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 cases are at an increased risk of having cardiovascular and neurovascular diseases. All the facts on symptoms, diagnosis, and treatment are presented in this article in a compact way, together with all the test-relevant details. This will definitely assist you to be in perfect preparation for your final examinations.

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

Etiology of Subarachnoid Hemorrhage

Causes of subarachnoid hemorrhage

The main cause of SAH is the rupture of a meningeal vessel. 85 % of SAH cases occur as a result of the circulation of an **intracranial arterial aneurysm**. In 25 % of reported cases, multiple aneurysms are responsible for SAH. They occur mainly during physical
exertion, but can also happen during rest. The localizations of aneurysms are distributed to certain vessels in descending order of frequency as follows:

- 40%: posterior communicating artery
- 30%: carotid siphon and MCA miscarriage
- 20%: bifurcation of the middle cerebral artery
- 10%: basilar artery, PICA miscarriage

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

Intracranial sequence after aneurysm rupture occurs, is 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 disability 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 subarachnoid hemorrhage are the following:

- Acute onset, violent, destructive headache ("thunderclap headache")
- Nausea
- Vomiting
- Meningism
- Vigilance discrepancies (transient up to comatose)

Specific symptoms

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

- Aneurysm of the posterior communicating artery: third nerve palsy
- Aneurysm of the middle cerebral artery: hemiplegia
- Aneurysm of the basilar artery: brain stem 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 of a very severe headache, which later turns into a persistent head and neck pain after a short time (grade I Hunt and Hess). If this warning bleeding is detected early, more efficient treatment for patients is possible.

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

SAH 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>I</td>
<td>Slight headache, neck stiffness</td>
<td>15</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 ischaemia especially within the period between the 3rd and 8th day after the event. Furthermore, a hydrocephalus is caused by blood clotting, which impedes fluid outflow (approximately 25 % of patients develop a symptomatic hydrocephalus during the acute phase of SAH).

Frequently, it results in cardiac arrhythmias and the complex symptom, Terson syndrome. 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. A direct correlation between severity and expansion of cerebral hemorrhage is detected.

Diagnosis of Subarachnoid Hemorrhage

A case of SAH suspicion warrants a medical emergency. Immediate hospitalization is necessary in order to carry out further diagnostics. A groundbreaking symptom is a strong thunderclap headache (a patient always describes 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 the CMRI (cranial magnetic resonance imaging). If the results are positive, hyperdense material is visible in basal cisterns and outer 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 cerebrospinal fluid is examined by lumbar puncture. A visual inspection of the supernatant (CSF tubes against a white background) is sufficient for the exclusion or evidence of xanthochromia.

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

**Monitoring**

Patients with SAH should be supervised or subdued to intensive care procedures in a special monitoring unit, in order to detect complications at an early stage and treat them.
According to guidelines, it is recommended to supervise the following parameters in the monitoring procedure, 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, we have measurements of tissue oxygenation, blood flow, temperature or extracellular molecular concentrations.

**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><strong>Diabetes mellitus</strong>, liver disease, intoxication</td>
</tr>
<tr>
<td>Meningism</td>
<td>Meningitis, meningoecephalitis</td>
</tr>
</tbody>
</table>

**Therapy for Subarachnoid Hemorrhage**

**Treatment of subarachnoid hemorrhage**

**Note:** The suspicion of SAH is an emergency case and requires an acute approach!
Further acute 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 oppressive actions (poss. use of laxatives and antiemetics)
- 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
- 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 treatment of a ruptured aneurysm is justified and can be dealt with, this should be done within the first 72 hours (before the vasospasm onset). 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 treated by coiling occurs more frequently than after clipping. The number of deaths that occur after clipping, after a period of 5 years, is higher compared to that recorded after coiling.

Next, the blood pressure must be set accordingly (adapted to the normal blood pressure range of the patient). In the case with normotensive patients, it should be in the target range of 120 – 140 mmHg; with hypertensive patients – at the level of 130 – 160 mmHg.

Very high blood pressure can encourage early re-occurrence of bleeding; very low pressure may put the patient in danger of cerebral perfusion pressure. The target value is a middle arterial pressure of 60 – 90 mmHg.

**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 the closed aneurysm to re-rupture 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; 35 % of them die within the first 30 days after the incident.

One-third of those affected die during in-patient treatment or suffer for a long time from its 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. As far as an aneurysmal SAH is concerned, patients should be advised regarding their lifestyle.
Review Questions

The solutions to the questions are located below the references.

1. You receive a call from a distraught woman during your internship: her husband, a 54-year-old man, suddenly got dizzy; he felt sick and barely reacted to her speech. You immediately go on call. You find the patient lying on the bed, hardly able to comfortably answer your questions. However, he happens to inform you of a sudden onset of a splitting headache, which he has never experienced before. By means of an extrinsic anamnestic questionnaire, you further learn that the man has recently changed the tires of his car. Apart from being slightly overweight, he has had no pre-existing illnesses and takes no medications. Furthermore, you discover he had taken an ASS pill to combat a headache. RR 160/100, pulse 102. Based on the diagnosis, you call for emergency admission of the patient. What are your suspicions?

A. Pulmonary embolism
B. Migraine without aura
C. Subarachnoid hemorrhage
D. Myocardial infarction
E. Venous sinus thrombosis

2. Stefanie M., previously a healthy 44-year-old gardener, who has a long history of smoking, suddenly suffers from a vigorous thunderclap headache and subsequent episodes of vomiting without any physical strain. She is immediately taken on an emergency basis into the nearest clinic. 15 hours later, the headache is still persistent; only a slight case of meningism is present. After performing a CCT and lumbar puncture, there is xanthochromic fluid in the white balance after centrifugation. What is the most likely diagnosis?

A. Encephalitis
B. Viral meningitis
C. Lyme disease of the secondary phase
D. Glioblastoma
E. Spontaneous subarachnoid hemorrhage

3. A 53-year-old woman initially had a case of serious misdiagnosis and drug misuse. Neck stiffness and general malaise were treated with an acetic acid infusion. She demonstrates no further neurological symptoms; vital signs are within normal limits. They initiate a CCT because of a stiff neck, and the cause of the symptoms is clear: subarachnoid hemorrhage in a brain artery aneurysm. What treatment was provided for the patient?

A. Coiling of a cerebral arterial aneurysm
B. Clipping of a cerebral arterial aneurysm
C. Stenting of sinovenous stenosis
D. Therapeutic occlusion of the internal carotid artery
E. Decompressive craniectomy for cerebral edema prophylaxis

References


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


**Correct answers:** 1C, 2E, 3A

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