs 4 doses, ASAP (ideally should be started 24 hrs prior to angiography).

**RESPIRATORY SYSTEM**

**Bronchodilators:**

**Albuterol:**
- 2.5-5 mg neb (repeat as often as needed unless tachycardia or hypertension) or @-4-8 puffs MDI q4-6 hrs PRN.

**Ipratropium (Atrovent):**
- 0.5 mg neb or 4 puffs MDI q4-6 hrs PRN.

**Others:**

**Glycopyrrolate (Robinul):**
- IV: 0.1-0.2 mg IV
- PO: 1-2 mg q8-12 hrs

**Racemic epinephrine:**
- 0.5-1 ml neb (repeat as often as needed unless tachycardia or hypertensions)

**GASTROINTESTINAL SYSTEM**

**Metoclopramide* (Reglan):** 10-20 mg NG/IV q6 hrs

**Ondansetron (Zofran):** 4 mg IV PRN q 6 hrs

**Famotidine* (Pepcid):** 20 mg PO/IV q12 hrs

**Esomeprazole (Nexium):** 20-40 mg daily

**Senna:** 15 ml q12-24 hrs

**Psyllium (Metamucil):** 1-2 packets QD-TID

**Bisacodyl (Dulcolax):** 5-10 mg PO or 10 mg PR

**APPENDICES:**
APPENDIX A:

Common scales to grade SAH:

- **Hunt Hess Scale** (clinical grading of SAH)
  I. Asymptomatic or mild headache
  II. Moderate to severe headache, nuchal rigidity with or without focal deficits
  III. Confusion, lethargy or mild focal deficits
  IV. Stupor and/or hemiparesis
  V. Comatose and/or extensor posturing

- **Fisher Scale** (based on initial CT appearance of SAH)
  I. No blood
  II. Diffuse or thin layer of blood (<1 mm thick)
  III. Localized clots and/or >1 mm thick layer of blood
  IV. Intraventricular or intracerebral blood without significant thick subarachnoid blood
APPENDIX B:

Richmond Agitation Sedation Scale (RASS)

Score Term Description
+4 Combative Overtly combative, violent, immediate danger to staff
+3 Very agitated Pulls or removes tube(s) or catheter(s); aggressive
+2 Agitated Frequent non-purposeful movement, fights ventilator
+1 Restless Anxious but movements not aggressive vigorous
0 Alert and calm
-1 Drowsy Not fully alert, but has sustained awakening
 (eye-opening/eye contact) to voice (>10 seconds)
-2 Light sedation, Briefly awakens with eye contact to voice (<10 seconds)
-3 Moderate sedation Movement or eye opening to voice (but no eye contact)
-4 Deep sedation No response to voice, but movement or eye opening to physical stimulation
-5 Unarousable No response to voice or physical stimulation

Procedure for RASS Assessment
1. Observe patient
   a. Patient is alert, restless, or agitated. (score 0 to +4)
2. If not alert, state patient’s name and say to open eyes and look at speaker.
   b. Patient awakens with sustained eye opening and eye contact. (score –1)
   c. Patient awakens with eye opening and eye contact, but not sustained. (score –2)
   d. Patient has any movement in response to voice but no eye contact. (score –3)
3. When no response to verbal stimulation, physically stimulate patient by shaking shoulder and/or rubbing sternum.
   e. Patient has any movement to physical stimulation. (score –4)
   f. Patient has no response to any stimulation. (score –5)

APPENDIX C:

Glasgow Coma Scale (best function):

- **Eye opening:**
  1. None
  2. To pain
  3. To voice
  4. Spontaneous

- **Verbal:**
  1. None
  2. Incomprehensible
  3. Inappropriate
  4. Confused
  5. Oriented

- **Motor:**
  1. None
  2. Extends
  3. Flexes
  4. Withdraws
  5. Localizes
  6. Follow commands
APPENDIX D:

Apnea testing
- Pre-oxygenate patient with 100% FiO₂. Assure that pCO₂ is normal, pulse oximetry is being monitored and BP is checked at least every 2 min.
- The patient should be disconnected from the ventilator and passively oxygenated with 2-L/min of oxygen via a catheter placed in the airway. Closely observe the patient for spontaneous ventilation. Be prepared for a BP drop.
- After 10-15 min, an ABG should be obtained. If pCO₂ ≥ 60 and pH ≤ 7.3, apnea has been established and the patient may be declared brain dead. Otherwise, continue with apnea test.
- If oxygen saturation drops during apnea testing, increase oxygen flow and apply PEEP by occluding the endotracheal tube with tape.

APPENDIX E:

Subclavian line placement guidelines
- Explain procedure to the patient/family, obtain assent.
- Bring all supplies and equipment to the bedside. Ascertain if the patient has Lidocaine allergy. If the patient is in contact isolation, do not bring the line cart into the room; wear an isolation gown and gloves upon entering.
- Place a rolled towel between the scapulae with the head turned away from the insertion site for a subclavian line. Do not excess hair, remove it with scissors.
- Wash hands for at least 30 seconds and turn off the faucet with a paper towel.
- Put on a hat, mask, sterile gown and sterile gloves. All personnel entering the room must have a mask and hat on. Minimize entering personnel, close the door.
- Cleanse area with Chlorhexidine from the central line kit. If inserted Cool Line, use Chloraprep. The area to be prepped should extend from the intended site of insertion to a radius of 15 cm. air dry, no blowing, fanning or waving.
- A sterile fenestrated full body drape should be applied. Cool Line kit does not have a long drape; non-fenestrated drapes are available on the line cart.
- Inject local Lidocaine. Flush the catheter with saline, prepare the guidewire and dilator.
- Place the patient in a supine Trendelenberg position of at least 15 degrees if ICP is normal. If ICP elevated, consider pretreating with mild transient hyperventilation (pCO₂ 25-30) or mannitol 0.5 g/kg IV.
- Use sterile technique for line insertion, suturing and applying a transparent dressing. If visible blood around the insertion site, remove it with sterile gauze before applying the dressing. Do not use any antimicrobial preparations.
- If the catheter is placed into the subclavian artery by accident, do not remove the catheter and obtain a stat Vascular Surgery consult/
- Dispose of all sharps in the needle disposal box, bloodstained equipment in the red biohazard bag.
- Order STAT portable CXR, confirm line position, notify nurses that the line is OK to use.

APPENDIX F:

Telemetry indications
- Atrial fibrillation or flutter
- Arrhythmia old or newly diagnosed
- Pacemaker
- Syncope
- Falls of unknown cause
- Newly prescribed cardiac or antihypertensive medication
APPENDIX G:
Screening for Swallowing Capability (Stroke and SAH)

Patient is NPO (for all oral medication, fluid, and food) until screened.
Perform screening tasks in order and do not skip any questions; stop when instructed to do so.
Note that other factor besides those listed below may preclude safe swallowing.

<table>
<thead>
<tr>
<th>SECTION ONE: Screening for Dysphagia</th>
</tr>
</thead>
<tbody>
<tr>
<td>If “Yes” is the response to statement 1 below, STOP the screening. The patient remains NPO for all oral medication, fluid, and food until able to be tested for swallowing. If the response is “No” in Section One, proceed to Section Two.</td>
</tr>
<tr>
<td>1. Decreased level of consciousness, unable to follow commands, or severely agitated</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECTION TWO: Screening Procedure for PO Medication Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>If “Yes” is the response to either of the statements 2 or 3, STOP the screening. The patient remains NPO until evaluated by a MD, PA, NP or Speech-Language Pathologist. If the response is “No” to all of the statements below, the patient is NPO except for medication with sips of water.</td>
</tr>
<tr>
<td>2. Give patient a sip (approximately 1 teaspoon) of water to drink Observe for the following: Choking, coughing, drooling, gurgling before, during or after swallow, delay in swallowing, effortful swallow, other signs of swallowing problem, pocketing liquid in mouth or wet voice after the swallow.</td>
</tr>
<tr>
<td>3. Give patient a half a cup (approximately 60 ml) of water to drink. Let patient drink at own rate Observe for the following: Choking, coughing, drooling, gurgling before, during or after swallow, delay in swallowing, effortful swallow, other signs of swallowing problem, pocketing liquid in mouth or wet voice after the swallow.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECTION THREE: Screening Procedure for PO Food or Fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td>If “Yes” is the response to any of the statements 4-7, STOP the screening. The patient remains NPO for food and fluid until evaluated by a Speech-Language Pathologist or physician. If the response is “No” to all of the statements below, the patient may have a PO diet.</td>
</tr>
<tr>
<td>4. Patient has aspiration pneumonia</td>
</tr>
<tr>
<td>5. Prior to admission, patient or caregiver reports difficulty swallowing medications, liquids or solids, or coughing/choking episodes when eating</td>
</tr>
<tr>
<td>6. Voice has a weak vocal quality (hoarse, wet gurgly voice), or patient has no voice</td>
</tr>
<tr>
<td>7. Unable to volitionally cough, or abnormal cough, or unable to manage saliva, or excessive drooling or thick profuse secretions</td>
</tr>
</tbody>
</table>

**Relative contraindications for PO food and fluid:**
The following statements 8-11 are relative contraindications for PO food or fluid, depending on severity of impairment.

| 8. Facial droop, asymmetry of facial features, or inability to close lips or fully retract lips into a smile | ☐ Yes  ☐ No |
| 9. Tongue deviation from midline on protrusion, or inability to protrude tongue | ☐ Yes  ☐ No |
| 10. New onset slurred speech (dysarthria) | ☐ Yes  ☐ No |
| 11. Oral pocketing | ☐ Yes  ☐ No |
1. First meal given to patient should be observed by a nurse or other qualified care provider.

2. If patient has any difficulty swallowing during meal, make NPO.

3. Have the patient in an upright position while eating or drinking.

4. Keep patient in an upright position at least 30 minutes after eating or drinking.

5. Have patient eat slowly and take small bites of food and chew well before swallowing.

6. Have patient take small sips of liquid.

7. No straws for drinking liquids.

8. Minimize distractions while patient is eating or drinking.


10. Have bedside suction equipment available at all times.

11. Consult physician for signs or symptoms of aspiration pneumonia.
APPENDIX H:

NSICU Bowel Management Protocol

This protocol is a set of guidelines to help patients to avoid constipation and diarrhea in a surgical ICU. We should follow it for all patients especially those who have narcotics ordered whether that is scheduled or PRN. It also serves as guidelines for Spinal Cord Injuries and head injured patients.

Admitted to NSICU < 48 hours or 65 and older
(Pt not on narcotics):
1) Docusate 100mg every 12hr

PRN: Senna 1 Tablet PO at bedtime
Psyillium 5.85g packet three times a day
MOM concentrate 10ml
Bisacodyl 1 suppository every 12hr or daily

Admitted to NSICU > 48 hours:
1) Docusate 100mg every 12hr
2) Senna 1 tab every night

PRN: Bisacodyl 1 suppository daily (up to double dose if needed)
Psyillium 5.85g packet three times a day
MOM concentrate 10 ml every 12 hours
Bisacodyl 1 Suppository every 12hr or daily

Daily Assessment should include but not limited too:
Bowel sounds
Amount of NG aspirate
Visible peristalsis
LBM (if diarrhea state color, consistency & quantity)
**Constipation**

**Having less than 3 BM’s per week.**

**Assess patient for:**
- Assess LBM and patient normal BM pattern
- Assess for Feedings, Tube feeds or PO
- Assess GI system for Bowel Sounds, tenderness, high residuals, distended abdomen
- Assess for excessive use of pain medication

**Possible causes:**
- Iron, Antidepressants, anti-seizure meds.
- Endocrine, electrolytes.

**If all are within normal limits and last BM was >2 days:**

**Then start constipation relief:** (do not do all at once)
- Mobilization of patient.
- 2 Biscodyl suppositories
- Disimpaction
- MOM concentrate 10ml
- Docusate
- Senna
- Fleets enema/ soap suds enema
- Mag citrate
- Electrolyte replacement.
- Mobilization of patient.

**Prevention:**
- Make sure patient is getting at least 1.5 liters of fluid each day.

**S/S:** vomiting, restlessness

**Complications:** Perforation, prolonged ventilation, delay in nutrition, hemorrhoids, ileus, and rectal tear.

---

**Diarrhea**

**Any loose stool or watery stools at least 3X per day or in daily volumes of at least ½ liter (about 2 cups) for 2 consecutive days or more.**

**Assess patient for:**
- Urinary retention/ Distended bladder
- Use of antibiotics
- Medications- Reglan, etc
- Sorbitol based medication
- Some cardiac meds
- Acute infections
- Phosphate level/ refeeding syndrome

**C-Diff**
- Lactose Intolerance (use lactaid if pt taking PO Calcium)
- (our TF’s do not contain lactose)
- Hypoalbuminanemia
- Cardiac meds such as digoxin
- Fecal incontinence
- Impaction
- Magnesium replacement
- K+ and Phos replaced( make sure properly diluted)
- Sepsis

**If these are normal then start anti-diarrhea medications such as:**

1) Psyillium 5.85g packet three times a day
2) Lactobacilius (consider use with patient on antibiotics)
3) Assess for potential need for re: hydration
4) Hold caffeinated products

**Hold BM meds if patient is having diarrhea.**
- Protect skin w/ Barrier cream.

**Assess need for fecal incontinence device:**
- If flexi seal is needed use only with patients with frequent liquid stools. If there is no stool within 12hrs D/C device. Please mark on bag where last stool was measured and change bag as needed.

**If C-diff is positive from lab, pt should be treated with Flagyl or Vancomycin.**

**Complications:**
- Dehydration
- Malnourished
- Skin breakdown

---

**Documentation:**

Nursing to document stools frequency, color and consistency. Also as a part of your assessment note LBM. When a patient is admitted and family is available assess and document patient normal bowel movement and daily amount. Document this on admission assessment. Also document any GI Hx such as IBS or surgeries as well as OTC drugs or aids used at home on home med sheet.

Make sure patient has privacy and proper toileting facility.
### APPENDIX I: TPA PROTOCOL

<table>
<thead>
<tr>
<th>Patient Characteristic</th>
<th>Goal blood pressure, mm Hg</th>
<th>Pharmacotherapy</th>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eligible for r-TPA</td>
<td>&lt;185/110 prior to administration</td>
<td>Labetalol 10-20mg IV over 1-2 min; may repeat x1 or Nitropaste 1-2” or Nicardipine 5mg/hr, titrate by 2.5 mg/hr every 5 min. up to 15mg/hr</td>
<td>If blood pressure does not decline and remains &gt;185/110mmHg, do not administer IV r-TPA</td>
</tr>
<tr>
<td>During and after r-TPA</td>
<td>&lt;180/105 for 24 hours following administration</td>
<td>Systolic 180-230 or diastolic 105-120: Labetalol 10-20mg IV over 1-2 min; may repeat every 10-20 min. or Labetalol 10mg IV x1 then 2-8mg/min infusion Systolic &gt;230 or diastolic 121-140: Labetalol 10-20mg IV over 1-2 min; may repeat every 10-20 min. or Labetalol 10mg IV x1 then 2-8mg/min infusion or Nicardipine 5mg/hr, titrate by 2.5 mg/hr every 5 min. up to 15mg/hr Uncontrolled by above measures: nitroprusside 0.5 mcg/kg/min</td>
<td>Monitor BP every 15 minutes during IV r-TPA treatment and then every 15 minutes for the next 2 hours, then every 30 minutes for 6 hours, then every 1 hour for 16 hours (first 24 hours after IV r-TPA)</td>
</tr>
<tr>
<td>Not eligible for r-TPA</td>
<td>&lt;220/120</td>
<td>Systolic &gt;220 or diastolic 121-140: Labetalol 10-20mg IV over 1-2 min; may repeat every 10-20 min. or Nicardipine 5mg/hr, titrate by 2.5 mg/hr every 5 min. up to 15mg/hr Diastolic &gt; 140: nitroprusside 0.5 mcg/kg/min</td>
<td>Frequent monitoring of blood pressure with goal reduction of 10-15% diastolic in first 24 hours</td>
</tr>
</tbody>
</table>
Algorithm for the management of acute ischemic stroke. : Appendix J

Acute Stroke Symptoms

1. Support airway, breathing, circulation (ABC’s)
2. Activate hospital stroke alert system
3. Provide oxygen if hypoxemic
4. Check blood glucose
5. Order emergent CT scan
6. Obtain 12-lead ECG

NINDS Time Goals
(from hospital arrival)

Within 10 minutes

1. Support airway, breathing, circulation (ABC’s)
2. Activate hospital stroke alert system
3. Provide oxygen if hypoxemic
4. Check blood glucose
5. Order emergent CT scan
6. Obtain 12-lead ECG

Within 25 minutes

1. Review history and establish time of symptom onset

Within 45 minutes

CT scan shows hemorrhage?

No

Evaluate inclusion/exclusion criteria for TPA administration.

Yes

1. Blood pressure control
2. Supportive care
3. Neurosurgery evaluation

Candidate for TPA?

No

1. Administer aspirin 325mg
2. Blood pressure management (see Appendix I)
3. Supportive care

Discuss risk/benefit with family, if acceptable:
1. Administer IV TPA if <3 hours symptom onset (consider if 3 – 4.5 hours)
2. Consider IA TPA if 3 – 6 hours symptom onset
3. Hold

Within 60 minutes

1. Blood pressure control (see Appendix I)
APPENDIX K: Algorithm for secondary prevention of stroke

Secondary Stroke Prevention

Blood pressure control
Follow JNC 7 guidelines (goal blood pressure < 140/80 mm Hg):
1. ACE-I
2. Thiazide diuretic

Lipid-lowering therapy
LDL > 100:
- Statin

Lifestyle modifications
1. Smoking cessation*
2. Limit alcohol consumption

Cardioembolic stroke?
No
Antipatelet medication at by hospital day 2 and at discharge:*
1. Aspirin 50 – 325 mg daily
2. Clopidogrel 75 mg daily

Yes
Antithrombotic medication at discharge:*
- Warfarin with goal INR 2 – 3
- Clopidogrel if risk>>benefit with warfarin

- Denotes JCAHO performance indicator.
APPENDIX L:

NEUROSURGICAL SEIZURE PROPHYLAXIS AT VCUHS

- The following recommendations are NOT for the treatment of epilepsy or seizures once they occur. They are intended to serve as literature-based recommendation for the prevention of seizures in common neurosurgical clinical scenarios.

- Appendix I include some evidence tables supporting these recommendations.

<table>
<thead>
<tr>
<th>TRAUMATIC BRAIN INJURY</th>
<th>RECOMMENDATIONS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) SEVERE TBI: 7 days Phenytoin/fosphenytoin for all severe TBI's¹</td>
<td>- Levetiracetam as monotherapy should not be used</td>
<td>- Longer courses are NOT indicated for penetrating TBI’s. If a patient has a seizure, then clinical decisions shift from prophylaxis to treatment.</td>
</tr>
<tr>
<td>*** No changes to current practice</td>
<td>2) MODERATE TBI (GCS 9-13): 7 days Phenytoin/fosphenytoin if…</td>
<td></td>
</tr>
<tr>
<td>- depressed skull fracture</td>
<td>- penetrating TBI</td>
<td></td>
</tr>
<tr>
<td>- EDH/SDH/IPH</td>
<td>- Traumatic SAH on 2 or more CT cuts (same foci)</td>
<td></td>
</tr>
<tr>
<td>3) MILD TBI (GCS 14-15): no prophylaxis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>RECOMMENDATIONS</strong></th>
<th><strong>COMMENTS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUBARACHNOID HEMORRHAGE</strong></td>
<td>3-7 days Phenytoin/fosphenytoin then stop&lt;br&gt;- Recent trend towards 3-day course however current staff prefers 7-day course until more data is accrued</td>
</tr>
<tr>
<td>1) No prophylaxis <em>unless</em> the patient presents with seizure&lt;br&gt;&lt;b&gt;PREOPERATIVELY:&lt;/b&gt;&lt;br&gt;1) Load Phenytoin/fosphenytoin 20mg/kg (check level 12 hours after loading)&lt;br&gt;2) Stop Phenytoin/fosphenytoin 7 days after surgery <em>if the patient remains seizure free</em>&lt;br&gt;3) NOT necessary for brainstem or cerebellar lesions.&lt;br&gt;- If the patient presented with a seizure then the AED should NOT be tapered off, this will be done as outpatient (again, this scenario now represents a <em>treatment</em> regimen and not a <em>prophylactic</em> one)&lt;br&gt;- With weight-based loading of Phenytoin/fosphenytoin (20mg/kg) every patient should have therapeutic levels.&lt;br&gt;- check level 12 hours after loading</td>
<td></td>
</tr>
<tr>
<td><strong>TUMOR/METS</strong></td>
<td>1) No prophylaxis for basal ganglia or cerebellar hemorrhages&lt;br&gt;2) 7 days Phenytoin/fosphenytoin for lobar hemorrhages <em>reaching cortical surface</em></td>
</tr>
<tr>
<td><strong>INTRACEREBRAL HEMORRHAGE</strong></td>
<td>1) No prophylaxis for basal ganglia or cerebellar hemorrhages</td>
</tr>
</tbody>
</table>

---


4 OPTIMIZING THERAPY OF SEIZURES IN PATIENTS WITH BRAIN TUMORS.
<table>
<thead>
<tr>
<th></th>
<th>RECOMMENDATIONS</th>
<th>COMMENTS</th>
</tr>
</thead>
</table>
| **GENERAL CRANIOTOMY** and BURR HOLE WASHOUTS | 1) No prophylaxis[^3][^4][^5]                           | - Option in high-risk patients:  
  Load Phenytoin/fosphenytoin 20mg/kg (check level 12 hours after loading).  
  Stop Phenytoin/fosphenytoin 7 days after surgery if the patient remains seizure free |
| DEEP BRAIN STIMULATION | 1) No prophylaxis                                       |                                                                          |


[^6]: ANTICONVULSANTS FOR PREVENTING SEIZURES IN PATIENTS WITH CHRONIC SUBDURAL HAEMATOMA Ratilal B, Costa J, Sampaio C Cochrane Database Syst Rev. 2005 Jul 20;(3)
### APPENDIX M:

**SELECTED EVIDENCE FOR RECOMMENDATIONS**

Table 1  Evidence based recommendations for AED prophylaxis in TBI

<table>
<thead>
<tr>
<th>Study and type</th>
<th>Results</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young et al. [8]; randomized, double-blind placebo-controlled; (n = 244)</td>
<td>No significant difference in the percentage of patients having early seizures in the phenytoin-treated and placebo groups</td>
<td>Suggested that AEDs be administered only after an early seizure has occurred</td>
</tr>
<tr>
<td>Glotzner et al. [9]; randomized, placebo-controlled trial; (n = 151)</td>
<td>Prophylaxis with carbamazepine significantly attenuated incidence of early post-traumatic seizures but not late seizures following TBI</td>
<td>Prophylactic AEDs (phenytoin and carbamazepine) recommended for up to 1 year following TBI</td>
</tr>
<tr>
<td>McQueen et al. [10]; randomized, double-blind, controlled trial (n = 164)</td>
<td>Low incidence of post-traumatic epilepsy (7% within 1 year and 10% between 1 and 2 years)</td>
<td>Larger clinical trials recommended</td>
</tr>
<tr>
<td>Temkin et al. [11]; randomized, placebo-controlled, double-blind trial (n = 404)</td>
<td>Seizure incidence of 3.6% in phenytoin-treated patients as compared to 14.2% in placebo-treated patients within 1 week of TBI</td>
<td>Phenytoin exerts a beneficial effect by reducing seizures only during the first week after severe head injury</td>
</tr>
<tr>
<td>Dickmen et al. [12]; randomized, placebo-controlled trial (n = 244)</td>
<td>In severe TBI, phenytoin significantly impaired functional performance at 1 month</td>
<td>Questions the use for long-term prophylaxis with phenytoin</td>
</tr>
<tr>
<td>Temkin et al. [13]; randomized, double-blind trial (n = 132)</td>
<td>Rates of early seizures were low and similar when using either valproate (4.5%) or phenytoin (1.5%). Trend toward a higher mortality rate in patients treated with valproate</td>
<td>Valproate demonstrated no benefit over short-term phenytoin therapy for prevention of early seizures and neither treatment prevented late seizures. Lack of additional benefit and the potentially higher mortality rate suggest that valproate should not be routinely used for the prevention of post-traumatic seizures</td>
</tr>
</tbody>
</table>

---

Table 2 Evidence based recommendations for AED prophylaxis in aSAH

<table>
<thead>
<tr>
<th>Study and type</th>
<th>Results</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baker et al. [25]; retrospective; (n = 387)</td>
<td>Postoperative AEDs instituted for 3 days. Overall seizure rate was 5.4% (early—1.5% and long-term seizure disorder—3%)</td>
<td>AEDs may be safely restricted to the immediate post-operative period</td>
</tr>
<tr>
<td>Rhoney et al. [20]; retrospective; (n = 95)</td>
<td>Pre-hospital seizure incidence—17.9%; post-hospital discharge seizure incidence—8% (50% of patients on prophylactic AEDs)</td>
<td>Majority of seizures occurred prior to medical presentation. Thickness of cisternal clot predictive of seizures</td>
</tr>
<tr>
<td>Naidech et al. [35]; retrospective; (n = 527)</td>
<td>“Phenytoin burden” associated with poor outcome at 14 days and worse cognitive outcomes at 3 months</td>
<td>Treatment with prophylactic phenytoin predicts poor neurologic and cognitive outcomes</td>
</tr>
<tr>
<td>Chumnanvej [36]; Retrospective; (n = 453)</td>
<td>Three-day treatment with phenytoin resulted in similar seizure incidence (5.7%) as those treated until discharge (4.6%)</td>
<td>Three-day regimen of phenytoin prophylaxis is adequate to prevent seizures in aSAH</td>
</tr>
</tbody>
</table>

REFERENCES:


4) OPTIMIZING THERAPY OF SEIZURES IN PATIENTS WITH BRAIN TUMORS. Vecht, Charles, MD, PhD, van Breemen, Melanie Neurology. Optimizing Therapy of Seizures in Specific Clinical Situations. 67(12) (Suppl 4):S10-S13, December 26, 2006


6) ANTICONVULSANTS FOR PREVENTING SEIZURES IN PATIENTS WITH CHRONIC SUBDURAL HAEMATOMA Ratilal B, Costa J, Sampaio C Cochrane Database Syst Rev. 2005 Jul 20;(3)
APPENDIX N:

Nutrition in the ICU

- Once fully resuscitated and hemodynamically stabilized, nutrition should be started within first 24-28 hours.
- If unable to establish feeding tolerance via gastric or intestinally, and/or access not available parenteral nutrition should be considered after the first seven days and only if duration is expected to be greater than 5 days until goal feeds are established.
- For each patient receiving TF, write and order for metoclopramide (unless contraindicated; ex. Parkinsons’). Start with 10 mg PT q 6h. For high residuals, increase 10 mg IV q 6h. As a next step, consider Erythromycin 250 mg PT q 6h, then 500 PT q 6h.
- If GI tract is functional use it!
- If pt is intubated or fails swallow screen, enteral feeds should be initiated.
- Do NOT feed pt when they are flat for a procedure or post-operatively. Head of bed needs to be elevated 30-45 degrees when feeding.
- Enteral feeds are ordered as continuous feedings around the clock. You do not need to change to intermittent feeds when they leave the ICU.
- Intermittent feeds can be helpful for patients who are extremely agitated and constantly removing feeding tubes.
- Route: Majority of patients will tolerate gastric feeds. If gastric residuals are significant >400ml and/or refractory to promotility agents consider early nasointestinal tube placement.
- Formula: Standard high protein formula is Promote. If patient requires fluid restriction, may need to change to Two Kcal HN. Recognize that Two Kcal is significantly lower in protein and will require additional protein supplementation.

<table>
<thead>
<tr>
<th>Product</th>
<th>Kcal/ml</th>
<th>CHO g/L</th>
<th>Protein g/L</th>
<th>Na mg/L</th>
<th>Water ml/L</th>
<th>mOs/kg</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promote</td>
<td>1</td>
<td>130</td>
<td>62.5</td>
<td>1000</td>
<td>839</td>
<td>340</td>
<td>High protein needs</td>
</tr>
<tr>
<td>Jevity 1.2</td>
<td>1.2</td>
<td>169.4</td>
<td>55.5</td>
<td>1350</td>
<td>807</td>
<td>450</td>
<td>General formula</td>
</tr>
<tr>
<td>Two Cal HN</td>
<td>2</td>
<td>218.5</td>
<td>83.5</td>
<td>1450</td>
<td>700</td>
<td>725</td>
<td>Fluid/volume restricted</td>
</tr>
<tr>
<td>Nepro</td>
<td>1.8</td>
<td>166.8</td>
<td>81</td>
<td>1060</td>
<td>725</td>
<td>585</td>
<td>Electrolyte restricted</td>
</tr>
</tbody>
</table>

- Unless there has been abdominal surgery/ injury this admission or pt is malnourished, feeds should be started at goal rate and not advanced slowly.
If at risk for refeeding syndrome due to malnutrition or alcoholism, initiate nutrition with less than 150gms of carbohydrate and monitor lab parameters, especially potassium, phosphorus, and magnesium closely. Supplement with daily multivitamin, thiamine 100mg and folic acid 1 mg.

Resting energy needs are calculated using Mifflin St Jeor equation using actual wt.

Men: 10 (wt in kg) + 6.25 (ht in cm)-5 (age) +5
Women: 10 (wt in kg) +6.25 (ht in cm) -5 (age) -161

Alternatively, the Penn State equation can be used in ventilated non-SCI pts to calculate resting energy expenditure and will adjust for medical management for ICP.

Mifflin St Jeor (0.96) + Tmax(167) + Ve(31) -6212

SAH, IVH, ICH, SDH are all hypermetabolic and hypercatabolic states and REE is multiplied by activity factor of 1.4 during the first 2 weeks of injury. In addition, they require increased protein requirements of 1.5-2.0 g/kg.

CVA, SCI, and other neurological diseases have the REE multiplied by activity factor of 1.25.

Feeds should be at goal rate consistently by day 7.

If unable to establish feeding tolerance via gastric or intestinally, and/or access not available consider parenteral nutrition until feeds are established.

PN orders must be ordered by 2pm daily and each new bag starts at 6pm. Patients on TPN require daily BMP, Mg and PO4. There should be one unused central line port dedicated to TPN only.

The NSICU nutritionist is available to assist with tube feeds, parenteral nutrition, and supplementation recommendations. You can page the on-call dietitian on weekends if you have questions.

TPN Guide:
Making the formula:

1. Fat: limit use in sepsis, inflammatory response or hypertriglyceridemia. Otherwise 100 ml 20% fat emulsion every day. This provides 2 kcal/ml.
2. Protein: Order in grams/liter. Maximum amount in one liter is usually 70 grams. This provides 4 kcal per gram.
3. Dextrose: makes up the remainder of calories. Divide calories by 3.4 to convert to grams of dextrose.
4. Always start with 1liter. Most patients will receive goal TPN of 2 liters and so you can divide grams by 2 for dextrose and protein to find 1liter goals.
5. If at risk for refeeding syndrome, always start with <200 grams of carbohydrate.

Lytes: Always review outside supplementation and labs for guide in ordering.
Ca: 4.8mEq is a starting point, this equals 1 gram of Ca
Mg: 8 mEq is a start, this equals 1 gram of Mg
PO4: look at lytes to figure K or Na PO4. Order 15mmol if refeeding risk. Usually ordered in multiples of 3. Each mmol gives approx 1.4mEq of Na or K
KAc or KCl: Standard TPN starts with 30mEq K.
NaAc or NaCl: Standard TPN starts at 40mEq

Additional Additives: Divide dose by number of liters desired.
  Daily MVI: 10 ml
  Trace Elements: 3 ml, if total bili is elevated give only 3 times a week or D/C
  Selenium: 60 micrograms, if renal insufficiency or failure cut in ½
  Vitamin C: 500 mg, if renal insufficiency or failure cut in ½
  Famotidine: 40mg, if renal insufficiency or failure cut in ½
  Insulin: Only add after reviewing last 24 hours usage of SSI, then add 2/3 of usage to bag
  Folic Acid: 1 mg if alcoholism or refeeding risk; Thiamine: 100mg if alcoholism or refeeding risk
APPENDIX O: Neuroscience Antibiotic Guide

1. Surgical prophylaxis
   a. Cefazolin 1g q8h within 60 minutes of incision then cefazolin 1g q8h x3 doses (order 1st dose now)
   b. **(Type I Hypersensitivity penicillin allergy (i.e. anaphylaxis) only!)** Vancomycin 1g within 120 minutes of incision then vancomycin 1g q12h x2 doses (order 1st dose now)

2. Urinary tract infection
   a. Uncomplicated
      i. Bactrim DS 1 tab po bid x3 days; **(sulfa allergy)** levofloxacin 250mg daily x3 days
   b. Complicated
      i. Levofloxacin 250mg daily for 7-10 days

3. VAP/HAP
   a. Vancomycin 15mg/kg q12h **plus** piperacillin/tazobactam 4.5g q6h or cefepime 2g q8h; consider adding levofloxacin 750mg daily or gentamicin 7mg/kg/daily for gram-negative double coverage
   b. **(Type I Hypersensitivity penicillin allergy (i.e. anaphylaxis) only!)** Vancomycin 15mg/kg q12h **plus** levofloxacin 750mg daily or gentamicin 7mg/kg/daily; consider adding aztreonam 2g q8h for gram-negative double coverage
   c. Treat for 7 days only unless *Pseudomonas/Acinetobacter* (14 days)

4. CSF infections
   a. Meningitis/ventriculitis
      i. Cefepime 2g q8h **plus** vancomycin 15mg/kg q12h (desired trough concentration 15 – 20 mg/L)
      ii. **(Type I Hypersensitivity penicillin allergy (i.e. anaphylaxis) only!)** Aztreonam 2g q6h or ciprofloxacin 400mg q8h **plus** vancomycin 15mg/kg q12h (desired trough concentration 15 – 20 mg/L)
      iii. May consider intrathecal therapy on case by case basis:
           1. vancomycin 10mg IT daily
           2. gentamicin 4mg IT qd
   b. Shunt infection
      i. Antibiotics same as meningitis/ventriculitis
      ii. May consider intrathecal therapy on case by case basis
      iii. Continue 5-7 days after CSF cultures negative for 72 hours
   c. Brain abcess
      i. Nafcillin 2g q4h (may omit if not post-traumatic or Neurosurgery) **plus** ceftriaxone 2g q12h **plus** metronidazole 500mg q8h
      ii. PCN 4 MU q 4h (may use in lieu of Nafcillin)
      iii. Immunocompromised
           1. Toxoplasmosis *most common in HIV*; sulfadiazine 1.5g q6h **plus** pyrimethamine 200mg x1 then 75mg/day **plus** leucovorin 10-20mg daily
              a. Continue for 4 – 6 weeks then suppressive Rx
           2. Cryptococcus; amphotericin 5mg/kg/day plus flucytosine 25 – 37.5mg/kg q6h
              a. Chronic suppressive therapy should be considered
   d. Open depressed skull fracture
      i. Infection prophylaxis in patients without CSF leak
           1. Ceftriaxone 2g q12h **plus** nafcillin 2g q4h **plus** metronidazole 500mg q8h; continue for 5 days only

1 – consult PharmD for dosing adjustments and pharmacokinetic monitoring.
2 – complicated = male, elderly, hospital-acquired, pregnant, DM, recent antibiotic use, immunosuppressed.
Hospital & Ventilator Associated Pneumonia
- Mechanical Ventilation for 48-72 hours
- New lung infiltrate or a progressive radiographic infiltrate plus at least two of three clinical features
- fever greater than 38°C,
  - leukocytosis or leukopenia,
- purulent secretions

Bacterial Meningitis/Ventriculitis
- Elevated WBC usually in the range of 1000–5000 cells/mm3,
- neutrophil predominance in CSF, typically between 80% and 95%
- Elevated CSF glucose concentration is <40 mg/dL in approximately 50%–60% of patients
- Serum glucose to CSF glucose ratio <0.4 is 80% sensitive and 98% specific
- Positive Gram Stain
- Positive Cultures

Catheter Related Infection
- Culture of catheters
  - Should be done only when catheter-related bloodstream infection is suspected
  - When culturing a CVC segment, either the catheter tip or a subcutaneous segment should be submitted for culture
- Pulmonary artery catheter infection, culture of the introducer tip should be done instead of catheter tip
- Culture of blood samples
- Two sets of blood samples for culture, with at least 1 drawn percutaneously,
- Specific recommendations
- Changing over a guide wire is not appropriate in a patient with suspected CVC infection

Asymptomatic Bacteriuria
- Pyuria accompanying asymptomatic bacteriuria is not an indication for antimicrobial treatment
- A single catheterized urine specimen with 1 bacterial species isolated in a quantitative count of ≥10^2 cfu/mL identifies bacteriuria in women or men
- For asymptomatic women,
  - bacteriuria is defined as 2 consecutive voided urine specimens with isolation of the same bacterial strain in quantitative counts of ≥10^5 cfu/mL.
- For Asymptomatic men
  - A single, clean-catch, voided urine specimen with 1 bacterial species isolated in a quantitative count of ≥10^5 cfu/mL identifies bacteriuria in asymptomatic men.

Symptomatic Bacteriuria
- Presence of clinical symptoms
- Dysuria, urgency, frequency
- Urinalysis (mid-stream clean catch) one of:
  - Leukocyte esterase +
  - Nitrate +
  - Pyuria >10WBCs
  - Bacteriuria

Open Depressed Skull Fractures
- Skin laceration over the fracture with exposed/depressed dura
APPENDIX P:  
PROTOCOL FOR THE ADMINISTRATION OF:  
CONTINUOUS INTRAVENOUS INSULIN INFUSION (CII)  

**Indication:**  
- The standard of care for hyperglycemia in adult patients is to maintain blood glucose levels 80 - 140  
- For cardiothoracic surgery or surgical trauma patient, blood glucose goal is 80 – 120  
- Obtain hemoglobin A1C on all patients with hyperglycemia  
- Patients with an A1C > 8 % will require insulin to control their blood glucose.  
- An intravenous insulin infusion should be instituted within 24 hours if blood glucose is uncontrolled  
- If patient has Diabetic Ketoacidosis (DKA) or Hyperglycemic Hyperosmolar Non-Ketotic Syndrome (HHNK) follow additional guidelines contained in this protocol.  

**Expected Outcome:** Blood glucose will decrease by approximately 50 mg/dl each hour until blood glucose is maintained within the target range  

**Monitoring:**  
- Monitor BG every hour  
- Once a stable infusion rate is reached AND two values are in the target range, then monitor every two hours  
- If BG is changing rapidly or there is a change in the infusion rate monitor every hour  
- Once the insulin infusion is discontinued, monitor blood glucose every two hours until two values are in the target range, then monitor every four hours until two values are in the target range then every six hours.  

**Insulin Drip Solution:**  
Discontinue all other insulin orders when insulin drip is started.  
Insulin infusion must be administered through an infusion pump.  
Insulin solution must only be mixed by pharmacy services by adding 250 units of regular buffered human insulin into a 250 cc bag of 0.9% normal saline  
1 unit of insulin = 1 cc solution  
Prior to administering insulin solution to patient, IV tubing must first be flushed with insulin solution and the first 15 cc of fluid discarded. This must be done each time tubing is changed.  

**Intravenous Fluids:**  
If patient is NPO or receiving < 50% of adequate exogenous carbohydrate then D10W should be hung at a minimum of 25cc/hr to avoid hypoglycemia when an insulin drip is in place.  
Most patients will need 5 – 10 grams of glucose per hour to avoid inducing a catabolic state (example D5 % dextrose at 125 ml/hr or hyperalimentation and/or tube feedings at infusion rate per goals set by registered dieticians)  
If TPN or tube feedings are stopped and insulin is prescribed, hang D10W at same rate as TPN or tube feeding rate.
**Initiating Insulin Drip:**
- If blood glucose is >300 provide an intravenous bolus dose of regular insulin at 0.1 unit/kg.
- Begin drip at 2 units of regular insulin per hour

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**Insulin Dosage Adjustment Table**

**New Blood**
- Glucose Level (mg/dl)
- Any Rise in BG, or fall in BG of 0–50 mg/dl
- Fall in BG of 50–75 mg/dl
- Fall in BG > 76

<table>
<thead>
<tr>
<th>Change in Blood Glucose</th>
<th>New Blood Glucose Level (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 200</td>
<td>Increase dose 2 units/hr</td>
</tr>
<tr>
<td>150 – 200</td>
<td>Increase dose 2 units/hr</td>
</tr>
<tr>
<td>100 – 149</td>
<td>Maintain dose</td>
</tr>
<tr>
<td>80 – 99</td>
<td>Decrease dose by one-half</td>
</tr>
<tr>
<td>61 – 79</td>
<td>Decrease dose by one-half</td>
</tr>
<tr>
<td>&lt; 60</td>
<td>Stop drip, recheck blood glucose in 1 hour</td>
</tr>
</tbody>
</table>

**BG MUST BE CHECKED 1 HOUR AFTER ANY DOSE CHANGES !!!**
- Infusion pump will be set at cc/hr, which will reflect units/hr, as it is a 1:1 solution
- If blood glucose is < 140 but is not yet within target range increase rate by 1 unit per hour until tighter target goal range of 80 – 120

**Using table:**
1) Check new BG level and locate its BG range in the first column
2) Calculate the change in the new BG from the last BG and locate the proper “change in blood glucose” column
3) Follow the correct “change in blood glucose” column down and correct “new blood glucose level” row to where they intersect to find dose adjustment

**Examples:**
1) If BG falls from 475 to 350 (a fall of 125 mg/dl), you would decrease dose 2 unit/hr.
2) If BG falls from 250 to 175 (a fall of 75 mg/dl), you would increase dose 1 units/hr.
3) If BG rises from 120 to 165 (a rise of 45 mg/dl), you would increase dose 2 unit/hr.
4) If BG falls from 150 to 80 (a fall of 70 mg/dl), you would decrease dose by \( \frac{1}{2} \) dose.

2-19-08 3

**Initiating Subcutaneous Insulin:** (Please see Careset for Inpatient Guideline)

DO NOT USE SLIDING SCALE INSULIN in lieu of long acting insulin

Patients with an A1C > 8% will require long acting subcutaneous insulin to control their blood glucose

Initiate long acting basal subcutaneous insulin (NPH human insulin or Glargine/Lantus insulin) 2 hours **before** discontinuing insulin drip.

Restart previous subcutaneous insulin dose if Hemoglobin A1C < 8% on that dose.

If new to insulin and Hemoglobin A1C is > 8% start subcutaneous insulin. Two options:

- Begin NPH insulin at 0.3 units/kg/day in two equally divided doses 12 hours apart (ex 8 AM & 8 PM or 10 AM & 10 PM)
- Or Glargine/Lantus insulin at 0.3 units/kg/day as a once daily dose in AM or PM.

Long acting insulin (NPH or Glargine) should be administered even if patient is NPO

When patient is able to eat > 50% of food on hospital tray, add aspart 6 units with meals

If patient is receiving parenteral nutrition (TPN) and daily insulin requirements are stable, insulin may be added to TPN solution (0.1 unit per gram of glucose) Consult nutrition services.

May supplement with aspart 6 units for Blood glucose > 300

Will need to adjust basal/bolus insulin on a daily basis if supplemental insulin is required.

**Special Considerations:**

- Acute or chronic kidney disease – If GFR < 40 consider reduced dose of insulin or endocrine consult
- When Hct is < 20% can cause false elevations on the glucose meter

**References:**


**ORIGINAL:** 10/2002

**REVIEW/REVISION:** 02/2008

**NEXT REVIEW:** 02/2010

Reviewed By: John Clore MD, Pat Selig RN, PhD, FNP, Critical Care Committee
APPENDIX Q: Catastrophic Brain Injury Guidelines

**Purpose:** To offer management guidelines for the neurologically devastated patient when the Organ Donation Protocol is activated by established clinical triggers. These guidelines are to preserve organ function in the event that organ donation becomes an option.

Organ donation should **not** be mentioned to the family before the physician along with the patient care team discusses the patient’s prognosis with them.

These suggestion must only be instituted when the Attending Physician has given permission to use all or part of these suggested clinical interventions.

**Maintain SBP>100 (MAP>60)**
1. Consider invasive hemodynamic monitoring
2. Adequate hydration: Ensure adequate hydration to maintain euvoolemia
3. Vasopressor support: If hypotensive post adequate rehydration, use Neosynephrine as the first pressor of choice up 2mcg/kg/min, followed by dopamine

**Maintain Urine Output >0.5ml/kg/hr<400ml/hr** (consider DI if >400ml/hrx2 hrs)
1. Treat DI with Vasopressin drip 1-2.5 units/hr, if UO still >400ml/hr
2. If UO falls below 0.5ml/kg/hr, assess fluid status—may need rehydration or BP support

**Maintain PO2> 100 and pH 7.35-7.45**
Adequate ventilation maintained by:
1. Peep 5.0-8.0
2. Aggressive pulmonary hygiene if not contraindicated by patient’s condition (sx and turn every 2hrs)
3. Respiratory treatments to prevent bronchospasm

**Hypothermia**
- Maintain core body temperature between 36C and 37.5C

**Labs**
1. Basic metabolic panel, Magnesium, phosphate, heme8, ABG’s, liver panel, initially and prn
   a. Consider transfusion with PRBC for Hgb<8.0g/dL
   b. If PT>18, give 2 units FFP
   c. Replete electrolytes as needed
   d. Monitor glucose and treat with insulin drip if needed (keep 80-200)

Blood bank sample for ABO typing

DRAFT 2/20/06, SK
APPENDIX R: Guidelines for Recombinant Activated Factor VII (rFVIIa, NovoSeven®) Use
VCUHS Neuroscience Service

Mechanism of Action
• **Initiation** – tissue factor (TF) complexes with Factor VIIa formed at the site of tissue injury; the subsequent activation of Factor X generates small amounts of thrombin
• **Amplification** – thrombin activates platelets and cofactors (V and VIII); coagulation factors and cofactors assemble on surface of activated platelets (VIIa, Va, IXa); multiple feedback loops amplify the process
• **Propagation** – assembled complexes continue cascade on surface of activated platelets; the prothrombinase complex converts prothrombin to thrombin which then converts fibrinogen to fibrin; this is followed by clot stabilization

Pharmacokinetics following bolus administration *(established in non-hemophiliac patients)*
• Onset of Action (hemostasis): ~10 minutes
• Half-life: 2.5-3.2 hours
• Duration of PT/INR normalization: 2-6 hours (dose dependent)
  o Administration of Vitamin K and FFP necessary for continued INR reversal

**Adverse Effects of rFVIIa**
• Thromboembolic events (majority are arterial vs. venous)
  o MI
  o Cerebral infarction
  o Bowel infarction
  o DVT/PE
  o Thrombophlebitis

**Warnings/Precautions**
Caution should be used in the following patients. An increased risk of thrombotic events in nonhemophiliac patients with the following disease states has been noted due to circulating tissue factor or predisposing coagulopathy

1-2:
• Disseminated intravascular coagulopathy (DIC)
• Advanced atherosclerotic disease
• Crush injury
• Septicemia
• Concomitant treatment with activated or nonactivated prothrombin complex concentrates (aPCCs/PCCs)

**Dosing Guidelines in ICH Patients**
• Approval for rFVIIa must be obtained by a Neurosurgery attending physician prior to patient administration
• Platelet count must be >20 x10³/mm³ for rFVIIa to be effective.
• For patients NOT on warfarin, the dose should be administered WITHIN 3 HOURS of the onset of ICH.3,6

**Target population for FVII administration (based on FAST results):**
• Age <70
• Time to dose < 3 hours
• Baseline ICH < 60 ml
• Baseline IVH < 5ml
  o Early hematoma growth has been shown to be greatest within 4 hours of the onset of symptoms, with minimal growth occurring after that time frame.
  4-5
• Doses should ALWAYS be rounded to the nearest vial size or vial size combination (milligram) due to high cost.
  o Vial sizes for rFVIIa: 1mg, 2 mg and 5mg vials
  o Cost is ~ $1/mcg, or $1200-8000 per dose

**Indication Dose Additional Comments**

**ICH on warfarin** 1 mg (fixed dose)
• Dose of 15-20 mcg/kg rounds to approximately a 1 mg vial in most patients
• Also administer Vitamin K and FFP

**ICH not on warfarin** 40-80 mcg/kg
• Round dose to the nearest milligram
• Administer within 3 hours of injury

**Other Neurosurgery patients**
40-80 mcg/kg
• No evidence-based dosing guidelines available
• Round dose to the nearest milligram

Example of dose adjustment:
Pt weight: 83 kg. Desired dose of 40 mcg/kg gives exact dose of 3320 mcg.
Round dose to 3 mg (3000 mcg) and will be filled with a 1 and 2 mg vial.

References

*Updated 7/08: Questions? Contact: Gretchen Brophy, Pharm.D. #6811 Stacy Voils, PharmD #6790*
APPENDIX S: DIABETES INSIPIDUS

Table 1. Diagnostic Tests
- Urine Osmolality
- Serum electrolytes
- Serum osmolality
- Serum Mg, Serum PO4,
- Serum glucose

Table 2. Diagnostic Criteria
For diagnosis of DI need all 3 of:
- Serum Na > 145
- Serum osmolality > 302
- Urine osmolality < 300

Note: If diagnostic criteria not met but ongoing concern contact ICU team to review.

START HERE

Does the patient have polyuria?
(urine output 250 ml/hour)

STEP 1. Rule out the following causes.
Osmotic diuresis secondary to mannitol, hyperglycemia
(check serum glucose), or diuretics

If none of the above apply

Send urine and blood for diagnosis of DI (Table 1). Do not wait for results to proceed to next step

YES

Inform ICU team to obtain order for DDAVP

NO

Give 2 mcg DDAVP (IV)

YES

Inform ICU team
1. Assess response (urine output should decrease less than 150 ml/hr in hour following DDAVP)
2. Check labs to confirm diagnosis (See Table 2)
3. If diagnosis not confirmed or ongoing diuresis after DDAVP contact ICU team or Attending
4. Correct electrolyte abnormalities
5. Monitor electrolytes including Mg and PO4 every 2 hours

NO

If polyuria recurs and diagnostic criteria have been met previously, repeat DDAVP.
Otherwise go to STEP 1.

Is urine output >400ml/hr?

YES

NO

Is urine output > 300ml/hr for 2 consecutive hours?

YES

NO

Send urine and blood for diagnosis of DI (Table 1)

Are diagnostic criteria met? (See Table 2)

YES

NO

1. Inform ICU team
2. Continue to monitor
3. Recheck urine and blood within 2 hours if diuresis continues
4. If diagnostic criteria not met on recheck contact ICU Fellow or Attending to review

Monitor for 2 hours

Ongoing diuresis > 250 ml/hr?

YES

NO

Monitor
Ask ICU resident to review if ongoing concern
APPENDIX T: Fluid management for Diabetes Insipidus  (Goal Na = 136-146)

<table>
<thead>
<tr>
<th>Na level</th>
<th>Fluid</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 135</td>
<td>NS</td>
<td>Call HO</td>
</tr>
<tr>
<td>135 – 142</td>
<td>NS</td>
<td>Restrict fluids</td>
</tr>
<tr>
<td>142 – 145</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>145 – 155</td>
<td>½ NS</td>
<td></td>
</tr>
<tr>
<td>155 – 160</td>
<td>¼ NS</td>
<td></td>
</tr>
<tr>
<td>&gt; 160</td>
<td>Free water/D5</td>
<td>Call HO</td>
</tr>
</tbody>
</table>

Preparations and Dosing of mVasopressin and Desmopressin

Vasopressin (Anti-Diuretic Hormone) is used to increase water reabsorption. Desmopressin (DDAVP) is a synthetic analog of vasopressin.

Available Preparations of Vasopressin

<table>
<thead>
<tr>
<th>Generic</th>
<th>Trade</th>
<th>Route</th>
<th>Concentration</th>
<th>Available dose</th>
<th>Bioavail.</th>
<th>Mean Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arginine vasopressin</td>
<td>Pitressin</td>
<td>SQ, IM</td>
<td>20 units/mL (50 ug/mL)</td>
<td>0.5 ml &amp; 1.0 mL vials</td>
<td>N/A</td>
<td>5-20 units/ day (given q4-6h)</td>
</tr>
</tbody>
</table>

Available Preparations of Desmopressin

<table>
<thead>
<tr>
<th>Generic</th>
<th>Trade</th>
<th>Route</th>
<th>Concentration</th>
<th>Available dose</th>
<th>Bioavail.</th>
<th>Mean Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>desmopressin</td>
<td>DDAVP®</td>
<td>SQ, IM, IV</td>
<td>4 ug/mL</td>
<td>1.0 mL SD amp, 10 mL MD vials</td>
<td>100%</td>
<td>2-4 mcg/ day (given BID)</td>
</tr>
<tr>
<td>desmopressin</td>
<td>DDAVP®</td>
<td>Nasal Spray</td>
<td>100 ug/mL each spray delivers 10 ug</td>
<td>5.0 mL pump (50 sprays per bottle)</td>
<td>3.3%-4.1%</td>
<td>10-40 mcg/ day (given BID)</td>
</tr>
<tr>
<td>desmopressin</td>
<td>DDAVP®</td>
<td>Tablet</td>
<td>0.1 mg, 0.2 mg</td>
<td>100 tablet bottle</td>
<td>0.15%</td>
<td>0.05-0.6 mg/ day (given QDAY or BID)</td>
</tr>
</tbody>
</table>

SD = Single Dose   MD = Multi Dose

Desmopression Dose Dependent Mean Duration of Action

<table>
<thead>
<tr>
<th>Route</th>
<th>Dose</th>
<th>Mean Duration of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQ, IM, IV</td>
<td>1 mcg</td>
<td>12 hours</td>
</tr>
<tr>
<td></td>
<td>2 mcg</td>
<td>16 hours</td>
</tr>
<tr>
<td></td>
<td>4 mcg</td>
<td>20 hours</td>
</tr>
<tr>
<td>Nasal Spray</td>
<td>10 mcg</td>
<td>12 hours</td>
</tr>
<tr>
<td></td>
<td>15 mcg</td>
<td>16 hours</td>
</tr>
<tr>
<td></td>
<td>20 mcg</td>
<td>20 hours</td>
</tr>
</tbody>
</table>
APPENDIX U: Hyponatremia

Is the hyponatremia severe? (Sodium < 125mmol/L)

YES

Are there symptoms? Confusion, ataxia, headache, seizures, obtundations (see Box 1)

YES

What is the duration of the hyponatremia?

Acute < 48 hours

Emergency correction with hypertonic (3%) saline (0.5 -1 ml/kg/hr until sodium >125 mmol/L)

Use 2% hypertonic saline if patient has no central line.

Chronic/unknown >48 hours

Urgent correction with 0.9% saline or, until symptoms resolve, with hypertonic (3%) saline (0.5 -1 ml/kg/hr); thereafter, correct at rate of about 0.5 mmol/L/hr with 0.9% saline

Use 2% hypertonic saline if patient has no central line.

NO

Significant sequelae unlikely

Hyponatremia likely chronic

Urgent intervention unnecessary. Assess ECF volume and correct sodium at hourly rate of about 0.5 mmol/L

What is the ECF volume status?

Hypovolemic

Discontinue offending medications; restore intravascular volume with IV 0.9% NS; then give PO salt and water

Normal or near normal

Rule out hypothyroidism and hypoadrenalism; discontinue offending medications; restrict fluids to 750-1500 ml/day; give demeclocycline, 600 mg/day

Hypervolemic

Optimize treatment of underlying problems (cardiac, hepatic, renal); restrict salt and water intake; give diuretics

Normal or near normal

Rule out hypothyroidism and hypoadrenalism; discontinue offending medications; restrict fluids to 750-1500 ml/day; give demeclocycline, 600 mg/day

Hypervolemic

Optimize treatment of underlying problems (cardiac, hepatic, renal); restrict salt and water intake; give diuretics

Box 1. Symptoms of hyponatremia
- Headache
- Lethargy
- Dizziness and ataxia
- Mild confusion
- Psychosis
- Seizures
- Coma

Box 2: Causes of syndrome of inappropriate secretion of ADH (SIADH)
- Malignant disease: Bronchogenic carcinoma
- Pulmonary disorders: bacterial and viral pneumonitis, tuberculosis, positive pressure
- Neurologic disorders: Encephalitis, meningitis, trauma, stroke, alcohol withdrawal, brain tumor, subarachnoid hemorrhage
- Other: HIV/AIDS, acute psychosis, acute intermittent porphyria, idiopathic

Box 3: Drugs causing hyponatremia
- Antineoplastic agents (cyclophosphamide, vincristine, ifosfamide)
- Antipsychotics (haloperidol, thiothixine)
- Carbamazepine, oxcarbazapine
- Desmopressin
- NSAIDs
- Opiates (morphine, meperidine)
- SSRIs (sertraline, fluoxetine)
- Tricyclic antidepressants (amitriptyline, imipramine)
- Diuretics
APPENDIX V: HYPONATREMIA

Check plasma osmolality

>302 mOsm/kg

Hypertonic hyponatremia

Consider:
- Hyperglycemia
- Mannitol administration
- Glycerol administration

<280 mOsm/kg

Hypotonic hyponatremia

Check volume status

280-302 mOsm/kg

Isotonic hyponatremia

Consider:
- Hypertriglyceridemia
- Paraproteinemia

Hypovolemic

Check urine sodium

<20 mEq/L

Consider:
- Vomiting
- Diarrhea
- Third space loss

>20 mEq/L

Consider:
- CSW
- Diuretics
- Mineralocorticoid deficiency
- Ketonuria
- Osmotic diuresis
- Bicarbonaturia

Euvolemic

Check urine osmolality

<100 mOsm/kg

Primary nolvinsisi

↑TSH

↓FT₄

Hypothyroidism

Check TSH

Check FT₄

Perform cosyntropin stimulation

Normal TSH

Normal FT₄

SIADH

Subnormal Response

Normal response

Adrenal insufficiency

>100 mOsm/kg

Hypervolemic

Check urine sodium

<20 mEq/L

Consider:
- CHF
- Cirrhosis
- Nephrotic syndrome

>20 mEq/L
APPENDIX W: SCI PROTOCOL

VCU HEALTH SYSTEM
RESPIRATORY CARE SERVICES

RESPIRATORY CARE OF THE NEWLY
ADMITTED SCI - QUADRIPLEGIC PATIENT

1. PURPOSE

To provide guidance and support of the Respiratory Care staff who evaluate and work with patients following injury to the nervous system causing quadriplegia.

II. POLICY

Respiratory Care Practitioners will evaluate and provide care to the patient with suspected quadriplegia of the nervous system using a prescribed, physician approved protocol. Regardless of the physical location of the patient, Respiratory Care Practitioners will actively support the respiratory needs of this patient population.

Questions regarding this policy can be addressed to the shift supervisor or department administrator on call.

III. RESPIRATORY DYSFUNCTION AFTER SPINAL CORD INJURY (SCI)

The higher (more superior) the injury to the spinal cord, the greater neurologic dysfunction will result. Injury to the cervical spine results in the following:

1. C2 and higher: Continuous mechanical ventilatory support required
2. C3-4: Mechanical ventilatory support needed, the potential to wean from the ventilator exists
3. C5 and below: The patient maintains the ability to breathe spontaneously. 2 out of 3 require initial mechanical ventilatory support but are successfully weaned from the ventilator
4. T1 – T12: The patient has a weak cough
5. L1 and below: No impairment in the respiratory system noted.

IV. PRESSURE AND VOLUME MEASUREMENTS

A. The serial monitoring of inspiratory and expiratory pressures, average exhaled tidal volume and vital capacity from the patient with SCI provides an indication of the injury’s impact on the respiratory system. The comparison (below) of pressure and volume measurements of patients with and without cervical SCI:
<table>
<thead>
<tr>
<th>Patients without SCI</th>
<th>Patients with cervical SCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative inspiratory pressure:</td>
<td>Negative inspiratory pressure:</td>
</tr>
<tr>
<td>- 60 cm H2O</td>
<td>closer to 20 cm H2O</td>
</tr>
<tr>
<td>Positive expiratory pressure:</td>
<td>Positive expiratory pressure is poor and can be less than + 10 cm H2O</td>
</tr>
<tr>
<td>+ 60 cm H2O</td>
<td></td>
</tr>
<tr>
<td>Average tidal volume:</td>
<td>Average tidal volume: Low</td>
</tr>
<tr>
<td>8 – 16 mL/Kg</td>
<td></td>
</tr>
<tr>
<td>Vital capacity: 3.0 – 5.0 liters</td>
<td>Vital capacity is a critical parameter as it provides the first indication of impending</td>
</tr>
<tr>
<td></td>
<td>respiratory failure. 65% of the vital capacity comes from diaphragmatic function</td>
</tr>
</tbody>
</table>

2. On arrival of the patient to Emergency Department, the Respiratory Care supervisor, or team leader carrying pager # 6258, will be contacted. The “SCI Assessment Sheet” form H-MR-247 (Rev. 9/7/98) 57-139 (attached) is to be completed PRIOR to the MRI, Ideally within sixty minutes of arrival in the Emergency Department.

3. The SCI Assessment Sheet to be completed in full, including volume and pressure measurements if patient is medically stable to be taken off mechanical ventilation or supplemental oxygen.

4. If the measured Vital Capacity is < 1500 mL, the Neurology Junior Attending Resident (JAR) is to be paged with the results.

5. Based on the results of the measured Vital Capacity, the following will be performed:

<table>
<thead>
<tr>
<th>Vital Capacity &lt; 1500 mL</th>
<th>Vital Capacity &lt; 1000 mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notify NSICU physician immediately of results</td>
<td>Notify NSICU immediately, consider paging Anesthesia (pager # 1475) for advice on placement of an artificial airway</td>
</tr>
<tr>
<td>Weaning parameters will be measured every six hours</td>
<td>Weaning parameters will be measured every four hours</td>
</tr>
<tr>
<td>Consider BiPAP by nasal mask (Vision) to assist with prevention of atelectasis</td>
<td>BiPAP (Vision) with nasal mask if not intubated</td>
</tr>
<tr>
<td>Obtain CXR of patient</td>
<td>Obtain CXR of patient</td>
</tr>
<tr>
<td>Titrate FiO2 for saturations &gt; 92%</td>
<td>Obtain ABG results, keep SpO2 &gt; 92%</td>
</tr>
<tr>
<td>Albuterol and Atrovent by inhalation every six hours</td>
<td>Albuterol and Atrovent by inhalation every four hours</td>
</tr>
<tr>
<td>Incentive Spirometry every four hrs</td>
<td>Incentive Spirometry every four hrs</td>
</tr>
<tr>
<td>Patient WITH Acute Chest Trauma (ACT)</td>
<td>Patient WITHOUT Acute Chest Trauma</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Provide <strong>LUNG PROTECTION</strong> ventilation strategy</td>
<td>Provide <strong>LUNG EXPANSION</strong> ventilation strategy</td>
</tr>
<tr>
<td>6-8 mL / Kg IBW. Any mode of ventilation as appropriate UNTIL ACT is resolved, then must be placed in assist control mode</td>
<td>15 mL / Kg IBW. Assist control mode ONLY</td>
</tr>
<tr>
<td>Deliver inhaled medications with patient in Trendelenburg position</td>
<td>Deliver inhaled medications with patient in Trendelenburg position</td>
</tr>
<tr>
<td>Chest physiotherapy with VEST device and or sport bed</td>
<td>Chest physiotherapy with VEST device and or sport bed</td>
</tr>
<tr>
<td>Quad cough and suction</td>
<td>Quad cough and suction</td>
</tr>
<tr>
<td>Weaning Parameters every day @ 6A and perform as directed in protocol</td>
<td>Weaning Parameters every day @ 6A and perform as directed in protocol</td>
</tr>
<tr>
<td>Wean ventilator as soon as patient is medically stable</td>
<td>Wean ventilator as soon as patient is medically stable</td>
</tr>
</tbody>
</table>
A. Exclusion Criteria for Lung Expansion Protocol

1. Severe traumatic brain injury
2. Chest trauma
   i. Bilateral pulmonary contusions
   ii. Flail chest
   iii. Pneumothorax
   iv. Hemothorax
3. Bullous emphysema
4. ARDS

VII. NSICU MD NOTIFICATION CRITERIA

A. Spontaneous respiratory rate > 30 bpm
B. SpO2 < 92% or need for higher FiO2
C. pH < 7.35, PaCO2 > 45 mm Hg, PaO2 < 70 mm Hg.
D. Negative Inspiratory Pressure > -25 cm H2O or decrease by 10% from previous measurement
E. VC decrease by 10% from previous measurement
F. Absent or diminished Breath Sounds
G. Bronchospasm
H. Purulent secretions

VIII. WEANING OF THE SCI PATIENT

A. Prevention of atelectasis and fatigue are paramount to the success of patient weaning
B. Assist Control mode of ventilation will be employed throughout the ventilator course, mandatory rate should not be set less than 4
C. Weaning parameters each day at 6AM and 10 PM AND pre and post weaning trials
D. Progressively increase time off ventilator (use T-tube and wall driven O2)
E. Weaning to be performed with patient in supine position until the patient successfully can perform 3 hours on an aerosol
F. T-tube trials begin and end with a measured vital capacity
G. T-tube trials should start by 6 AM

IX. PROGRESSIVE WEANING SCHEDULE

A. Two minutes – three times a day*
B. Five minutes – three times a day*
C. Ten minutes – three times a day*
D. Twenty minutes – three times a day*
E. Thirty minutes – three times a day*
F. Sixty minutes – three times a day
G. Two hours – three times a day
H. Three hours – three times a day
I. Four hours – twice a day
J. Five hours – twice a day
K. Twelve hours
L. Fourteen hours
M. Sixteen hours
N. Twenty hours
O. Twenty two hours
P. Twenty four hours

1. All weaning intervals completed between 6 AM and 10 PM, if the patient is on an aerosol < sixteen hours

2. If patient does not successfully complete each interval on an aerosol weaning is stopped twenty-four hours. The patient returns to the previous successful interval until completed

* Respiratory Care Provider to remain with patient throughout weaning interval

IX. CRITERIA FOR DISCONTINUING OF T-TUBE TRIAL

A. Respiratory rate > 30 bpm
B. Heart rate > 20 bpm over baseline
C. Pulse oximetry < 92%
D. Blood pressure change 30 mm Hg (+/-) baseline
E. Vital capacity decreases > 25%