# MANAGEMENT OF SUBARACHNOID HEMORRHAGE

**Sean Ruland, DO**
Loyola University Chicago—Stritch School of Medicine
Chicago, IL

Approximately 24,000 cases of subarachnoid hemorrhage (SAH) occur annually in the U.S. which accounts for nearly 3% of all strokes. The incidence is higher in Japan and Finland compared to North American and other European countries. Saccular aneurysms on cerebral vessels of the circle of Willis are the culprit in 85% of cases. Risk factors for aneurysmal SAH include hypertension, smoking, autosomal dominant polycystic kidney disease, aneurysm size and location, and family history of one or more affected first-degree family members. The 30-day case fatality rate is 50% and nearly a third of survivors are physically disabled. Long term cognitive impairment is common. Many deaths occur prior to hospital arrival. In patients that survive to hospital admission, delayed cerebral infarction due to vasospasm accounts for considerable long term morbidity. Treatment in a high volume center with a dedicated neurointensive care unit by physicians experienced with aneurysm obliteration techniques and co-morbidity management is recommended.

## Diagnosis

The classical presentation includes thunderclap (i.e. sudden and diffuse with maximal intensity within seconds to minutes) headache at onset. It is commonly described as the patient's worst headache ever. However, it is the suddenness rather than the severity that matters most. Nausea, vomiting, impaired consciousness, nuchal rigidity, seizures, intraocular hemorrhage, and focal neurological signs and symptoms can all be present. Focal neurological signs and symptoms are due to direct compression from the ruptured aneurysm (e.g. third nerve palsy from a posterior communicating artery aneurysm), intracerebral hemorrhage and caudal brainstem shift due to increased intracranial pressure (e.g. untreated obstructive hydrocephalus causing sixth nerve stretch-related injury). Patients with aneurysmal SAH are frequently found to have had a sentinel hemorrhage within the past few weeks. A clinical grading scale such as the Hunt and Hess scale and the World Federation of Neurological Surgeons scale should be used to predict outcome after aneurysmal SAH. Although correct diagnosis is not difficult in patients presenting with altered consciousness, initial misdiagnosis is common in alert patients. Diagnostic delay is a major contributor to adverse outcomes as early aneurysmal rebleeding is associated with high mortality and prompt aneurysm obliteration is paramount.

Most modern CT scanners have high sensitivity and specificity for subarachnoid blood within the first 6 hours from onset. Detection rates decline gradually thereafter. MRI with fluid-attenuated inversion recovery (FLAIR) and Gradient Recalled Echo (GRE) sequences is also sensitive for SAH. MRI sensitivity increases to 100% between 6 and 30 days after onset. In patients with presentations suggestive of SAH but negative early imaging, lumbar puncture and CSF analysis may be helpful. However, if CSF is obtained within 12 hours of SAH, CSF interpretation and definitive diagnosis can be challenging as xanthochromia may not yet be present. CSF red blood cell count (RBC) can be confounded

by a traumatic tap. A decreasing RBC count from the first to last tube is consistent with trauma but often a high volume of RBCs in the last tube yields persistent uncertainty. There is controversy regarding the best method for CSF pigment analysis. Visual inspection of centrifuged CSF for yellow pigment compared to a tube of water is employed in most U.S. hospitals while mass spectrophotometry is available in most U.K. hospitals. Although the latter is more sensitive, it is offset by a higher false positive rate leading to potential harms from invasive diagnostic procedures and complications associated with treating incidentally detected unruptured aneurysms that otherwise may not have merited treatment. If SAH is confirmed, vascular imaging is necessary to diagnose the culprit lesion and determine appropriate treatment. CT angiography may be useful but can miss small aneurysms and most ruptured aneurysms are small despite the paradox that the prospective rupture rate of small aneurysms is low. Digital subtraction angiography (DSA) remains the gold standard and aneurysms amenable to endovascular coiling can be treated in the same session. However, initial DSA is negative in 20% and delayed repeat DSA may be necessary.

## Treatment

Endotracheal intubation may be required for high grade SAH patients with compromised airways or refractory hypoxemia. Early neurosurgical consultation is recommended. Ventriculostomy placement for CSF diversion in those with acute obstructive hydrocephalus is often needed and occasionally results in immediate clinical improvement. Delayed treatment can contribute to secondary neurologic injury and even death.

Seizures should be treated with an antiepileptic drug. Perioperative seizure prophylaxis is reasonable (e.g. 7 days) but supportive evidence is lacking. Phenytoin is associated with poor outcomes and is not recommended for routine use. Continuous EEG monitoring for non-convulsive seizures can be considered for patients with impaired consciousness. Long term seizure prophylaxis is not recommended. Aneurysmal rebleeding risk is highest early after SAH and decreases to less than 2% daily by post-bleed day two. Until the ruptured aneurysm is treated (if identified), elevated blood pressure is commonly lowered with an easily titratable agent such as nicardipine. Oral nimodipine, a calcium antagonist, 60 mg every 4 hours (or 30 mg every 2 hours for those whose blood pressure cannot tolerate 60 mg) improves neurological outcomes after aneurysmal SAH and should be given to all patients. It is uncertain whether nimodipine prevents vasospasm by blocking calcium channels on vascular smooth muscle cells or exerts a neuroprotective effect on neuronal and glial cell membranes. Neurogenic myocardial injury is common. Nearly a third of patients have elevated troponin I and 25% have left ventricular dysfunction on echocardiography. It resolves over several weeks but can cause hemodynamic instability and pulmonary edema early in the course. Neurogenic pulmonary edema can also occur. These phenomena are likely due to direct catecholamine-induced injury of the myocardium and pulmonary vasculature. Treatment may include diuretics, judicious fluid management, lung protective ventilation strategies, and inotropic medication.

Given the severe consequences of early rebleeding, expeditious culprit aneurysm obliteration if identified is recommended. Craniotomy with microsurgical clipping and endovascular coil embolization are both viable options. The decision to clip or coil is complex and should be made by a multidisciplinary

team. Multiple factors including aneurysm location and morphology, presence of large intracerebral hemorrhage warranting evacuation, clinical severity, co-morbidity, likelihood of achieving complete obliteration and treating physician skill and experience must be considered. Coiling is generally preferred for ruptured aneurysms amenable to both treatments as long term death and dependency rates have been lower for coiled patients in randomized trials despite higher recurrent aneurysm risk. If there is an unavoidable delay to definitive aneurysm treatment and no contraindications, a short course of an antifibrinolytic agent such as tranexamic acid or aminocaproic acid may be reasonable.

The majority of long term morbidity in survivors of aneurysmal SAH is due to delayed cerebral infarction (DCI) from vasospasm. Radiographic vasospasm occurs in nearly two thirds of cases but less than half are symptomatic. DCI seldom occurs sooner than 72 hours. The risk peaks between the first and second weeks after SAH, and it slowly resolves within several weeks. Vasospasm monitoring is primarily via clinical assessments in a neurocritical care environment. Adjunctive transcranial Doppler ultrasound (TCD) is commonly employed but can be limited by patient anatomy and operator-dependence. There are multiple interpretive criteria for TCD having variable sensitivity and specificity. The role of CT and MR perfusion is uncertain but they may be reasonable in selected circumstances. Statins and IV magnesium have not been proven beneficial for preventing nor treating vasospasm. However, premorbid statin use should be continued as abrupt cessation after SAH has been associated with increased DCI risk.

Although a common practice in the past, prophylactic hypervolemia can be detrimental and no longer recommended. Hypovolemia should be avoided. Similarly, studies do not support a role for prophylactic percutaneous transluminal balloon angioplasty. However, balloon angioplasty and/or intra-arterial injection of vasodilator agents such as papaverine, calcium antagonists, and milrinone may be reasonable for patients with symptomatic vasospasm refractory to medical therapies. Induced hypertension with a vasopressor infusion is the mainstay of symptomatic vasospasm management. Occasionally, adjunctive inotropy can be useful. Targets and protocols vary by institution.

Hospitalization can be complicated by several frequently occurring delayed systemic sequelae after SAH. Hyponatremia commonly develops in the post-SAH period. Cerebral salt-wasting syndrome is the presumed cause. Hypertonic saline infusion, enteral sodium chloride, and fludrocortisone are usually effective. Fluid restriction should be avoided as this may result in hypovolemia which can aggravate cerebral ischemia if vasospasm is present. Hyperglycemia is associated with worse outcomes and should be controlled. However, tight glycemic control protocols are complicated by the potential for hypoglycemia which may be even more injurious. Fever is also associated with worse outcomes and can be due to infectious and non-infectious etiologies which should be sought and addressed. Although the cause-effect relationship between fever and outcome has not been established, treatment of fever is generally recommended. Anemia occurs in nearly half of cases and brain oxygen delivery can be compromised. However, studies regarding the utility of red blood cell transfusion are contradictory and optimal hemoglobin threshold for transfusion is uncertain. Lastly, SAH patients are at-risk for venous thromboembolism. Sequential compression devices are typically employed in most patients. Pharmacologic prophylaxis may also be appropriate once the hemorrhage has stabilized and bleeding source secured. However, treatment of deep venous thrombosis or pulmonary embolism with

anticoagulation may be precluded in patients with recent craniotomy and/or ventriculostomy and an inferior vena cava filters may be considered.

## References

Diringer MN, Bleck TP, et al. Critical Care Management of Patients Following Aneurysmal Subarachnoid Hemorrhage: Recommendations from the Neurocritical Care Society's Multidisciplinary Consensus Conference. Neurocrit Care (2011) 15:211-240.

Connolly Jr, ES, Rabinstein AA, et al. Guidelines for the Management of Aneurysmal Subarachnoid Hemorrhage: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. Stroke 2012; 43: 1711-1737.

Robinson C, Ruland S. Chapter 16: Pitfalls in the diagnosis of subarachnoid hemorrhage. Common Pitfalls in Cerebrovascular Disease. Biller J and Ferro J editors. Cambridge Medicine Publishing; 2015.