



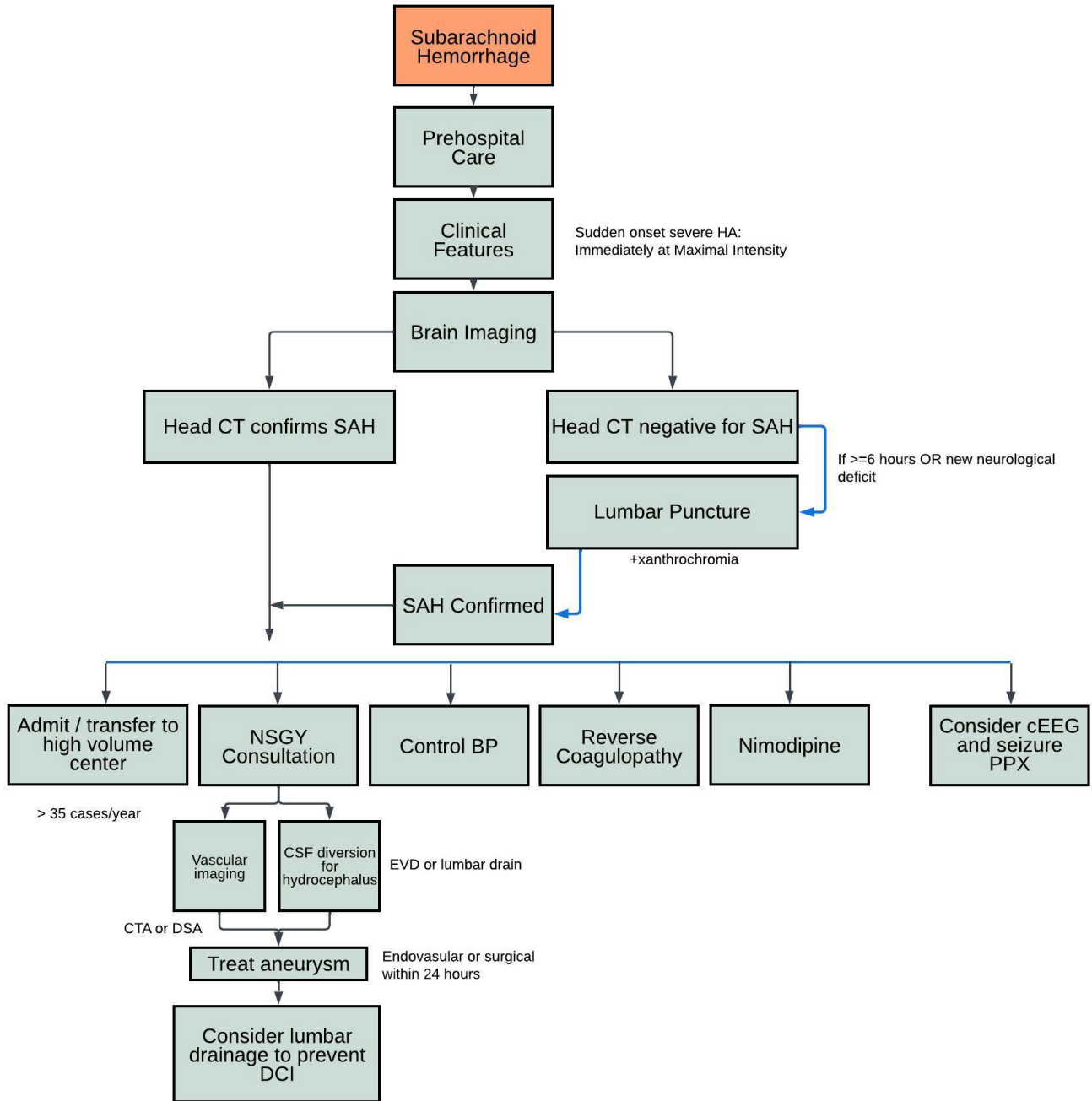
Emergency Neurological Life Support® Subarachnoid Hemorrhage Protocol Version 6.0

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Subarachnoid Hemorrhage Algorithm



CHECKLIST

- Airway, breathing, circulation
- Head computed tomography (CT)
- Lumbar puncture, if head CT nondiagnostic (LP)
- Laboratories: PT/INR, PTT, CBC, chemistries, troponin, toxicology screen
- 12-lead ECG
- Control blood pressure, suggest SBP < 140-160 mmHg
- Reverse coagulopathy
- Consult neurosurgery/NCC team
- Address hydrocephalus if present
- Admit/transfer to a high-volume center (> 35 aneurysm cases per year)

COMMUNICATION

- Clinical presentation (level of consciousness, motor examination, pupils)
- WFNS score and Hunt–Hess Grade
- Imaging findings/LP results
- Airway status
- Hemodynamic status and blood pressure control (BP goals)
- Coagulopathy present/reversed
- Hydrocephalus present/addressed
- Medications given, including sedatives, analgesics, seizure prophylaxis, anti-hypertensives, and nimodipine
- Coordination of other vascular imaging

SUBARACHNOID HEMORRHAGE (SAH)

Blood within the subarachnoid space

Subarachnoid hemorrhage (SAH) is most commonly produced by trauma and next most common by a ruptured intracranial aneurysm. For the latter, it is imperative that a timely diagnosis is made because the prevention of aneurysm re-rupture can be lifesaving.

CLINICAL DIAGNOSIS OF SUBARACHNOID HEMORRHAGE (SAH)

Clinical features

The diagnosis of **traumatic SAH** is based on history and brain imaging. The protocol for management of traumatic SAH can be found under the ENLS protocol Traumatic Brain Injury.

Spontaneous aneurysmal SAH (aSAH) has a classic presentation, though signs and symptoms may vary.

Classic presentation:

- Abrupt onset of a sudden, severe headache; onset is typically less than 1 minute.
- The headache is a NEW, QUALITATIVELY DIFFERENT headache for the patient.
- May have neck pain, nausea, and vomiting.
- The patient may transiently lose consciousness, or present in coma.
- The nature and onset of the headache is the key distinguishing feature from other forms of stroke, syncope, and seizure.

Variant presentation:

- Headache is not reported as abrupt (the patient may not remember the event well).
- Headache responds well to non-narcotic analgesics or “anti-migraine” medications.
- Headache resolves on its own within hours.
- Approximately 50% of patients with SAH will have a normal neurological examination. They may or may not have meningismus (which may take time to develop) and do not necessarily appear acutely ill.

Key aspects of the neurological examination:

- Glasgow Coma Scale (GCS)
- Pupillary exam
- Fundoscopic exam for subhyaloid hemorrhages
- Neck exam for meningismus
- Focal neurological deficits

Determine the clinical severity of the SAH using one of the scales below:

World Federation of Neurological Societies (WFNS) scale:

- Grade 1: GCS 15
- Grade 2: GCS 13-14 without motor deficit
- Grade 3: GCS 13-14 with motor deficit
- Grade 4: GCS 7-12
- Grade 5: GCS 3-6

Hunt-Hess Scale (increase by 1 grade for angiographic vasospasm or serious systemic illness):

- Grade 1. Asymptomatic, mild headache, slight nuchal rigidity
- Grade 2. Moderate-to-severe headache, nuchal rigidity, no neurologic deficit other than cranial nerve palsy
- Grade 3. Drowsiness/confusion, mild focal neurologic deficit
- Grade 4. Stupor, moderate-severe hemiparesis
- Grade 5. Coma, decerebrate posturing

AIRWAY

Assess need for intubation

Factors contributing to necessity of intubation include:

- Inability to protect airway
- Hypoxia resistant to supplemental oxygen
- Expected decompensation during transport within hospital or to another hospital

See ENLS protocol *Airway, Breathing, and Mechanical Ventilation*.

PREHOSPITAL CARE

A variety of prehospital neurological screening tools exist for stroke, but none are validated in aSAH. For patients presenting with isolated headache who are neurologically intact, there are no specific prehospital interventions, apart from consideration of analgesics. For patients presenting with a headache and neurological deficits, prehospital stroke screening tools should be used with emergency department pre-notification of the neurological deficits and the fingerstick glucose. Prehospital endotracheal intubation may also be considered in patients who are comatose or not protecting their airway (refer to airway, breathing, mechanical ventilation module for further discussion). Patients with aSAH should be managed at hospitals that are “high-volume centers,” defined as caring for more than 35 patients with aSAH per year. This is because receiving care at a high-volume center results in improved patient outcomes. Admission or transfer to a high-volume center with availability of vascular neurosurgeons, endovascular specialists, and multidisciplinary neurointensive care services is recommended.

BRAIN IMAGING FOR aSAH

If you suspect aSAH by history, head imaging is the next step

Noncontrast CT imaging of the brain is the gold-standard for identifying SAH (Class1, LOE B).

- However, CT imaging is more sensitive in the first few days following aSAH and becomes progressively less sensitive with the passage of time (by day 5, sensitivity drops to 60%-85%). Other reasons for a false negative CT include anemia, low-volume SAH and a technically poor scan.
- Some clinicians advocate for a CT angiogram (CTA) at the time of the CT scan to look for an intracranial aneurysm. Although this is helpful if an aneurysm is seen, the negative predictive value is less clear. One should not use a negative CTA alone to rule out aSAH.
- MRI is highly sensitive for intracranial hemorrhage but is most useful in patients who present a few days following the SAH; hemosiderin sensitive sequences are most useful in identification of SAH.

An axial noncontrast head CT revealing aneurysmal SAH is shown below:



CT CONFIRMS SAH

Subarachnoid blood is seen on the CT scan

The diagnosis of aSAH is confirmed and cerebrospinal fluid analysis is not necessary.

CT SCAN IS NEGATIVE — PERFORM LUMBAR PUNCTURE (LP) NEXT

Must perform an LP if the CT is negative

A noncontrast CT of the brain is close to 100% sensitive for SAH if all of the following are true:

- The patient has a classic presentation with a thunderclap headache,
- The CT is done within 6 hours of headache onset,
- The patient is completely neurologically intact, and
- The CT is read by an attending radiologist (or someone with equivalent experience reading brain CT scans)

If all of these criteria are met, clinicians can consider not doing an LP. The sensitivity of CT in these patients is ~ 99.5% (may miss aSAH in 1-2 patients per 1,000 who fulfill all of these criteria).

However, if these criteria are not met, one should perform an LP to determine if the patient has a radiographically occult SAH.

The LP is done to look for xanthochromia, the yellowish discoloration of CSF by heme breakdown products (chiefly bilirubin). It takes several hours for blood in the subarachnoid space to break down, so the presence of xanthochromia is time-dependent and is nearly universally present after 12 hours from onset of hemorrhage.

- If the CSF shows xanthochromia, the diagnosis of SAH is confirmed (CSF protein exceeding 100 mg/dl can lead to a false positive).
- If the CSF is clear of RBCs and xanthochromia is absent, it is highly unlikely that the patient had a subarachnoid hemorrhage. However, a rapidly expanding aneurysm without subarachnoid rupture can present with a classic thunderclap headache ('sentinel headache,' which typically occurs about 2-8 weeks prior to overt subarachnoid hemorrhage). If there is ongoing clinical suspicion for an aneurysm on clinical grounds, emergent neurosurgical consultation is recommended.

In summary, the typical findings of SAH on cerebrospinal fluid analysis are:

- Presence of RBCs (generally in the thousands)
- Xanthochromia is present
- Minimal clearing of RBCs between tubes 1 and 4 (fewer than $2000 \times 10^6/L$ RBCs in the final tube and the absence of xanthochromia had a negative predictive value of 100% (95% confidence interval 99.2 to 100%) for excluding SAH).

Note:

- The sensitivity of all tests for SAH are dependent upon the time from the bleed. CT is more sensitive early and less so with time. RBCs in the spinal fluid is also more likely to be seen early and will clear with time. Xanthochromia is absent early and nearly always present by 12 hours after the bleed.
- Spectrophotometry is more sensitive (but much less specific) for xanthochromia than is visual inspection (spin down CSF, compare to water in neutral light; see figure below); however visual inspection is the only test available at most hospital labs.

Typical appearance of xanthochromia (left) compared to water (right). CSF is centrifuged first to take any RBCs out of the solution.



SAH IS CONFIRMED

CT or LP evidence of SAH

Diagnosis of SAH is confirmed. The goal is to reduce the chance of aneurysm re-rupture and expedite treatment of the aneurysm while preventing any medical complications.

INITIAL ORDERS

First steps

Once aSAH is confirmed, in addition to the items outlined below (neurosurgical consultation, reverse coagulopathy, treatment of anxiety and pain, and blood pressure management):

- Bed rest with cardiac monitoring
- 12-lead electrocardiogram
- Labs
 - Blood: CBC, coagulation tests (prothrombin time, partial thromboplastin time, international normalized ratio), electrolytes, renal function tests, troponin, and a type and screen
 - Urine: toxicology screen

NEUROSURGICAL CONSULTATION

Definitive therapy is obliteration of the aneurysm, by either endovascular coiling or surgical clipping. Both of these treatments isolate the aneurysm from the cerebrovascular circulation and should be carried out as soon as feasible, ideally within the first 24 hours of presentation.

SEIZURE PROPHYLAXIS

Should one prescribe anticonvulsants now?

- Approximately 20% of SAH patients have seizures prior to hospital arrival, and another 5%-10% experience seizures after admission.
- Early seizures may increase the risk of aneurysm re-rupture and elevated intracranial pressure (ICP).
- Acute seizures should be treated with antiseizure medications.
- In patients with persistent altered mental status, nonconvulsive status epilepticus may be present, which can only be diagnosed by continuous electroencephalography (EEG).
- Both the AHA and NCS guidelines suggest consideration of antiseizure medications in the immediate post-hemorrhage period for patients with high-risk features.
- A very short course of prophylactic antiseizure medications may be recommended in the period following diagnosis and before definitive aneurysm treatment because of a concern for seizure-related aneurysm re-rupture.
- As phenytoin may lead to worse long-term cognitive outcomes, the use of a different agent should be considered. Refer to ENLS Pharmacology module for more information.

REVERSE COAGULOPATHY

Coagulopathy should be urgently treated.

- Patients taking Vitamin K antagonists, including warfarin, with an INR ≥ 1.4 should be treated with some combination of IV vitamin K (10 mg IV), and prothrombin complex concentrates.
- Fresh Frozen Plasma (FFP) is an alternative for reversal if PCC is unavailable.
- Thrombocytopenia (platelets $< 100,000$) can be treated with platelet transfusions.

See the ENLS Pharmacology protocol regarding reversal of Factor Xa and thrombin inhibitors.

For patients with SAH taking oral antiplatelet agents, such as aspirin, clopidogrel, or prasugrel, NCS and SCCM management recommendations include:

- Antiplatelet agents can potentially increase the risk and severity of aneurysm re-rupture, as well as neurosurgical complications.
- Platelet transfusion is recommended for patients with aspirin- or adenosine diphosphate (ADP) inhibitor-associated SAH who will undergo a neurosurgical procedure.
- Platelet transfusion is not recommended if no neurosurgical procedure is planned.
- The risk–benefit ratio of antiplatelet therapy reversal using other hemostatic agents such as desmopressin (DDAVP) should be considered for individual patients.

TREAT PAIN AND ANXIETY

An uncomfortable patient can re-rupture his or her aneurysm

It is important to avoid straining, Valsalva maneuver, and writhing, as this can cause re-rupture of an unsecured aneurysm. One must also be careful to not over-sedate the patient, as this could mask the symptoms of hydrocephalus (obtundation).

- Use IV medications with short half-lives (fentanyl, for example).
- Liberal use of anti-emetics is justified, especially if vomiting occurs.
- Blood pressure control is enhanced with adequate analgesia.
- If anxiety is present, consider small doses of a short-acting anxiolytic.

BLOOD PRESSURE MANAGEMENT:

Avoid hypertension to prevent re-rupture

General principles:

- Current guidelines suggest treating severe hypertension in patients with an unsecured ruptured aneurysm.
- Antihypertensive medications that are short-acting, titratable, and can be administered as a continuous infusion, such as nicardipine or clevidipine, to reduce the systolic pressure < 160 mmHg should be used, keeping in mind the principles mentioned above.
- Premorbid BPs should be considered and used to inform the risks and benefits of treatment.
- Nitroprusside and nitroglycerine should be avoided because these agents may cause cerebrovascular dilation and thereby increase ICP.

See the ENLS Pharmacology protocol.

DECLINE IN NEUROLOGICAL EXAM

Worsening neurological examination?

There are several immediate causes of early (within the first hour) neurological decompensation.

- Re-rupture of the aneurysm: repeat head CT is diagnostic.
- Hydrocephalus: repeat head CT is diagnostic; need for external ventricular drain (EVD) is paramount.
- Seizure: consider cEEG in patients with a poor neurological exam and treat seizures.
- Cardiopulmonary cause: neurogenic pulmonary edema, catecholamine cardiomyopathy manifesting with worsening hypoxia or hypotension. Echocardiography is diagnostic of cardiomyopathy.

HYDROCEPHALUS

Are the ventricles dilated?

Hydrocephalus is caused by blockage of CSF absorption and is diagnosed by interpreting the head CT scan. If the patient is obtunded or comatose, it is important to provide ventricular drainage by having an external ventricular drain placed. This both treats the hydrocephalus and provides a monitor of ICP.

- If a neurosurgeon is not available at your hospital and hydrocephalus is present, consider treating the patient with mannitol 1 gm/kg and expediting transfer to a facility with neurosurgical capability within the next hour.