IBCC

Intracerebral hemorrhage checklist

history – key information

- Time of symptom initiation.
- Medications (especially antihypertensives & anticoagulants – including timing of the last dose).

initial lab panel

- Electrolytes, complete blood count.
- INR, PTT, fibrinogen.
- Anti-Xa activity for patients on riveroXaBAN/apiXaBAN.
- Toxicology screen if clinically warranted.
- Pregnancy evaluation as appropriate.
- ABG/VBG if patient is intubated.

anticoagulation management

- Reversal of medications:
    - Warfarin reversal:
    - Dabigatran reversal:
    - Xaban reversal:
    - Thrombolysis reversal:
    - Heparin reversal:
    - Antiplatelet reversal: (DDAVP may be considered:)
    - **Don't delay reversal** of warfarin/DOACs while awaiting labs – empiric reversal should be given immediately.(2022 AHA/ASA; 35579034)
- Treat endogenous coagulopathies:
    - Target platelet count >100

blood pressure control

- For patients with an initial systolic Bp of 150-220, target reduction to a **systolic Bp of 130-150 mm** (but avoid dropping the systolic Bp <130 mm as this may cause *harm*).
- Preferred agents: Infusion of nicardipine or clevidipine.

neurosurgical consultation – especially if:

- Consider hematoma evacuation in cerebellar hemorrhage.
- Consider ventricular drain in hydrocephalus.

other

- **Fever control**.
- **EEG** if altered mental status is disproportionately severe compared to abnormality on CT scan, or if there is other evidence of seizure.
- **Repeat CT scan** with **CT angiography** (if CT angiography wasn't initially obtained). Also consider CT venography if there is suspicion for cerebral venous thrombosis.
- **DVT prophylaxis** initially with intermittent pneumatic compression.

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pathophysiology

hematoma expansion

- Up to a third of patients whose CT is obtained within 3 hours of onset will experience an increase in hematoma size.
- Hematoma expansion is most common within the first 6-**24 hours** (yet it can occur within ~48 hours in coagulopathic patients).
- Risk factors for hematoma expansion include:
    - Anticoagulation.
    - Shorter duration since initiation of symptoms.
    - Various signs on CT scanning.

cytotoxic edema

- Cytotoxic edema occurs surrounding the hematoma (perihematomal edema). This worsens over a period of days, before improving. Edema volume may peak after **~5-6 days**.(Shutter 2019)
- Remember that cytotoxic edema does *not* respond to steroids – only vasogenic edema does.

intracranial pressure (ICP)

- Intracranial pressure may increase due to the mass effect of the hemorrhage and the perihematomal edema, as well as either blood accumulation in the ventricles (if the hematoma extends into the ventricles) or mass effect on the ventricles leading to obstructive hydrocephalus.

terminology

- Intracerebral hemorrhage (ICH) refers to a primary or secondary non-traumatic hemorrhage.

- The term “hemorrhagic stroke” encompasses ICH, but also hemorrhagic conversion of an ischemic stroke and subarachnoid hemorrhage, and should be avoided in order to avoid confusion.

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causes of ICH

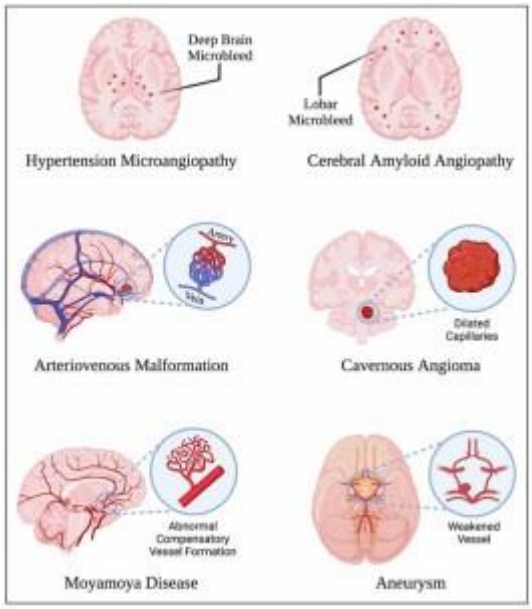


Figure 1. Cerebrovascular causes of intracerebral hemorrhage (ICH). Several vascular pathologies increase the risk for ICH. Hypertension microangiopathies (**top left**) present as microhemorrhages primarily localized in the deep brain structures following chronic hypertension due to structural and mechanical age-related changes within arterial walls. Microhemorrhages caused by cerebral amyloid angiopathy (**top right**), however, are generally found within lobar regions and are caused by amyloid deposit which weakens vascular integrity. Arteriovenous malformations (**middle left**) are abnormal connections between arterial and venous vasculature. Cavernous angioma disease (**middle right**) is a neurovascular disorder characterized by dilated leaky capillaries following dysfunctional endothelium. Moyamoya (**bottom left**) is a rare condition causing vascular constriction within the arteries at the circle of Willis and ensuing abnormal vessel formation compensating for the blockage of normal blood flow to this area. Finally, aneurysms (**bottom right**) are dilations of blood vessels caused by a weakening in the parent artery angioarchitecture.

Magid-Bernstein J et al. PMID: 35420918

(#1/3) small vessel disease

hypertensive intraparenchymal hemorrhage

- Location is most commonly the same locations where patients develop lacunar strokes (both processes relate to arteriolar lipohyalinization):(26046515)
    - Basal ganglia/external capsule (60-65%).
    - Thalamus (15-20%).
    - Pons or deep nuclei of the cerebellum (10%).
- Epidemiology:
    - Causes ~80% of all intracranial hemorrhage.(Torbey, 2019)
    - Risk factors include age, hypertension, and diabetes.
    - Supported by other evidence of hypertension (e.g., left ventricular hypertension, chronic kidney disease).
- Imaging often reveals additional chronic white matter changes and microhemorrhages (the latter may be seen on GRE/SWI MRI sequences).

cerebral amyloid angiopathy (CAA)

- Location:
    - Usually lobar hemorrhage, more often in the occipital and parietal lobes.(29262441)

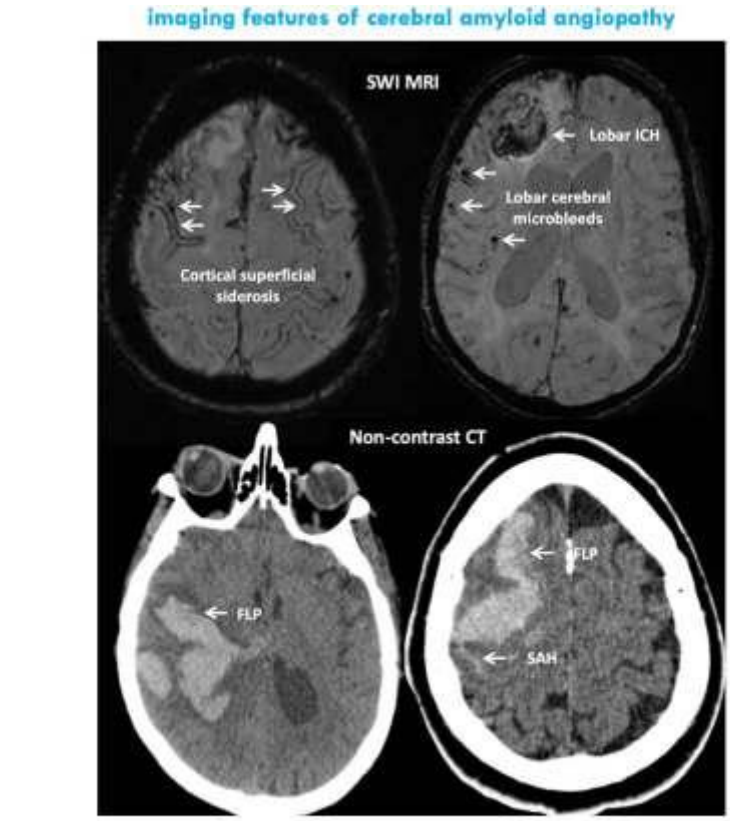
- Sometimes with subarachnoid extension or *finger-like projections* of the hemorrhage (image below).

- Hint: If the patient has underlying cognitive decline, and the hemorrhage is lobar/cortical and with a small degree of high cortical subarachnoid hemorrhage, chances are you are looking at an amyloid hemorrhage.

- Epidemiology:
  - Cerebral amyloid angiopathy has a prevalence of ~5% among people >65YO, accounting for ~15% of all spontaneous intracranial hemorrhages.(34618759) Amyloid angiopathy is associated with Alzheimer's disease.(33272397)

  - This is the most common cause of lobar hemorrhage in normotensive elderly patients. However, half of lobar ICH in the elderly *aren't* due to amyloid angiopathy, so these two factors alone do not establish the underlying mechanism of the hemorrhage.(32299594)
  - It is often provoked by anticoagulation or thrombolysis.
- GRE/SWI sequences on MRI may show additional microhemorrhages at the gray-white junction and/or convexity hemosiderosis.
- The short-term prognosis is often favorable, but there is a high risk of hemorrhage recurrence (~7.5%/year) and subsequent cognitive decline.(32299594)

- If you diagnose with someone with cerebral amyloid angiopathy, those patients should *not* be restarted on anticoagulation as they carry a very high risk of recurrent hemorrhage.



Cerebral amyloid angiopathy may be suggested by cortical location of the hematoma, the presence of additional cortical micro-bleeds on MRI, subarachnoid extension, and finger-like projections (elongated projections arising from the hematoma which are longer than they are wide).

Hostettler IC et al. PMID 31188036

(#2/3) macrovascular etiologies

Macrovascular etiologies often require surgical resection and/or embolization by interventional radiology to avoid re-bleeding. Vascular malformations are the most common cause of ICH in young adults.(33288539)

aneurysmal rupture

- Potential clues:
    - (1) Aneurysms usually have at least a *small* subarachnoid component, along with the intraparenchymal hematoma.(29262441)
    - (2) Often frontal location (due to aneurysm of the ACA or AComm) or temporal location (due to aneurysm of the MCA). The hematoma may extend down to a vessel within the circle of Willis.
    - (3) Relatively young patients.
    - (4) Personal/family history of aneurysmal disease.
- The aneurysmal nature is usually diagnosed based on CT angiography.
- Management:
    - Consult neurosurgery and/or interventional radiology for aneurysmal protection.

- Manage blood pressure management mirrors the management of subarachnoid hemorrhage. (Torbey, 2019)

other macrovascular causes

- **Cerebral venous thrombosis (CVT)** with secondary hemorrhage
    - Risk factors and clues are discussed in the section below.
- **Arteriovenous malformation (AVM).**
- **Cavernous malformation** (aka., cavernomas or cavernous hemangiomas). These are notable for their unique popcorn-like appearance on T2 MRI images.
- **Dural arteriovenous fistula (dAVF)**.
- **Mycotic aneurysm** may result from endocarditis or bacteremia.
- **Moyamoya disease.**

(#3/3) other etiologies

malignancy:

ischemic stroke with hemorrhagic conversion:

less common causes:

- Vasculitis: Usually caused by polyarteritis nodosa or lupus, but may also occur with ANCA vasculitis, rheumatoid arthritis, sarcoidosis, drug-induced vasculitis, or Henoch-Schonlein purpura.
- Reversible cerebral vasospasm syndrome (RCVS):
- Coagulopathy.
- Sympathomimetic drug use.

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which scans to order initially

***most* patients receive CT angiography +/- CT venography (CTA +/- CTV)**

- CT angiography (+/- CT venography) can be helpful to exclude vascular causes of hemorrhage. Obtaining CTA +/- CTV is a Class 2A recommendation for *any* patient with ICH.(2022 AHA/ASA; 35579034)
- Nearly all patients should receive a CTA (unless imaging and epidemiology is strongly consistent with ICH due to chronic hypertension).(33288539) Scenarios where CT angiography would be mandatory include: (2022 AHA/ASA; 35579034)
    - Lobar intracranial hemorrhage in a patient <70 years old.

    - Deep/posterior fossa ICH in a patient <45 years old.
    - Deep/posterior fossa ICH in a patient 45-70 years old without a history of hypertension.
- Patients will be returning to the CT scanner for serial scans (more on this below). If CT angiography wasn't performed during the first scan, it may be included in one of the followup CT scans.
- Whether to obtain a CT venogram (CTV) depends on the index of suspicion for cerebral vein thrombosis (CVT). Risk stratification for this is described next.

CT venography (CTV) if there is suspicion for cerebral vein thrombosis (CVT)

- Cerebral vein thrombosis with hemorrhagic transformation is an important cause of ICH, because this requires specific management. Clues suggesting the possibility of cerebral vein thrombosis include the following:

- (1) Epidemiological clues:
    - Younger age (e.g., ~20-50 years old).
    - Hypercoagulability (including oral contraceptive use, pregnancy, antiphospholipid syndrome, sickle cell disease, dehydration).
    - Cranial infection (e.g., meningitis, mastoiditis, cerebral empyema).

- (2) Imaging clues:
    - Lobar hemorrhage, gyriform hemorrhage, or bilateral hemorrhages.
    - Cerebral edema in excess of what might otherwise be expected.
    - Hyperdensity in a venous sinus may occasionally be seen.
- (3) Clinical clues:
    - Gradual onset of headache and neurologic deficits.

serial CT scan

- Serial head CT can be useful within the first 24 hours after symptom onset to evaluate for hemorrhage expansion. In patients with stable examination and preserved level of consciousness, follow-up CT scans at **~6 hours** and at **24 hours** appear adequate to evaluate for hemorrhage expansion and final hematoma volume.(2022 AHA/ASA; 35579034)
    - Hematoma expansion will often occur within 6-24 hours (or later in anticoagulated patients).
- In patients with new abnormalities on neurological examination or inability to perform an examination (e.g., due to sedation), more frequent scanning may be useful.

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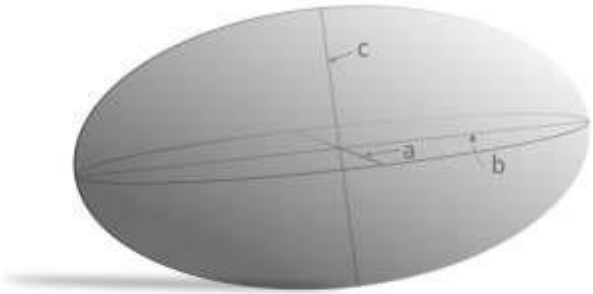
noncontrast CT scan

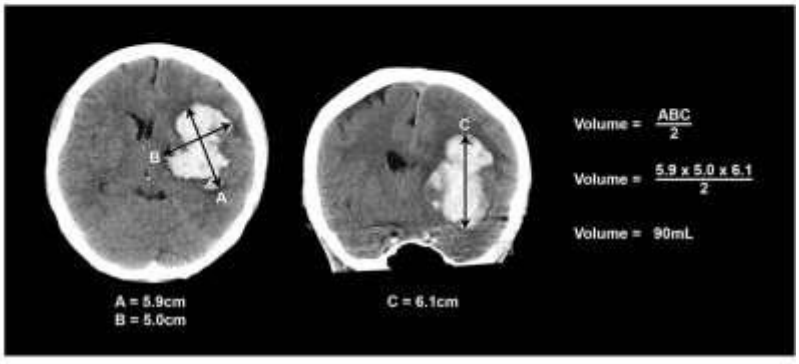
diagnosis

- Noncontrast CT scan is the standard diagnostic test to rapidly evaluate for acute intracranial hemorrhage.
- Clotting occurs within minutes to hours, causing the hematoma to be *hyperdense*. However, among patients on oral anticoagulants, hematomas may remain isodense or hypodense for longer periods of time.(33272397)
    - Isodense or hypodense blood on CT scan may be an indicator of coagulopathy.

hematoma volume

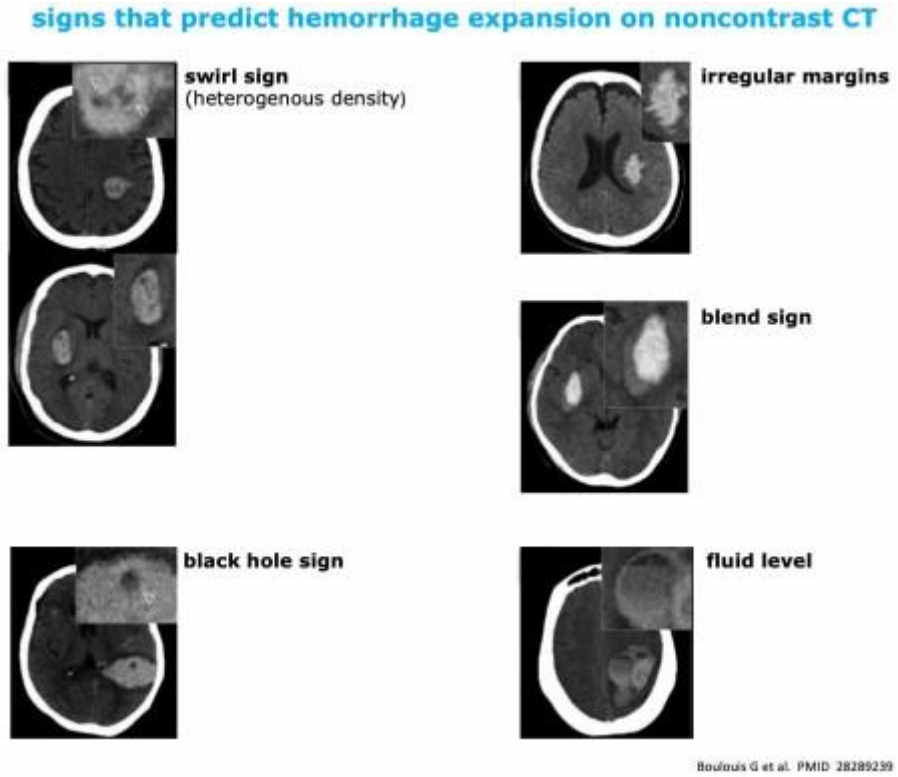
- Hematoma volume may be estimated as the multiple of the diameters divided by two (ABC/2).
    - A is the largest hematoma diameter on any axial CT image.
    - B is the largest diameter *perpendicular* to A, within that axial CT slice.
    - C is the number of axial CT slices showing hemorrhage, multiplied by the slice thickness (which may vary from 3-10 mm depending on the scanner).(34618759) This should only include slices with at least 75% of the hematoma volume. Slices that include 25-75% of the hematoma volume may be counted as a half-slice.(33272397)
- All measurements should be made in *centimeters*. This will yield a volume measured in milliliters (mL).
- Interpretation of hematoma volume: >30 ml may correlate roughly with a moderate-severe ICH (this is the cutoff used in the ICH score). However, the *location* of the ICH is often more important than absolute blood volume (e.g., 20 ml of blood in the pons is more dangerous than 40 ml in the frontal lobe).





Barras CDJ et al. 2014 DOI 10.1594/ranzcr2014/R-0129

markers of hemorrhage expansion on noncontrast CT



- **Swirl sign** may indicate active hemorrhage: entry of unclotted fresh blood has lower attenuation than blood that has already clotted. There isn't necessarily a distinct "swirl,"

  rather the key finding is blood of varying density.

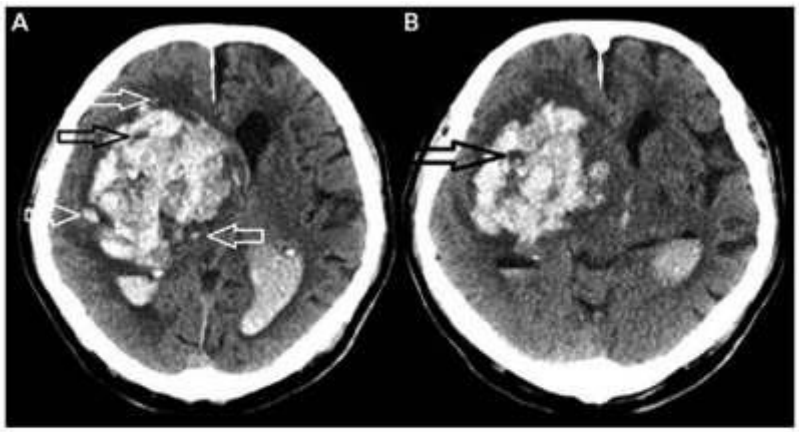
- **Black hole sign:** Defined as a relatively dark area within a hematoma that is not connected with adjacent brain tissue. This predicts hematoma growth with 32% sensitivity and 94% specificity.

- **Blend sign**: Hemorrhage contains hyperdense and hypodense regions.

- **Fluid-fluid level:** Fluid level in a hematoma suggests the presence of coagulopathy (albeit with only moderate sensitivity).(32299594)

    - A blood-fluid level is **highly specific for coagulopathy** or use of anticoagulants and should prompt a search for these factors, if none have been identified.(33288539)

- **Island sign**: At least three small hemorrhages which are separated from the main hemorrhage.(32224753)



Imaging characteristics of intracerebral hemorrhage associated with poor prognosis. *A*, Axial noncontrast CT showing the island sign (ie, at least three scattered small hemorrhages separate from the main hemorrhage) (*white arrows*), whereas the hemorrhage has hyperdense and hypodense regions (the blend sign) (*black arrow*). *B*, Axial noncontrast CT showing the black hole sign (a hypodense region surrounded by a hyperdense region not connected with the adjacent brain tissue) (*arrow*).
Reprinted with permission from Sporns PB, et al, Stroke.[70] © 2018 Wolters Kluwer Health.

Menon BK PMID 32224753

CT angiography +/- venography (CTA +/- CTV)

overview of CT angiography +/- venography

- This is the front-line test to evaluate for an underlying cause of ICH due to speed and safety (especially for causes which require more immediate management).
- CT angiography may be useful to detect an underlying aneurysm or vascular malformation. CT venography is utilized to evaluate for cerebral venous thrombosis.
- Please note that **contrast dye is not nephrotoxic**. Appropriate imaging should *not* be deferred due to renal dysfunction.
- Both CT angiography and venography may be performed together (CTAV) following a *single* administration of contrast dye.

spot sign on CT angiography

- The *spot sign* reveals leakage of contrast into the hematoma (predicting expansion with 51% sensitivity and 85% specificity).
- The spot sign must not be in anatomic continuity with any adjacent blood vessels.(32224753)

MRI

MRI generally isn't performed immediately, due to logistic constraints, but should be performed within 2 days of ictus if you wish to administer gadolinium. The reason is that after 2 days, the blood becomes hyperintense on T1 and you may not be able to see beneath the hemorrhage when the gadolinium is administered. If you are searching for amyloid, a non-gadolinium enhanced MRI will suffice.

MRI may be superior for detecting certain underlying pathologies:

- Tumor with intra-tumoral hemorrhage.
- Ischemic stroke with hemorrhagic transformation.
- Cerebral amyloid angiopathy (CAA) with multiple occult cerebral micro-bleeds.
- Underlying hypertensive microangiopathy (may be suggested by white matter lesions and small lacunar strokes).
- MRI is the most sensitive modality for cavernous malformations, which may be occult on CT angiography and invasive angiography.(33272397)

MR angiography +/- MR venography

- Usually not the front-line mode of vascular imaging.
- May be useful to provide vascular imaging (e.g., if there is a concern for venous sinus thrombosis, but CT venography hasn't been performed).

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invasive angiography

basics

- This is the definitive study to evaluate for aneurysm, dural arteriovenous malformation (dAVF), or vasculitis.
- Angiography can be both diagnostic and therapeutic (if an aneurysm or arteriovenous malformation is discovered, some may be embolized immediately).

indications for invasive angiography

- Invasive angiography is typically obtained if other imaging studies raise *concern* for a possible vascular lesion, yet are unable to resolve this issue definitively.

- Examples of indications for invasive angiography include the following clinical scenarios, if CT angiography cannot reveal a cause:(2022 AHA/ASA; 35579034)
    - (1) Lobar ICH in patient <70 years old.
    - (2) Deep/posterior fossa ICH in a patient <45 years old.
    - (3) Deep/posterior fossa ICH in a patient 45-70 years old without a history of hypertension or signs of small vessel disease on imaging.
    - (4) Patients with primary intraventricular hemorrhage.(IVH)

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airway management

- Intubation may be required for airway protection. However two thirds of patients won't require intubation.(31092052)
- There are no validated or well-defined criteria for intubation – this is a clinical judgement based on examination and trajectory.

- Care is required to avoid stimulation and hypertension, which could worsen intracranial pressure elevation.

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blood pressure management

theoretical rationale & risks

- **Rationale:** Blood pressure reduction should theoretically reduce hematoma expansion. This would be expected to be most effective within the immediate post-hemorrhage period when hematoma expansion risk is greatest.
- **Risks:**
    - Neurological: Reduced blood pressure could impair perfusion of penumbra surrounding the hematoma. This could cause necrosis, leading to worsening edema and intracranial pressure (leading to a cascade of secondary brain insults).
    - Renal failure may result from excessive blood pressure reduction.

blood pressure targets

- In patients with an initial systolic Bp of 150-220, acute lowering to **target a systolic Bp of 130-150 mm** may be reasonable. *However*, l*owering the blood pressure below <130 mm is potentially harmful and should be avoided*.(2022 AHA/ASA; 35579034)
- Benefit from antihypertensives is maximized if they are **started immediately** (when the risk of hematoma expansion is greatest).
- **Personalization** of blood pressure targets may be reasonable in patients with unusually high or low baseline blood pressure. For example, in a patient presenting with a systolic blood pressure >220 mm, it might be reasonable to target a higher blood pressure.
- The optimal duration of blood pressure control is not known. Benefit would be expected to extend through the period when there is a high risk of hemorrhage expansion (e.g., perhaps the first 24 hours in patients without coagulopathy).

preferred agents

- *Before initiating antihypertensives, always make sure that pain and anxiety have been adequately treated*. Especially among intubated patients, hypertension can be a manifestation of pain. Proper analgesia and sedation may go a long way towards blood pressure control.

- **Clevidipine** may provide the smoothest control of blood pressure, since it has a short half-life (allowing it to be a truly titratable agent).
- **Nicardipine** is more widely available and less expensive. Nicardipine is effective, but close attention is required to avoid causing overshoot hypotension (discussed further here).

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neurosurgical interventions

surgical hematoma evacuation for supratentorial hemorrhage

- STITCH-I Trial (15680453)
    - RCT involving 1,033 patients randomized to medical management vs. early surgical hematoma evacuation.
    - Outcomes were nearly identical between two groups. However, there was a non-significant trend toward benefit from surgery in patients with hematoma extending to within 1 cm of the cortical surface. Likewise, there were trends toward benefit from early surgery among patients with lobar hemorrhage and Glasgow Coma Scale score of 9-12.
    - Patients with ICH >1 cm from cortical surface or GCS<9 tended to do *worse* with surgery.
- STITCH-II Trial (23726393)
    - RCT involving 601 patients predicted to obtain maximal benefit from surgery based on the results of the STITCH-1 trial (patients were conscious, had superficial hemorrhage <1 cm from the cortical surface, had a hemorrhage volume of 10-100 ml, and had no intraventricular hemorrhage).
    - Patients were randomized to early surgery vs. early conservative approach.
    - Outcomes were nearly identical between the two groups.
- Evidence summary:
    - Available evidence suggests no outcome benefit for early hematoma evacuation. Some patients in the medical arm of these studies *did* cross over into the surgical arm due to progressive deterioration, so surgery might still be beneficial in selected cases with progressive deterioration over time.
    - Emerging evidence suggests that minimally invasive surgery could be more promising.
- Possible indications for surgery?
    - Large hematoma with significant midline shift.
    - Elevated ICP refractory to medical management.
    - Hemorrhage secondary to an underlying lesion that could benefit from resection (e.g., arteriovenous malformation or tumor).

external ventricular drain (EVD)

- Ventricular drainage may be considered for hydrocephalus (e.g., due to ventricular extension of the hemorrhage).
- An ideal candidate might be a patient who was initially doing well, then subsequently developed hydrocephalus with neurologic deterioration.
- Unfortunately, overall evidence suggests that ventricular drainage increases survival *without* increasing the likelihood of a good neurologic outcome. This implies that

patients whose lives are saved by drain placement often have poor neurologic outcome. (10751114, 22732889)

- In patients with hydrocephalus that is contributing to a reduced level of consciousness, ventricular drainage should be performed to reduce mortality.(2022 AHA/ASA; 35579034)

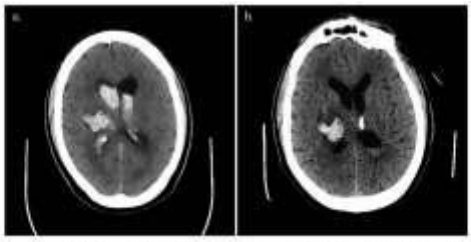

Figure 4. (a) Non-contrast CT scan revealing a R basal ganglia ICH with significant intraventricular blood and early hydrocephalus on presentation. (b) The patient underwent external ventricular drain placement and was given intraventricular t-PA with moderate improvement in intraventricular blood.
Rajeev R et al. PMID 31832852

intrathecal tPA

- There has been some interest in the utility of intrathecal/intraventricular tPA, to promote dissolution of thrombus following intraventricular hemorrhage.
- Intrathecal/intraventricular tPA has been safely studied to assess improvement in outcome or mortality and was published as the CLEAR III trial.(28081952)
    - 500 patients were randomized to receive intrathecal tPA vs. saline.
    - Unfortunately, this trial demonstrated no clear mortality benefit with intrathecal tPA use.
- Intrathecal tPA is still used in some centers, particularly when it is felt that the patient predominantly has IVH without significant ICH, and when the hydrocephalus might resolve if the IVH dissipates.

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cerebellar hematoma

basics of cerebellar hemorrhage

- The cerebellum is unique due to its enclosed location.
- Potential consequences of a cerebellar hemorrhage include:
    - (1) Direct compression causing catastrophic damage to the adjacent brainstem.
    - (2) Compression of CSF flow due to obstructive compression of the fourth ventricle may cause obstructive hydrocephalus.
    - (3) Herniation (which may include *upwards transtentorial herniation* of the cerebellum).
- Patients with cerebellar hematomas tend to have a *better* prognosis than other types of hemorrhage. Put together, this implies a greater benefit for hematoma evacuation in this location.

surgical hematoma evacuation for *cerebellar* hemorrhage

- No RCTs exist (these patients were excluded from the STITCH trials).

- Ventriculostomy placement *without* decompression and/or hematoma evacuation is *not* recommended, as this increases the chances of causing upward transtentorial brain herniation.
    - (Note also that if an external ventricular drain is placed, the pressure it measures may *not* accurately reflect the pressure in the posterior fossa.)

- Indications for immediate surgical evacuation: (2022 AHA/ASA; 35579034)
    - Larger volume (>15 ml).
    - Neurological deterioration.
    - Brainstem compression.
    - Hydrocephalus.

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seizure diagnosis & management

seizure prophylaxis isn't recommended

- Clinical seizures occur in ~10% of patients, but the rate of subclinical seizures may be substantially higher.(34618759, LaRoche 2018)
- Risk factors for seizures:(35420918)
    - Cortical involvement (e.g., lobar hemorrhages).
    - Coexistence of subarachnoid and/or subdural hemorrhage.
    - Complications, including rebleeding.
- Prior evidence has *not* revealed benefit with prophylactic phenytoin (which may relate to phenytoin's numerous side-effects).

monitoring & diagnosis

- Indications for continuous EEG:
    - Impaired consciousness that is out of proportion to what would be expected based on the CT scan.
    - Unexplained fluctuations in mental status.
    - Any history or clinical signs of seizure.
    - (More on the indications for continuous EEG monitoring:)
- ICH may also be associated with lateralized periodic discharges, generalized periodic discharges, stimulus-induced rhythmic periodic or ictal discharges (SIRPIDs), and frontally predominant intermittent rhythmic delta activity (FIRDA).(LaRoche 2018)

management

- Antiepileptic therapy is indicated for a patient with witnessed seizure, electroencephalographic seizure, or nonconvulsive status epilepticus.

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other supportive measures

fever control

- Any fever should be treated aggressively (e.g., with scheduled acetaminophen).
- If fever is refractory to antipyretics, an external cooling device may be used to achieve aggressive normothermia (similar to treatment of a post-arrest patient).
- Neurogenic fever may occur, especially among patients with intraventricular extension of the hematoma.(33952393) However, this remains a diagnosis of exclusion.

DVT prophylaxis

- Intermittent pneumatic compression should be used initially for DVT prophylaxis.(2022 AHA/ASA; 35579034)
- Initiating low-dose unfractionated heparin or low molecular-weight heparin prophylaxis at **24-48 hours** from ICH onset may be reasonable.(2022 AHA/ASA; 35579034) However, patients with underlying coagulopathy or imaging evidence of hemorrhage expansion may require a more personalized approach.

nutritional support

- Formal dysphagia screening should be implemented before initiation of oral intake to reduce the risk of pneumonia.(2022 AHA/ASA; 35579034)

sodium management

- Avoid hyponatremia or *rapid decreases* in sodium.
- *Routine* use of hypertonic saline isn't supported by evidence.
- Boluses of hypertonic saline or hypertonic bicarbonate may be used to manage elevated intracranial pressure, ideally as a bridge to more definitive therapy (e.g., an external ventricular drain).

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prognostication

overall prognosis

- Mortality is high, with only half of patients alive after one year and only ~30% alive after five years.
- Only ~20% of patients achieve functional independence after one year.(33272397)

predictors of poor outcome

- Hematoma volume >60 ml.
- Glascow Coma Scale <8.
- Deep or infratentorial location.
- Intraventricular extension.
- Increasing age.

ICH score

- The ICH score is widely used to provide risk stratification. It is composed of the following elements associated with worse outcomes:
    - Lower GCS (Glasgow Coma Scale).
    - Age >80.
    - Hematoma volume >30 ml.
    - IVH (intraventricular hemorrhage).
    - Infratentorial origin of hemorrhage.
- There are numerous *limitations* to the ICH score. For example: (Alpin & Dangayach 2022)
    - Transient impairment of neurologic function may increase the ICH score (e.g., due to sedation or hypercapnia).
    - Hydrocephalus may cause impaired mental status. This may be quite treatable, with improvement following external ventricular drain placement. Attempts to prognosticate may be inaccurate in the context of untreated hydrocephalus.
    - There is no differentiation between *tiny* intraventricular hemorrhage vs. *massive* intraventricular hemorrhage.
    - There is no differentiation between a pontine bleed vs. a cerebellar bleed (although the latter is more treatable).
    - There is no differentiation between an 18-year-old versus a 79-year-old.
    - ICH score doesn't account for pre-existing functional capacity (e.g., frailty).
- ICH score was designed to stratify disease severity, not to be an acute prognostication tool. Thus, the ICH score **shouldn't be used as the primary basis for limiting life-sustaining therapies**.(35579034)

- For an in-depth discussion of the optimal use of the ICH score:

FUNC score

- The FUNC score provides an estimate of the likelihood of functional independence at 90 days.

- Tables below provide more granular detail about how the FUNC score is obtained and interpreted.(18556582)

- Note that many of the limitations of the ICH score discussed above also apply to the FUNC score.

FUNC score to predict functional independence after 90 days

Determinants of the Functional Outcome in Patients With Primary Intracerebral Hemorrhage Score

Component	Functional Outcome in Patients With Primary Intracerebral Hemorrhage (FUNC) Score Points
Intracerebral hemorrhage volume, cm^3	
<30	4
30-60	2
>60	0
Age in years	
<70	2
70-79	1
≥80	0
Intracerebral hemorrhage location	
Lobar	2
Deep	1
Infratentorial	0
Glasgow Coma Scale score	
≥9	2
≤8	0
Pre-intracerebral hemorrhage cognitive impairment	
No	1
Yes	0
Total FUNC score	0-11

Proportion of Patients Who Achieve Functional Independence at 90 Days Stratified by Functional Outcome in Patients With Primary Intracerebral Hemorrhage Score[a]

	Functionally Independent at 90 Days, n/N (%)	
Functional Outcome in Patients With Primary Intracerebral Hemorrhage (FUNC) Score	Development Subset (n = 418)[b]	Validation Subset (n = 211)[b]
0	0/1 (0)	0/0 (0)
1	0/12 (0)	0/2 (0)
2	0/15 (0)	0/8 (0)
3	0/37 (0)	0/17 (0)
4	0/28 (0)	0/13 (0)
5	2/48 (4)	2/19 (10)
6	4/36 (11)	0/16 (0)
7	14/77 (18)	10/46 (22)
8	20/51 (39)	14/30 (47)
9	60/87 (69)	24/40 (60)
10	9/12 (75)	6/12 (50)
11	12/14 (86)	6/8 (75)

Ziai WC et al. 2018 PMID 30516598

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intraventricular hemorrhage

basics

- Primary intraventricular hemorrhage refers to hemorrhage into ventricles *without* associated parenchymal ICH.
- Primary intraventricular hemorrhage is rare, accounting for 3% of nontraumatic intracranial hemorrhage.(34618759)

causes of intraventricular hemorrhage

- ~90% are idiopathic.
- ~10% have an underlying etiology, including:
    - Hypertension.
    - Arteriovenous malformation (AVM), arteriovenous fistula, or aneurysm.
    - Moyamoya disease.
    - Coagulopathy.
    - Choroid plexus tumor or ependymal lesion.

investigation of the etiology of an intraventricular hemorrhage

- CT scan with CT angiography is often the initial investigation.
- In patients with spontaneous intraventricular hemorrhage and no detectable parenchymal hemorrhage, catheter intra-arterial digital subtraction angiography is recommended to exclude a vascular cause.(2022 AHA/ASA; 35579034)

role for external ventricular drain (EVD)

- Drainage is indicated for acute obstructive hydrocephalus.
- Intrathecal fibrinolytic therapy may be beneficial, if available.(33272397)

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podcast

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questions & discussion

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To keep this page small and fast, questions & discussion about this post can be found on another page ***here***.

- Cerebellar hematomas may threaten brainstem compression as well as hydrocephalus, so these patients potentially benefit the most from urgent surgical evacuation and/or ventricular drainage.
- Steroid doesn't help ICH. Don't use steroid in these patients unless there is some other indication.

Acknowledgement: Thanks to Dr. Richard Choi (@rkchoi) for thoughtful comments on this chapter.

Guide to emoji hyperlinks

- = Link to online calculator.
- = Link to Medscape monograph about a drug.
- = Link to IBCC section about a drug.
- = Link to IBCC section covering that topic.
- = Link to FOAMed site with related information.
- = Link to supplemental media.

Going further

- Radiopaedia (Craig Hacking and Jeremy Jones)
- Golden hour in intracerebral hemorrhage (EMCases with Anton Helman, Scott Weingart, and Salter Himmel)
- **INTERACT-2 trial**
    - WikEM Journal Club

    - EMNerd – The case of the differing perspectives

- **ATACH-2 trial**
    - TheBottomLine review by Adrian Wong
    - Intensive blood pressure control doesn't benefit patients with acute cerebral hemorrhage (RebelEM, Anand Swaminathan)
    - Don't bring my blood pressure down (intensively) – SGEM with Ken Milne
- **AHA/ASA Guidelines 2022**: Review by the NeuroEMCrit team including Scott Weingart, Neha Dangayach, and Casey Albin.
- The Perils of the ICH score (NeuroEMCrit by Casey Albin and Neha Dangayach)