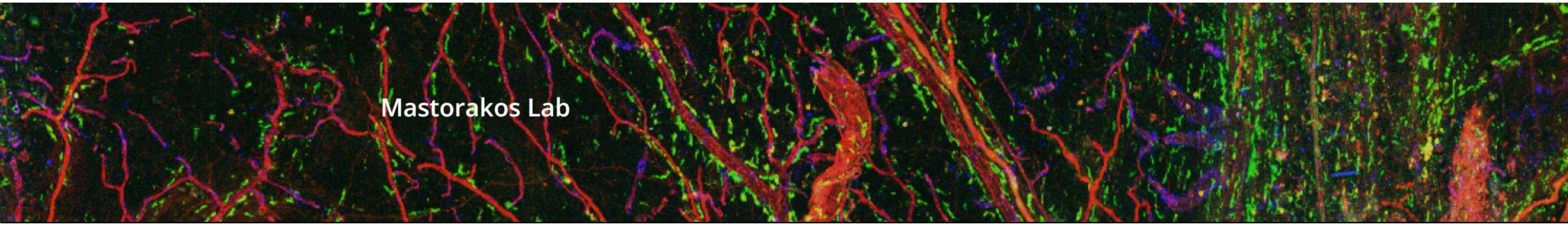
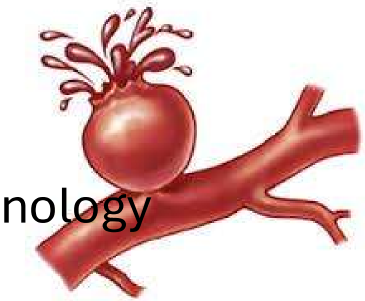


Surgical Intervention in ICH Updates



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Peter O'Donnell Jr. Brain Institute

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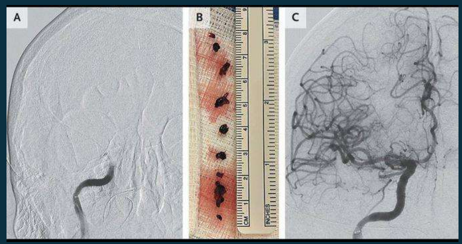
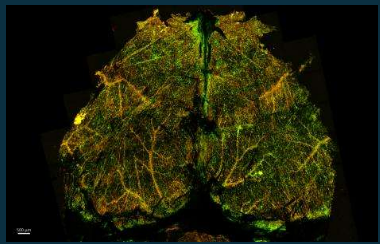
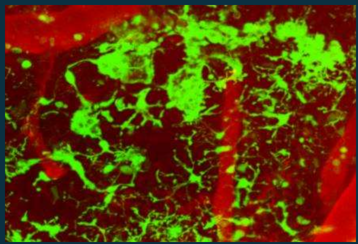
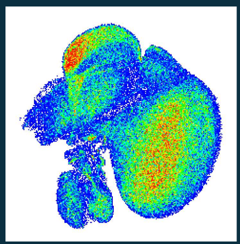
O'Donnell Brain Institute









Disclosures

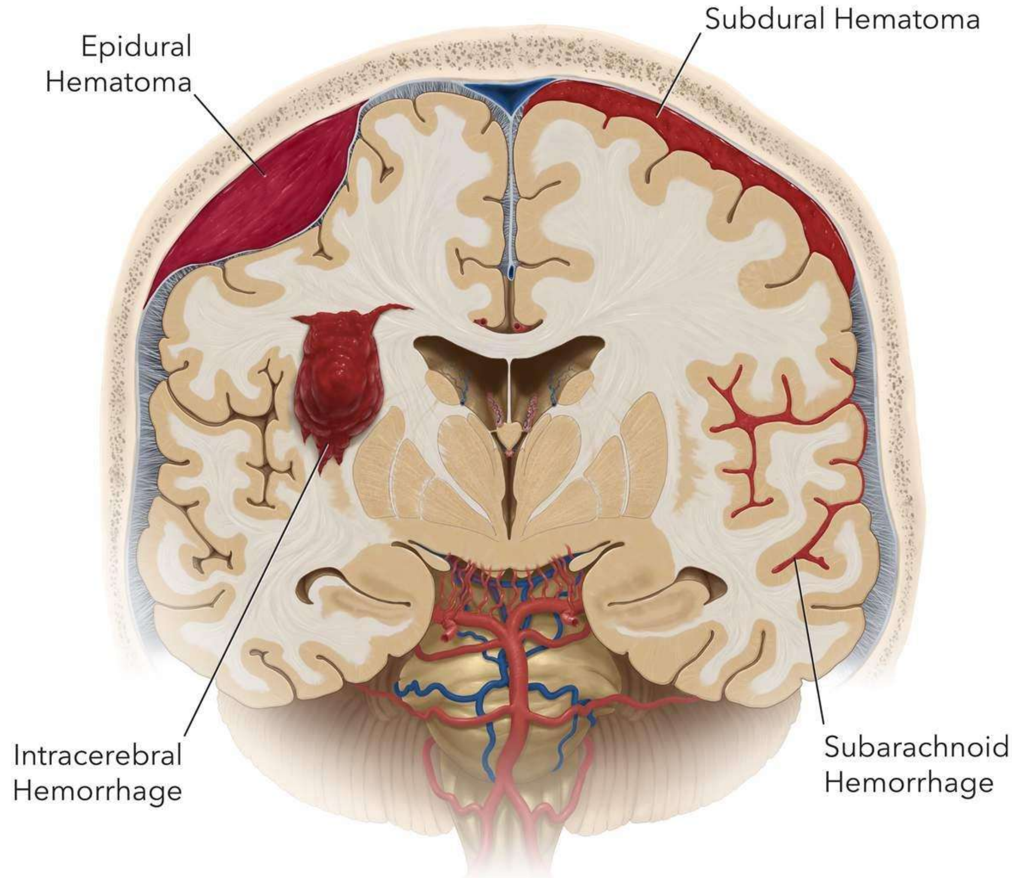
- Peter O'Donnell Jr. Brain Institute Sprouts Program
- NREF Research Fellowship Grant / Young Clinician Investigator Award
- Disease-Oriented Clinical Scholars (DOCS) Program

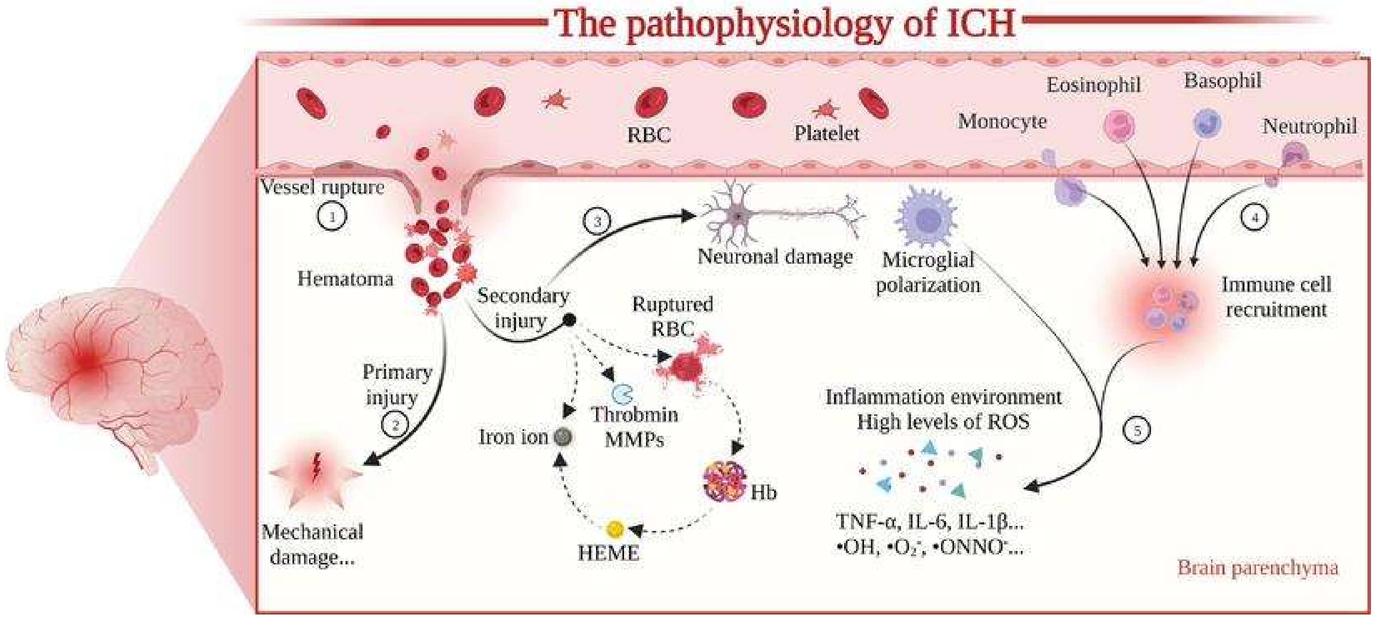
Learning Objectives

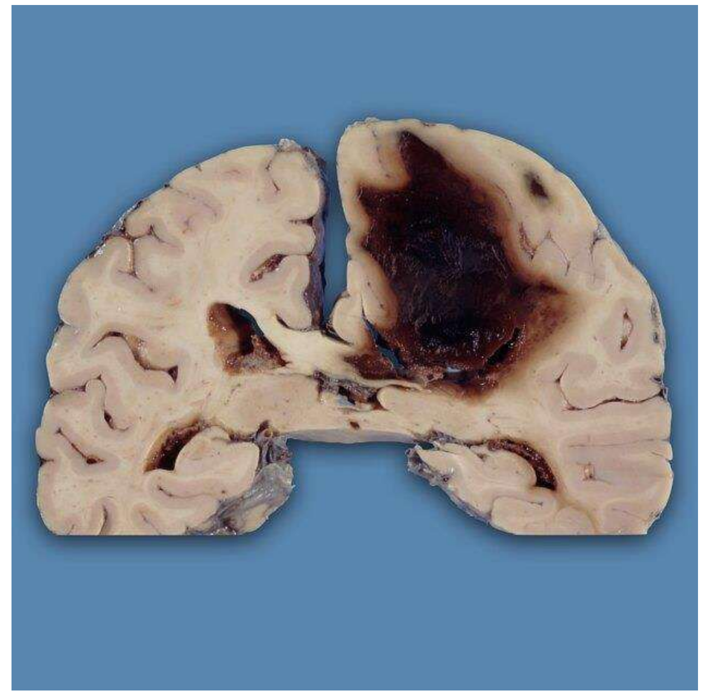
- ICH pathophysiology
- Surgical approaches to ICH
- Identify ICH patients most likely to benefit from surgery
- Summarize results/limitations of key randomized trials
- Compare open vs minimally invasive approaches
- Apply a practical selection & timing framework

Background

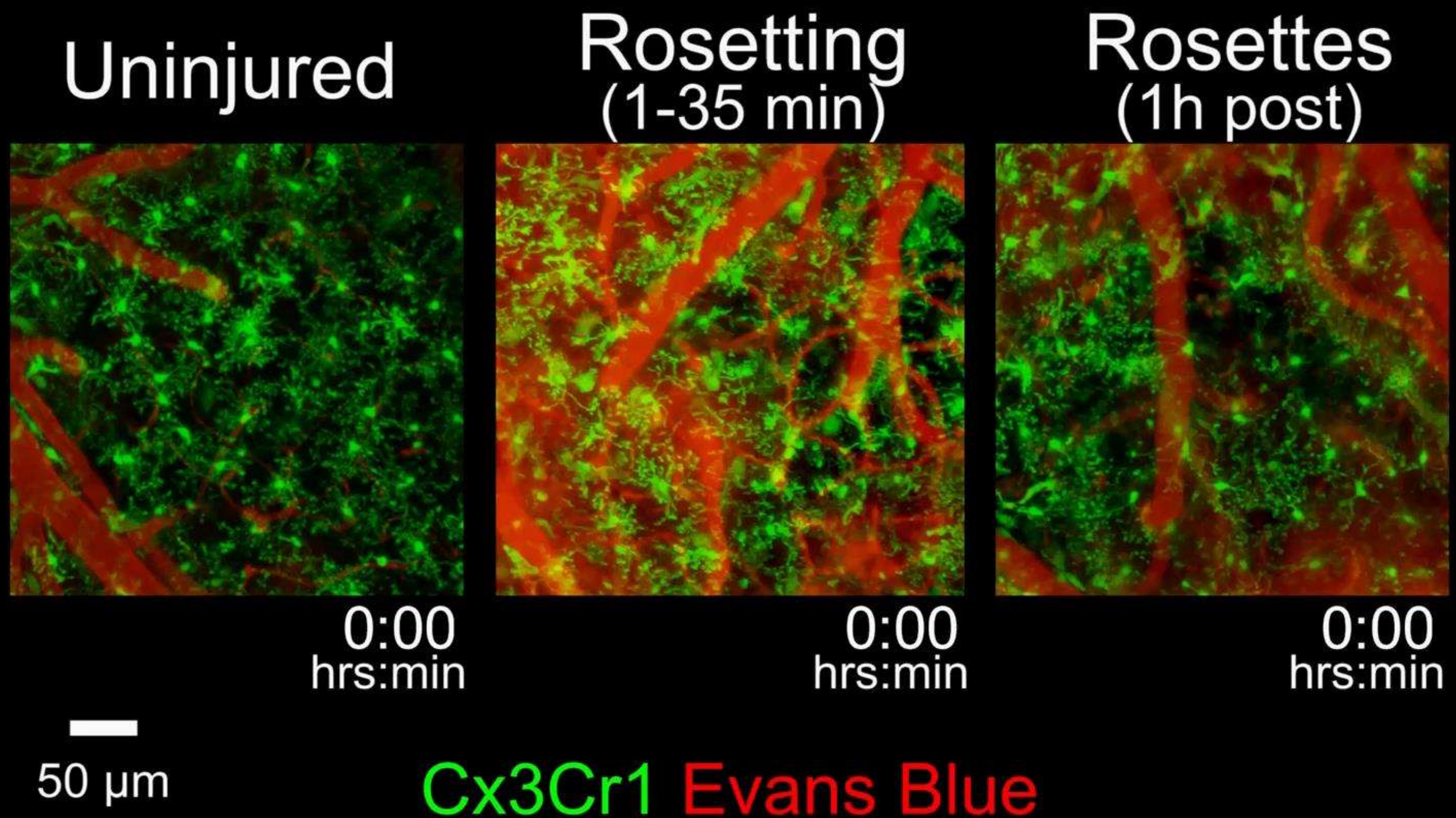
- ✓ Accounts for **~10% of all strokes**
- ✓ Associated with **high early mortality and morbidity**
- ✓ Limited disease-modifying medical therapies
- ✓ Secondary injury driven by:
  - Mass effect and elevated ICP
  - Perihematomal edema
  - Neuroinflammation and toxicity of blood products
- ✓ Optimal role of surgery remains **controversial and context-dependent**



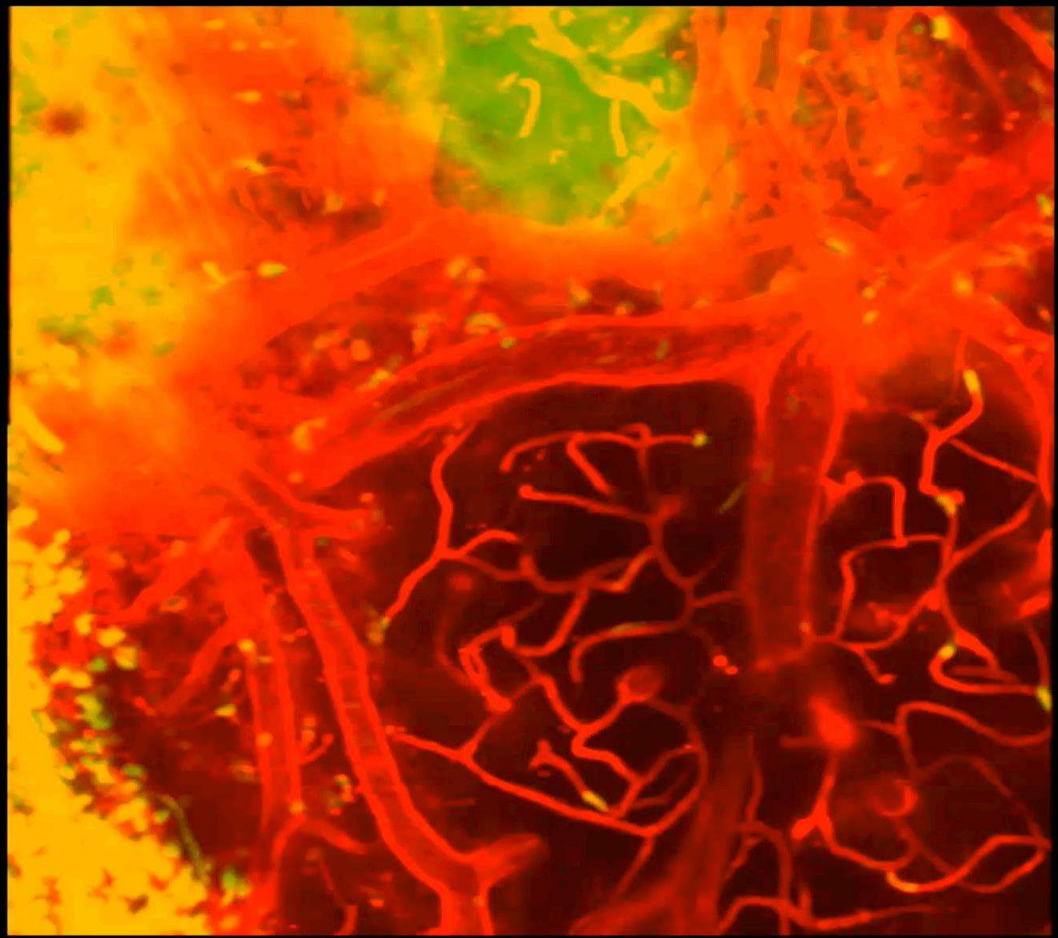

The pathophysiology of ICH
RBC
Platelet
Eosinophil
Basophil
Monocyte
Neutrophil
Vessel rupture
1
Hematoma
Secondary injury
3
Neuronal damage
Microglial polarization
4
Immune cell recruitment
Ruptured RBC
Primary injury
2
Throbmin
MMPs
Iron ion
Hb
HEME
Mechanical damage...
Inflammation environment
High levels of ROS
5
TNF-α, IL-6, IL-1β...
•OH, •O_2^-, •$ONNO^-$...
Brain parenchyma



Innate immune response to ICH: Microglia



Innate immune response to ICH: Monocytes



“Surgery for ICH” Is Not One Entity

Scenario	Primary Goal	Evidence Base
Salvage surgery (large ICH, herniation)	Survival	Observational
Trial-based evacuation (ENRICH, MISTIE)	Functional outcome	RCTs
Cerebellar ICH	Survival	Observational + consensus
ICH with underlying lesion (AVM, aneurysm, tumor)	Treat underlying cause ± evacuation	Etiology-specific literature

Life-Saving Surgery in ICH: Salvage Indications

Large supratentorial ICH with:
- Herniation physiology
- Refractory intracranial hypertension
- Rapid neurologic deterioration

Goal: **prevent death**, not proven functional recovery

Evidence base:
Observational data + physiologic rationale
No randomized trials

Often involves:
Decompressive craniectomy and/or ICH evacuation

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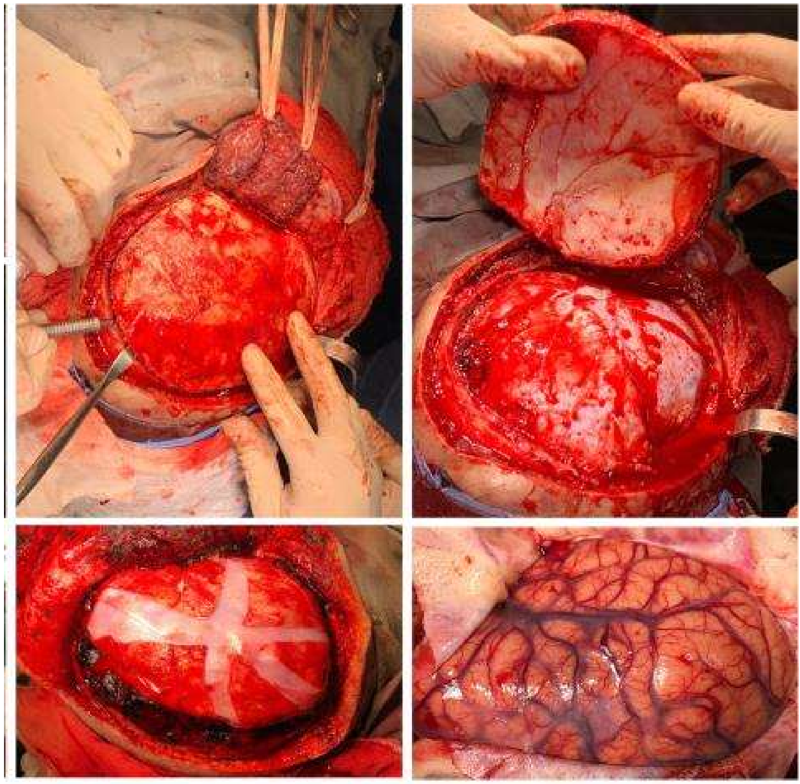
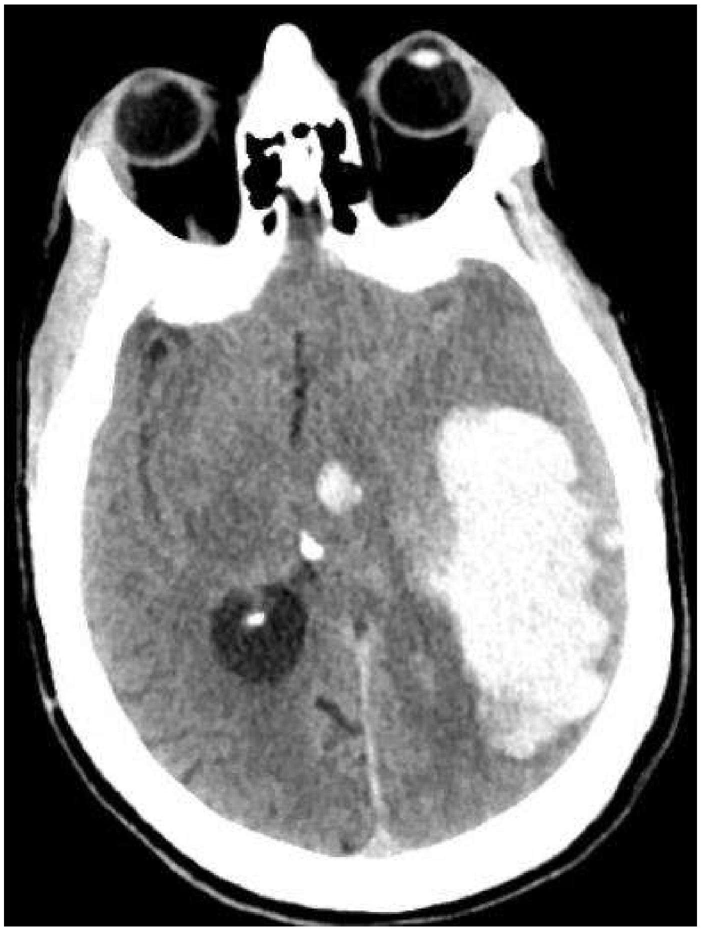


Craniectomy complications could be avoided with MIS



STICH I & STICH II: Open Craniotomy for ICH

Trial	Population / Criteria	Intervention	Primary Outcome	Key Signals / Limitations
STICH I (2005)	Supratentorial ICH ≤72 h Hematoma ≥2 cm GCS ≥5 ~40% lobar, 40% deep Median vol 38 mL	Early surgery (75% craniotomy) ≤24 h vs medical	No difference in favorable GOS at 6 mo OR 0.89 (95% CI 0.66–1.19)	Possible benefit in **lobar ICH ≤1 cm from surface** 26% crossover to surgery
STICH II (2013)	Lobar ICH only Volume 10–100 mL No IVH GCS-M ≥5, GCS-E ≥2	Early surgery (99% craniotomy) ≤12 h vs medical	No difference in favorable GOS at 6 mo OR 0.86 (95% CI 0.62–1.20)	Surgery **did not worsen outcomes** Signal toward benefit in **poor-prognosis patients**

STICH I & STICH II: Open Craniotomy for ICH

- **STICH I (2005)**
  Early surgery vs initial conservative treatment
  Broad supratentorial ICH population
  No overall functional or mortality benefit
- **STICH II (2013)**
  - Selected patients with **superficial lobar ICH** (no IVH)
  - Early surgery **did not worsen outcomes**
  - Small signal toward survival benefit, no clear functional improvement
- **Key Limitations**
  - Delayed timing in many patients
  - Large craniotomy with significant tissue disruption
  - Heterogeneous patient selection

Why do we still do open crani/evac?

- **What STICH Studied**
  - Stable supratentorial ICH
  - GCS thresholds suggesting survivability (e.g., GCS ≥5)
  - Patients **not requiring immediate life-saving decompression**
  - Timing allowed for randomization (often hours after ictus)
- **What STICH Did *Not* Study**
  - Moribund patients
  - Patients with **active herniation requiring emergent evacuation**
  - Clear-cut "no-choice" surgical scenarios
  - Posterior fossa hemorrhage

Cerebellar ICH: A Clear Surgical Indication

Posterior fossa has **minimal compensatory reserve**

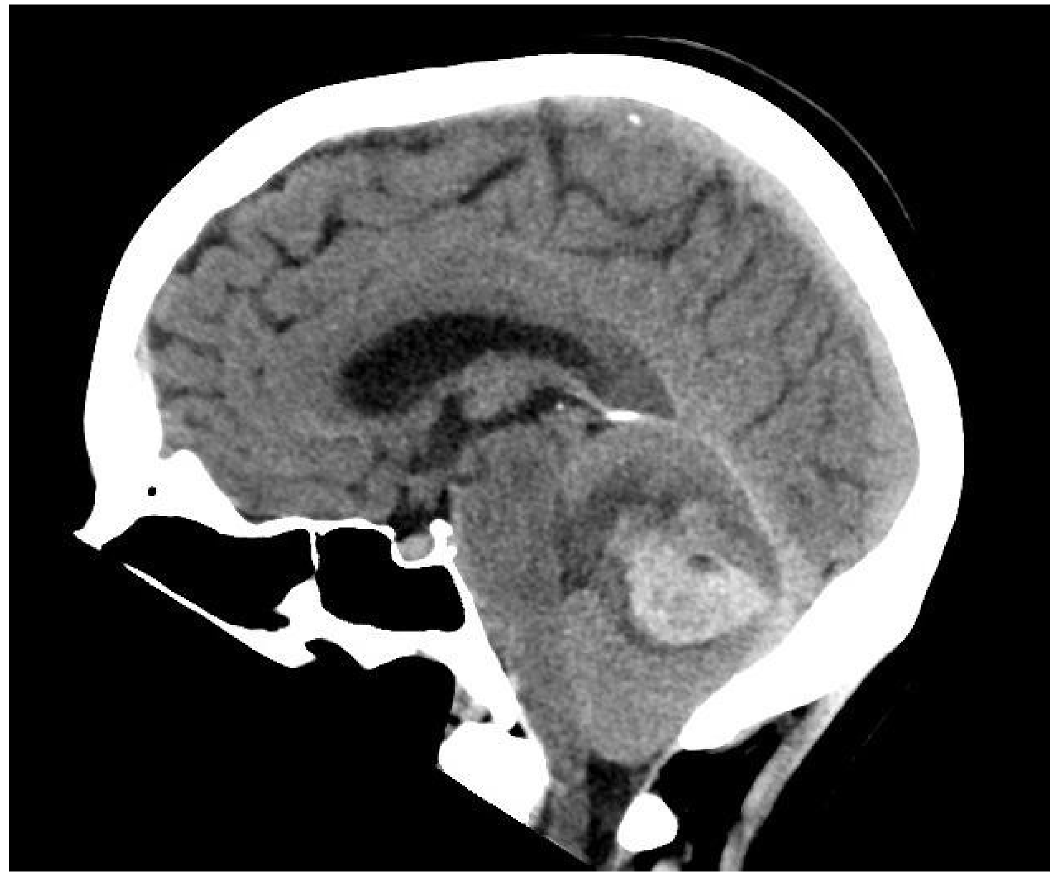
Rapid brainstem compression and hydrocephalus common

Surgery recommended for:

- Neurologic decline
- Brainstem compression
- Obstructive hydrocephalus
- Large hematoma (>3 cm/ >15 cc)

Evidence:

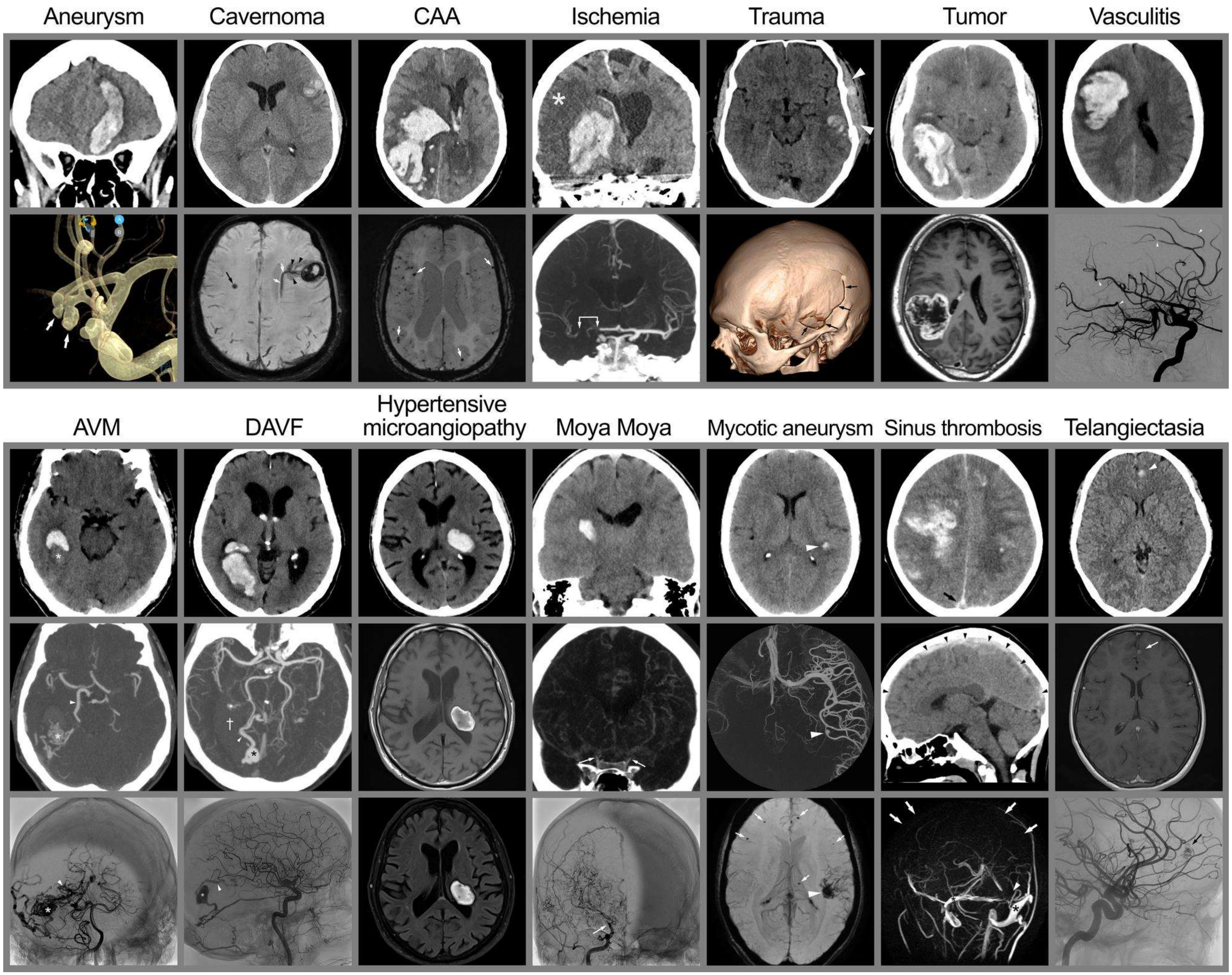
- Observational data + consensus
- **Guideline-driven**



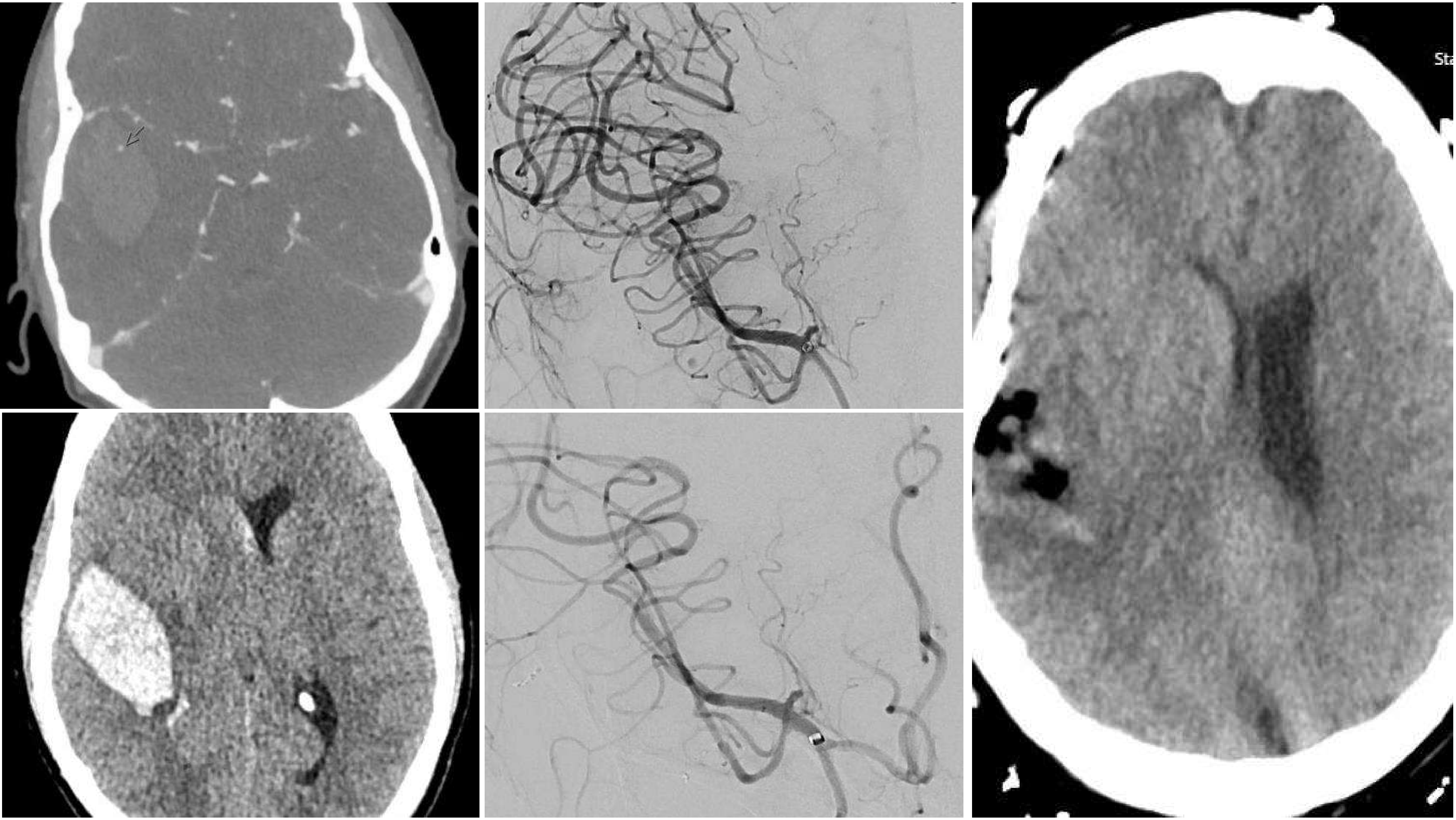

Station Na
23.5 mm

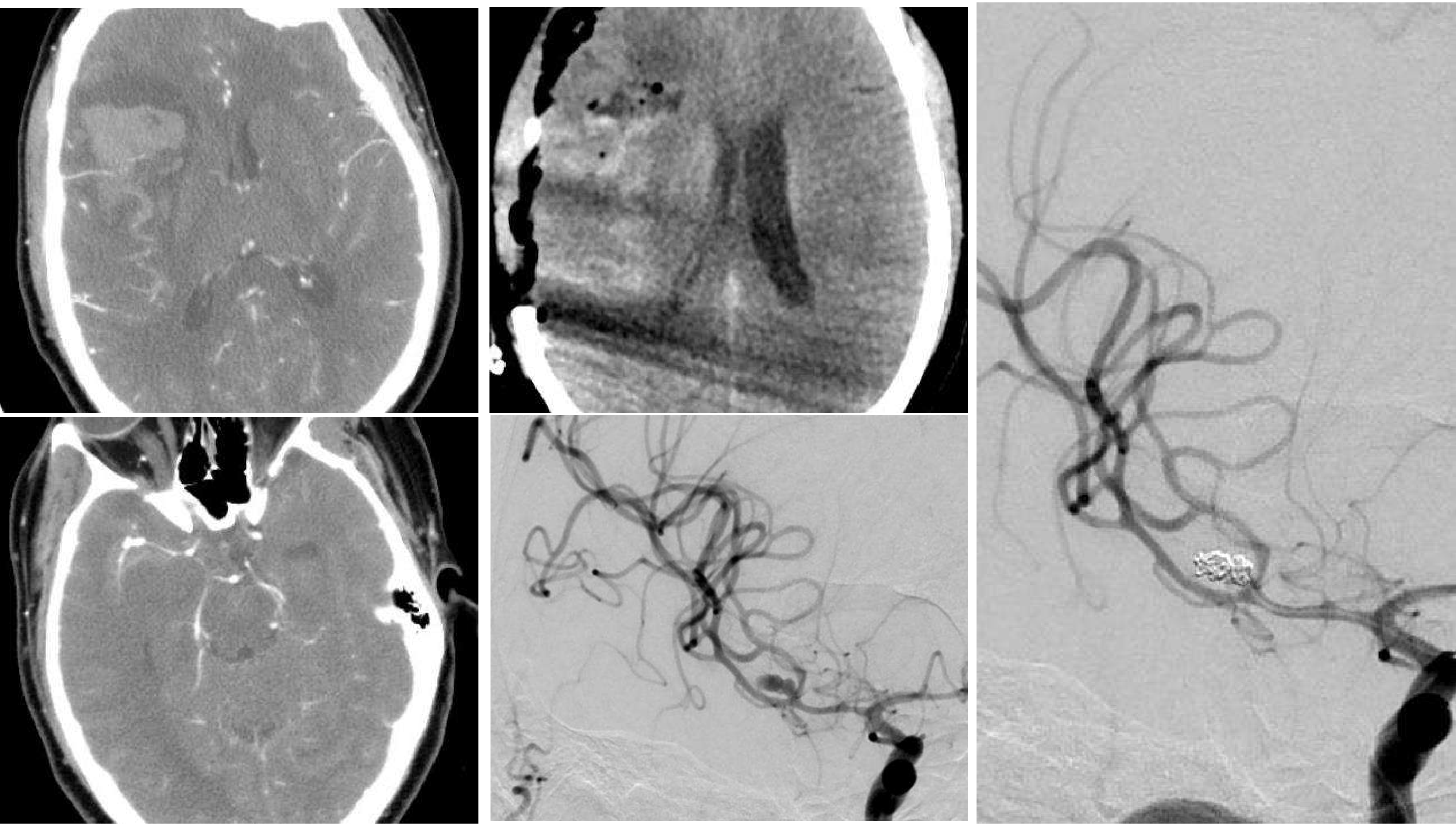
Secondary ICH: Etiology-Directed Surgery

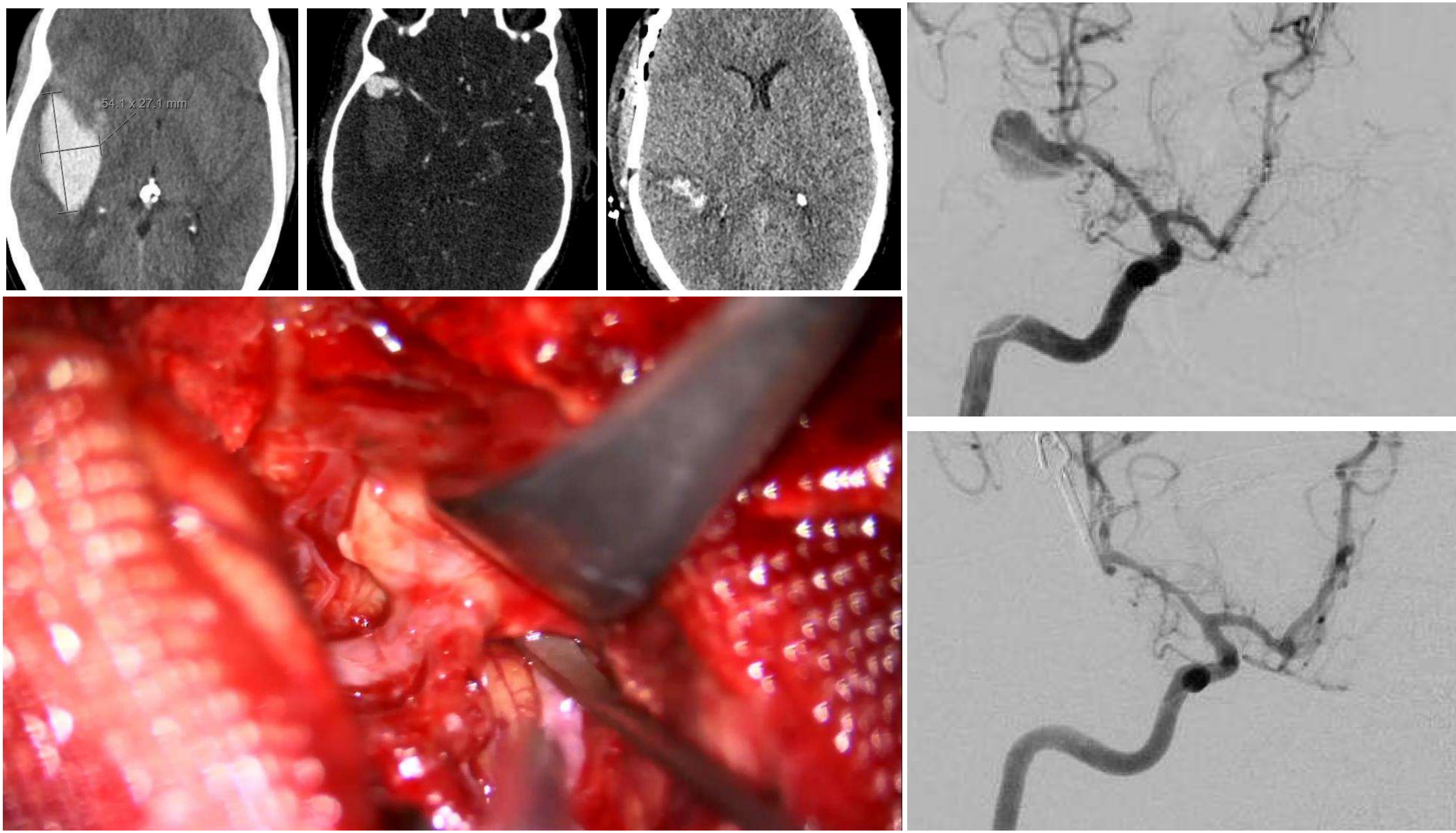
- Surgery/endovascular intervention targets the **underlying pathology**
- Hematoma evacuation is often **adjunctive**
- Excluded from primary ICH evacuation trials
- Fundamentally different from “primary ICH”

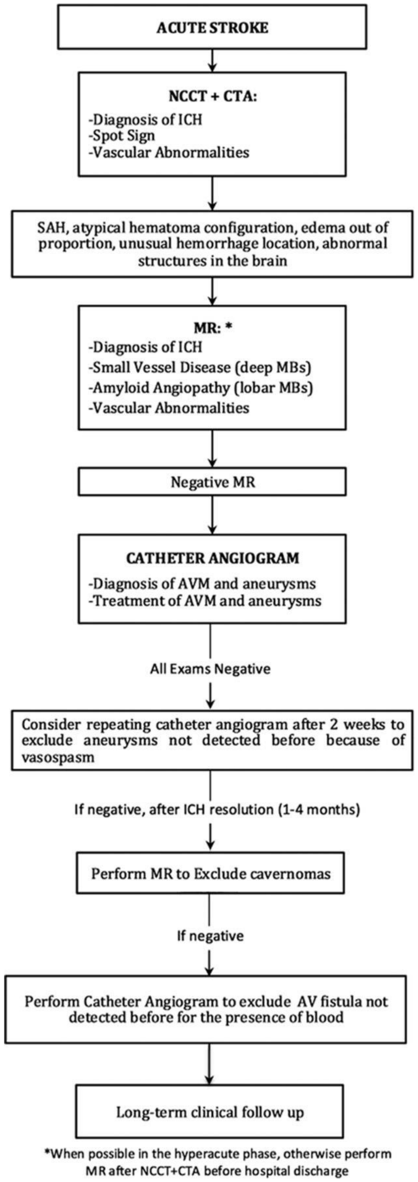


Aneurysm
Cavernoma
CAA
Ischemia
Trauma
Tumor
Vasculitis
AVM
DAVF
Hypertensive microangiopathy
Moya Moya
Mycotic aneurysm
Sinus thrombosis
Telangiectasia





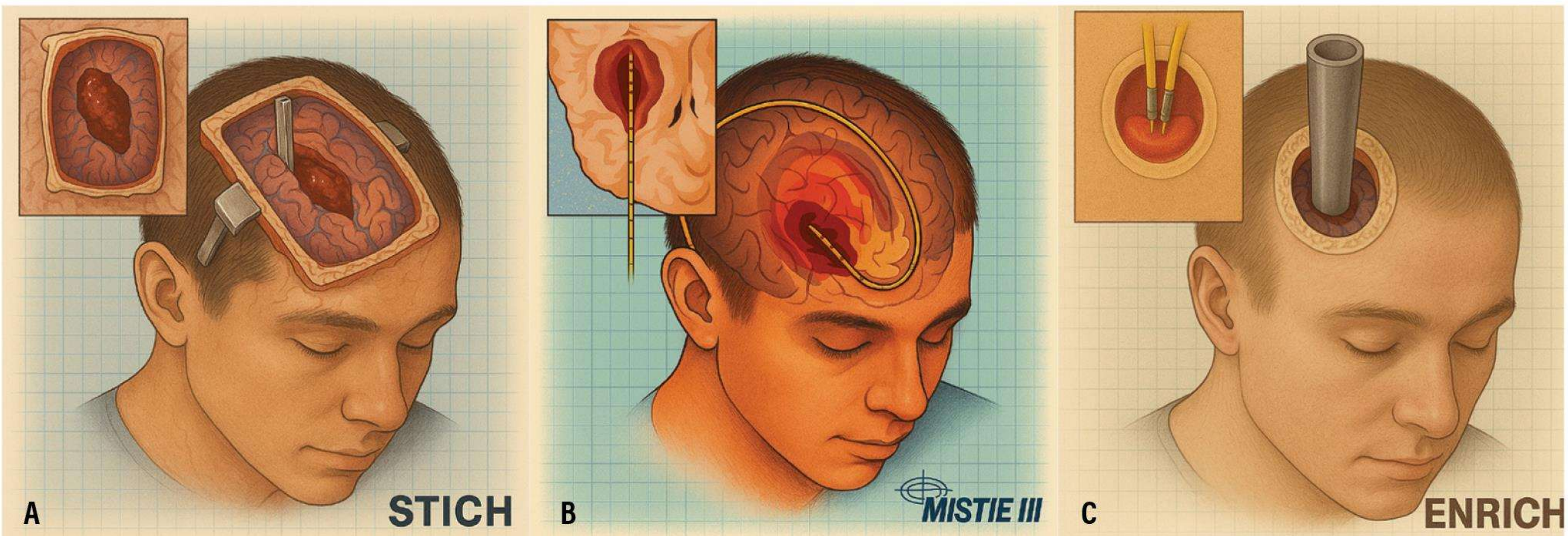

54.1 x 27.1 mm

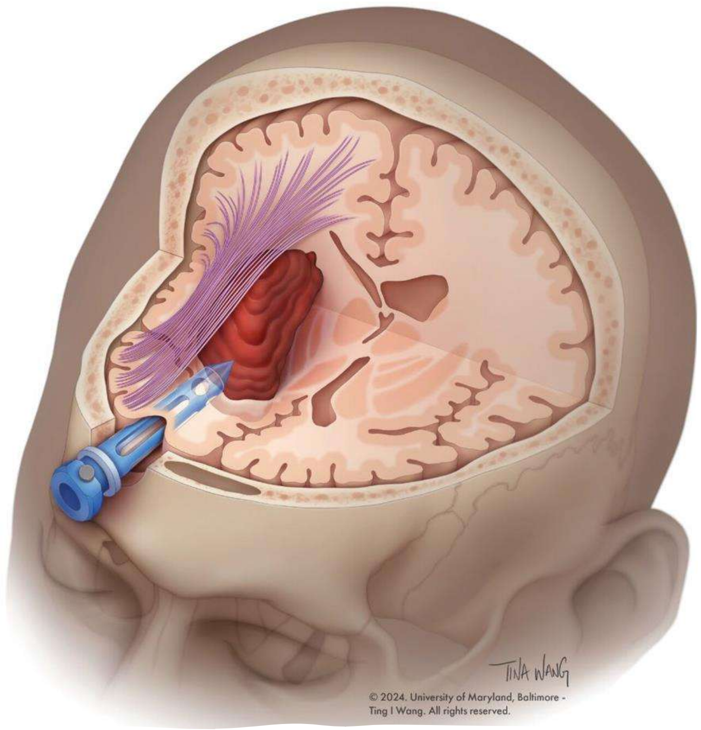


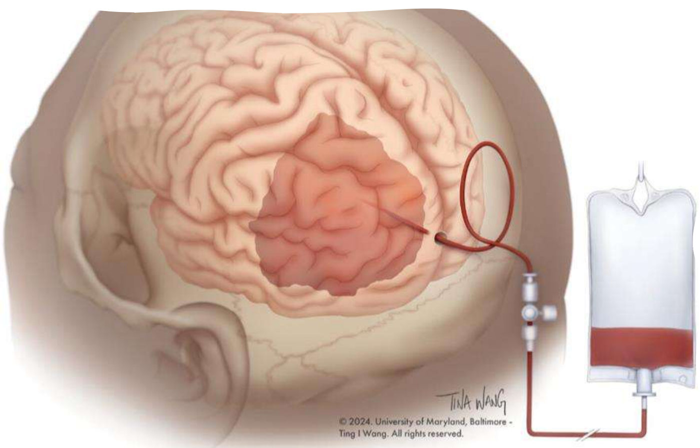
When Is DSA Warranted in Intracerebral Hemorrhage?

- **Positive or equivocal CTA**
- **CTA negative but high suspicion for secondary cause**
- Young patient
- Lobar or posterior fossa ICH
- No history of hypertension / no small-vessel disease on CT
- Primary IVH or atypical hemorrhage pattern
- **Spot sign?**
- **If CTA negative**
- Consider **MRI/MRA** or **delayed vascular imaging** once hematoma resolves

Evacuation for Selected Primary ICH







Why Minimally Invasive Surgery (MIS) for ICH?

Rationale

- Conventional craniotomy failed to improve functional outcomes
- Surgical corridor injury may negate clot removal benefit
- MIS aims to:
    - Reduce **mass effect**
    - Minimize **white-matter disruption**
    - Limit secondary injury from blood products

MISTIE III (2019): Catheter-Based Evacuation + Alteplase

Domain	Key Details
Population	ICH ≥30 mL Clot stability on repeat CT at 6 h 62% basal ganglia, 38% lobar Median volume 41.8 mL (IQR 30.8–54.5)
Intervention	Alteplase via stereotactic catheter (up to 9 doses, q8h) Target residual clot ≤15 mL
Comparator	Medical management
Primary Outcome	No difference in favorable outcome (dichotomized mRS at 12 mo) Absolute risk difference 4% (95% CI −4% to 12%), p = 0.33
Key Secondary Findings	↓ Mortality with surgery Adjusted HR 0.67 (95% CI 0.45–0.98), p = 0.037 **Evacuation target mattered:** 58% achieved residual clot ≤15 mL +10.5% absolute increase in favorable mRS vs medical therapy (95% CI 1.0–20.0), p = 0.03

Functional benefit was seen **only when effective clot reduction (≤15 mL residual) was achieved**, establishing a dose–response relationship.

ENRICH Trial (2023):
Early Minimally Invasive Parafascicular Surgery (MIPS)

Domain	Key Details
Population	ICH 30–80 mL (68% lobar, 32% anterior basal ganglia) GCS 5–14 Mean volume 50.5 mL (±14.6)
Intervention	MIPS (BrainPath) Median surgery time 16.6 ± 6.3 h Initiation ≤24 h (≤8 h preferred)
Comparator	Guideline-based medical management
Primary Outcome	Improved posterior distribution of treatment effect Mean utility-weighted mRS: • Overall: **0.913** • Lobar ICH: **0.9968** • Anterior basal ganglia ICH: **0.5301**
Key Secondary Findings	Mean end-of-treatment ICH volume 14.9 mL 72.7% achieved residual clot ≤15 mL Shorter ICU LOS (7.0 vs 9.6 d, p < 0.001) Shorter hospital LOS (14.7 vs 17.1 d, p = 0.021) Fewer decompressive craniectomies (3.3% vs 20%, p < 0.001)
Mortality	Lower 30-day mortality (9.3% vs 18.1%, p = 0.027) No difference in 180-day mortality HR 0.789 (95% CI 0.485–1.285), p = 0.341

MISTIE III

Technique: catheter-based aspiration + tPA

No primary functional outcome benefit

Strong volume–outcome relationship

<15 mL residual = better outcomes

It's not enough to operate, you have to **evacuate effectively**.

ENRICH Trial

Early, minimally invasive parafascicular surgery

Target: lobar ICH

Improved functional outcomes

Reinforces:

- Early intervention
- Anatomy-based approach

Supporting & Adjunctive Trials in ICH Surgery

Endoscopic & Device-Assisted Evacuation

- Multiple feasibility and safety studies of endoscopic hematoma evacuation
- Demonstrate effective clot removal with reduced surgical exposure
- Functional outcome benefit remains variable and technique-dependent *(e.g., MIND trial)*

Intraventricular Hemorrhage (IVH): Mechanistic Support

- **CLEAR III**: intraventricular thrombolysis did not improve functional outcome overall
- There's still utility in select cases

Practical Decision-Making

Who Should Be Considered for Surgery?

- Lobar ICH
- Moderate size (30–80 mL)
- Clinical deterioration or mass effect
- Younger patients / good baseline function

Who Should NOT

- Deep basal ganglia hemorrhage
- Extensive IVH without hydrocephalus
- Severe comorbidities
- Poor premorbid status

Timing Matters

- Earlier = better
- Before irreversible secondary injury
- Avoid ultra-delayed “salvage” surgery