



- UCH/ENTERPRISE
- UCMC
- WCH
- DRAKE - LTCH
- DRAKE - BWP
- DRAKE - SNF
- DRAKE - OUTPATIENT
- AMBULATORY/UCPC
- LEGAL/COMPLIANCE
- MEDICAL STAFF
- MEDICATION MGMT
- OTHER

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## STANDARD OPERATING PROCEDURE

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<b>SOP #</b>	<u>UCH-NEURO-SOP-008-05</u>
<b>SOP NAME</b>	<u>Management of Subarachnoid Hemorrhage/Vasospasm</u>
<b>ORIGINATION DATE</b>	<u>05/29/2006</u>
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### I. STANDARD OPERATING PROCEDURE

Administrative     Interdepartmental     Departmental     Unit Specific

This document details the process for the management of subarachnoid hemorrhage / vasospasm at UC Health.

### II. PURPOSE

To define treatment options for managing subarachnoid hemorrhage / vasospasm.

### III. DEFINITIONS

None

## IV. PROCEDURE

### A. Assessment

1. Clinical assessment includes:
  - a. WFNS. Glasgow Coma Scale. Hunt and Hess Scale. 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. Other assessment scores: Fisher CT Grade.
2. Diagnostic assessment of subarachnoid hemorrhage may include:
  - a. Brain imaging: CT, MRI
  - b. Cerebrovascular imaging: angiogram, CTA, MRA, MRV
  - c. Neuro- monitoring options:
    - 1) Intracranial pressure (ICP); LICOX Brain tissue oxygen (PbtO<sub>2</sub>); EEG; Multimodality Neuro Monitoring; Microdialysis
  - d. Neurovascular monitoring options:
    - 1) Transcranial Dopplers (TCDs); Cerebral blood flow studies

### B. Initial Management - Emergency Department or on ICU Admission

1. Implement initial general resuscitation protocols. Appropriate interventions include:
  - a. Airway Management
    - 1) Supplemental O<sub>2</sub> to maintain SaO<sub>2</sub> ≥ 95%.
    - 2) Intubate for an inability to protect airway: Use RSI Protocol. Titrate ventilator to maintain PaO<sub>2</sub> ≥ 100 mm Hg, and PaCO<sub>2</sub> Normalized
  - b. Circulation
    - 1) Establish minimum of 2 large bore IVs
    - 2) Place NG/Foley if indicated (may defer as appropriate for elevated BP).
    - 3) Draw initial assessment labs (CBC, renal profile, & cardiac enzymes, TEG profile, ASA and Plavix Assay)
    - 4) Place central intravenous catheter and arterial line if indicated during initial care. If patient has limited peripheral access and/or multiple infusions or blood draws requiring additional access may consider central intravenous catheter placement.
  - c. Diagnosis/ Assessment
    - 1) Arrange for appropriate diagnostic imaging.
    - 2) Obtain baseline physical exam/assessment including GCS
    - 3) Document severity measurement - Hunt and Hess score. Must be documented within 6 hours of arrival OR prior to any surgical intervention.
  - d. Hemodynamic Management
    - 1) Avoid hypotension and hypertension (ie, goal SBP < 140 mm Hg).
    - 2) Goal MAP ≤ 70 mm Hg.

- e. Sedatives and Analgesics as indicated. Preferred agents based on desired goal:
  - 1) For Sedation: use propofol for mechanically ventilated patients.
  - 2) For Analgesia: use fentanyl
- f. Management options for signs of intracranial hypertension or herniation.
  - 1) Hyperventilation (temporary)
  - 2) Mannitol
  - 3) Hypertonic Saline Per NSICU Protocol
  - 4) Consider placement of ICP monitor/ventriculostomy
  - 5) Preferred device: ventriculostomy. If in ED, consider transfer to ICU or OR for placement.
- g. Management options for signs of hydrocephalus or intraventricular hemorrhage.
  - 1) Insert ventriculostomy. If in ED, consider transfer to ICU or OR for placement.
  - 2) Keep ventriculostomy open to drain as specified by neurosurgery.
  - 3) Monitor intracranial pressure (ICP) every hour, goal ICP  $\leq$  20 mm Hg.
- h. Seizure prophylaxis
  - 1) Keppra with initial dose of 1000mg PO/IV BID
  - 2) Other antiepileptics may be indicated based on clinical situation
- i. Calcium Channel Blockers
  - 1) Start Nimodipine 60mg PO q 4 hours x 21 days or while hospitalized.
  - 2) Must be started/administered within 24 hours of hospital arrival.
  - 3) If the patient is NPO it must be documented in the medical record as to why the patient is NPO and thus will not receive nimodipine within 24 hours.

**C. Intensive Care Unit: Pre-Operatively**

- 1. Review all initial care needs from Section II. A.
  - a. Place Arterial line/Central lines if clinically indicated.
  - b. Initiate analgesia if mechanically ventilated, monitor for effects on MAP.
- 2. Respiratory Management
  - a. Maintain SaO<sub>2</sub>  $\geq$  95% with supplemental O<sub>2</sub> as needed
  - b. If intubated, goal PaCO<sub>2</sub> = 35 - 45 mm Hg.
  - c. If PbtO<sub>2</sub> monitor placed, titrate ventilator to maintain PbtO<sub>2</sub>  $\geq$  20 mm Hg.
- 3. Neurological Examinations
  - a. Nursing documentation of hourly vital signs and GCS. NIHSS documentation every 12 hours. Cranial nerve exam documented every shift.

4. Hemodynamic Management
  - a. Maintain MAP  $\leq$  70 mm Hg or SBP  $<$  140 mm Hg with antihypertensive agents until etiology of SAH determined and causative aneurysm is secured. Agents for blood pressure control include IV labetalol as needed or Nicardipine drip.
  - b. Administer fluids. Avoid hypervolemia, fluid balance goal is a range of 0 - 500 ml positive every 24 hours. Goal is euvolemia.
  - c. Fluid options: Normal Saline with or without 20 meq KCl, Normosol, Lactated Ringer's Solution
5. Ventriculostomy / Acute Phase ICP Management
  - a. Keep ventriculostomy open to drain as specified by neurosurgery.
  - b. Monitor ICP every hour, goal ICP  $\leq$  20 mm Hg.
  - c. Neurosurgical resident be notified for ICP elevation.
  - d. Management options for signs of intracranial hypertension or herniation.
    - 1) Hyperventilation (temporary)
    - 2) Mannitol
    - 3) Hypertonic Saline per NSICU Protocol
6. Seizure prophylaxis
  - a. Keppra at 1000mg PO/IV BID
  - b. Other antiepileptics may be indicated based on clinical situation.
7. General Care Issues
  - a. Glucose: Initiate treatment for hyperglycemia. Goal glucose  $<$  180 mg/dL.
  - b. Sodium: Maintain in normal range (135 - 146 mEq/L).
  - c. Magnesium: Maintain  $\geq$  1.8 mg/dL.
  - d. Hematologic: Reverse coagulopathy (FFP/Cryoprecipitate/Platelets/vitamin K).
  - e. Temperature: Goal is normothermia. Culture per NSICU protocol for fever  $\geq$  101.5 F
  - f. Nutrition: address within first 24 - 48 hours after admission. Keep NPO while awaiting imaging and neurosurgical plan.
  - g. Nimodipine 60mg PO q 4 hours x 21 days or while hospitalized.
8. Prepare for any Neurosurgical procedures

**D. Aneurysm Treatment/Neurosurgical Management**

1. Surgical Clipping or Endovascular Treatment of a ruptured aneurysm will occur as early as feasible.
2. Goal is to secure aneurysm within 24 hours of presentation to UCMC
  - a. Complete obliteration of the aneurysm is the goal of treatment
  - b. Determination of aneurysm treatment is a multidisciplinary decision made by cerebrovascular specialists based on characteristics and condition of the patient and aneurysm.
3. If the patient presents in a delayed fashion or is found to have vasospasm on admission, treatment of the aneurysm may be delayed until it is deemed to be safe by the cerebrovascular specialist.

**E. General Management - ICU care after aneurysm is secured**

1. 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. Track medication effects on MAP.
  - c. Closely monitor fluid status (Refer to Table 1)
    - 1) Daily body weights and fluid balance calculations with a goal range of 0 - 500 ml positive every 24 hours.
    - 2) Fluid options: Normal Saline with or without 20 meq KCl, Normosol, Lactated Ringer's solution
2. Respiratory management:
  - a. Maintain SaO<sub>2</sub> ≥ 95% with supplemental O<sub>2</sub> as needed
  - b. If intubated, goal PaCO<sub>2</sub> = 35 - 45 mm Hg.
  - c. If PbtO<sub>2</sub> monitor placed, titrate therapies to maintain PbtO<sub>2</sub> ≥ 20 mm Hg
3. Neurological examinations
  - a. Nursing documentation of hourly vital signs and GCS while in the NSICU. NIHSS documented every 12 hours. Cranial nerve exam documented every shift.
4. Ventriculostomy / ICP management:
  - a. Keep ventriculostomy open to drain at 5- 10 mm Hg or as specified by neurosurgery.
  - b. Monitor ICP every hour, goal ICP ≤ 20 mm Hg.
  - c. Neurosurgical resident to be notified for ICP elevation.
  - d. Management options of ICP elevations and herniation
    - 1) Ensure patent drainage from EVD
    - 2) Mild Hyperventilation
    - 3) Hypertonic Saline per NSICU protocol
    - 4) Mannitol
5. Seizure prophylaxis:
  - a. Continue Keppra for total of 3 days unless GCS less than 8 then total of 7 days, unless clinically indicated to continue treatment.
  - b. In patients with GCS < 8, continuous EEG monitoring x 72 hours.
  - c. Other antiepileptics may be indicated based on clinical situation.
6. Corticosteroids: There is no indication for corticosteroids after aneurysmal clipping.
7. TCDs:
  - a. Baseline as soon as possible or at day 1 - 3 post- hemorrhage.
  - b. Surveillance every Monday, Wednesday, and Friday unless patient has exam change or severely elevated TCD's.
8. General Care Issues:
  - a. Glucose: Treat hyperglycemia. Goal glucose < 180/dL.
  - 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  $\geq 101.5$  F
  - e. Nutrition: address by 24 – 48 hours after admission.
  - f. DVT prophylaxis: Initiate sequential compression devices upon admission. Consider subcutaneous heparin after aneurysm is secured, or if patient is not surgical candidate.
  - g. Nimodipine 60mg PO q 4 hours x 21 days or while hospitalized.
  - h. Early Physical, Occupational, and Speech Therapy consultations.
  - i. Consult to Social Services
  - j. Consult other ancillary departments such as nutrition services, wound care, diabetes education, etc as indicated.
9. Multidisciplinary Management
- a. Patients admitted to the NSICU with aneurysmal SAH have a multidisciplinary team including neurosurgery and neurocritical care who evaluate patients before and after surgery and/or endovascular procedures.
  - b. Patients undergoing endovascular procedures will also be evaluated prior to and post procedure by a physician from interventional radiology.
  - c. Consultations to other services for pre and/or post-operative evaluation such as internal medicine, cardiology, pulmonology will be made on an as needed basis per the patients clinical status and past medical history.

**F. Vasospasm Treatment Algorithms. For specific management guidelines (See Appendix A - Algorithm) The algorithms are based on the neurological exam.**

1. Aneurysmal Subarachnoid Hemorrhage with Stable Neurologic Exam
  - a. Continue to monitor TCD's and perform per protocol.
  - b. Treatment will be guided by any changes in exam in conjunction with TCD data, including Lindegaard Index.
  - c. Patients with elevations in TCD readings will not be treated based on readings alone rather treatment will be guided based on neurological exam.  
**Do not initiate vasospasm treatment empirically.**
  - d. For patients with elevated TCD readings and stable neurological exam can consider more frequent assessment with TCD and or blood flow studies.
  - e. For patients who are severely neurologically impaired and difficult to assess for neurological change consider angiogram if velocity  $>200$ , interval rise  $> 50\%$  since last study or Lindegaard Index  $> 4:1$ .
2. Aneurysmal Subarachnoid Hemorrhage with New Neurologic Deficit
  - a. Algorithm # 1
  - b. Consider full differential (Table 2 below)
  - c. Contact Neurosurgery Immediately for any acute neurological worsening.
  - d. Treatment goals for patients with symptomatic vasospasm is induced hypertension with euvolemia

- e. Careful consideration in treatment of vasospasm in those with preexisting cardiac disease. In patients with heart disease if vasospasm is suspected may consider early angiogram.
- 3. Specific Vasospasm Management Issues
  - a. Refer to tables in vasospasm management algorithm
  - b. Options to increase volume (Table 3)
  - c. Options to increase blood pressure (Table 4)
  - d. Options to increase cardiac index (Table 5)
  - e. Cerebral angioplasty and/or selective intra-arterial vasodilator therapy will be considered in patients with cerebral vasospasm who are not responding rapidly to other treatment measures.

**V. RESPONSIBILITY**

<b>Tasks</b>	<b>Responsible Staff</b>
Medical Management	Emergency Staff, Neurocritical Care, Neurologists, NSICU Nursing staff
Ventriculostomy, Clipping, Coiling, endovascular treatments	Neurosurgery, Neurointerventionalist

**VI. KEY WORDS**

Management of Subarachnoid Hemorrhage  
 Subarachnoid  
 Subarachnoid Hemorrhage  
 Vasospasm

**VII. APPENDIX**

- A. Algorithm 1
- B. Tables for Vasospasm Algorithms

**VIII. RELATED FORMS**

None

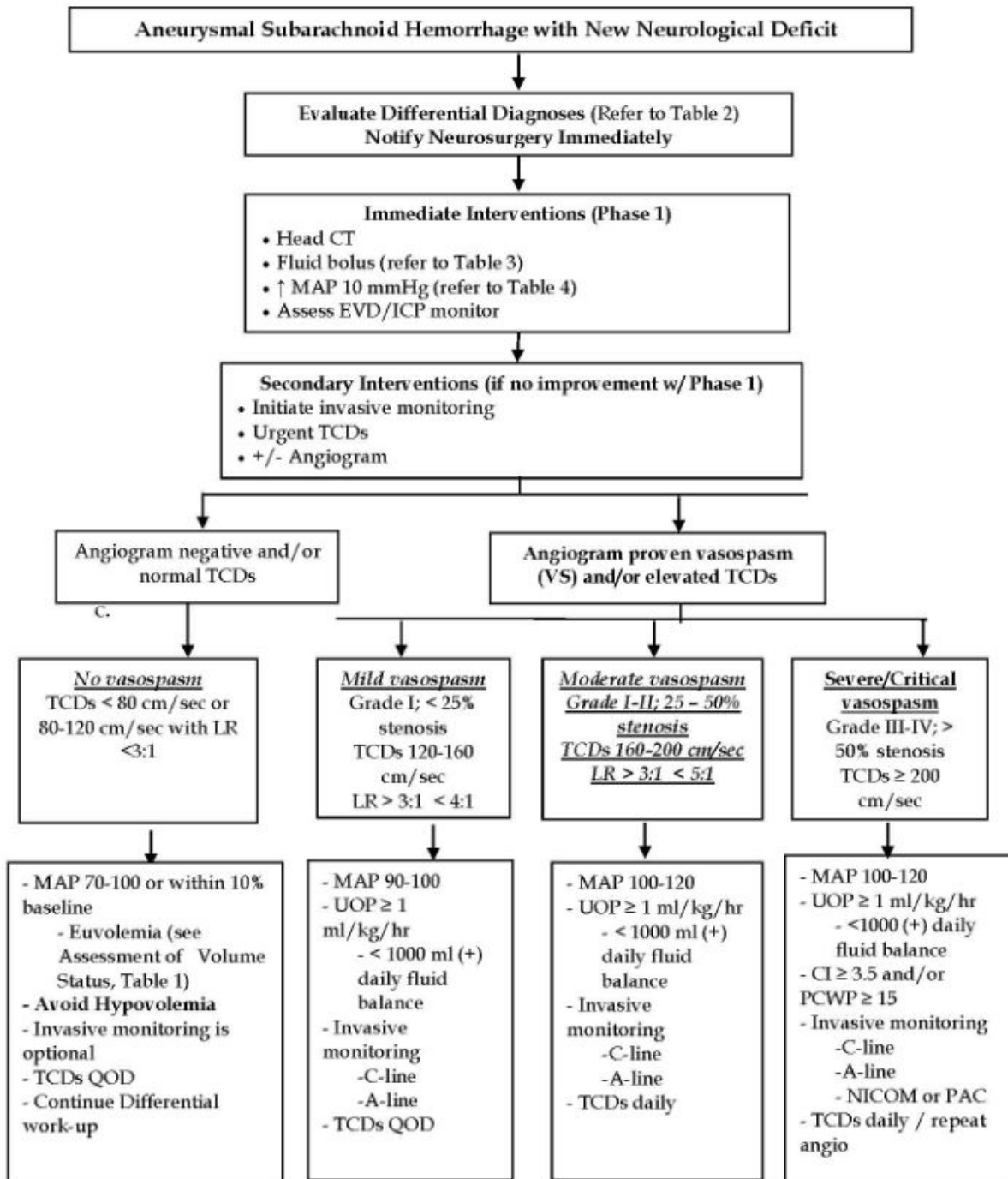
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## A. Algorithm 1



## B. Tables for Vasospasm Algorithms

Physical exam	Vital signs; Daily weight
Daily fluid balance	I's & O's; UOP
Urine studies	Specific gravity; FENA; Osmolality
Serum studies	<b>Renal panel: Na, BUN, Cr; Osmolality</b>
CXR	Pulmonary edema
Cardiopulmonary status	CVP; PCWP, Nicom, Passive leg raise Systolic pressure variability if mechanically ventilated

Differential diagnosis	Diagnostic Work-up
Re-bleed/new infarct/acute HCP	Head CT
Vasospasm	TCDs, angiogram
↑ ICP	refer to ICP Treatment Algorithm
Seizure	√ AED level, EEG
Metabolic abnormality	√ renal panel, LFTs, NH3
Hypotension	fluid bolus, √ CBC (? sepsis/hemorrhage)
Infection	√ temp, WBC, cultures
Medication overdose	√ MAR, consider narcan
Hyper/hypothermia	normalize temperature
Hyper/hypoglycemia	√ FSBS
Respiratory issues (hypoxia, Hyper/hypocarbica)	ABG, ↑ FIO2, assess need for intubation

Agent	Volume
NS or normosol	500-1000 ml
5% Albumin	250-500 ml
3% saline (if Na low)	250 ml
Blood (if HGB < 10)	1 - 2 units PRBC

<b>Table 4: Options to increase blood pressure</b>	
<b>Intervention</b>	<b>Considerations</b>
Fluid bolus	Refer to table 3 for recommendation
Review medications	Eliminate or decrease those that lower BP Sedation / analgesia: propofol, fentanyl Calcium channel blockers: nimodipine; Beta-blockers Antiepileptics: phenytoin
Vasopressors	Norepinephrine Vasopressin if serum sodium normal (not more than 0.04 units/min)
<b>Table 5: Options to increase cardiac index</b>	
Dobutamine Norepinephrine Milrinone (long T <sup>1/2</sup> )	