

**OHSU HEALTH CARE SYSTEM  
PRACTICE GUIDELINES**

**Acute Stroke Practice Guidelines for Inpatient Management of Subarachnoid Hemorrhage, PS 01.20**

Last Reviewed Date: April 30, 2012

**POLICY**

OHSU Hospitals and Clinics have adopted these practice guidelines in order to delineate a consistent, evidenced-based approach to treating the patient who presents with signs and symptoms consistent with acute non-traumatic Subarachnoid Hemorrhage (SAH). Although these guidelines assist in guiding care, responsibility to determine appropriate care for each individual remains with the provider themselves.

Outcomes/ goals	<p>Create a multi-disciplinary, evidence-based, approach to the management of acute non-traumatic subarachnoid hemorrhage (SAH) patients.</p> <p>Patient plan of care to take into consideration the entire continuum of care from emergency department through rehabilitation.</p>
Physician	<p>1. Determine the appropriate unit for admission.</p> <p><b>Admission Criteria for Neurosciences ICU</b></p> <p>a. All acute non-traumatic subarachnoid hemorrhage patients (CT or LP positive) will be admitted to the NSICU.</p>
Physician	<p>2. Complete appropriate physician order set in electronic medical record.:</p> <p>a) <a href="#">NSG: Aneurysmal Subarachnoid Hemorrhage Orders.</a></p> <p>b) <a href="#">NSG: Craniotomy for Aneurysm: ICU post-op Orders.</a></p> <p>c) <a href="#">INR: Ruptured Aneurysm: Post Embolization Orders.</a></p> <p>d) NSICU: Daily care orders on rounds. Admission orders include: CBC, CMP (complete metabolic set), PT/INR/PTT, lipid panel, cardiac enzymes, urine toxicology, CXR and EKG. Transthoracic echocardiogram (TTE) and BNP (B-natriuretic peptide) optional. Activity and diet orders, code status, GI and DVT prophylaxis must also be addressed.</p>
Pharmacy, and RN	<p>3. Process physician orders according to OHSU policy.</p>
RN	<p>4. Complete admission database and initiate nursing plan of care according to the appropriate OHSU Adult Inpatient Standards of Care. <a href="#">Adult Critical Care Standard of Care</a> <a href="#">Adult Acute Care Inpatient Standard of Care</a></p> <p>5. Perform focused neurological assessments based on patient condition and physician orders, every 1-2 hour while in the ICU and every 2-4 hours in acute care.</p>

	<p>6. Neurological assessment to include at a minimum: Glasgow Coma Scale (GCS), level of alertness, orientation, pupil reactivity, speech, visual fields, strength based on drift, hand grip, and foot movement. Physician to be notified for any change on exam; notification to be documented.</p> <p>7. Intracranial pressure (ICP), and partial brain tissue oxygen (PbtO<sub>2</sub>) to be recorded hourly, if monitor in place.</p> <p>8. Provide a quiet, low light, environment for the patient. Strict bed rest until aneurysm secured, less stringent activity restrictions in setting of non-aneurysmal perimesencephalic or cortical SAH.</p> <p>9. Cautious sedation &amp; analgesia, if intubated. In non-intubated patients, analgesia will always include non-opiates, if no contraindications, and opioids only if necessary.</p> <p>10. Anti-emetics as needed.</p>
Physician	<p>11. Evaluate for loss of airway protection and need for intubation. Intubation recommended for GCS &lt; 8 and patients with deteriorating GCS (i.e. Hunt &amp; Hess Scale 4, 5 and select Hunt &amp; Hess 3).</p> <p>12. Consider nasogastric tube insertion to reduce risk of aspiration.</p>
Physician, RN, and RT	<p>13. Maintain oxygenation saturation greater than or equal to at least 93% (optimal &gt; 95% with PaO<sub>2</sub> &gt; 70 mmHg especially in high grade SAH) and adequate ventilation. Avoid prophylactic or prolonged hyperventilation. If 'lung protective ventilation' instituted for ALI/ARDS, permissive hypercarbia is strongly discouraged; use ETCO<sub>2</sub>, correlate with ABG reading at least once daily, (goal PaCO<sub>2</sub> 35-45).</p>
Physician and RN	<p><b>(ORDERS PLACED) PRIOR to SECURING ANEURYSM</b></p> <p>14. Keep mean arterial pressure (MAP) &gt; 70 and systolic blood pressure &lt; 140 in patients with no concern for elevated ICP (Hunt &amp; Hess 1-2); MAP &gt; 80 and SBP &lt; 160 for patients with concern for elevated ICP (Hunt &amp; Hess 3-5) prior to external ventricular drainage (EVD) placement and availability of ICP monitoring.</p> <p>15. Continuous infusion (IV Nicardipine 5-15 mg/hr or Labetalol) preferred for optimization of blood pressure as opposed to PRN IV meds. Consider placement of arterial line for blood pressure monitoring, if clinically indicated.</p> <p>16. Initiate vasopressors, if necessary, to achieve MAP and cerebral perfusion pressure (CPP) goals. If hypotensive and/or evidence of pulmonary edema on CXR, order <i>urgent</i> TTE and consider diagnosis of stunned cardiomyopathy (SM). Norepinephrine &gt;&gt; phenylephrine &gt; dopamine as vasopressor of choice for MAP goals; consider concomitant use of dobutamine.</p> <p>17. Consider ICP and/or EVD for patients based on neurological status, GCS score &lt; 8 or evidence of neurological deterioration and suspected or proven hydrocephalus.</p> <p>18. If EVD placed, ICP goal &lt; 20, surveillance sampling of cerebrospinal fluid (CSF) every 72 hours by Neurosurgery (more frequent if clinically indicated) and CPP goal &gt; 70.</p> <p>19. Measures to prevent increased ICP include: head of bed elevation &gt; 30 degrees, avoiding excessive hip flexion, keeping head in midline position as much as possible, avoiding pressure on neck from endotracheal tube tape, and suctioning only as needed using short acting sedative and/or analgesic or lidocaine prior to suctioning.</p>

20. Measures to treat elevated ICP include controlled hyperventilation (PaCO<sub>2</sub> goal 28-32, short term use only), osmotherapy with mannitol and/or hypertonic saline, analgesia and sedation, controlled external ventricular drainage, pharmacological coma, hypothermia (goal 34-36 degrees centigrade; if persistently elevated ICPs may escalate to moderate hypothermia: 32-34 degrees centigrade post aneurysm clipping/coiling) and, in refractory cases, craniectomy as indicated by patient condition.

21. Isotonic fluids at 1-1.5 mL/kg/hr recommended for maintenance.

22. Intake/output (I/O) goals: euvolemia to + 500 mL/day. Restrict diuresis to patients exceeding goals of euvolemia, and only if clinical evidence of volume overload that manifests as hypoxia and/or evidence of significant pulmonary edema/heart failure (HF), and always aim for euvolemia with I/O balance positive for hospital stay.

23. If failure to maintain lower limit of I/O goals, increase maintenance fluids to 2mL/kg/hr or higher. Consider providing crystalloid fluid boluses until I/O at least even.

24. Failure to respond to crystalloids or presence of significantly increased urine output suggestive of cerebral salt wasting (CSW) may necessitate use of hypertonic saline or colloids (25g albumin = 500 mL 5% albumin or 25-50 mL 25% albumin) as single bolus or on prn basis every 4-6 hours for CVP goals (CVP 5-8 mmHg), PiCCO goals (stroke volume variation [SVV] < 10% or global end diastolic index [GEDI] > 700 mL/m<sup>2</sup>), pulmonary artery catheter goals (PCWP 8-12 mmHg) or consistent with clinical (I/O) euvolemia goals. Consider addition of hypertonic saline and/or fludrocortisone for associated hyponatremia.

25. Consider central venous pressure monitoring, non-invasive or invasive hemodynamic pressure monitoring, with clearly stated goals, if clinically indicated.

26. Aggressively reverse coagulopathy with INR goal < 1.3 using Fresh Frozen Plasma (FFP). Vitamin K 10 mg every 12-24 hours times three doses (every 12 hours with significantly elevated INR), IV must be given as slow infusion. Administer IV upon admission, may be continued IV or transitioned to po.

For warfarin-associated ICH and INR > 1.9:

**Not Bleeding: Goal is INR in 2-3 range**

INR	Action
3- 4.5	Hold dose until INR decreased
4.5-10	1.25 mg Vitamin K PO
> 10	2.5 - 5 mg Vitamin K PO

Should see INR back in therapeutic range in 24-48 hours

**Bleeding: Goal is INR under 2**

INR	Action
2-4.5	2.5 mg Vitamin K ± FFP (15 ml/kg)
4.5-10	5 mg Vitamin K ± FFP (15 ml/kg)
>10	5-10 mg Vitamin K ±FFP (15 ml/kg)

FFP: Fresh Frozen Plasma

Life or Brain Threatening: Profilnine 4000 units + 1 mg rVIIa

Factor rVIIa (20 mcg/kg) restricted only to exceptional cases with *warfarin-associated hemorrhage* with either a) failure to respond to FFP with neurological deterioration with associated hematoma expansion; or b) ongoing neurological deterioration with delayed FFP availability; or c) elective use of factor rVIIa with evidence of spot sign on CTA or evidence of hematoma expansion on two serial CT.

For hemorrhage related to dabigatran: Reverse if patient shows signs of bleeding and has an elevated aPTT > 40 seconds using Profilnine (Factor IX complex) 4000 units (50 units/kg for patients under 80 kg.), plus one mg of Factor rVIIa.

27. Platelet transfusions (2-6 units, higher end of range if evidence of aneurysm re-rupture) in patients on anti-platelet therapy. In Epic, 1 unit of platelet pheresis leukoreduced product equals 6 units of platelets.

28. Consider seizure prophylaxis in select patients (associated cortical intraparenchymal hemorrhage (IPH), especially when IPH is temporal; associated subdural hematoma (SDH); and with unclear etiology, or with possibly traumatic SAH) for no greater than 1 week. In high grade SAH Hunt & Hess 3-5 or in patients with neurologic deterioration not otherwise explained, continuous EEG monitoring to rule out non-convulsive status epilepticus (NCSE). Recommendation for IV Keppra >> Fosphenytoin as drug for seizure prophylaxis. If evidence of seizure activity, start anti-epileptic therapy as usual.

29. Start nimodipine 60 mg po every 4 hours to be given for 21 days, alter regimen to 30 po every 2 hours if medication causes hemodynamic (and/or neurological) instability, hold if patient in clinical vasospasm and unable to tolerate medication secondary to undesired blood pressure drops.

30. Start pravastatin 40 once daily for 14 days, discontinue if abnormal liver function or increasing CPK. Monitor LFT weekly and CPK every 72 hours through the first week.

31. Monitor laboratory values as needed to monitor electrolytes, CBC, coagulation status, and drug levels.

32. Serial labs:

- a) CBC: Check Hemoglobin (Hgb) daily, goal Hgb > 9; transfuse to Hgb goal > 10 in setting of vasospasm (either clinical, angiographic, per CTA/CTP or per TCD criteria: score  $\geq 4$  in patient with Modified Fisher 1-3 or  $\geq 3$  in patient with Modified Fisher 4).
- b) Na (sodium): Goal of normonatremia unless evidence of increased ICP, significant mass effect, or global cerebral edema.
- c) Na, K (potassium): Concern for cerebral salt wasting, check every 6 hours (see #52).
- d) Mg (magnesium): Goal higher end of normal 2-2.5 mg/dL, check daily.
- e) Phenytoin level: If phenytoin used for treatment or prophylaxis, check daily initially, goal is to maintain therapeutic levels.

33. Maintain glucose levels with sliding scale insulin titrated to blood glucose 120-160 mg/dL. Use Insulin infusion if blood glucose > 180 mg/dL for two consecutive checks.

34. Maintain normothermia. Treat fever by trying to identify source; tailor interventions to

possible source(s); provide antibiotics, if indicated; and use of antipyretics. Attempt to achieve goals with acetaminophen, cooling blankets, ice packs etc; if failure to achieve goal of 36-37 degrees centigrade in 4 hours, transition to Arctic Sun and institute the [Anti-shivering protocol](#). Cultures every 48 hours, if on normothermia protocol.

35. Daily transcranial Doppler (TCD) for vasospasm surveillance.

36. CTA or Conventional angiogram for aneurysm detection.

37. When patients are admitted with SAH due to a ruptured aneurysm the Neurosurgeon and the Interventional Neuroradiologist will collaborate to determine whether definitive surgical aneurysm repair or coil embolization is the superior treatment. If it appears endovascular coiling would be safe and effective, the patient or their surrogate should be given this option.

38. Repeat CTA/ conventional angiogram in 1 week if angio negative for SAH and high clinical suspicion for aneurysmal etiology.

### **POST ANEURYSM CLIPPING/ COILING**

#### **VASOSPASM:**

39. Keep MAP > 70 in all patients; if clinical evidence of symptomatic vasospasm increase MAP goal with goal titrated to reversal of neurological deficits.

40. Routine choice of vasopressor: Norepinephrine >> phenylephrine > dopamine.

41. If evidence of stunned myocardium OR failure to respond to hypertensive therapy, ADD or SUBSTITUTE inotropic therapy (dobutamine/ milrinone) with titration to cardiac index (CI) > 3 in former (stunned myocardium) and supra-normal CI > 4.5 in latter (refractory vasospasm without evidence of stunned myocardium). Patient will ideally need non-invasive or invasive hemodynamic monitoring PRIOR to institution of inotropic support and to guide treatment.

42. Fluid goals in absence of vasospasm: euvolemia to +500 mL (CVP: 6-8 mmHg, PICCO: SVV < 10% or GEDI > 700 mL/m<sup>2</sup>, PA catheter: PCWP 8-12mmHg).

43. Fluid goals if vasospasm present: If hypertensive therapy alone or in combination with inotropic therapy fails, trial of hypervolemia with colloid boluses (25 gm 5% or 25% albumin x 2 doses or 1 liter 0.9NS x 2 or hypertonic saline with goal of Na 140-160, with CVP goal 8-12 mmHg, PCWP 12-16 mmHg or aggressively meeting PiCCO goals of SVV < 10% or GEDI > 700 mL/m<sup>2</sup> with CI goal > 4.5. If patient responds to hypervolemia, cautious maintenance of hemodynamic goals as long as consistent with neurological improvement. If no response or only transient response and apparent need to escalate goals of hypervolemia further, consider alternative strategy (addition of inotropes or neurointerventional strategies).

44. Transfuse to Hemoglobin goal > 10.

45. Indications for non-invasive and invasive hemodynamic monitoring (PiCCO >>> Swan Ganz):

- a. Vasospasm and failure of traditional triple-h therapy necessitating inotrope trial.
- b. Vasospasm in setting of significantly stunned myocardium (SM).
- c. Vasospasm in setting of patient with past medical history of moderate to severe HF (ejection fraction < 40%).

#### **Goals:**

1. CI > 3 (SM/HF), >4.5 as tolerated in all other patients.

2. Extravascular lung water index (EVLWI) < 10.
3. GEDI 700-850 mL/m<sup>2</sup> OR SVV < 10% (latter if sedated on ventilator).
4. Systemic vascular resistance index (SVRI) 1600-2400 dynes sec/cm<sup>5</sup>.

46. Indications for cerebral angiogram (diagnostic/ therapeutic: IA [intra-arterial] vasodilators, balloon angioplasty):

- A) STAT order/ Emergent (To be performed within 0 – 4 hours): Failure to respond to traditional medical therapy OR complications secondary to institution of triple-h therapy necessitating alternative management (patient with high pre-test probability of vasospasm).
- B) Urgent (To be performed the same day or following morning if ordered after hours): Diagnostic in patients in whom etiology of neurological deterioration unclear.
- C) Surveillance: at 7 days.

47. Indications for CT Angiogram + CT Perfusion (CTA/CTP):

- a) Alternative to criteria for 46. B) (Urgent cerebral angiogram) if angiography not available or quicker turnaround desired.
- b) Clinical evidence of vasospasm with negative conventional angiogram to evaluate for distal vasospasm and possible perfusion deficits.
- c) TCD evidence of vasospasm in high grade SAH (Hunt & Hess 4, 5) with unreliable neurological exam (Alternative: conventional cerebral angiogram).

48. Transcranial Doppler (TCD) Scoring Criteria:

1. MCA-FV > 120 or BA-FV > 60: 1
2. MCA-FV > 160 or BA-FV > 80: 2
3. MCA-FV > 200 or BA-FV > 95: 3
4. LI > 3 or BA/ VA > 2: 1
5. LI > 6 or BA/VA > 3: 2
6. 24 h increase > 50 cm/s (same operator): 1

Recommend CTA/P in patients with Score of  $\geq 3$  in MF 4 or  $\geq 4$  in MF 1-3

(MCA-FV: Middle Cerebral Artery mean flow velocity; BA-FV: Basilar Artery Flow velocity, LI: Lindegaard's Index; BA/ VA: Basilar Flow velocity/ Vertebral Artery Flow velocity ratio; MF: Modified Fisher's Grade.)

49. TCD evidence of vasospasm without clinical correlate in a patient with reliable neurological exam (Hunt & Hess 1, 2): watchful observation, maintain 1-2 hour neuro-checks, ensure optimization of hemodynamic goals (MAP > 70).

50. TTE may be repeated after 1 week in patients with stunned myocardium if clinically indicated.

51. Consider IABC (Intra-aortic balloon counter-pulsation) or cardiac assist device in patients with stunned myocardium, and vasospasm refractory to medical interventions and neuro-interventional therapy; will need close assistance by 8CSICU or MICU team, consider transfer out of NSICU but followed by Neurosurgery and NSICU teams.

52. CEREBRAL SALT WASTING

- a. Na, K every 6 hours.
- b. Fludrocortisone 0.2mg bid, maximal dose 0.2-0.3 mg tid.
- c. Hypertonic saline for Na < 135 mmol/dL.
- d. Match fluid losses with crystalloids.
- e. If patient shows evidence of neurological deterioration or failure to respond to # b-d, 25 gm albumin to be given every 4-6 hours prn to achieve volume goals and

	<p>normonatremia and/or CVP goal 6-8 (may titrate to PiCCO or pulmonary artery catheter goals, if available); higher goals as previously outlined if patient in symptomatic vasospasm.</p> <p>53. All other goals remain identical to orders from pre-op (normothermia, blood glucose 120-160 mg/dL, Mg 2-2.5 mg/dL, use of statins, nimodipine, seizure prophylaxis if indicated and ICP goals with CSF surveillance).</p>
RN	<p>54. Changes in patient condition to be reported to the physician in a timely manner. Maintain VAP (Ventilator Associated Pneumonia) precautions per protocol.</p>
RN and Rehabilitation Services	<p>55. Keep head of bed 30-45 degrees, if vented, and not contraindicated. Use reverse trendelenberg position as needed.</p> <p>56. Bedrest until aneurysm is secured, then advance activity as tolerated to promote active exercise, strength training, and gait training when the interdisciplinary team assesses patient as clinically appropriate for early mobilization.</p> <p>57. RN to initiate interventions as needed to prevent formation of contractures and minimize edema formation, using bracing/orthotic devices as needed.</p> <p>58. Consult Rehabilitation Services to provide aphasia treatment, cognitive rehabilitation, communication devices, movement therapy, spasticity treatment, and functional adaptation to visual/spatial neglect.</p>
RN, Rehabilitation Services, and Nutrition Services	<p>59. Dysphagia screening, using the <a href="#">Bedside Swallow Screen</a>, to be completed prior to anything by mouth. Initiate Speech Language Therapist consult for formal swallow evaluation, as needed, and when patient able to participate.</p> <p>60. Place dobbhoff tube (DHT) within 24 hours of admission if patient unable to swallow to optimize nutrition needs.</p> <p>61. Nutrition consult, as needed, to maximize nutritional support. Initiate dietary interventions to lower LDL's, if greater than 100 mg/dL.</p>
Physician and RN	<p>62. Initiate VTE prophylaxis upon admission with intermittent pneumatic compression (SCD's) in all SAH patients. Initiate chemoprophylaxis with Lovenox 40 mg subcutaneous every day or Heparin 5000 subcutaneous every 8 hours following 48 hours after aneurysm is secured via clip or coil, and at least 24 hours following insertion of extra-ventricular drain. Chemoprophylaxis will be continued throughout ICU stay regardless of patient's mobilization status. Primary Attending may choose to opt out of chemoprophylaxis for individual patients, and this decision must be documented in the medical record. Vascular ultrasound for patients with clinical symptoms of DVT or PE.</p> <p>63. Initiate peptic ulcer prophylaxis (PUD) as appropriate.</p> <p>64. Review FAST HUG during daily rounds.</p>
RN, Social Worker (MSW), Case Manager, and Physician	<p>65. Provide social and psychological support for the patient and their significant others as needed.</p> <p>66. Case management services to begin upon admission. providing ongoing utilization review. Works with multiple disciplines to determine patient's condition and needs/barriers for discharge. Coordinates discharge planning with patient and family (e.g., inpatient rehab, skilled nursing facility, home health, durable medical equipment).</p>

Multi-disciplinary team	<p>67. Identify patient and family education needs and provide appropriate information and resources found in the stroke education packet. This should include identification of personal modifiable risk factors, such as tobacco cessation, alcohol intake, nutrition, exercise, and blood pressure regulation; warning signs for stroke; activation of EMS; need for follow-up after discharge; and medications prescribed.</p> <p>68. Document education provided in the Patient Education section of the electronic medical record or LIP documentation in progress notes.</p>
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## Related documents:

- Acute Stroke Practice Standard for the Emergency Department,  
<http://ozone.ohsu.edu/healthsystem/HealthSystems/PracStand/PS01-11.html>

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NSICU and 10K UBNPC (2007, 2008, 2010)

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Dept. of Neurosurgery Faculty (2009, 2012)

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