

Triple-H therapy for vasospasm associated with subarachnoid hemorrhage

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When a patient presents with headache described as "the worst headache of my life," plain CT scan can make the diagnosis of subarachnoid hemorrhage (SAH). Once the diagnosis of SAH is confirmed, then high-resolution 4-vessel cerebral angiography should be carried out. The most effective proven treatment for a patient with a ruptured cerebral aneurysm is to proceed with microsurgical clipping of the lesion. This is currently indicated as soon as possible after the initial hemorrhage. With the aneurysm adequately clipped, the risk of rehemorrhage is avoided. Vasospasm is a complication that develops in response to the initial hemorrhage. It is a devastating medical complication affecting 30-70% of survivors of aneurysmal SAH. The risk of developing cerebral vasospasm is directly proportional to the amount of blood seen on the initial CT scan.¹ Over the past 20 years, elevation of blood pressure with intravenous medications and administration of large volumes of intravenous fluids (hypertension, hypervolemia, hemodilution or "triple-H therapy") has become the principle method for treating ischemic neurological deficits from vasospasm after SAH. This treatment improves cerebral blood flow in regions of ischemia by 3 mechanisms: 1. Elevation of blood pressure, 2. Elevation of cardiac output and total blood volume, and 3. Reduction of blood viscosity. All 3 of these factors serve to "drive" blood flow through and around blocked arteries, which in turn can lead to immediate reversal of symptoms.

We present a 42-year-old Indian male that was admitted through accident and emergency with the complaint of sudden onset of severe headache, nausea and vomiting associated with painful stiff neck. He did not have a past history of any medical illness. On examination his blood pressure (BP) was 110/76 mm Hg, mean arterial pressure (MAP) 88 mm Hg, heart rate 111/min, respiratory rate 18/min and he was drowsy but arousable. A noncontrast head CT showed a SAH and bleeding in the intraventricular and intracerebellar space. Cerebral angiography was carried out, showing rupture of the anterior communicating artery aneurysm. He was taken up for surgery and evacuation, and clipping was carried out. He was shifted to the intensive care unit (ICU) postoperatively. On admission to the ICU, he was hemodynamically stable, conscious but drowsy, responding to verbal commands and moving all 4

limbs, pupils equal and reacting to light. He had a BP of 124/84 mm Hg, MAP 90 mm Hg, heart rate 104/min, oxygen saturation 94% on 4 liter oxygen (O₂) by face mask. Intravenous fluid at a rate of 120 ml/hr was started along with nimodipine. Fourteen hours after surgery he developed drowsiness and weakness in right upper and lower limb (power 2/5), and was suspected of having vasospasm. Transcranial Doppler ultrasound was carried out, which confirmed this. Accordingly, cerebral angiography was performed and it confirmed the presence of spasm of the basilar artery. Triple H therapy was initiated with the goal of keeping the MAP more than 140 mm Hg. He responded very well and his neurological deficit improved over the next 36 hours. He remained stable and was transferred from the ICU, and later discharged from the hospital.

The most common cause of nontraumatic SAH is hemorrhage from an intracranial aneurysm. Other causes include vascular malformations, tumors, and infection. Diagnosis of SAH is confirmed by CT scan. The amount of blood seen on CT is prognostic of the risk of vasospasm; the larger the hemorrhage, the higher the risk. The CT appearance is graded from minimal blood to major hemorrhage (Fisher-grading system) (Table 1).¹ Bleeding may extend into the ventricular system (intraventricular hemorrhage) or into the substance of the brain (intraparenchymal/intracerebral hemorrhage).¹ A CT is a sensitive method of predicting a ruptured intracranial aneurysm in patients with SAH. If angiography does not reveal an aneurysm, the bleeding pattern on CT may predict if a patient is still at risk of rebleeding. Current guidelines recommend early surgery (0-3 days) for good-grade patients with an uncomplicated aneurysm, but either early or delayed surgery is recommended for patients with other clinical situations, such as aneurysm complexity or surgical difficulty. Early surgeries have several advantages: elimination of rebleeding risk; removal of subarachnoid blood, which reduces risk of vasospasm; and potential reduction in length of hospitalization.²

The 3 major complications that can occur within the first 2 weeks of SAH are cerebral arterial

Table 1 - Fisher-grading system.

Fisher Grade	Blood on CT
1	No subarachnoid blood detected
2	Diffuse or vertical layers < 1 mm thick
3	Localized clot and/or vertical layers > 1 mm thick
4	Intracerebral or intraventricular clot with diffuse or no subarachnoid hemorrhage

vasospasm, hydrocephalus, and aneurysmal rebleeding. Of these 3 complications, cerebral arterial vasospasm is the most common.³ The incidence of vasospasm, detected by angiography, is approximately 70%. The incidence of symptomatic vasospasm (resulting in neurological deficit) is approximately 25-30%. The major risk factor for the development of vasospasm is the amount, and location of subarachnoid blood visualized on the CT scans. This is graded using the Fisher system.⁴ Once diagnosed, treatment of vasospasm involves elevation of the BP (induced hypertension), hemodilution to improve cerebral blood flow, and maintenance of high normal circulating blood volume (hypervolemia). This so-called "triple H" therapy, combined with monitoring with transcranial Doppler, has proven effective in preventing stroke due to vasospasm. Hypertension is provided to increase cerebral perfusion to any potentially vasospastic areas. A simple equation for determining cerebral perfusion pressure is: mean arterial pressure minus intracranial pressure equals cerebral perfusion pressure ($MAP - ICP = CPP$). Hemodilution therapy reduces the blood viscosity, which maximizes oxygen delivery to tissues that facilitate cerebral oxygenation and perfusion. The target hematocrit (Hct) is 33-38%. A Hct below this level does not lead to any significant further reduction in blood viscosity, but it can decrease oxygen carrier capacity by 10-15%. Therefore, transfusions of whole blood are given to anemic patients ($Hct < 30$). Phlebotomy can be performed on polycythemic patients, and volume is replaced with colloids.⁴ Hypervolemic therapy involves administering volume expanders to elevate the patient's volume status. Hypervolemia can be obtained by infusion of colloids (5% albumin, dextran) or crystalloids (normal saline) to achieve a central venous pressure of 10-12 mm Hg, or a pulmonary artery wedge pressure (PAWP) of 15-18 mm Hg, and cardiac index greater than 2.2 l/m. Medlock et al⁵ showed that providing prophylactic hypervolemia (PAWP 14-16 mm Hg), led to 85% of patients having good neurological outcome and 6% mortality, findings that were not different from those found for a historical control group.⁵

Pharmacological treatment of vasospasm includes the use of calcium channel blockers that act on the smooth muscle, causing relaxation and vasodilation. Triple-H therapy is recommended for preventing and treating ischemic complications from vasospasm, with the aneurysm to be clipped surgically when possible.

The natural history of vasospasm is not well known, and no adequately controlled studies are available. The reported observations involved a small series analyzed retrospectively, with different approaches in the management. Accordingly, it is difficult to determine whether the beneficial effects attributed to triple-H therapy are different than those the natural history would produce. Thus, a well-designed clinical trial should be conducted to address these questions. Cerebral vasospasm will remain a common, yet potentially lethal, consequence of blood in the subarachnoid space. Triple-H therapy has become widely used in this field, although evidence from clinical trials is still lacking.

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