**Supplement 1**

**Summary of the American Society of Regional Anesthesia and Pain Medicine Evidence-Based Guidelines (Third Edition) for Regional Anesthesia in the Patient Receiving Antithrombotic or Thrombolytic Therapy and Neurocritical Care Society’s Evidence Based Consensus Statement on Insertion and Management of External Ventricular Drains**

The American Society of Regional Anesthesia and Pain Medicine (ARSA) Evidence-Based Guidelines (Third Edition) for Regional Anesthesia in the Patient Receiving Antithrombotic or Thrombolytic Therapy 118 and Neurocritical Care Society’s (NCS) Insertion and Management of External Ventricular Drains: An Evidence-Based Consensus Statement 8 have been summarized with reference to neuraxial and external ventricular catheter placement in patients with potential abnormalities in coagulation. The goals of the guidelines are to reduce the risk of hemorrhagic complications associated with placement of ventricular and neuraxial catheters. The ARSA guidelines are applicable to placement of a lumbar drain while the NCS guidelines are specific for insertion of an external ventricular drain. It is important to note that the ASRA guidelines are in the process of being updated and the practitioner is encouraged to use the most updated guidelines. Current complete guidelines are available at:

<http://journals.lww.com/rapm/Fulltext/2010/01000/Regional_Anesthesia_in_the_Patient_Receiving.13.aspx> (accessed September 28th, 2016)

<http://www.neurocriticalcare.org/Portals/61/Docs/Guidelines/EVD/EVD%20FINAL.pdf?ver=2016-07-27-104710-000> (accessed September 28th, 2016)

**1. Lumbar Drain Placement**

* 1. **Fibrinolytic and Thrombolytic Therapy**
     1. In patients who received fibrinolytic or thrombolytic drugs the guidelines recommend against performance of a neuraxial puncture
     2. For those patients who received fibrinolytic or thrombolytic drugs at or near the time of neuraxial puncture, close neurological monitoring (not more than 2 hours between checks) is recommend.
     3. No definitive recommendations exist for removal of catheters in those patients who unexpectedly received fibrinolytic or thrombolytic drugs. The guidelines recommend evaluation of fibrinogen level to assess for residual fibrinolytic or thrombolytic effect
  2. **Unfractionated Heparin**

* + 1. No contraindication exists for neuraxial technique in patients receiving subcutaneous heparin 5000 U twice daily. Administrating heparin after placement of the drain placement reduces the risk of spinal hematoma
    2. The safety of patients receiving greater than 10 000 U/day subcutaneous heparin or three times a day dosing has not been established. Careful monitoring is advocated.
    3. Time of lumbar drain placement to systemic intravenous heparinization should be greater than 60 minutes
    4. Lumbar drains should be removed 2-4 hours after the last heparin dose and after the coagulation status has been assessed. Re-initiate heparin 1-hour after catheter removal.
  1. **Low-molecular Weight Heparin (LMWH)**
     1. The anti-Xa levels are not predictive of bleeding and the guidelines recommend against the routine monitoring of this variable
     2. Concomitant use of LMWH and other antithrombotic agents is not recommended
     3. The presence of blood with either catheter or needle placement does not necessitate postponement of surgery. However LMWH should be delayed for at least 24 hours after postoperatively

*Preoperative LMWH*

* + 1. Patients receiving preoperative thromboprophylaxis with LMWH should have neuraxial puncture delayed for 10-12 hours after the last dose
    2. Patients receiving higher doses of LMWH (treatment doses) should have neuraxial puncture delayed for 24 hours after the last dose
    3. Neuraxial puncture is not recommended if LMWH has been administered 2 hours preoperatively

*Postoperative LMWH*

* + 1. Twice daily dosing: If a catheter is left in place, the guidelines recommend removal of the catheter prior to initiation of treatment. LMWH should be delayed for 2 hours after catheter removal. The first dose of LMWH should be administered no earlier than 24 hours postoperatively and in the presence of adequate hemostasis.
    2. Single-daily dosing: First postoperative dose should be administered 6-8 hours postoperatively with the second dose not occurring sooner than 24 hours after the first dose. Catheters can be continued with the single daily dosing however a minimum period of 10-12 hours is required from the last dose prior to removal. LMWH should be delayed for 2 hours after catheter removal.
  1. **Warfarin**
     1. Anticoagulation therapy should be stopped 4-5 days before the procedure with normalization of the International Normalized Ratio (INR) prior to neuraxial puncture
     2. Concomitant use of other antithrombotic agents is not recommended
     3. Patients who have received a dose of warfarin prior to neuraxial puncture should have an INR checked
     4. Patients receiving low-dose warfarin therapy with a neuraxial catheter in place should have their INR monitored daily
     5. Neuraxial catheters should be removed when the INR is less than 1.5. The guidelines suggest ongoing neurological evaluation for 24 hours after removal of catheters
     6. In patients with an INR between 1.5 and 3, removal of the catheter should be done with caution with careful monitoring of the neurological status. Careful review of other concomitant anti-thrombotic administration should be performed
     7. In patients with an INR greater than 3, warfarin should be held or reduced. The guidelines do not make definitive recommendations regarding the management to facilitate removal of neuraxial catheters in these patients
  2. **Antiplatelet Medication**
     1. Nonsteroidal anti-inflammatory drugs alone confer no added risk during neuraxial puncture. The guidelines however highlight the increased risk of neuraxial hematoma associated with combing nonsteroidal anti-inflammatory and other anti-thrombotic drugs.
     2. Ticlopidine, clopidogrel, prasugrel and ticagrelor should be discontinued 14, 7, 7-10 and 5-7 days respectively before neuraxial puncture. Normalization of platelet function should be documented
     3. With platelet GP IIb/IIIa inhibitors, neuraxial techniques should be avoided until platelet function has recovered. The time to normal platelet aggregation is 24 to 48 hrs. for abciximab and 4 to 8 hrs for eptifibatide and tirofiban.
  3. **Direct Thrombin Inhibitors** 
     1. In patients receiving direct thrombin inhibitors (Desirudin,

Lepirudin, Bivalirudin, and Argatroban) neuraxial puncture is not recommended

* + 1. Dabigatran should be stopped 5 days before neuraxial puncture.
  1. **Oral Factor Xa Inhibitors** 
     1. Neuraxial puncture with fondaparinux should occur under conditions used in clinical trials (single-needle pass, atraumatic needle placement, avoidance of indwelling neuraxial catheters)
     2. Apixaban and Rivaroxaban should be stopped 3 days before neuraxial puncture
  2. **Herbal Medications**

* + 1. There does not appear to be an increased risk of neuraxial hematoma associated with the use of herbal medications (garlic, gingko and ginseng). The guidelines recommend against mandatory discontinuation of these medications or avoidance of neuraxial techniques in these patients

**2. External Ventricular Drain**

The NCS guidelines suggest that coagulopathy should be corrected prior to insertion of an EVD, except under emergent conditions. As no specific thresholds for International Normalized Ratio (INR), activated Partial Thromboplastic Time (a-PTT), and platelet count are currently recommended, providers are encouraged to follow current institutional protocols for correction of the coagulopathy.