Acute management of stroke — II: haemorrhagic stroke

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Learning objectives

After reading this article you should be able to:

- describe the initial assessment and management of acute haemorrhagic stroke
- identify the causes of haemorrhagic stroke
- identify the prognostic factors in acute haemorrhagic stroke

Abstract

Haemorrhagic strokes are relatively less common compared to ischaemic strokes, with the vast majority of haemorrhages being intracerebral as opposed to subarachnoid. The definitive diagnosis of a haemorrhagic stroke is based on non-contrast CT imaging of the brain. Acute care should focus on prompt identification of the cause, minimizing the risk of haemorrhage expansion by controlling blood pressure and correcting any underlying coagulopathy, and obliterating vascular lesions with a high risk of rebleeding. Patients should be closely monitored, and emergent surgery should be considered in those patients who display signs of clinical deterioration, especially in the presence of posterior fossa haemorrhages. Future directions include refining the use of bedside neuro-monitoring and neuro-imaging techniques as well as developing novel approaches to minimize the complications of haemorrhagic stroke.

Keywords intracerebral haemorrhage; intraventricular haemorrhage; outcome; perimesencephalic haemorrhage; stroke; subarachnoid haemorrhage

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Introduction

Spontaneous intracranial haemorrhage accounts for up to 30% of all strokes and is often associated with a substantially worse outcome compared to ischaemic strokes. Mortality rates approach 50% in the first month, and no evidence-based treatment strategies are available. Intracranial haemorrhages can be classified on the basis of the intracranial compartment into which the haemorrhage occurs. In this brief review, we will concentrate on the management of the most commonly encountered forms of spontaneous intracranial haemorrhage: intracerebral haemorrhage (ICH) and subarachnoid haemorrhage (SAH).

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Clinical presentation

The symptoms and signs of haemorrhagic stroke reflect the location, size of the haematoma and associated oedema. The ictus often occurs during activity and is manifest as the sudden onset of a neurological deficit. Patients with SAH typically present with a sudden and severe headache ("the worst ever") associated with photophobia, vomiting and neck stiffness (late signs). On occasions, patients with SAH report a headache in the preceding weeks ("sentinel headache"). In contrast, patients with ICH tend to develop a headache that is not as acute as SAH but it is often associated with impaired consciousness, vomiting, and progressive focal deficits. Risk factors for haemorrhagic strokes include hypertension, coagulopathies or anticoagulants, age, recent heavy alcohol consumption, cocaine use, a personal or familial history of SAH, subacute endocarditis, connective tissue disease (e.g. Ehlers—Danlos syndrome and Marfan syndrome) and autosomal dominant polycystic kidney disease.

Emergency department assessment

The Initial management of patients with haemorrhagic stroke is to ensure stabilization of the airways, breathing and circulation, followed by an assessment of neurological deficits and co-morbidities. The neurological examination should focus on eliciting signs of raised ICP (e.g. unilateral fixed pupil, sixth nerve palsy). About a third of patients with haemorrhagic strokes deteriorate in their level of consciousness within the first 24 hours. This is most commonly caused by haematoma expansion, but mass effect secondary to oedema, hydrocephalus and seizures should all be considered in the differential diagnoses. On the basis of the findings on clinical examination, patients can be categorized on a grading scale such as the Hunt and Hess Scale, the World Federation of Neurological Societies (WFNS) scale, the modified Fisher or the ICH score (Table 1). Emergency investigations should include a full blood examination, blood glucose, electrolytes with renal function, and cardiac markers. Special consideration should be given to coagulation parameters (platelet count, prothrombin time, international normalized ratio). ECG monitoring is important, as patients with haemorrhagic strokes can develop supraventricular/ventricular arrhythmias, ST-segment alteration, T wave inversion, and QT prolongation.

Identify the aetiology

CT is the first line imaging investigation for patients with suspected haemorrhagic stroke due to its wide availability and high sensitivity to acute blood seen as hyperdense signal within

Predictors of outcome and risk of vasospasm in subarachnoid haemorrhage

Hunt and Hess Scale
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. *Mild focal deficit, lethargy, confusion*
Grade 4. *Stupor, moderate to severe hemiparesis*
Grade 5. *Coma, decerebrate posturing*

WFNS Scale	Mortality
Grade 1. *GCS 15*	*1-5%*
Grade 2. *GCS 13-14, No motor deficit*	*5-9%*
Grade 3. *GCS 13-14, Motor deficit*	*19-20%*
Grade 4. *GCS 7-12*	*33-40%*
Grade 5. *GCS 3-6*	*77%*

Modified FisherScale	% with vasospasm
Grade 1. *SAH ⟵1 cm thick on CT; No IVH*	*24%*
Grade 2. *SAH ⟵1 cm thick on CT; With IVH*	*33%*
Grade 3. *SAH ⟶1cm thick on CT; No IVH*	*33%*
Grade 4. *SAH ⟶1 cm thick on CT; With IVH*	*40%*

SAH = Subarachnoid haemorrhage; IVH = Intraventricular haemorrhage

ICH Score	Mortality
0	*0 %*
1	*13 %*
2	*26 %*
3	*72 %*
4	*97 %*
5	*100 %*
(6)*	*(100 %)*

** A score of 6 is assumed to have a mortality of 100%, although no patients had an ICH score of 6 in the original study (Hemphill JC III, Bonovich DC, Besmertis L, et al. Stroke 2001; 32: 891-7).*

Criteria for the ICH Scale are as follows:

Criteria	ICH Score
GCS (on presentation)	
- 13-15	0
- 5-12	1
- 3-4	2
ICH Volume (ABC/2 Method)	
- ⟵ 30 cm^2	0
- ≥ 30 cm^2	1
Presence of intraventricular haemorrhage	
- Yes	0
- No	1
Infratentorial Origin	
- No	0
- Yes	1
Age	
- ⟵ 80 years	0
- ≥ 80 years	1

ICH Score. This score predicts 30-day mortality from ICH. Total ICH score 0—6. Mortality rate (score 0, 0%, score 1, 13%, score 2, 26%, score 3, 72% and score 4, 97%, score 5, 100%). GCS score indicates GCS on initial presentation. ICH volume is calculated using the ABC/2 method. SAH = subarachnoid haemorrhage; IVH = intraventricular haemorrhage; ICH = intracerebral haemorrhage.

Table 1

4 hours (Figure 1). MRI can provide additional information regarding the timing of the haemorrhage, the degree of perihaematomal oedema and infarction, and the presence of microbleeds. CT and MR angiography are useful as an initial screen for the presence of vascular malformations. Cerebral catheter angiography is used to confirm the diagnosis and to plan the treatment. The risk of permanent neurological deficits from cerebral angiography is relatively low (0.2% for patients with SAH). The most common causes of haemorrhagic stroke are listed in Box 1.

Spontaneous ICH is caused predominantly by hypertensive vasculopathy and usually occurs in deep locations in the brain (putamen, subcortical white matter, cerebellum and thalamus). The presence of lobar haemorrhages in young, normotensive patients should prompt the search for an underlying vascular lesion. About a third of patients with ICH show an expansion in haematoma volume after the diagnostic scan. On CT angiogram, active bleeding may be detected as a 'spot sign', a serpiginous focus of enhancement within the margins of the haematoma.

Non-traumatic SAH is usually caused by (saccular) aneurysmal rupture. SAH is visible on non-contrast CT in >98% of patients on the day of presentation, but the sensitivity for the detection of SAH drops significantly with time (50% after a week). If the initial CT scan is negative and there is a clinical suspicion of SAH, lumbar puncture is mandatory to allow identification of CSF bilirubin by spectrophotometry (most reliable between 12 hours and 2 weeks from ictus). MRI can also be useful in the detection of SAH, particularly in the subacute phase (between day 4 and 14 from the ictus). Other causes of subarachnoid hyperintensity (propofol, prior administration of gadolinium and movement artefact) should be excluded. The sensitivity of CT and MR angiography for detecting cerebral aneurysms depends on the aneurysmal size (>5 mm, sensitivity 95—100%; <5 mm, sensitivity 56—83%). Cerebral angiogram remains the gold standard for the diagnosis and treatment of aneurysmal SAH, as it can provide anatomical details of the aneurysm (neck, nearby vessels, etc.), exclude the presence of multiple aneurysms, and assess the degree of vasospasm.

The most common cause of non-aneurysmal SAH is perimesencephalic haemorrhage (PMH) which accounts for 10% of all SAH. The haemorrhage is confined to posterior fossa cisterns. PMH is treated conservatively and generally has an excellent prognosis.

Critical care management

Patients with haemorrhagic strokes should receive initial monitored care in a neurointensive care unit. Supportive measures include aggressive control of blood pressure (BP), controlling intracranial pressure (ICP), limiting haematoma expansion, managing vasospasm and rebleeding, and treating attendant medical complications.

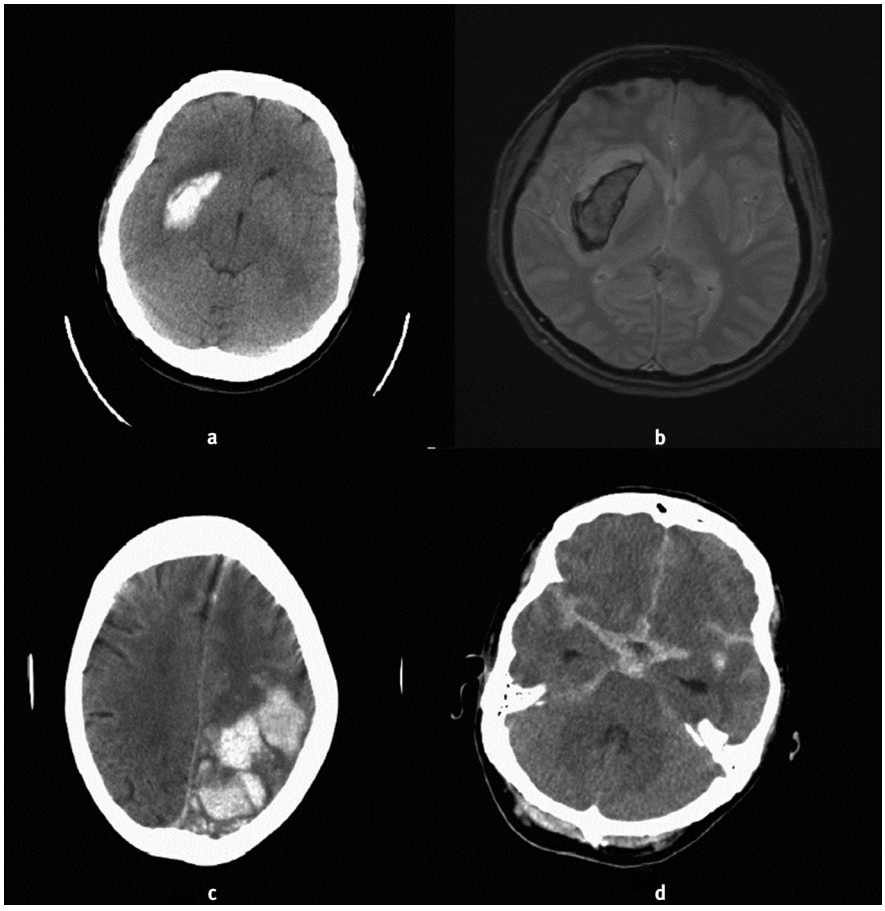

Figure 1 (**a**) Non-contrast CT brain and (**b**) MRI brain of a patient with a basal ganglia haemorrhage. This location is typical for a hypertensive ICH. (**c**) Non-contrast CT brain of a different patient demonstrating a large, acute left parietal intra-parenchymal ICH. The location and appearance of the lesion, in addition to the patient's advanced age, was suggestive of amyloid angiopathy. (**d**) CT brain of a third patient, showing the classic appearance of a subarachnoid haemorrhage.

Blood pressure management

Blood pressure is the single most important factor which contributes to rapid haematoma expansion, especially in the first 24 hours. The INTERACT and ATACH I trials evaluated intensive BP lowering (BP 110—140 mmHg) treatment in ICH. These trials have demonstrated that the treatment is not hazardous to patients, but it did not affect the primary outcomes (death or disability). Although there is currently insufficient evidence to recommend precise blood pressure targets in patients with ICH, the National Stroke Foundation advocates a systolic BP < 180 mmHg.

In patients with SAH, lowering the blood pressure to 140—160 mmHg is reasonable. Once the aneurysm is secured, blood pressure parameters can be liberalized to as high as 120—220 mmHg as the patient enters the vasospasm period. Common intravenous antihypertensive agents used are labetalol, hydralazine and nitroprusside. Treatment of pain and anxiety can contribute to controlling the BP.

Intracranial pressure management

Elevated ICP is considered a major contributor to mortality after haemorrhagic strokes. ICP should be kept less than 20 mmHg and cerebral perfusion greater than 70 mmHg. Patients should be nursed with the head elevated at 30 degrees. Strategies to reduce elevated ICP include osmotic diuretics such as intravenous mannitol, surgery and controlled hypoventilation. Randomized clinical trials on steroids and glycerol to reduce the oedema and the ICP have not shown any significant benefit. Induced barbiturate coma and therapeutic hypothermia are sometimes considered in refractory elevated ICP. Hemicraniectomy improves mortality in patients with elevated ICP, but does not improve the likelihood of meaningful neurologic recovery.

Limiting haematoma expansion

Haematoma expansion is a critical determinant of mortality and functional outcome. Haemorrhagic stroke related to anticoagulant therapy has a very high mortality rate, and patients on warfarin should receive vitamin K and fresh frozen plasma (FFP) aiming for a normalization of the INR to 1.3. Alternatively, unactivated prothrombin-complex concentrate normalizes the INR within 30 minutes, but its high cost and unproven benefit limit its use. Newer anticoagulants such as rivaroxaban, apixaban or dabigatran may have a better safety profile, but currently no antidotes for these agents exist.

Recombinant activated factor VIIa (rFVIIa) has been studied to counteract the haematoma expansion in patients with ICH. In the FAST trial, rFVIIa reduced ICH expansion but this failed to translate into any clinical improvement at 90 days. In addition, patients treated with rFVIIa had increased risk of myocardial and

Major causes of spontaneous SAH and ICH

Subarachnoid haemorrhage

Aneurysmal

- Saccular
- Fusiform
- Mycotic

Non-aneurysmal

- Benign perimesencephalic
- Arteriovenous malformation
- Dural arteriovenous fistula
- Vertebral dissection
- Cavernous angioma
- Vasculitis
- Amyloid angiopathy
- Cerebral venous thrombosis
- Reversible cerebral vasoconstriction syndrome
- Pituitary apoplexy

Intracerebral haemorrhage

- Hypertension
- Amyloid angiopathy
- Ischaemic stroke with haemorrhagic transformation
- Ruptured vascular malformation or aneurysm
- Coagulopathy
- Tumours
- Venous infarction
- Vasculitis
- Encephalitis, Abscess
- Drugs (cocaine, amphetamine)
- Moyamoya Disease

Box 1

cerebral ischaemic events. Further studies targeted patients with a positive 'spot sign' on CT angiography (SCORE-IT and the SPOTLIGHT trials) or who were on anticoagulants, but the results were inconsistent.

Securing the aneurysm

Aneurysms can be secured endovascularly or surgically (through a craniotomy and clipping). A large international study found that patients treated endovascularly had a better outcome at 1 year. Early intervention (within 3 days) should be offered to those who suffer a SAH with a WFNS grade of 1 to 3 to reduce the risk of rebleeding (Table 1).

Clot removal

Surgical evacuation for supratentorial ICH is controversial. Indeed, the Surgical Trials in Intracerebral Haemorrhage (STICH) I and II concluded that there is no overall benefit from early surgery versus conservative management. However, there is an increasing interest in minimally invasive approaches to drain the haemorrhage. A recent randomized controlled trial reported significantly improved functional outcome in patients with 25–40 ml basal ganglia ICHs treated with stereotactic haematoma aspiration versus conservative management. Patients with cerebellar haematoma and obstructive hydrocephalus may benefit from surgical treatment even if they are in coma. Elderly patients in a poor neurological state (GCS <8) with deep basal ganglia haematomas and/or intraventricular extension do not usually benefit from surgery.

Patients with intraventricular extension are at risk of hydrocephalus and may require ventricular drainage of CSF. The resolution of the intraventricular bleed can be facilitated by the intraventricular administration of thrombolytic agents as demonstrated in the CLEAR IVH trial.

Vasospasm and delayed cerebral ischaemia

Cerebral infarction related to vasospasm is a significant source of long-term disability. Vasospasm typically develops between 3 and 14 days after SAH. The risk of developing vasospasm is related to the thickness of the SAH and the presence of intraventricular blood (Table 1). Vasospasm may be an asymptomatic angiographic phenomenon or it may lead to clinical symptoms (delayed cerebral ischaemia). Nimodipine is traditionally used to prevent vasospasm, and it does improve the outcome of these patients. Experimental approaches to prevent vasospasm include endothelin receptor antagonists, magnesium sulphate, and nicardipine prolonged-released implants. In the presence of symptomatic vasospasm, the use of hyperdynamic therapy, comprising modest haemodilution, induced hypertension and hypervolaemia (so-called 'Triple H' therapy) should be instituted before considering endovascular treatment. Intra-aortic balloon counter pulsation should be considered in patients with refractory vasospastic ischaemia.

Rebleeding

Aneurysmal rebleeding occurs in up to 10% of SAH patients and is a major cause of mortality. Rebleeding occurs within 3 days of ictus in most cases. The most important predictors of rebleeding are neurologic grade on admission (Table 1) and aneurysm size. Aneurysm obliteration is the treatment of choice. However, when there is an unavoidable delay in achieving obliteration, a brief course of antifibrinolytic therapy can reduce the risk of aneurysmal rebleeding.

Medical complications

Medical complications contribute to significant morbidity, and include arrhythmias, pulmonary oedema, fever, hyperglycaemia, hyponatraemia and hepatic dysfunction. Hyponatraemia is extremely common and results from excessive natriuresis or cerebral salt wasting, rather than syndrome of inappropriate antidiuretic hormone secretion (SIADH). The associated hypovolaemia increases the risk of vasospasm and it should be promptly corrected with saline.

Seizure treatment

Seizures occur in up to 20% of patients with haemorrhagic strokes, and often occur within the first 24 hours of bleeding. The frequency of non-convulsive status epilepticus is <10% but is associated with poor functional outcome. Seizures should be treated depending on individual circumstances, with available intravenous antiepileptic drugs such as phenytoin, valproate, levetiracetam and lacosamide. There are no prospective trial data to support the prophylactic use of anticonvulsants.

Prognosis

Haemorrhagic stroke is a devastating condition with an overall mortality approaching 50%. Prognostic variables include neurological state and BP on admission, age, medical co-morbidities, the underlying cause of the haemorrhage, as well as its size and location. Most functional and cognitive recovery occurs weeks to months after discharge. Currently available prognostic scores may allow us to estimate the likely level of functional independence and, as such, may act as independent tools to aid physicians in the often difficult process of medical decision-making in patients with haemorrhagic stroke. ◆

FURTHER READING

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