



# **Acute Stroke Standards and Policies 2023**

*\*Policies may be updated throughout the year, for the most current polices always refer to the SCR and Compliance 360\**

# Management of Acute Ischemic Stroke

**PURPOSE:** The University of Alabama at Birmingham Stroke Team has approved these guidelines to delineate a consistent, evidenced-based approach to treating patients who present with signs and symptoms consistent with acute ischemic stroke.

**SYNOPSIS:** These guidelines provide guidance for the rapid identification of patients with acute ischemic stroke, improve patient selection for thrombolysis, and manage patients based on guidelines<sup>1,2</sup> and the best available evidence. Each patient will be evaluated and treated with an individualized plan of care.

## STRATEGY:

### 1. Evaluation And Diagnosis Of Acute Ischemic Stroke In the University Emergency Department (ED):

- a. Patients arriving to the ED with symptoms of acute stroke will be taken directly to an ED room for urgent evaluation. The ED physician and charge nurse will be notified immediately of a potential stroke patient. The goal for door to physician evaluation time will be <10 minutes.
- b. The initial evaluation will begin with immediate stabilization of the airway, breathing, and circulation followed by obtaining a focused history and neurologic exam. The history will include key elements of time of symptom onset (or last seen normal), symptom location, medical history, and a current list of medications.
- c. In patients who are hypotensive (defined as blood pressure significantly lower than the pre-stroke state or SBP <120 mm Hg), placement of the head of the bed flat and saline (0.9% saline at 100 mL/h) will be administered to optimize cerebral perfusion.
- d. Patients at risk for airway obstruction or aspiration and those with suspected elevated ICP will have the head of the bed elevated 15° to 30°.
- e. If acute stroke is suspected and the time of onset or last known well is within 6 hours, the ED physician will activate a “Code Stroke” by calling the UAB operator (Dial “0” or “4-2244”).
  - A “Code Stroke Extended” will be activated for patients with a last known well time between 6-24 hours and/or for patients who woke up with new symptoms.
- f. A “Code Stroke” page will be automatically sent to all Neurology residents, Stroke attendings, pharmacy, Stroke Coordinators, stroke research personnel, and CT scan technicians. Members of the Stroke Team will immediately head to the ED to evaluate the patient. The goal for Stroke Team evaluation time will be <15 minutes from hospital arrival.
- g. The ED physician will order basic labs and a non-contrasted head CT scan found in the “UED Stroke” Order Set in IMPACT.
  - Standard laboratory tests will include a STAT serum glucose (finger stick is acceptable), coagulation studies (PT, PTT, INR), serum electrolytes, renal function tests, troponin, and a complete blood count. Tests may be obtained by Point of Care testing at the bedside if available.
  - A STAT non-contrast computed tomography (CT) scan will be done immediately. CT room technicians will receive the “Code Stroke” page in order to immediately prepare an open scanner.
    - A STAT CT head and neck with contrast (CTA) and CT perfusion will be obtained on each code stroke, unless contraindicated.
    - Stroke patients will have first priority for CT scanning.
    - Goals: door to CT initiation <20 minutes and CT scan to CT interpretation <35 minutes.

- If necessary, a 12 Lead EKG and a chest X-ray may be ordered and will be completed within 45 minutes from hospital arrival. Transport to CT will not be delayed for these tests.
  - Other components of the “UED Stroke” admission order set will be implemented as needed at the recommendations of the stroke team.
- h. Nursing will start 2 peripheral IVs (preferably in different extremities and one being at least 20 gauge), draw blood for labs, implement continuous cardiac monitoring, assess need for supplemental oxygen to maintain SpO<sub>2</sub> > 94%, and ensure that no food or medication is given by mouth until a dysphagia screen is completed.
  - i. IV fluids (0.9% saline at 100 mL/h) will be started with a goal to maintain euvolemia.
  - j. A neurological examination and a National Institutes of Health Stroke Scale (NIHSS) score will be determined and documented by the Stroke Team.
  - k. Based on the history, laboratory and neuroimaging information, the ED physician in consultation with the Stroke Team will determine eligibility for thrombolysis (See separate tenecteplase Guidelines).
    - Door to needle time primary goal for tenecteplase will be < 45 minutes. □ Post tenecteplase care is also outlined in the tenecteplase Guidelines.
  - l. Consideration for intra-arterial therapy will be made on a case-by case basis as outlined in the Intra-arterial Treatment of Acute Ischemic Stroke guidelines.
  - m. For patients who are not candidates for tenecteplase or intra-arterial therapy, aspirin will be administered if there are no contraindications, allergies, or concerns for active bleeding.
    - Aspirin ranging from 81 mg - 325 mg PO if the patient passes the dysphagia screen. □ Aspirin 300 mg per rectum if patient fails dysphagia screen.
  - n. Unless contraindicated, patients will also be given a high dose statin (atorvastatin 80 mg orally daily preferred).<sup>3</sup>
  - o. Ischemic stroke patients will be admitted to either the Neurology Stroke and Surgical Unit (NSSU) or Neuroscience Intensive Care Unit (NICU), and admission to any other unit will be at the discretion of the stroke team.
  - p. If there are more than one acute, complex stroke patients in the Emergency Department at one time, the Stroke Team physician will call the attending Stroke Neurologist, the General Neurology Consult resident, or the Emergency Department Attending Physician to assist the Stroke Team members on the scene to ensure that timely and effective care is given to all stroke patients.

## 2. Evaluation And Diagnosis Of Acute Ischemic Stroke On An Inpatient Ward or ICU:

- a. Patients with suspected stroke will be stabilized immediately. If acute stroke is suspected, the treating physician will activate a “Code Stroke” by calling the UAB operator (Dial “0” or “4-2244”).
  - A STAT nurse will respond to all inpatient code strokes. If the STAT nurse is unavailable then he/she is to notify a MET nurse to respond to the code stroke.
- b. In patients who are hypotensive, defined as blood pressure significantly lower than pre-morbid state or SBP <120 mm Hg, placement of the head of the bed flat and administration of 0.9% Sodium chloride solution will be administered to optimize cerebral perfusion.
- c. Patients at risk for airway obstruction or aspiration and those with suspected elevated ICP will have the head of the bed elevated 15° to 30°.
- d. A physician (Primary Treating Physician or Stroke Team) will order appropriate labs and neuroimaging.
  - Recommended laboratory tests include a STAT serum glucose (finger stick is acceptable), coagulation studies (PT, PTT, INR), serum electrolytes, renal function tests, markers of cardiac ischemia and a complete blood count.

- A STAT non-contrast computed tomography (CT) scan, CT perfusion, and a CT Angiogram Head and Neck.
  - Stroke patients will have first priority for CT scanning.
  - The goal time from discovery or onset of symptoms to CT initiation is 20 minutes and the goal from discovery or onset of symptoms to CT interpretation is 35 minutes.
- If necessary, a 12 lead EKG and a chest X-ray will be ordered and will be completed within 45 minutes. Transport to CT will not be delayed for these tests.
- e. Nursing will start 2 peripheral IVs (preferably in different extremities and one being at least 20 gauge), draw blood for labs, implement continuous cardiac monitoring, assess need for supplemental oxygen to maintain SpO<sub>2</sub> > 94%, and ensure that no food or medication is given by mouth until a dysphagia screen is completed.
- f. IV fluids (0.9% Sodium chloride at 100 mL/h) may be administered with a goal to maintain euvolemia.
- g. Based on the history, laboratory and neuroimaging information, the treating physician, in consultation with the Stroke Team, will determine if the patient is eligible for IV thrombolysis (See separate *tenectepase Protocol*). Onset to needle time primary goal for tenectepase will be <45 minutes.
  - Patients who are eligible for IV thrombolysis may receive the bolus on the floor. These patients will be moved to either the stroke unit (NSSU) or an intensive care unit depending on the coexisting medical/surgical needs.
  - Post- tenectepae care is outlined in the tenectepase Guidelines.
- h. Consideration for intra-arterial therapy will be made on a case-by case basis as outlined in the *Intra-Arterial Treatment of Acute Ischemic Stroke Guidelines*.
- i. Patients who are not candidates for tenectepase or intra-arterial therapy will be given aspirin if there are no contraindications, allergy or concerns for active bleeding. A bedside dysphagia screen will be done prior to oral medication administration.
  - Aspirin ranging from 81 mg - 325 mg PO if the patient passes the dysphagia screen. □ Aspirin 300 mg per rectum if patient fails dysphagia screen.
- j. Unless contraindicated, patients will also be given a statin (atorvastatin 80 mg orally daily is preferred).<sup>3</sup>

### 3. Evaluation of Acute Ischemic Stroke at UAB Highlands:

- a. When a patient with suspected stroke presents to the UAB Highlands Emergency Department, a Code Stroke will be activated by dialing 4-2244. The UAB eMedicine Stroke Service should be activated by entering a consult in to the eMedicine platform on the telemedicine cart and the teleneurologist will respond to the case. Together, the tele-neurologist and the Highlands Emergency Department Attending physician will determine treatment decisions and if the patient should be transferred to the UAB main hospital.
  - The Highlands Code MET Team will not be asked to respond to a Code Stroke in the Highlands ED.
  - When a decision is made to transfer a patient with a stroke to the UAB Main Hospital, the Highlands Emergency Department Attending will place a transfer order in IMPACT.

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The tele-neurologist will provide instructions about patient management while awaiting transfer to the UAB Main Hospital.

- Tenecteplase may be administered at UAB Highlands Emergency Department, if the tele-neurologist recommends treatment (See tenecteplase Guideline for instructions).
  - A NIH Stroke Scale will be determined by the Emergency Department physician prior to tenecteplase administration, if tenecteplase is administered at Highlands ED.
  - Transfers from Highlands to the UAB Main Hospital are not handled by the MIST operator, as these are internal transfers (i.e., from one unit to another).
  - The Highlands ED Attending physician will have primary responsibility for the patient until the patient is transferred to the UAB Main Hospital.
- b. For inpatients at UAB Highlands with symptoms of acute stroke, the Stroke Attending physician will communicate with the Highlands Attending physician and facilitate transfer to University Hospital for acute treatment when clinically appropriate.
- The Highlands Code MET Team will be called to respond to a Code Stroke in a Highlands inpatient unit.
  - The Attending Stroke Neurologist will provide instructions about patient management while awaiting transfer, and during transfer, to the UAB Main Hospital.
  - When a decision is made to transfer a patient with a stroke to the UAB Main Hospital, the Highlands Attending will place a transfer order in IMPACT and call Center for Patient Flow at 4-5278 to alert them of the emergency transfer request.
  - Transfers from Highlands to the UAB Main Hospital are not handled by the MIST operator, as these are internal transfers (i.e., from one unit to another).
  - The Highlands Attending physician will have primary responsibility for the patient until the patient is transferred to the UAB Main Hospital.

#### **4. Evaluation of Acute Ischemic Stroke at UAB Gardendale Freestanding Emergency Department:**

- a. When a patient with suspected stroke presents to the UAB Gardendale Freestanding Emergency Department (FED), a code stroke will be activated by dialing 4-2244. The UAB eMedicine Stroke Service should be activated by entering a consult in to the eMedicine platform. Together the tele-neurologist and the Gardendale FED physician will determine treatment decision and if the patient should be transferred to the UAB main hospital.
- b. When a decision is made to transfer a patient with a stroke to the UAB Main Hospital, the Gardendale Emergency Department Attending will place a transfer order in IMPACT.
- c. The tele-neurologist will provide instructions about patient management while awaiting transfer to the UAB Main Hospital.
- d. Tenecteplase may be administered at UAB Gardendale FED, if the tele-neurologist recommends treatment (See tenecteplase Guideline for instructions).
- e. A NIH Stroke Scale will be determined by the Emergency Department physician prior to tenecteplase administration, if tenecteplase is administered at Gardendale FED.
- f. Transfers from Gardendale FED to the UAB Main Hospital are not handled by the MIST operator, as these are internal transfers (i.e., from one unit to another).
- g. The Gardendale FED Attending physician will have primary responsibility for the patient until the patient is transferred to the UAB Main Hospital.

#### **5. Cerebral And Cerebellar Swelling<sup>2</sup>:**

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- a. Patients with significant cerebral or cerebellar swelling due to ischemic stroke are at risk of deterioration.
- b. Patients with the following findings and symptoms of significant swelling are at risk of rapid deterioration:
  - Cerebral swelling.
    - CT evidence of involvement of >1/3 of the affected middle cerebral artery territory and midline shift.
    - MRI evidence of infarction volume  $\geq 80$  mL.
    - Diminished level of consciousness or change in neurological examination
  - Cerebellar swelling.
    - Imaging evidence of a cerebellar infarction with mass effect and effacement of the fourth ventricle.
    - Obstructive hydrocephalus.
    - Diminished level of consciousness or worsening neurological symptoms
- c. Medical management of significant swelling.
  - Patients with significant cerebral or cerebellar swelling will be admitted to the NICU and intubation if protection of the airway appears to be threatened.
  - For intubated patients, normocarbia will be maintained.
  - For patients at risk for significant cerebral or cerebellar swelling, imaging studies will be performed within 12-16 hours of arrival.
  - If >1/2 of MCA territory shows DWI changes consistent with infarction and the patient is considered to be a candidate, then the primary team will consult the vascular neurosurgery attending on call for consideration of a decompressive craniectomy.
  - Discussion for utilization of hyperosmolar therapy should be initiated in discussion with the Neurocritical Care attending physician and Neurology team with an agreed upon goal
  - Prophylactic hyperosmolar therapy should not be utilized
  - Neurosurgery consult should be done before malignant cytotoxic edema maximizes.
- d. Neurosurgical management of significant swelling.
  - Cerebral swelling
    - Patients with significant cerebral swelling will be considered for decompressive craniectomy.
  - Cerebellar swelling
    - Patients with significant cerebellar swelling will be considered for ventriculostomy followed by decompressive craniectomy.

## 6. Evaluation For Stroke Source And Mechanism:

- a. Once the patient has been stabilized and admitted to the hospital, the source and mechanism of the stroke will be investigated.
- b. Laboratory studies:
  - All patients will have a lipid profile drawn and be screened for diabetes mellitus with a hemoglobin A1c.
- c. Neuroimaging:
  - Non-contrast head CT scan:
    - Required in the emergent evaluation of stroke to rule out hemorrhage and identify early ischemic changes in presence of large vessel occlusion.

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- Magnetic Resonance Imaging (MRI):
  - Most patients will receive a stroke protocol MRI of the brain to evaluate the vascular territory, extent, and in many cases mechanism of infarction. DWI sequencing is the most sensitive and specific test for detecting early infarction and can provide information on stroke mechanism. MRI may also be as accurate as CT in detecting hemorrhage and more sensitive than CT for detection of microbleeds. Patients will be assessed for any contraindication to MRI prior to performing this study.

d. Intracranial vascular imaging:

All patients will have intracranial vascular imaging. If not contraindicated, most patients will receive an MR Angiogram (MRA) which is performed with the MRI.

- CT Angiography (CTA) is an acceptable alternative to MRA in patients without renal impairment or contrast allergy.
- Transcranial Doppler (TCD) may be ordered to provide additional cerebrovascular hemodynamic evaluation.
- When indicated, a digital subtraction angiogram will be obtained.

f. Extracranial vascular imaging

- All patients will undergo extracranial vascular imaging. Most patients will receive at least one non-invasive, vascular imaging studies including an MRA or a carotid ultrasonogram. When indicated, a digital subtraction angiogram will be obtained.

g. Cardiac evaluation

- All patients will have a baseline troponin level drawn. Serial measurements will be obtained every 8 hours for 3 times or until troponin is trending down.
- All patients will be screened for arrhythmias with an EKG in the ED and at least 24 hours of cardiac monitoring during the hospitalization.
- Stroke patients will be evaluated with a trans-thoracic or trans-esophageal echocardiogram. Echocardiograms may be done outpatient in select patients.
- In patients with cryptogenic stroke who are suspected of a paroxysmal cardiac arrhythmia, outpatient cardiac monitoring (loop recorder/event monitor or implantable device) will be considered.

h. Other

- Additional work up (e.g hypercoagulable studies) will be obtained on individual basis in case of strong clinical suspicion.

## 7. Secondary Stroke Prevention:

- a. For all ischemic stroke patients a thorough stroke evaluation will be done to determine the underlying stroke mechanism and guide secondary stroke prevention treatment. b. Antiplatelet Agents:
- Aspirin will be started for ischemic stroke patients within 24-48 hours after stroke onset unless contraindicated.
  - Other antiplatelet agents (clopidogrel, aspirin/dipyridimole) may be substituted for aspirin in selected patients as indicated.
  - Some patients will receive dual antiplatelet therapy based on their unique risk and stroke mechanism.
  - Antiplatelet agents will not be given within 24 hours of teneceplase administration, unless medically indicated for other reasons.

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## c. Anticoagulation:

- Except in rare circumstances, therapeutic heparin will not be used for the treatment of acute ischemic stroke.
- In some circumstances where anticoagulation is preferred over antiplatelet therapy (e.g., atrial fibrillation), timing of the initiation of therapy will take into account the risk of hemorrhagic conversion.
  - In patients with atrial fibrillation, if anticoagulation is not used, justification will be documented.
- Anticoagulation (including for DVT prophylaxis) will not be given within 24 hours of tenecteplase administration.

d. Unless contraindicated, ischemic stroke patients will be treated with a high dose statin (atorvastatin 80 mg daily).<sup>3</sup>



Patients with carotid artery disease demonstrated by vascular imaging will be considered for surgical or endovascular intervention.

- For acute ischemic strokes caused by carotid occlusive disease, carotid revascularization will be performed in most cases within 2-14 days from the stroke onset unless otherwise contraindicated
- f. Patients will be screened for stroke risk factors and strategies will be identified to improve long term management of these conditions.
- g. Patients with poorly controlled or new onset diabetes will be seen by a diabetes educator.
- h. Patients who use tobacco products will be counseled on cessation and referral to appropriate cessation services will be provided.
- i. Patients will be counseled on appropriate lifestyle modifications including increasing physical activity.
- j. Patients will be counseled on dietary modifications based on their medical comorbidities. Some patients may benefit from a dietician consultation.

## **8. General Hospital Management:**

- a. Head of bed (HOB) positioning:
  - Beyond the acute window, there is limited data to guide HOB positioning. In general, HOB flat orders can be discontinued once the patient is admitted to the hospital. This will facilitate early activity with rehabilitation specialists.
  - Patients felt to be at high risk for neurologic deterioration or who are experiencing symptom fluctuation may be left on bedrest with the HOB flat at the discretion of the treating physician.
  - Patients at risk for airway obstruction or aspiration and those with suspected elevated ICP will have the head of the bed elevated  $>30^{\circ}$ .
- b. Hypoxia will be avoided and supplemental oxygen will be administered to maintain oxygen saturation  $>94\%$ .
- c. Sources of hyperthermia (temperature  $>38^{\circ}$  Celsius) should be identified and treated. Antipyretic medications may be used to lower temperature.
- d. Blood pressure management:
  - In patients who receive tenecteplase blood pressure will be maintained below 180/105 as outlined in the tenecteplase protocol.
  - In patients who do not receive tenecteplase permissive hypertension is allowed during the first 24 hours unless there is evidence of other end-organ involvement (aortic dissection, myocardial infarction, pulmonary edema, etc). Antihypertensive medications will be withheld unless the BP is  $>220/120$  mm Hg.
  - When needed to maintain BP within these parameters, the following regimen will be used:
    - Intravenous nicardipine may be administered as a continuous infusion with a starting dose of 5 mg/h, and then increased by 2.5 mg/h every 5-15 min as needed, up to a maximum of 15 mg/h.
    - Intravenous clevidipine may be administered as a continuous infusion with a starting dose of 1-2mg/h, and then titrate by doubling the dose every 2-5 minutes as needed, up to a maximum of 32mg/h. Total dose administered within a 24 hour period should not exceed 1,000mL of the 0.5 mg/mL emulsion due to lipid load restrictions
    - If BP is greater than the target, despite infusion of the maximum nicardipine or clevidipine dose for 30 min, a second agent will be used (Labetalol 10–20 mg IV bolus every 10 min; maximum dose 300 mg per 24 hours).

- Avoid a large sudden decrease in blood pressure to avoid hypoperfusion. The ideal blood pressure goal when treating hypertension is between SBP 160-180.
  - Routine oral antihypertensive medications will be resumed or initiated after 24 hours in patients who are neurologically stable.
- e. Nutrition:
- All stroke patients will undergo a bedside swallowing examination prior to oral intake, including oral medications.
  - For patients who fail the initial bedside swallowing evaluation, speech therapy will be consulted for further evaluation and recommendations.
  - Patients who are not cleared for an oral diet will be provided with enteral nutrition via a nasogastric, nasoduodenal, or PEG tube.
- f. Glycemic management: Hyperglycemia will be treated to achieve blood glucose levels in range of 140 to 180 mg/dL<sup>2</sup>. Patients will be closely monitored to avoid hypoglycemia.
- g. All patients will receive pharmacologic DVT prophylaxis unless contraindicated, in which case, mechanical prophylaxis will be used.

## 9. Rehabilitation evaluation

- a. All patients will be evaluated for rehabilitation needs.
- b. The Stroke Team may determine that the patient has no neurologic deficits in which case rehabilitation consultations are not necessary.
- c. In patients with persisting deficits, other services including physical therapy, occupational therapy, and speech therapy will be consulted to assist in determining the patient's rehabilitation needs.
- d. Patients with persisting deficits may also be evaluated by Physical Medicine and Rehabilitation.
- e. These evaluations will be performed to determine the optimal rehabilitation disposition for the patient (inpatient rehabilitation, skilled nursing facility, outpatient therapies) and will be communicated to the appropriate Case Manager to facilitate post-hospital care.

## 10. Follow up care

- a. Patients will be scheduled for appropriate follow up with their primary care physician for continuing treatment of modifiable risk factors.
- b. Patients with ischemic stroke will be provided with a follow up appointment after discharge in the Neurology Clinic.
- c. All patients will be provided with education on stroke risk factors, newly prescribed medications, importance of follow up care, signs and symptoms of stroke and will be instructed to call 9-1-1 should they experience any of these symptoms. This education will be provided verbally by the Stroke Team as well as contained in a take home education booklet.

## REFERENCES:

1. Jauch EC, Saver JL, Adams HP, Jr., Bruno A, Connors JJ, Demaerschalk BM, Khatri P, McMullan PW, Jr., Qureshi AI, Rosenfield K, Scott PA, Summers DR, Wang DZ, Wintermark M, Yonas H. **Guidelines for the early management of patients with acute ischemic stroke: A guideline for healthcare professionals from the American Heart Association/American Stroke Association.** *Stroke*. 2013;44:870-947 <http://stroke.ahajournals.org/content/44/3/870>

2. Wijdicks EF, Sheth KN, Carter BS, Greer DM, Kasner SE, Kimberly WT, Schwab S, Smith EE, Tamargo RJ, Wintermark M. **Recommendations for the management of cerebral and cerebellar infarction with swelling:** A statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2014;45:1222-1238  
<http://stroke.ahajournals.org/content/45/4/1222>
3. Amarenco P, Goldstein LB, Szarek M, Sillese H, Rudolph AE, Callahan A, 3rd, Hennerici M, Simunovic L, Zivin JA, Welch KM. **Effects of intense low-density lipoprotein cholesterol reduction in patients with stroke or transient ischemic attack:** The stroke prevention by aggressive reduction in cholesterol levels (sparcl) trial. *Stroke*. 2007;38:3198-3204
4. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, Jauch EC, Kidwell CS, Leslie-Mazwi TM, Ovbiagele B, Scott PA, Sheth KN, Southerland AM, Summers DV, Tirschwell DL; on behalf of the American Heart Association Stroke Council. 2018 Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2018;49:eXXX–eXXX. doi: 10.1161/STR.000000000000158.
5. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, Jauch EC, Kidwell CS, Leslie-Mazwi TM, Ovbiagele B, Scott PA, Sheth KN, Southerland AM, Summers DV, Tirschwell DL; on behalf of the American Heart Association Stroke Council. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2019;50:e344–e418 doi: 10.1161/STR.000000000000211.

# *Intravenous Administration of Tenecteplase for Acute Ischemic Stroke*

**PURPOSE:** The University of Alabama at Birmingham (UAB) Stroke Team has approved these guidelines to delineate a consistent, evidenced-based approach to treating patients who present with signs and symptoms consistent with acute ischemic stroke. These guidelines outline procedures for the rapid identification of neurovascular events, and improve patient selection for thrombolysis, and patient management of acute ischemic stroke. These guidelines are developed as general practice guidelines and are not a substitute for clinical judgement.

**SYNOPSIS:** Until recent studies, Alteplase has been the cornerstone of thrombolytic treatment since the National Institutes of Neurological Disorders and Stroke Trial was published in 1995. Current studies have shown the safety and efficacy of tenecteplase in the treatment of acute ischemic stroke and its use has become standard of care of many stroke centers not only in the United States, but globally as well. Its use has also been endorsed by the 2019 Update to the 2018 American Heart Association/American Stroke Association Guidelines.

## **STRATEGY:**

### **A. Indications for tenecteplase**

1. Clinical diagnosis of ischemic stroke causing a measurable neurological deficit.
  - a. Any disabling deficit will be considered.
2. Time of symptom onset established to be within 3 hours of tenecteplase administration.
  - a. Select patients may be eligible to receive tenecteplase between 3 and 4.5 hours from symptom onset. These patients must satisfy additional criteria outlined below.
3. Age  $\geq$  18 years
4. Determination of tenecteplase eligibility is the responsibility of the Stroke Team.

### **B. Contraindications to tenecteplase**

#### **1. Absolute Contraindications**

- a. Evidence of intracranial hemorrhage on baseline computed tomography (CT) scan.
- b. History of hypersensitivity or allergic reaction to alteplase or tenecteplase.
- c. Current known intracranial or subarachnoid hemorrhage
- d. Uncontrolled hypertension at time of treatment (blood pressure  $>185/110$  mmHg despite aggressive attempts at lowering).
  - i. Note: IV antihypertensive agents may be used to lower blood pressure to an acceptable level prior to tenecteplase injection.
  - ii. Intravenous clevidipine may be administered as a continuous infusion with a starting dose of 1 – 2mg/hr., and then titrate by doubling the dose every 2-5 minutes as needed, up to a maximum dose of 32 mg/hr. The total dose administered within a 24 hour period should not exceed 1,000mL of a 0.5 mg/mL emulsion due to lipid load restrictions.
  - iii. Intravenous nicardipine may be administered as a continuous infusion with a starting dose of 5 mg/hr., and then increased by 2.5 mg/hr every 15 minutes as needed, up to a maximum of 15 mg/hr. If blood pressure remains greater than the target, despite infusion of the maximum nicardipine dose for 30 minutes, a second agent will be used

- (labetalol 5–20 mg IV bolus every 10 minutes [maximum dose 300 mg per 24 hours]).
- e. Active internal bleeding
  - f. Any intracranial or spinal surgery or serious head trauma within the past 3 months
  - g. Acute bleeding diathesis, including but not limited to:
    - i. Current use of oral anticoagulants with PT >15 seconds. or INR>1.7
    - ii. Patients taking oral direct thrombin inhibitors and oral direct Factor Xa inhibitors within the last 48 hours
    - iii. Platelet count <100,000/mm<sup>3</sup> (patients may receive a platelet transfusion and be reconsidered for eligibility)
  - h. Arterial puncture at a noncompressible site in the past 7 days
  - i. CT demonstrates multilobar infarction (hypodensity >1/3 cerebral hemisphere) j. Acute aortic dissection
2. Relative Contraindications ( Risk of intracranial hemorrhage may be increased in the conditions listed below. In these situations, anticipated benefits for each individual case will be weighed against the potential risks.)
- a. Patients with non-disabling or rapidly improving stroke symptoms
  - b. Pregnancy
  - c. Lumbar puncture within the past 10 days
  - d. Patients with an INR between 1.4 and 1.7
  - e. Patients with recent myocardial infarction within the past 3 months
  - f. Recent subarachnoid hemorrhage
  - g. Recent intracranial hemorrhage
  - h. Previous stroke within the past 3 months
  - i. Major surgery or serious trauma within the past 14 days
  - j. Recent gastrointestinal or urinary tract hemorrhage within the past 21 days
  - k. Known untreated intracranial neoplasm, aneurysm, or arteriovenous malformation
  - l. Blood glucose concentration < 50 mg/dL or >400 mg/dL.
    - i. Note: An attempt should be made to correct the blood glucose and the patient should be reassessed for ongoing neurologic deficits. If the glucose is corrected and disabling neurologic symptoms persist, tenecteplase will be considered
  - m. Concern for infective endocarditis or subarachnoid hemorrhage at presentation
- Administration of unfractionated heparin or low molecular weight heparin (therapeutic dose) and an PTT >40 seconds or elevated anti-Xa level
3. Additional relative considerations for treating patients between 3 and 4.5 hours from symptom onset will be considered and include:
- a. Age >80 years
  - b. Use of oral anticoagulants regardless of the INR level
  - c. National Institutes of Health Stroke Scale (NIHSS) score >25
  - d. Patients with a history of both diabetes and previous stroke

### C. Evaluation prior to tenecteplase administration

1. The Stroke Team will respond to a Code Stroke page within 20 minutes in person or via telephone.
  - a. For UAB Highlands Inpatient Code Strokes, a Code Stroke will be activated by dialing 4-2244. The UAB eMedicine Stroke Service should be activated by entering an eMedicine consult into IMPACT and the tele-neurologist will respond to the case.
  - b. For UAB Highlands Emergency Department and UAB Gardendale Freestanding Emergency Department Code Strokes: Patients with suspected stroke, a Code Stroke will be activated by dialing 4-2244. The UAB eMedicine Stroke Service should be activated by entering a consult into IMPAC. Together the tele-neurologist and ED physician will

determine treatment decision and if the patient should be transferred to the UAB main hospital.

- c. In the instance that the eMedicine Service is not available, the in-patient Stroke Attending will be made aware that they are responsible to cover HED and GED Code Stroke

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Activations. The Stroke Attending will call in within 20 minutes and assist with acute stroke decisions, including the administration of IV thrombolytics, thrombectomy, and transfer disposition.

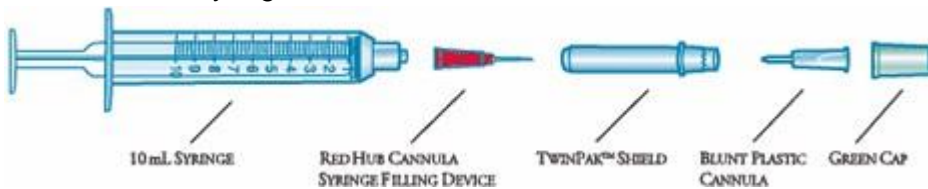
- d. In the instance the telestroke cart cannot be activated (technical failure) the ED provider should page the on-call telestroke physician (call schedule available through UAB MIST 205-934-6478). If the telestroke provider cannot be reached, the ED provider should contact the on-call UAB Stroke Attending.
2. The following components of the acute stroke evaluation must be ordered STAT and will be used in the tenecteplase decision making process.
  3. Laboratory Tests
    - a. Recommended tests
      - i. Blood glucose (finger stick is acceptable). Results required prior to administration of tenecteplase
      - ii. Platelet count and coagulation studies (INR, PT, PTT). If there is no clinical suspicion for bleeding abnormality or thrombocytopenia and there is no history of use of anticoagulants, the results are not required prior to administration of tenecteplase.
      - iii. Serum electrolytes
      - iv. Renal function tests
      - v. Markers of cardiac ischemia
      - vi. Complete blood count
    - b. Additional laboratory tests in selected patients
      - i. Liver function tests
      - ii. Toxicology screen and blood alcohol level
      - iii. Pregnancy test
      - iv. Arterial blood gas
  4. Neuroimaging
    - a. A STAT non-contrast CT scan will be done immediately. CT room technicians will receive the "Code Stroke" page in order to immediately prepare an open scanner. Stroke patients will have first priority for CT scanning. Goals: door to CT initiation <20 minutes and CT scan to CT interpretation <35 minutes.
  5. Twelve-lead EKG and chest x-ray
    - a. Transportation to CT will not be delayed to obtain an EKG or chest x-ray unless there is high clinical suspicion for aortic dissection or other life-threatening condition that mandates an EKG or chest x-ray.
  6. When indicated, placement of invasive lines, a nasogastric tube or a Foley catheter will be done prior to administration of tenecteplase.

#### D. Tenecteplase Consent, dosing and administration

1. **Tenecteplase Consent** - As soon as the decision is made to proceed with tenecteplase, verbal informed consent will be obtained from the patient or their representative.
  - a. Informed consent will include a discussion of the potential benefits, risks, side effects, likelihood of the patient achieving his or her goals, and any other potential problems that might occur as the result of treatment. The discussion will also include benefits and risks of alternative treatments.

- b. In case patient or patient's representative is unable to comprehend or provide verbal consent, tenecteplase may be considered for patients treated within 3 hours from symptom onset with two physician consent between a member of the ED (or primary) team and stroke attending
2. Tenecteplase dosing
  - a. Obtain patient weight in kilograms (can be estimated weight or stated weight from patient or family member) and calculate the appropriate tenecteplase dose. The dose of tenecteplase for acute ischemic stroke is 0.25 mg/kg. If the patient's weight is  $\geq 100$  kg, then the maximum dose is 25 mg. Round dose to the nearest 0.2mL (1mg)
  - b. Tenecteplase may be reconstituted by the pharmacist, the Registered Nurse, or the Stroke Team. In the absence of a pharmacist in the Emergency Department, registered nurses will be allowed to reconstitute tenecteplase following a second witness check off system.
    - i. Obtain the tenecteplase 50mg/10mL kit<sup>4</sup>

**NOTE:** The tenecteplase kit is supplied with a dual cannula system attached to a 10mL syringe as show below:



**Please discard the supplied cannula system in the sharps bin and use a 10 mL Luer-Lock® syringe and an 18 gauge needle to reconstitute Tenecteplase, then administer Tenecteplase via Luer-Lock® connection to the patient's IV catheter port.**

- ii. Withdraw 10mL of sterile water for injection (SWFI) from the supplied diluent vial.
 

**Note: Do NOT use Bacteriostatic Water for Injection.**
- iii. Inject 10mL of SWFI into the Tenecteplase vial directing the diluent stream into the powder. Slight foaming is common.
- iv. Gently swirl until contents are completely dissolved (usually ~1min). **DO NOT SHAKE.**
- v. Reconstituted preparation contains tenecteplase 5mg/mL
- vi. Inspect the solution for any particulate matter or discoloration (should be a colorless to pale yellow transparent solution).
- vii. Withdraw the appropriate volume of solution based on patient weight (Not to exceed maximum dose: 25mg = 5mL). Round dose to the nearest 0.2mL (1mg).
3. Tenecteplase administration
  - a. Administration of tenecteplase will not be delayed to obtain an EKG or chest x-ray unless there is high clinical suspicion for aortic dissection or other life-threatening condition that mandates an EKG or chest x-ray.
  - b. Ensure that the patient's blood pressure at the time of bolus is below 185/110 mm Hg. Use IV antihypertensives to achieve this goal before the tenecteplase bolus. If this cannot be achieved, then tenecteplase will not be administered.
  - c. Flush the intravenous line with normal saline before and after administration of tenecteplase to avoid precipitation.
  - d. Administer as an intravenous BOLUS over 5 seconds, followed by a normal saline flush. Tenecteplase is for IV administration only.

## E. Post-tenecteplase general patient management

1. Patients receiving tenecteplase will be admitted to the Stroke Unit (NSSU) or Neuroscience, Intensive Care Unit (NICU) unless otherwise ordered by the Stroke attending physician.
2. Orders will be administered using the Impact Post-Tenecteplase Powerplan.
3. Order blood pressure checks and neurologic assessments. The goal blood pressure following tenecteplase administration is <180/105 mmHg.
  - a. Every 15 minutes for 2 hours from the tenecteplase bolus, then
  - b. Every 30 minutes for 6 hours, then
  - c. Every hour for 16 hours, then
  - d. At a minimum every 4 hours thereafter.
4. Patients will Not be given anticoagulants (including DVT prophylaxis) or antiplatelet agents during the first 24 hours following tenecteplase injection unless medically indicated and approved by the Stroke Attending.
5. Avoid nasogastric tubes, unnecessary blood draws to non-compressible sites, or invasive lines/procedures or intramuscular injections for 24 hours following tenecteplase injection whenever possible.
6. A follow up CT or MRI will be obtained within 24 hours following tenecteplase administration to evaluate for hemorrhage and guide initiation of secondary prevention measures.
7. Emergency Department, NSSU, and NICU nursing will:
  - a. Notify the Stroke Team or on-call neurology resident for any deterioration in neurological status, change in level of consciousness, nausea/vomiting, diaphoresis or new headache.
  - b. Notify the Stroke Team or on-call neurology resident for any of the following complications:
    - i. Gingival bleeding/oozing
    - ii. Ecchymosis or petechiae 5
    - iii. Abdominal or flank pain
    - iv. Hemoptysis or hematemesis
    - v. Shortness of breath, rales, or rhonchi
    - vi. Arrhythmias
    - vii. Facial or oropharyngeal swelling
  - c. Observe any existing invasive lines for bleeding and apply pressure as needed.
  - d. Maintain IV access already in place (restart only if necessary).
  - e. Monitor extremities for changes in color, temperature or sensation.

## F. Complications

1. Elevated blood pressure
  - a. Blood pressure will be maintained < 180/105 mmHg following tenecteplase administration.
  - b. Avoid a large sudden decrease in blood pressure to avoid hypoperfusion. Ideal blood pressure goal when treating hypertension is between SBP 160-180.
2. Neurological deterioration
  - a. Causes of neurological deterioration may include hemorrhagic conversion, seizure, or worsening of existing stroke.
  - b. If there is clinical suspicion for intracerebral hemorrhage (neurological deterioration, new headache, acute hypertension, nausea or vomiting), a STAT head CT will be obtained.
  - c. A STAT head CT will be obtained in any circumstance in which there is significant neurological deterioration.
3. Angioedema - Angioedema is an uncommon complication of tenecteplase administration but it may cause oropharyngeal edema and airway compromise. a. Treatment options include:
  - i. Methylprednisolone 125 mg IV
  - ii. Diphenhydramine 50 mg IV



- iii. Epinephrine 0.3 mg IM- if airway is compromised
- b. If there is evidence of respiratory distress, an ED physician or Anesthesia will be paged STAT for intubation.

**REFERENCES:**

- Jauch EC, Saver JL, Adams HP, Jr., Bruno A, Connors JJ, Demaerschalk BM, Khatri P, McMullan PW, Jr., Qureshi AI, Rosenfield K, Scott PA, Summers DR, Wang DZ, Wintermark M, Yonas H. Guidelines for the early management of patients with acute ischemic stroke: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2013;44:870-947
- Del Zoppo GJ, Saver JL, Jauch EC, Adams HP, Jr. Expansion of the time window for treatment of acute ischemic stroke with intravenous tissue plasminogen activator: A science advisory from the American Heart Association/American Stroke Association. *Stroke*. 2009;40:2945-2948
- Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Southerland AM, Summers DV, Tirschwell DL; on behalf of the American Heart Association Stroke healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2018;49:eXXX–eXXX. doi: 10.1161/STR.000000000000158.
- Kheiri B, Osman M, Abdalla A, Haykal T, Ahmed S, Hassan M, Bachuwa G, Al Qasmi M, Bhatt DL,. Tenecteplase versus alteplase for management of acute ischemic stroke: a pairwise and network metaanalysis of randomized clinical trials. *J Thromb Thrombolysis*. 2018: 46:440-450. doi: 10.1007/s11239-0181721-3.
- Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, Jauch EC, Kidwell CS, Leslie-Mazwi TM, Ovbiagele B, Scott PA, Sheth KN, Southerland AM, Summers DV, Tirschwell DL; on behalf of the American Heart Association Stroke Council. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2019;50:e344–e418 doi: 10.1161/STR.000000000000211.

# *Intra-Arterial Treatment of Acute Ischemic Stroke*

**PURPOSE:** The University of Alabama at Birmingham Stroke Team has approved these guidelines to delineate a consistent, evidenced-based approach to catheter-based treatment of acute ischemic stroke.

**SYNOPSIS:** These guidelines provide guidance for the rapid recognition of acute ischemic stroke caused by large vessel occlusion, improve patient selection for endovascular revascularization, and manage patients according to current published guidelines<sup>1</sup> and available evidence.<sup>2</sup>

**Indications for intra-arterial treatment of acute ischemic stroke:** All acute ischemic stroke patients are first considered for possible intravenous thrombolytic therapy and are then considered for endovascular therapy if they have large vessel occlusions and are beyond the time window or otherwise ineligible for - intravenous thrombolytic therapy, or have received intravenous thrombolytic therapy with a clinical suspicion that the patient will not respond accordingly. .

1. A significant neurologic deficit expected to result in long-term disability.
2. Deficits attributable to large vessel occlusion (basilar, vertebral, internal carotid or middle cerebral artery M1 or M2 branches).
3. Non-contrast CT scan without hemorrhage or well-established infarction.
4. Acute ischemic stroke symptoms with clearly defined time of onset or last known time prior to onset of symptoms.
5. Patients who are not a candidate for IV thrombolytic therapy, or who have a persisting severe deficit from large vessel occlusion after IV thrombolytic infusion (See Intravenous Tenecteplase Guidelines).
6. Expected time of recanalization of affected artery is within 6-8 hours of established, non-fluctuating deficits due to anterior circulation (carotid/MCA) stroke.
  - a. A thrombectomy may be considered in select patients who are within 6-24 hours of symptom onset and meet other DAWN<sup>1</sup> or DEFUSE-3<sup>2</sup> eligibility criteria.
7. Vertebral/ basilar ischemia may cause fluctuating, reversible ischemic symptoms over many hours or even days and still be appropriate candidates for therapy.

**Absolute contraindications:**

1. Intracranial hemorrhage by imaging.
2. Suspected aneurysmal subarachnoid hemorrhage.
3. Well-established acute infarct on CT/MR in the affected brain region.
4. If intra-arterial infusion of thrombolytic medication is anticipated, intracranial lesions with a high likelihood of hemorrhage (e.g., brain tumor, abscess, vascular malformation, aneurysm, or contusion).

**Relative contraindications:** These factors may increase the chance of an unfavorable outcome but are not absolute contraindications intra-arterial treatment.

1. Severe stroke (NIHSS > 22).
2. Rapid neurological improvement.
3. Mild stroke (NIHSS < 6).
4. Severe comorbid disease with limited life expectancy.
5. Poor baseline status (modified Rankin Scale Score  $\geq 3$ ).
6. ASPECTS Score < 6.

**STRATEGY:**

1. Evaluation and initial management of acute ischemic stroke in the Emergency Department or inpatient ward (see Acute Ischemic Stroke Guidelines)
2. Pre-procedure management
  - a. Supplementary oxygen will be administered if unable to maintain O<sub>2</sub> SAT ≥ 94%.
  - b. Treat any fever with rectal acetaminophen.
    - i. Start two peripheral IVs and administer IV fluids (preferably 0.9% Sodium chloride, and avoid dextrose containing fluids if possible) with a goal to maintain euvolemia.
  - c. NPO for any oral intake (e.g. food, medication, etc.).
  - d. Placement of a Foley catheter, nasogastric tube, arterial line and central venous line will be done as indicated when they are necessary for the procedure, and when they will not delay transportation of the patient to the angiography suite.
  - e. Avoid any femoral catheters (venous or arterial).
  - f. Do not lower blood pressure unless it is causing myocardial ischemia or exceeds 220/120 mm Hg.
  - g. Do not administer heparin unless recommended by the Acute Stroke Team.
  - h. Obtain STAT head CT head, CTA head and neck, and/or CT perfusion.
  - i. The Stroke Neurology attending on call will contract the Neurointerventionalist on call after the patient is evaluated in the UAB ED. "Heads up" calls, prior to the patient's arrival and evaluation in the ER, will be avoided. This applies to patients transferred from other centers as well as UAB inpatients and patients undergoing the initial evaluation in the UAB ED.
  - j. Patients who are already admitted to another center and who are transferred to UAB for intraarterial treatment of acute ischemic stroke will be admitted directly to the UAB NICU.
  - k. Patients at UAB Highlands and UAB Gardendale Freestanding Emergency Department may be brought directly to the Neuro Angio Suite.
  - l. After discussion with the on call Interventionalist, the stroke attending will activate a "Neuro IR Alert" by dialing (205) 934-3411.
  - m. The STAT nurse will respond to the "Neuro IR Alert" to assist with patient and HVC room preparation.
  - n. Consider bypassing CTA if risk of contrast nephropathy increased or if the CTA procedure may be difficult (e.g., renal failure, acute CHF, poor IV access). Hold metformin for 48 hrs. after administration of iodinated contrast.
  - o. Review CT, CTA, and/or CTP with Interventionalist and Stroke Team.
  - p. Obtain written or verbal informed consent for endovascular procedure and general anesthesia from patient or appropriate representative. If no individual is available for consent, consider emergency consent procedure.
3. Procedure technique
  - a. UAB Anesthesia will be involved in every case. The neurointerventionalist (attending or fellow) and the anesthesia team will determine the form of anesthesia to be used for the case.
  - b. Intravenous heparin (3,000-5,000 units bolus and 1,000 units/hr) will be administered after arterial access is obtained, as needed.
  - c. Foley and/or NG tubes will be placed prior to thrombolytic drug infusion when feasible.
  - d. Permissive or induced hypertension may be used until reopening of affected arteries is accomplished in patients with poor collateral flow.
  - e. Choice of technique (endovascular thrombolytic vs. mechanical thrombectomy vs. combined) will be made by the interventionalist during the procedure.
  - f. Angioplasty and/or stenting will be used when necessary in appropriate cases. Antiplatelet therapy with a GP IIb/IIIa inhibitor will be used when necessary.

4. Multiple case situations
  - a. If there is more than one acute, complex stroke patient requiring intra-arterial therapy at the same time, a second angiography suite (Room 10, Heart and Vascular Center) will be prepared.
  - b. An additional nurse and technologist team will assemble. If outside of business hours, then the Vascular Interventional Radiology call team will be called in.
  - c. The additional procedure will be started by the interventional neuroradiology fellow or resident under the supervision of the neurointerventionalist, or back-up neurointerventionalist as available.
  
5. Post-procedural management
  - a. Call respiratory therapy for ventilator delivery to NICU when necessary.
  - b. Call for CT scan to be done post thrombolysis en route to Neuro ICU when there is a concern for bleeding or swelling.
  - c. Admit the patient to the NICU or NSSU.
  - d. Assess Vital Signs and neurological exam Q 15 min for 2 h and Q 30 min for next 6 h, then Q 1 h for a total of 24 h after treatment.
  - e. Assess arterial puncture site and distal pulses Q 15 min for 1 hour, Q 30 min for 1 hour, and Q 1 h for a total of 4 hours after treatment.
 

The Neurointerventionalist and Stroke Attending will discuss appropriate blood pressure targets after completion of the procedure based on unique patient factors and degree of recanalization.
  - f. Obtain a head CT if the patient develops worsening neurological status, severe headaches, acute severe hypertension or acute sustained elevation in blood pressure, nausea/vomiting.
  - g. For patients treated with thrombolytic medications, avoid placement of NG tubes, Foley catheters, or intra-arterial catheters until the day after treatment if possible.
  - h. Avoid antithrombotic agents (e.g. heparin, aspirin) for 24 hours post IV thrombolytic.
  - i. Routine head CT or MRI/MRA on post-procedure day one.
  - j. Antithrombotics can then be administered if the CT shows no evidence of hemorrhage.
  
6. Ongoing Stroke Management
  - a. See Ischemic Stroke Guidelines for complete stroke work up and management.

#### REFERENCES:

1. Jauch EC, Saver JL, Adams HP, Jr., Bruno A, Connors JJ, Demaerschalk BM, Khatri P, McMullan PW, Jr., Qureshi AI, Rosenfield K, Scott PA, Summers DR, Wang DZ, Wintermark M, Yonas H. Guidelines for the early management of patients with acute ischemic stroke: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2013;44:870-947
2. Powers WJ, Derdeyn CP, Biller J, Coffey CS, Hoh BL, Jauch EC, Johnston KC, Johnston SC, Khalessi AA, Kidwell CS, Meschia JF, Ovbiagele B, Yavagal DR; on behalf of the American Heart Association Stroke Council. 2015 American Heart Association/American Stroke Association focused update of the 2013 guidelines for the early management of patients with acute ischemic stroke regarding endovascular treatment: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2015;46:3020–3035.
3. Meyers PM, Schumacher HC, Connolly ES, Jr., Heyer EJ, Gray WA, Higashida RT. Current status of endovascular stroke treatment. *Circulation*. 2011;123:2591-2601
4. Amarenco P, Goldstein LB, Szarek M, Sillensen H, Rudolph AE, Callahan A, 3rd, Hennerici M, Simunovic L, Zivin JA, Welch KM. Effects of intense low-density lipoprotein cholesterol reduction

- in patients with stroke or transient ischemic attack: The stroke prevention by aggressive reduction in cholesterol levels (sparcl) trial. *Stroke*. 2007;38:3198-3204
5. Qureshi AI, Palesch YY. Antihypertensive treatment of acute cerebral hemorrhage (atach) ii: Design, methods, and rationale. *Neurocrit Care*. 2011;15:559-576
  6. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, Jauch EC, Kidwell CS, Leslie-Mazwi TM, Ovbiagele B, Scott PA, Sheth KN, Southerland AM, Summers DV, Tirschwell DL; on behalf of the American Heart Association Stroke Council. 2018 Guidelines for the early management of patients with acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2018;49:eXXX–eXXX. doi: 10.1161/STR.000000000000158.

## *Primary Intracerebral Hemorrhage*

**PURPOSE:** The University of Alabama at Birmingham Stroke Team has approved these guidelines to delineate a consistent, evidenced-based approach to treating patients who present with signs, symptoms and imaging findings of acute hemorrhagic stroke.

**SYNOPSIS:** These guidelines provide for the rapid identification of patients with hemorrhagic stroke, optimal patient selection for intervention, and the management of patients according to current published guidelines<sup>1</sup> and the best available evidence.

### **STRATEGY:**

1. **Evaluation and management of acute hemorrhagic stroke in the Emergency Department (ED):**
  - a. . The ED physician and charge nurse will be notified immediately of a potential stroke patient. Door to physician evaluation should be <10 minutes.
  - b. Based on the initial evaluation, the ED physician will decide if the patient is having an acute stroke. If acute stroke is suspected and the onset or last known well is within 6 hours, the ED physician will activate a “Code Stroke” by calling the UAB operator (Dial “0” or “4-2244”).
    - i. A “Code Stroke Extended” will be activated for patients with a last known well time between 6-24 hours and/or for patients who woke up with new symptoms.
    - ii. A “Code Stroke” page will be automatically sent to all Neurology Residents, the Stroke Attending on call, and the CT scan technicians. Members of the Stroke Team will immediately respond and evaluate the patient in the emergency department. A member from the Stroke Team should evaluate the patient within 15 minutes from hospital arrival.
  - c. The initial evaluation will begin with immediate stabilization of the airway, breathing and circulation followed by obtaining a focused history and neurologic exam. The history will include the key elements of time of symptom onset (or last seen normal), symptom location, medical history, and a current list of medications.
  - d. The Stroke Team will determine and document the following patient findings:
    - i. National Institutes of Health Stroke Scale Score (NIHSS).

- ii. Glasgow Coma Scale Score
- iii. Intracerebral Hemorrhage Score
- e. Nursing will start two peripheral IVs (preferably in different extremities and one 20 gauge or larger), draw blood for labs, implement continuous cardiac monitoring, assess need for supplemental oxygen to maintain SpO<sub>2</sub> > 94% and ensure that no food or medication is given by mouth until a dysphagia screen is completed.

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- f. The ED physician will order basic labs, a non-contrast head computed tomography (CT) scan, and a CT Angiogram Head and Neck found in the “UED Stroke” Order Set in IMPACT.
  - i. Standard laboratory tests will include a STAT serum glucose (finger stick is acceptable), coagulation studies (PT, PTT, INR and anti Xa), serum electrolytes, renal function tests, markers of cardiac ischemia, and a complete blood count.
  - ii. A STAT non-contrast CT scan and a CT Angio Head and Neck. CT technicians will receive the “Code Stroke Page” in order to immediately prepare an open scanner. Stroke patients will have first priority for CT scanning. Goals: door to CT initiation <20 minutes and CT scan to CT interpretation <35 minutes.
  - iii. If necessary, a 12 lead EKG and a chest X-ray may be ordered but will be completed within 45 minutes from order; transport to CT will not be delayed for these tests.
- g. IV fluids (normal saline; dextrose-containing fluids will be avoided) may be started with a goal to maintain euvolemia.
- h. Based on the history, laboratory and neuroimaging information, the primary physician in consultation with the Stroke Team will determine appropriate treatment for the patient.
- i. Once the patient has been diagnosed with an intracranial hemorrhage (ICH) and raised intracranial pressure is suspected clinically, then the head of bed will be elevated to 30 degrees.
- j. Patients with coagulopathy will be appropriately treated. Antithrombotic medications will be held acutely.
- k. Patients with ICH will have intermittent pneumatic compression devices ordered for prevention of venous thromboembolism. Therapeutic prophylaxis of venous thromboembolism (VTE) will begin at least 48 hours from ictus with unfractionated heparin or low molecular weight heparin if there is no concern for ongoing bleeding and deemed safe by the stroke team.
  - i. Select patients with EVD will have chemical prophylaxis administered with approval from neurosurgeon.
- l. Blood pressure control:<sup>1-3</sup>

Blood pressure will be monitored until blood pressure is stable and SBP is consistently 130 – 150 mm Hg at the discretion of the Stroke Team. Upon admission to the Stroke Unit or NICU, blood pressure will be monitored closely for patients with unstable blood pressure; once blood pressure is stable, blood pressure monitoring will be assessed every 1 hour. For patients with an arterial catheter in place (radial artery or femoral artery), blood pressure monitoring will be continuous. Intravenous antihypertensive medications will be administered, as needed, to maintain SBP 130 – 150 mm Hg or at the discretion of the Stroke Team. The following medication regimen will be used:

  - i. Intravenous nicardipine may be administered as a continuous infusion with a starting dose of 5 mg/h, and then increased by 2.5 mg/h every 15 min as needed, up to a maximum of 15 mg/h. If BP is greater than the target, despite infusion of the maximum

- nicardipine dose for 30 min, a second agent will be used (Labetalol 5–20 mg IV bolus every 10 min; maximum 300 mg per 24 hours).
- ii. Intravenous clevidipine may be administered as a continuous infusion with a starting dose of 1-2mg/h, and then titrate by doubling the dose every 2-5 minutes as needed, up to a maximum of 32mg/h. Total dose administered within a 24 hour period should not exceed 1,000mL of the 0.5 mg/mL emulsion due to lipid load restrictions.
- m. Further management (as needed):
- i. CTA/contrasted CT/ MRI/MRA may be indicated to rule out underlying vascular or structural abnormalities.
  - ii. Normoglycemia will be maintained.
  - iii. EEG monitoring may be needed for diagnosis and monitoring of clinical as well as subclinical seizures. Patients found to have seizures on EEG monitoring will be treated with anticonvulsant medication.
  - iv. Patients with a GCS score of < 8, those with clinical evidence of herniation, or those with significant intraventricular hemorrhage or hydrocephalus will be considered for external ventricular drain or ICP monitoring and may require neurosurgery treatment. Neurosurgery will be consulted in such patients.
  - v. CBC, CMP, PT/INR/aPTT will be monitored routinely for the first 48 hours and other relevant tests should be ordered as indicated.
  - vi. Hemorrhagic stroke patients will be admitted to either the Stroke Unit (NSSU) or Neuroscience Intensive Care Unit (NICU) depending on level of acuity, any other admitting unit will be at the discretion of the Stroke Team.
  - vii. If there are more than one acute, complex stroke patients in the Emergency Department at one time, the Stroke Team physician will call the Attending Stroke Neurologist, the General Neurology Consult Resident, ED Attending Physician, or the Neurosurgery Service to assist the Stroke Team members on the scene to ensure that timely and effective care is given to all stroke patients.

## 2. Evaluation and diagnosis of hemorrhagic stroke on an inpatient unit

- a. Patients with suspected stroke will be stabilized immediately. The primary treating physician will be paged to the bedside to assist in the evaluation and management of the patient. The floor charge nurse will also be notified. If acute stroke is suspected, the treating physician will activate a “Code Stroke” by calling the UAB operator (Dial “0” or “42244”).
- b. Nursing will start two peripheral 20 gauge IVs, draw blood for labs, implement continuous cardiac monitoring, assess need for supplemental oxygen to maintain SpO<sub>2</sub> > 94% and ensure that no food or medication is given by mouth until a dysphagia screen is completed.
- c. A physician (Primary Treating Physician or Stroke Team) will order appropriate labs and neuroimaging.
  - i. Standard laboratory tests include a STAT serum glucose (finger stick is acceptable), coagulation studies (PT, PTT, INR, and Xa), serum electrolytes, renal function tests, markers of cardiac ischemia and a complete blood count.
  - ii. A STAT non-contrast CT scan will be done immediately. Stroke patients will have first priority for CT scanning. The time between Code Stroke page activation and CT initiation will be <20 minutes and the time between CT scan and CT interpretation will be <35 minutes.
  - iii. If necessary, a 12 Lead EKG and a chest X-ray may be ordered but should be completed within 45 minutes from order; transport to CT will not be delayed for these tests.

- d. IV fluids (0.9% Sodium chloride; dextrose-containing fluids will be avoided) may be started with a goal to maintain euvolemia.
- e. Based on the history, laboratory and neuroimaging information, the primary physician in consultation with the Stroke Team will determine appropriate treatment for the patient.
- f. Once the patient has been diagnosed with an intracranial hemorrhage and raised intracranial pressure is suspected clinically, then the head of bed will be elevated to 30 degrees.
- g. Patients with coagulopathy will be appropriately treated.
- h. Patients with ICH will have intermittent pneumatic compression devices ordered for prevention of venous thromboembolism (VTE). Therapeutic prophylaxis of VTE will only begin after 48 hours from ictus with unfractionated heparin or low molecular weight heparin if there is no concern for ongoing bleeding and deemed safe by the stroke team.
- i. Select patients with EVD will have chemical prophylaxis administered with approval from neurosurgeon.
- i. Blood pressure control:
  - i. As appropriate, patients who are receiving intravenous medications for BP control will be transitioned to an oral antihypertensive medical regimen to maintain SBP <mm Hg.
- j. Further management (as needed):
  - i. CTA/ contrast CT/ MRI/MRA or digital subtraction cerebral arteriography may be indicated to rule out underlying vascular or structural abnormalities.
  - ii. iii. Normoglycemia will be maintained.
  - iv. EEG monitoring may be needed for diagnosis and monitoring of clinical as well as subclinical seizures. Patients found to have seizures on EEG monitoring will be treated with antiepileptic drugs.
- k. Patients with a GCS score of <8, those with clinical evidence of herniation, or those with significant intraventricular hemorrhage or hydrocephalus will be considered for external ventricular drain or ICP monitoring and may require neurosurgery or neurointerventional treatment. Neurosurgery will be consulted in such patients at the discretion of the Stroke Team..
- l. If there is more than one hemorrhagic stroke inpatient requiring attention from the Stroke Team at the same time, the Stroke Team physician will call the attending Stroke Neurologist, the General Neurology Consult resident, or the Neurosurgery Service to assist the Stroke Team members on the scene to ensure that timely and effective care is given to all stroke patients.

### **3. Evaluation of Hemorrhagic Stroke at UAB Highlands:**

- a. When a patient with suspected hemorrhagic stroke presents to the UAB Highlands Emergency Department, then a Code Stroke will be activated by dialing 4-2244. The UAB eMedicine Stroke Service should be activated by entering a consult into the eMedicine platform in IMPACT and the tele-neurologist will respond to the case. Together the teleneurologist and the Highlands Emergency Department Attending physician will determine treatment decisions and if the patient should be transferred to the UAB main hospital.
  - i. The Highlands STAT Nurse will respond to a Code Stroke in the Highlands ED.
  - ii. .
  - iii. The tele-neurologist will provide instructions about patient management while awaiting transfer to the UAB Main Hospital.
  - iv. Transfers from Highlands to the UAB Main Hospital are not handled by the MIST operator, as these are internal transfers (i.e., from one unit to another).



- v. The Highlands ED Attending physician will have primary responsibility for the patient until the patient is transferred to the UAB Main Hospital.
- b. For inpatients at UAB Highlands with symptoms of acute stroke, a Code Stroke will be activated by dialing 4-2244. The UAB eMedicine Stroke Service should be activated by entering a consult into the eMedicine platform in IMPACT and the tele-neurologist will respond to the case. Together the tele-neurologist and the Highlands Attending physician will determine treatment decisions.
  - i. The Highlands STAT Nurse will be called to respond to a Code Stroke in a Highlands inpatient unit.
  - ii. The Attending Stroke Neurologist will provide instructions about patient management while awaiting transfer, and during transfer, to the UAB Main Hospital.
  - iii. When a decision is made to transfer a patient with a stroke to the UAB Main Hospital, the Highlands Attending will place a transfer order in IMPACT and call Center for Patient Flow at 4-5278 to alert them of the emergency transfer request.
  - iv. Transfers from Highlands to the UAB Main Hospital are not handled by the MIST operator, as these are internal transfers (i.e., from one unit to another).
  - v. The Highlands Attending physician will have primary responsibility for the patient until the patient is transferred to the UAB Main Hospital.

#### **4. Evaluation of Hemorrhagic Stroke at UAB Gardendale Freestanding Emergency Department:**

- a. When a patient with suspected stroke presents to the UAB Gardendale Freestanding Emergency Department (FED), activate an internal code stroke and activate the telestroke consult. The UAB eMedicine Stroke Service should be activated by entering a consult in to the eMedicine platform in IMPACT. Together the tele-neurologist and the Gardendale FED physician will determine treatment decision and if the patient should be transferred to the UAB main hospital.
- b. When a decision is made to transfer a patient with a stroke to the UAB Main Hospital, the Gardendale Emergency Department Attending will place a transfer order in IMPACT.
- c. The tele-neurologist will provide instructions about patient management while awaiting transfer, and during transfer, to the UAB Main Hospital.
- d. Transfers from Gardendale FED to the UAB Main Hospital are handled by the MIST operator.
- e. The Gardendale FED Attending physician will have primary responsibility for the patient until the patient is transferred to the UAB Main Hospital.

#### **5. Surgical Management of Hemorrhagic Stroke**

- a. Patients with GCS  $\leq 8$ , those with clinical deterioration, and those with significant ICH or intraventricular (IVH) will be considered for intracranial (ICP) monitoring and treatment of elevated ICP.
- b. Patients with hydrocephalus or significant IVH will be considered for ventriculostomy and CSF diversion.
- c. Patients with cerebellar hemorrhage and neurologic deterioration, evidence of brainstem compression or hydrocephalus will be considered for emergent ventriculostomy and surgical clot evacuation.<sup>1</sup>
- d. For patients presenting with lobar hemorrhage  $\geq 30$  mL within one centimeter of the cortical surface, surgical evacuation of the hemorrhage will be considered.<sup>4</sup>

- e. For patients presenting with deep supratentorial hemorrhages (ie Basal Ganglia, Thalamic) that are  $\geq 30$  mL and are causing significant mass effect, surgical evacuation will be considered in select cases to relieve mass effect and limit secondary injury from blood product breakdown.

If there is more than one hemorrhagic stroke patient requiring surgery at the same time, the oncall Neurosurgery Attending physician, the on-call Neurosurgery Chief Resident, and the in-house on-call Neurosurgery Resident will work with the Operating Room Staff and Anesthesia to ensure that all operations be done expeditiously and simultaneously if needed. Additional Neurosurgery Attendings and Residents will be contacted for additional assistance as needed.

**Secondary stroke prevention:**

- a. All patients will receive a stroke evaluation to determine the underlying stroke mechanism to help guide secondary stroke prevention.
- b. Blood pressure will be well controlled. After judicious management of BP based on SBP, MAP, or CPP goals in the acute phase, the goal is to gradually obtain normotension over several days. Normotension (goal of  $<140/90$  mm of Hg or  $<130/80$  if diabetic or chronic kidney disease is present) will be maintained.
- c. Patients will be screened for hemorrhagic stroke risk factors and strategies will be identified to improve long-term management of these conditions.
- d. Patients with poorly controlled or new onset diabetes will be evaluated by a diabetic educator.
- e. Patients who use tobacco products will be counseled on cessation and referral to appropriate cessation services will be provided.
- f. Patients will be counseled on appropriate lifestyle modifications including increasing physical activity.
- g. Patients will be counseled on dietary modifications based on their medical comorbidities. Some patients may benefit from a dietician consultation.

7. **General hospital management**

- a. Hypoxia will be avoided and supplemental oxygen should be administered to maintain oxygen saturation  $>94\%$ , unless contraindicated.
- b. Sources of hyperthermia (temperature  $>38^{\circ}\text{Celsius}$ ) should be identified and treated. Antipyretic medications and cooling blankets will be used to lower temperature as needed.
- c. Glycemic management: normoglycemia (serum glucose  $<180$  mg/dL) will be maintained. Patients will be closely monitored to prevent hypoglycemia.
- d. .
- e. Patients with seizures will be treated with anticonvulsants.

8. **Rehabilitation evaluation**

- a. All patients will be evaluated for rehabilitation needs.
- b. The Stroke Team may determine that the patient has no neurologic deficits in which case formal rehabilitation consultations are not necessary.
- c. In patients with persisting deficits, services including physical therapy, occupational therapy and speech therapy will be consulted to assist in determining the patient's rehabilitation needs.
- d. All patients must pass a dysphagia screening prior to oral intake, including oral medications. For patients who do not pass the bedside dysphagia screen, speech therapy will be consulted for further evaluation and recommendations.

- e. Patients with persisting deficits may also be evaluated by Physical Medicine and Rehabilitation.
- f. These recommendations will be evaluated together to determine the optimal rehabilitation disposition for the patient (inpatient rehabilitation, subacute rehabilitation, skilled nursing facility, home health therapies, or outpatient therapy).

## 9. Follow-up care

- a. Patients will be scheduled for appropriate follow up with their primary care physician for continuing treatment of modifiable risk factors.
- b.
- c. All patients will be provided with education on stroke risk factors, newly prescribed medications, importance of follow up care, signs and symptoms of stroke and will be instructed to call 9-1-1 should they experience any of these symptoms. This education will be provided verbally by the Stroke Team as well as in a take home education booklet.

## REFERENCES

1. Morgenstern LB, Hemphill JC, 3rd, Anderson C, Becker K, Broderick JP, Connolly ES, Jr., Greenberg SM, Huang JN, MacDonald RL, Messe SR, Mitchell PH, Selim M, Tamargo RJ. Guidelines for the management of spontaneous intracerebral hemorrhage: A guideline for healthcare professionals from the american heart association/american stroke association. *Stroke*. 2010;41:2108-2129
2. Qureshi AI, Palesch YY. Antihypertensive treatment of acute cerebral hemorrhage (atach) ii: Design, methods, and rationale. *Neurocrit Care*. 2011;15:559-576
3. Anderson CS, Heeley E, Huang Y, Wang J, Stapf C, Delcourt C, Lindley R, Robinson T, Lavados P, Neal B, Hata J, Arima H, Parsons M, Li Y, Heritier S, Li Q, Woodward M, Simes RJ, Davis SM, Chalmers J. Rapid blood-pressure lowering in patients with acute intracerebral hemorrhage. *N Engl J Med*. 2013;368:2355-2365
4. Mendelow AD, Gregson BA, Rowan EN, Murray GD, Gholkar A, Mitchell PM. Early surgery versus initial conservative treatment in patients with spontaneous supratentorial lobar intracerebral haematomas (stich ii): A randomised trial. *Lancet*. 2013;382:397-408
5. Greenberg, SM, Ziai, WC, Cordonnier, C, Dowlathshahi, D, Francis, B, Goldstein, JN, Hemphill III, JC, Johnson, R, Keigher, KM, Mack, WJ, Mocco, J., Newton, EJ, Ruff, IM, Sansing, LH, Schulman, S, Selim, MH, Sheth, KN, Sprigg, N, Sunnerhagen, KS. on behalf of the american heart association/american stroke association. 2022 guideline for the management of patients with spontaneous intracerebral hemorrhage: A guideline from the american heart association/american stroke association. *Stroke*. 2022; 53:e282-e361

# *Aneurysmal Subarachnoid Hemorrhage*

**PURPOSE:** The University of Alabama at Birmingham Cerebrovascular Neurosurgery and Stroke Teams have approved these guidelines in order to delineate a consistent, evidenced-based approach to treating patients who present with aneurysmal subarachnoid hemorrhage (aSAH).

**SYNOPSIS:** These guidelines provide guidance for the diagnosis and management of patients with aneurysmal subarachnoid hemorrhage according to current published guidelines<sup>1</sup> and the best available evidence.

## **STRATEGY:**

### **1. Evaluation and diagnosis**

#### **a. Initial clinical suspicion**

- i. Any patient suspected of having aSAH will be evaluated for aSAH. Symptoms and signs of aSAH include a spontaneous thunderclap headache (usually “the worst headache of my life”), nausea, vomiting, photophobia, cranial nerve problems and diminished level of consciousness.
- ii. Patients with spontaneous, non-traumatic subarachnoid hemorrhage will be managed on the assumption that they have a ruptured intracranial aneurysm. Some patients will ultimately be found to have a subarachnoid hemorrhage without a ruptured aneurysm; for these patients, once a ruptured aneurysm is excluded, management according to this protocol may not be necessary, and this will be determined by the neurosurgical and neurocritical care teams.

#### **b. Imaging**

- i. A STAT head CT will be obtained for any patient suspected of having aSAH.
- ii. Patients with SAH identified on CT will undergo a brain computed tomography angiogram (CTA).
- iii. If the CTA is negative or inconclusive, then a digital subtraction angiogram (DSA) may be done. For patients with a classic perimesencephalic SAH pattern on CT, DSA is optional; the decision to proceed with DSA in this circumstance will be made by the Neurosurgery Service.

#### **c. Lumbar puncture**

- i. A lumbar puncture (LP) will be considered for patients suspected of having an aSAH who have a negative CT.
  1. The LP may be done at least six hours after the onset of symptoms.
  2. Four tubes of CSF will be drawn:
    - a. Tube 1: Cell count and xanthochromia
    - b. Tube 2: Gram stain and culture
    - c. Tube 3: Protein and glucose
    - d. Tube 4: Cell count and xanthochromia

#### **d. Neurosurgical consultation**

- i. The Neurosurgery Service will be consulted for any patient with aSAH.
- ii. The Neurosurgery Service will determine and document the following patient findings:
  1. Hunt Hess scale score

### **2. Initial management**

- a. The patient will be admitted to the NICU on the Neurosurgery Service and be followed concurrently by the NICU Critical Care Service.
- b. Medical stabilization

- i. The patient will undergo immediate stabilization of the airway, breathing and circulation.
- ii. At least two peripheral 20 gauge IVs will be placed. Upon admission to the NICU, a central venous catheter (in select patients), an arterial catheter, and a Foley catheter will be inserted if feasible and if not already present.
- iii. Blood pressure control. 1. Blood pressure will be monitored until blood pressure is stable and is at a target, as specifically indicated by the Neurosurgery Service.2

a. Laboratory evaluation

- i. Standard laboratory tests will include serum glucose, coagulation studies (PT, PTT, INR), serum electrolytes, renal function tests, liver function tests, toxicology screen, markers of cardiac ischemia (CK, CK-MB and troponin) and a complete blood count. A serum HCG will be included for female patients of childbearing age.
- ii. A 12 lead EKG and a chest X-ray (following central venous line placement) will be obtained.

b. Treatment of hydrocephalus

- i. Patients with ventriculomegaly on CT scan and symptoms of hydrocephalus (e.g., diminished level of consciousness and/or ongoing severe head pain and nausea) will be considered for ventriculostomy.

c. Nursing neurological assessments

- i. The patient will undergo hourly neurological examinations by the NICU nurse.

d. Medications

- i. Nimodipine per AHA guidelines.

e. Diet

- i. The patient will be kept NPO except for medications until:
  - 1. The patient has passed a bedside swallow screen
  - 2. The ruptured aneurysm has been secured (unless treatment of the ruptured aneurysm is scheduled for the following day and the patient has passed a swallowing evaluation).

f. Activity: the patient will be kept on bedrest until the ruptured aneurysm is secured.

g. DVT prophylaxis

- i. External pneumatic compression devices will be used on the lower extremities.

h. "SAH precautions" until aneurysm is secured.

- i. NICU patient room noise, lighting, and stimulation will be kept to a minimum.
- ii. "SAH precautions" can be discontinued after the aneurysm is secured.

i. Patients will be evaluated for participation in a clinical trial, as indicated.

1. Management of the ruptured aneurysm

- a. A management plan for the aneurysm will be formulated by the Neurosurgery Service and will be individualized according to each patient and imaging findings.
- b. Determination of aneurysm treatment will be multidisciplinary and will involve both cerebrovascular surgeons and endovascular specialists.1
- c. Treatment of the aneurysm will be targeted to occur within 36 hours of arrival.
- d. The goal of treatment of the aneurysm will be complete obliteration of the aneurysm.
- e. Multiple case scenarios
  - i. If there is more than one aneurysmal subarachnoid hemorrhage patient requiring surgery at the same time, the on-call Neurosurgery attending physician, the on-call Neurosurgery Chief Resident, and the in-house on-call Neurosurgery Resident will work with the Operating Room Staff and Anesthesia to ensure that all operations be done expeditiously and simultaneously, if

needed. Additional Neurosurgery attendings and residents will be contacted for additional assistance as needed.

ii. If there is more than one aneurysmal subarachnoid hemorrhage patient requiring endovascular treatment at the same time, a second angiography suite (Room 10, Heart and Vascular Center) will be prepared. An additional nurse and technologist team will assemble. If outside of business hours, then the Vascular Interventional Radiology call team will be called in. The additional procedure will be started by the interventional neuroradiology fellow or resident under the supervision of the neurointerventionalist, or back-up neurointerventionalist as available.

## 2. NICU management

a. Following treatment of the aneurysm, the patient will be readmitted to the Neurosurgery Service in the NICU and be followed concurrently by the NICU Critical Care Service.

b. Routine laboratory studies: CBC and serum electrolytes, daily or twice a day, as indicated.

c. Transcranial Doppler examination Q day for 14 days while in the NICU, or as specifically indicated by the Neurosurgery or Stroke Service.

d. NICU nursing neurological assessments will be done hourly. For patients determined by the Neurosurgery Service to be at low risk of vasospasm, nursing neurological assessment intervals may be increased to every two or three hours.

### e. Fluid management

i. Central venous pressure (in select patients) and urine output will be recorded hourly.

ii. Euvolemia will be maintained (CVP 8-12 mm Hg and matched fluid input and output).

iii. Intravenous fluids: 0.9% Sodium chloride or an equivalent isotonic fluid; the rate may be adjusted depending on the patient's fluid status.

iv. Liberal oral intake of fluids will be encouraged for patients who have passed a swallowing evaluation; fluid restriction will be avoided.

### f. Nutrition

i. All patients will undergo a bedside swallowing screen before they begin eating and drinking.

ii. Patients who are not cleared for an oral diet will be provided with enteral nutrition via a nasogastric, nasoduodenal, or PEG tube. .

### g. Pulmonary care

i. Management of pulmonary issues and mechanical ventilation will be supervised by the NICU Critical Care Service.

ii. Target parameters: Maintain PaO<sub>2</sub> >80%, PCO<sub>2</sub> 30-40, and pH 7.35-7.45.

## 3. Diagnosis and management of cerebral vasospasm

a. The Neurosurgery Service will evaluate any patient exhibiting a neurological change promptly.

b. One or more of the following tests may be used to investigate for the cause of neurological change, as indicated on an individual basis:

i. Serum electrolytes

ii. Head CT

iii. CTA

iv. CT perfusion study

v. Transcranial Doppler examination vi. Electroencephalogram

vii. DSA

c. If symptomatic vasospasm is presumed to be present, one or more of the following treatment modalities will be employed:

i. Fluid volume resuscitation

1. Intravenous 0.9% normal saline fluid bolus.
  2. 5% Albumin 250 mL IV Q 6 h.
  - ii. Induced hypertension
    1. NICU Critical Care Service will supervise the use of a vasopressor to maintain SBP > 160 mm Hg.
    - iii. Endovascular treatment (angioplasty with or without intra-arterial infusion of a calcium channel blocker).
  - d. Patients with symptomatic vasospasm will be kept in the NICU until the vasospasm resolves.
4. Management of hydrocephalus
- a. Patients with chronic symptomatic hydrocephalus will undergo surgery for placement of a ventriculoperitoneal shunt.
5. Management after transfer out of the NICU
- a. Patients who are stable and no longer at significant risk of vasospasm will be transferred to NSSU or UNSN.
  - b. All patients will be evaluated by physical therapy; occupational therapy and speech therapy evaluations will be done as indicated.
  - c. Patients requiring on-going therapy will be evaluated by Physical Medicine and Rehabilitation.
  - d. Social work evaluations will be done as indicated.
6. Follow-up
- a. At the time of discharge, arrangements will be made for outpatient follow-up in the Neurosurgery Clinic.

REFERENCES: 1. Connolly ES, Jr., Rabinstein AA, Carhuapoma JR, Derdeyn CP, Dion J, Higashida RT, Hoh BL, Kirkness CJ, Naidech AM, Ogilvy CS, Patel AB, Thompson BG, Vespa P. Guidelines for the management of aneurysmal subarachnoid hemorrhage: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke; a journal of cerebral circulation.* 2012;43:1711-1737 2. Widjicks EFM. Aneurysmal subarachnoid hemorrhage. *The clinical practice of critical care neurology.* Oxford, UK: Oxford University Press; 2003:185-220. 3. Black PM, Crowell RM, Abbott WM. External pneumatic calf compression reduces deep venous thrombosis in patients with ruptured intracranial aneurysms. *Neurosurgery.* 1986;18:25-28 4. Leifer D, Bravata DM, Connors JJ, 3rd, Hinchey JA, Jauch EC, Johnston SC, Latchaw R, Likosky W, Ogilvy C, Qureshi AI, Summers D, Sung GY, Williams LS, Zorowitz R. Metrics for measuring quality of care in comprehensive stroke centers: Detailed follow-up to brain attack coalition comprehensive stroke center recommendations: A statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke; a journal of cerebral circulation.* 2011;42:849-877