Subarachnoid Hemorrhage (SAH) — Symptoms, Diagnosis and Treatment

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A sudden, violent ‘thunderclap headache’ is the main symptom of subarachnoid hemorrhage (SAH). Mostly, this intracerebral hemorrhage is caused by the rupture of an aneurysm. The lethality rate in SAH cases has fallen in recent years, but not the number of incidences. Patients who survive SAH have an increased risk of cardiovascular and neurovascular diseases. This article summarizes the symptoms, diagnosis, and treatment of SAH, together with test-relevant details.

Definition of Subarachnoid Hemorrhage

Subarachnoid hemorrhage (SAH) is a type of stroke caused by bleeding into the cranial and/or spinal subarachnoid space surrounding the brain. SAH may occur spontaneously or after trauma.
Classification of Subarachnoid Hemorrhage

In non-traumatic SAH cases, we can distinguish:

- Aneurysmal SAH
- Perimesencephalic SAH
- Non-perimesencephalic basal SAH
- SAH due to other non-traumatic causes (such as arteriovenous malformation, arteritis, intracranial arterial dissection, venous thrombosis, cerebral amyloid angiopathy, cerebral vasoconstriction syndrome, and cocaine abuse)

Epidemiology of Subarachnoid Hemorrhage

Occurrence of a subarachnoid hemorrhage

The annual prevalence rate of SAH in Central Europe and the USA is 6–9 per 100,000. The peak age for patients with a spontaneous (non-traumatic) SAH is about 50 years. Women, on average, are affected more often than men. SAH is the most common cause of stroke-related death.

Etiology of Subarachnoid Hemorrhage

Causes of subarachnoid hemorrhage

The main cause of SAH is the rupture of a meningeal vessel. Eighty-five percent of SAH cases occur as a result of the rupture of an intracranial arterial aneurysm. In 25% of cases, the ruptures of multiple aneurysms are responsible for SAH. They occur mainly
during physical exertion, but can also occur during rest. Aneurysms are found in certain vessels in descending order of frequency as follows:

- 40%: posterior communicating artery
- 30%: carotid siphon and middle cerebral artery
- 20%: bifurcation of the middle cerebral artery
- 10%: basilar artery and posterior inferior cerebellar artery

Acquired aneurysms mainly occur within the framework of arteriosclerosis.

<table>
<thead>
<tr>
<th>General risk factors</th>
<th>Risk factors in family history</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>Adult autosomal dominant polycystic kidney disease</td>
</tr>
<tr>
<td>Smoking</td>
<td>Coarctation of the aorta</td>
</tr>
<tr>
<td>Excessive alcohol consumption</td>
<td>Ehlers-Danlos IV</td>
</tr>
<tr>
<td>Sympathomimetic drugs</td>
<td>Marfan’s syndrome</td>
</tr>
</tbody>
</table>

Pathogenesis of Subarachnoid Hemorrhage

**Origin and development of subarachnoid hemorrhage**

The intracranial sequence after aneurysm rupture occurs as follows: rupture of an aneurysm ⇒ bleeding into the subarachnoid space ⇒ acute increase of intracranial pressure or reduction of the perfusion pressure ⇒ reduced cerebral blood flow ⇒ initial loss of consciousness ⇒ reactive hyperemia ⇒ possible recovery of consciousness

Consequences of blood leakage:

- Adherence of basal cisterns with the prevention of fluid passage (risk of hydrocephalus)
- Vasospasm in the arteries of the pia mater (cerebral under-perfusion)

Symptoms and Clinic of Subarachnoid Hemorrhage

**General symptoms**

The main symptoms of SAH include:

- Acute-onset severe headache (‘thunderclap headache’)
- Nausea
- Vomiting
- Meningism
- Vigilance discrepancies (from transient loss of vigilance up to coma)

**Specific symptoms**

Depending on the location of the bleeding, specific cranial nerve palsies may occur:

- Aneurysm of the posterior communicating artery: 3rd nerve palsy
- Aneurysm of the middle cerebral artery: hemiplegia
- Aneurysm of the basilar artery: brainstem or cerebellar symptomatology
Warning bleeding

Approximately one-quarter of patients with severe SAH demonstrate the so-called ‘warning bleeding’. Patients are affected by a sudden-onset very severe headache, which shortly turns into a persistent head and neck pain (grade I Hunt and Hess). If this warning bleeding is detected early, more efficient treatment is possible.

Note: Ischemia in an ECG can be an indicator of a warning bleeding.

Subarachnoid hemorrhage scale by Hunt and Hess

The classification according to Hunt and Hess divides the severity of SAH into 5 stages. In the following table, they are shown in relation to the Glasgow coma scale.

<table>
<thead>
<tr>
<th>Degree</th>
<th>Symptoms</th>
<th>Glasgow coma scale (GCS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Slight headache, neck stiffness</td>
<td>15</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------</td>
<td>----</td>
</tr>
<tr>
<td>II</td>
<td>Moderate to severe headache, neck stiffness, cranial nerve palsies</td>
<td>13 – 14</td>
</tr>
<tr>
<td>III</td>
<td>Somnolence, lighter focal symptoms</td>
<td>13 – 14</td>
</tr>
<tr>
<td>IV</td>
<td>Stupor, severe neurological and autonomic disorders</td>
<td>7 – 12</td>
</tr>
<tr>
<td>V</td>
<td>Coma, stretch synergies</td>
<td>3 – 6</td>
</tr>
</tbody>
</table>

Complications of Subarachnoid Hemorrhage

**Note:** The occurrence of recurrent hemorrhaging within the first 24 hours is the most severe complication; immediate treatment is crucial. Vasospasms represent an important complication of SAH. They cause ischemia especially within the period between the 3rd and 8th days after the event. Furthermore, hydrocephalus is caused by blood clotting, which impedes fluid outflow (approximately 25% of patients develop symptomatic hydrocephalus during the acute phase of SAH).

Frequently, cardiac arrhythmias and the complex symptom, Terson syndrome, are noted. In the case of Terson syndrome, bleeding occurs in the vitreous body as well as in the retina due to a build-up of pressure in the retinal veins. Direct correlation between severity and expansion of cerebral hemorrhage is detected.

![Image: Subhyaloid macular hemorrhage. Note the layered blood (black arrow) and breakthrough bleeding (white arrow)](https://openi.nlm.nih.gov/detailedresult.aspx?aid=1012306699706033700)  
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Diagnosis of Subarachnoid Hemorrhage

Suspected SAH is a medical emergency. Immediate hospitalization is necessary in order to carry out further diagnostics. The classical symptom is the thunderclap headache (patients usually describe it as ‘the worst ever”).

**Imaging techniques**

In the first 24 hours, CCT (cranial computed tomography) demonstrates a sensitivity of 95%, which is far more common and available than CMRI (cranial magnetic resonance imaging). If the results are positive, hyperdense material is visible in basal cisterns and outer cerebrospinal fluid (CSF) spaces.

CMRI with flair sequences, DSA (digital subtraction angiography), and CT/MR angiography are also useful to locate the source of bleeding.
CSF analysis

If findings in the imaging are negative, the CSF is examined by lumbar puncture. A visual inspection of the supernatant (CSF tubes against a white background) is sufficient to determine the presence or absence of xanthochromia.

- **Bloody**: fresh bleeding
- **Xanthochromic**: the yellowish color of fluid due to increased protein content

Monitoring

Patients with SAH should receive intensive care in a special monitoring unit, in order to detect and treat complications at an early stage. According to guidelines, it is recommended to supervise the following parameters during monitoring, in order to primarily detect **vasospasms** and **hypervolemia**:

- Daily transcranial doppler sonography
- Fluid balance
- Blood pressure monitoring
Measurements of central venous pressure

Under invasive neuromonitoring, tissue oxygenation, blood flow, temperature, or extracellular molecular concentrations are continuously observed.

Differential Diagnosis of Subarachnoid Hemorrhage

Diseases similar to subarachnoid hemorrhage

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Important differential diagnoses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache, increased intracranial pressure</td>
<td>Decompensated occlusive hydrocephalus, insufficient fluid shunt, migraine, cluster headache</td>
</tr>
<tr>
<td>Altered consciousness, vomiting</td>
<td>Diabetes mellitus, liver disease, intoxication</td>
</tr>
<tr>
<td>Meningism</td>
<td>Meningitis, meningoencephalitis</td>
</tr>
</tbody>
</table>

Therapy for Subarachnoid Hemorrhage

Note: Suspected SAH is a medical emergency! Further emergency diagnosis and treatment should be carried out in neurovascular centers.

Conservative measures

- Stabilization of vital functions
- Sedation
- Monitoring of volume and electrolyte balance
- Immobilization and avoidance of strenuous actions (laxatives and antiemetics can help prevent difficult defecation and vomiting.)
- Neuroprotection: treatment of hyperglycemia, hypoglycemia, hyponatremia, and fever
- Hydrocephalus: In the case of acute symptomatic hydrocephalus, fluid effluence is indicated. In the chronic course, the construction of a ventriculoperitoneal or ventriculoatrial shunt is necessary.
- Anticonvulsant therapy for epileptic symptoms
- Subcutaneous thromboprophylaxis with low-molecular-weight heparins according to the supply of the aneurysm
- No prophylactic administration of glucocorticoids and antifibrinolytics

Neurosurgical measures

If the treatment of a ruptured aneurysm is feasible and justified, it should be done within the first 72 hours (before the onset of vasospasm). Two methods of aneurysm exclusion are mainly used:

- Endovascular coiling: metal spirals (coils) are placed inside the aneurysm using a catheter, after which it is closed
- Microneurosurgical clipping of the ruptured aneurysm: the aneurysm is closed off at its base from the outside

Note: A large-scale, long-term study (ISAT) was able to demonstrate that a new rupture of the aneurysm occurs more frequently after coiling than after clipping. However, the number of deaths that occur after clipping, after a period of 5 years, is higher compared
Next, the blood pressure must be set accordingly (adapted to the normal blood pressure range of the patient). In normotensive patients, it should be in the target range of 120–140 mm Hg. With hypertensive patients, the range should be 130–160 mm Hg.

Very high blood pressure can encourage the early reoccurrence of bleeding; very low pressure may put the patient in danger of poor cerebral perfusion. The target value is a middle arterial pressure of 60–90 mm Hg.

**Prognosis of Subarachnoid Hemorrhage**

**Lethality and chances of recovery for patients with subarachnoid hemorrhage**

If a patient has survived an aneurysm rupture, the risk of re-rupture of the closed aneurysm is 4% on the first day and then 1–2% per day within the first month. The mortality rate among such patients is relatively high and 35% of them die within the first 30 days after the incident.

One-third of those affected die during in-patient treatment or experience long-term consequences. The previous state of health before SAH or the state of mild discrepancies is reached only by one-third of all the patients after the incident.

**Prevention of Subarachnoid Hemorrhage**

Influential risk factors include smoking, hypertension, and alcohol abuse. Patients should be advised regarding their lifestyle as this could be contributory to aneurysmal SAH.

**References**


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treatment. Wien: Springer.

Tetsuka, Syuichi, Matsumoto, & Eiji. (2016). *Diagnosis of a subarachnoid hemorrhage with only mild symptoms using computed tomography in Japan*. (BioMed Central Ltd.)

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