



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

STANDARD OPERATING PROCEDURE

SOP #	<u>UCH-NEURO-SOP-008-07</u>
SOP NAME	<u>Management of Subarachnoid Hemorrhage/Vasospasm</u>
ORIGINATION DATE	<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 (PbtO₂); 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 O₂ to maintain SaO₂ ≥ 95%.
 - 2) Intubate for an inability to protect airway: Use RSI Protocol. Titrate ventilator to maintain PaO₂ ≥100 mm Hg, and PaCO₂ 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 (unless otherwise specified by physician).
- h. Seizure prophylaxis
 - 1) Kepra 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 /NGT q 4 hours (or 30 mg PO/NGT q2h dependent on pt BP) 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 SaO₂ \geq 95% with supplemental O₂ as needed
 - b. If intubated, goal PaCO₂ = 35 - 45 mm Hg.
 - c. If PbtO₂ monitor placed, titrate ventilator to maintain PbtO₂ \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 (unless otherwise specified).
 - c. Notify neurosurgical resident 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 /NGT q 4 hours (or 30 mg PO/NGT q2h dependent on pt BP) 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 UC Health
 - 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 SaO₂ ≥ 95% with supplemental O₂ as needed
 - b. If intubated, goal PaCO₂ = 35 - 45 mm Hg.
 - c. If PbtO₂ monitor placed, titrate therapies to maintain PbtO₂ ≥ 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. CT Angiography

- a. Consider obtaining CTA 7-10 days post-hemorrhage to evaluate for clinical unsuspected vasospasm.
- 9. General Care Issues:
 - a. Glucose: Treat hyperglycemia. Goal glucose < 180/dL.
 - b. Sodium: Maintain in normal range (135 – 146 mEq/L).
 - c. Magnesium: Maintain \geq 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 /NGT q 4 hours (or 30 mg PO/NGT q2h dependent on pt BP) 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.
- 10. 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 patient’s 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 laststudy 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

Tasks	Responsible Staff
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

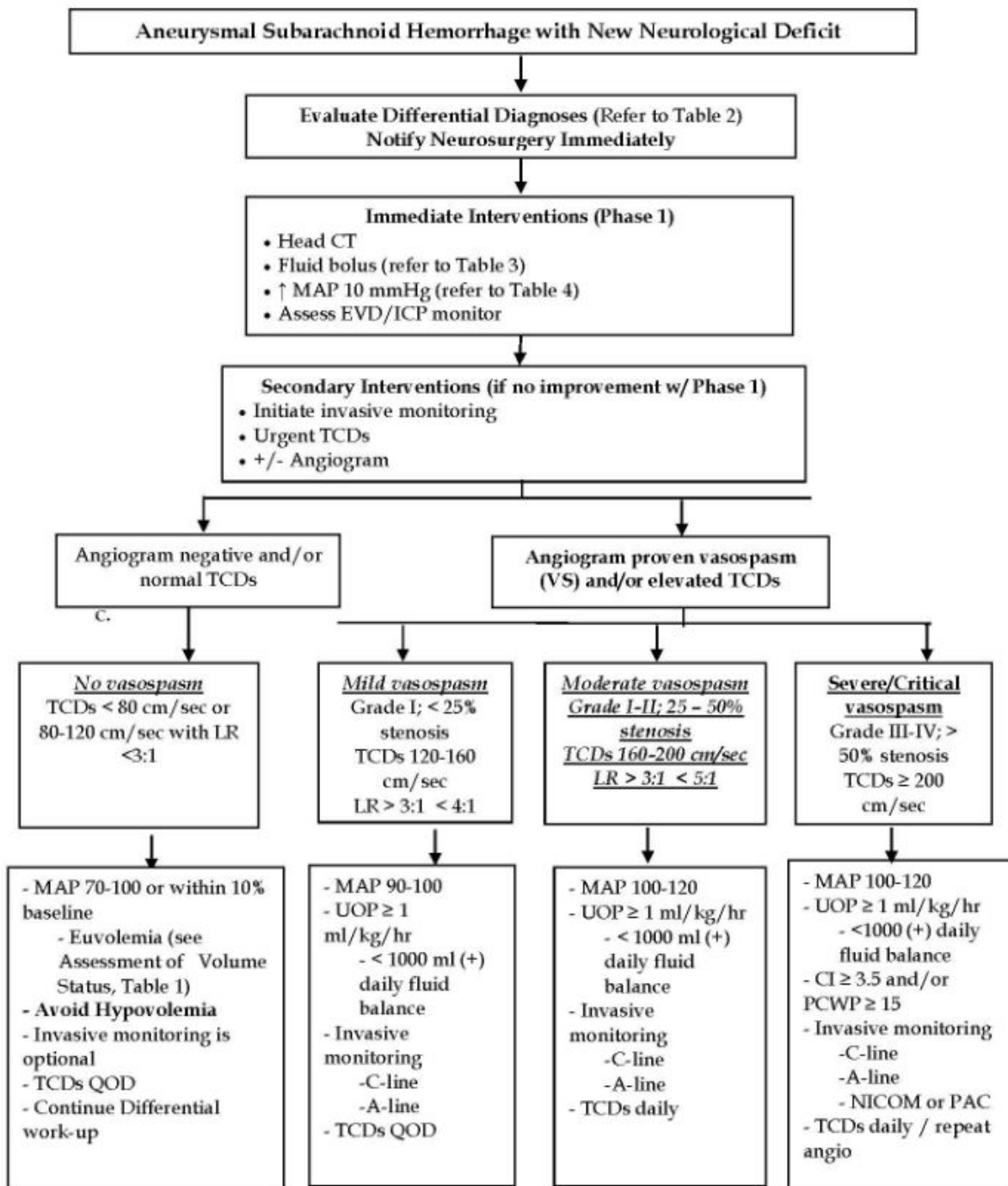
None

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Appendix A. Algorithm 1



Appendix B. Tables for Vasospasm Algorithms

Table 1: General Assessment of Volume Status	
Physical exam	Vital signs; Daily weight
Daily fluid balance	I's & O's; UOP
Urine studies	Specific gravity; FENA; Osmolality
Serum studies	Renal panel: Na, BUN, Cr; Osmolality
CXR	Pulmonary edema
Cardiopulmonary status	CVP; PCWP, Nicom, Passive leg raise Systolic pressure variability if mechanically ventilated

Table 2: Differential and preliminary diagnostic work-up for a new neurological deficit in patients with aneurysmal subarachnoid hemorrhage	
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, NH ₃
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, ↑ FIO ₂ , assess need for intubation

Table 3: Options to increase volume	
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

Table 4: Options to increase blood pressure	
Intervention	Considerations
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)
Table 5: Options to increase cardiac index	
Dobutamine Norepinephrine Milrinone (long T _{1/2})	