



# Decompressive Craniectomy for Stroke

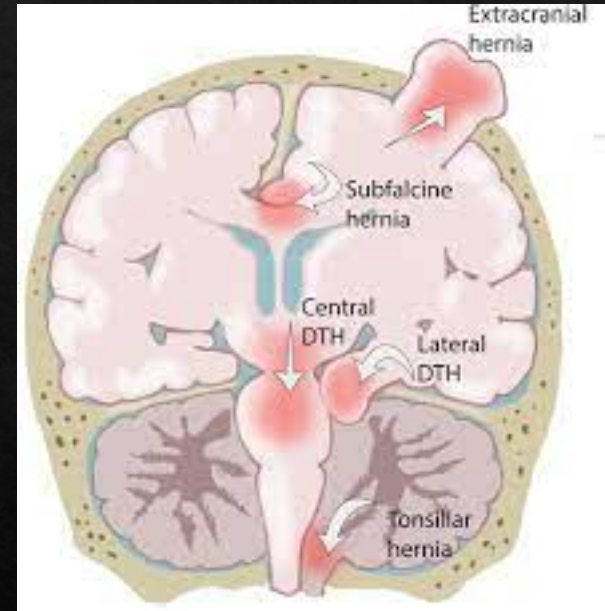
N. Stetson DO

# Objectives

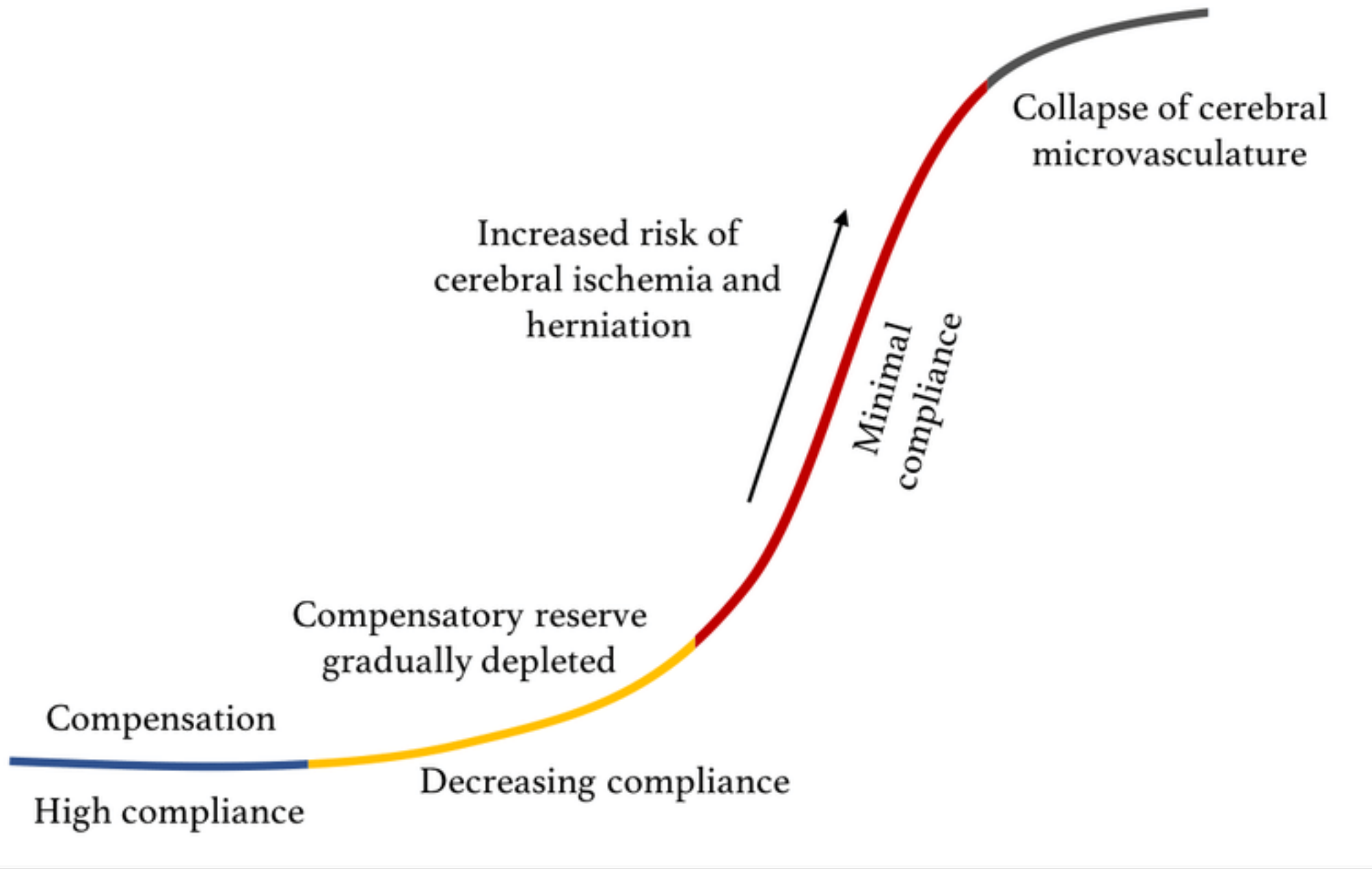
- ◇ Definitions
- ◇ Medical management of Malignant Cerebral Edema
- ◇ Rationale for DC
- ◇ Timing of DC
- ◇ Surgical technique
- ◇ Complications of DC

# Edema develops from ischemia

- ◆ Acute ischemic strokes can lead to significant cerebral edema
- ◆ Cytotoxic edema can occur within minutes to hours
- ◆ Vasogenic edema occurs within hours to days
- ◆ Pathophysiology is complex
- ◆ This edema, if not controlled medically, can lead to increased ICP and eventual herniation
  - ◆ Subfalcine herniation
  - ◆ Uncal herniation - compression of the brainstem
  - ◆ Central herniation - downward herniation across the tentorium involving descent of the diencephalon and midbrain through the foramen magnum

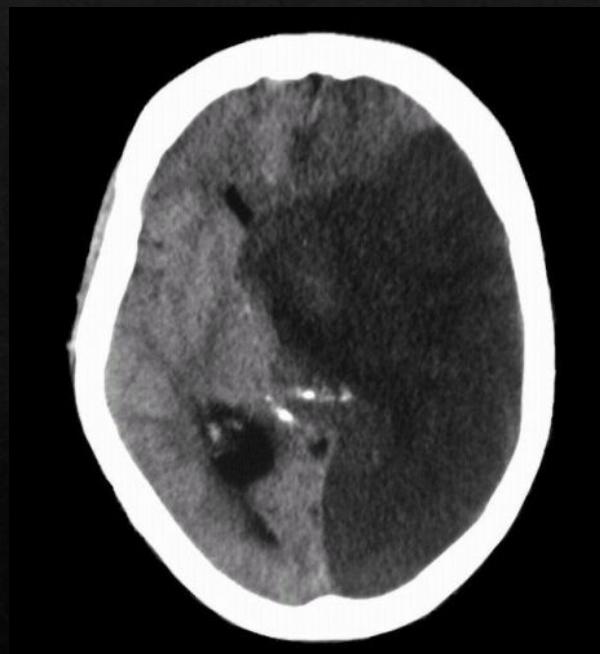


Intracranial Pressure



Intracranial Volume

# Large Ischemic Strokes



# Incidence

- ◆ Stroke is ranked as the second most common cause of death globally
- ◆ Stroke is the most common cause of acquired disability in adult patients
- ◆ Despite advancements in IV thrombolysis and endovascular thrombectomy, a high proportion of patients suffer ischemic brain damage
- ◆ In 1-10% of all patient with acute middle cerebral artery occlusion, the subsequent ischemic stroke can be classified as “malignant”, defined by ischemic brain tissue large enough to cause considerable increase in ICP and potential cerebral herniation

# Medical management – to protect the normal brain and ischemic penumbra

- ◇ ABCs
  - ◇ Airway support with ventilator for decreased levels of consciousness
  - ◇ Supplemental oxygen --> maintain oxygen > 94%
  - ◇ Hyperbaric oxygen not recommended
- ◇ Blood Pressure
  - ◇ Avoid hypotension, hypertension and hypovolemia
  - ◇ CPP > 60, MAP > 80
- ◇ Temperature
  - ◇ Avoid/treat hyperthermia
  - ◇ Induced hypothermia – questionable benefit, large phase III trial ongoing
- ◇ Blood glucose
  - ◇ Avoid/treat hypoglycemia and hyperglycemia
- ◇ Alteplase
  - ◇ Eligible patients benefit from this, but there are significant risks (bleeding, angioedema, etc)

# When medical management fails

- ◆ Decompressive craniectomy (DC) is used as a mode of surgical treatment to physically decompress the involved brain and reverse/treat malignant cerebral edema
  - ◆ Hemicraniectomy – supratentorial/hemispheric infarctions
  - ◆ Posterior Fossa Craniectomy – cerebellar infarctions/hemorrhage



# Rationale - RCTs

- ◇ **DECIMAL** (Decompressive craniectomy In MAlignant MCA Infarction) – French study
  - ◇ Age 18-55
  - ◇ Assigned to best medical care or DC with best medical care
  - ◇ MMCAI (malignant middle cerebral artery infarction) was defined by 1) NIHSS score > 15, 2) involvement of more than 50% of the MCA territory on CT and 3) Infarct volume > 145 cc
  - ◇ 38 total patients: 20 randomized to DC and 18 to medical group
  - ◇ Primary outcome measure: favorable functional outcome 6 months after event (MRS score 0-3)
  - ◇ Study was stopped due to significant difference in mortality → 25% of the DC had favorable functional outcome and 5.6% of the medical management had the same
  - ◇ After one year, these numbers increased to 50% vs 22.2%
  - ◇ DC led to 52% reduction in death, whereas 22% of the medical group survived

Modified Rankin Scale (MRS)
0 No symptoms
1 No significant disability, despite symptoms; able to perform all usual duties and activities
2 Slight disability; unable to perform all previous activities but able to look after own affairs without assistance
3 Moderate disability; requires some help, but able to walk without assistance
4 Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance
5 Severe disability; bedridden, incontinent, and requires constant nursing care and attention
6 Death

# Rationale - RCTs

- ◇ Decompressive Surgery for the Treatment of Malignant Infarction of the Middle Cerebral Artery (Destiny) – German trial
  - ◇ 18-60 years
  - ◇ First endpoint was mortality at 30 days.
  - ◇ After this endpoint reached, enrollment was interrupted and sample size was recalculated based on good functional outcome, defined by mRS score of 0-3 vs 4-6 at 6 months
  - ◇ Clinical inclusion:
    - ◇ 1) NIHSS score of > 18 (non dominant)/> 20 (dominant) affected
    - ◇ 2) decreased level of consciousness of > 1 on item 1a of NIHSS,
    - ◇ 3) >2/3 of the MCA territory involved
  - ◇ After 32 patients had been included, a significant reduction in mortality was evident with survival of 88% of DC group compared to 47% medical group
  - ◇ After 6 and 12 months, there was no significant difference in rate of favorable functional outcomes in both patient groups
  - ◇ Study terminated in favor of pooled analysis with other European studies

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# Rationale - RCTs

- ◆ **HAMLET: Dutch Hemispherectomy After Middle Cerebral Artery Infarction With Life-Threatening Edema Trial**
  - ◆ Pts 18-60
  - ◆ Patient randomized up to 96 hours from sx onset
  - ◆ Criteria:
    - ◆ 1) NIHSS score > 16 for right side and > 21 for left side
    - ◆ 2) > 2/3 MCA territory involved
    - ◆ 3) Decreased LOC (GCS < 13 for right side or an eye and motor score of < 9 for left side)
  - ◆ Primary endpoint was “good functional outcome” (mRS 0-3 vs 4-6)
  - ◆ Secondary outcome measures included mRS at 3 years
  - ◆ 64 patients total: 50% DC and 50% medical care
  - ◆ At one year, DC had no effect on good functional outcome, but significantly reduced case fatality (38%)
  - ◆ At 3 years, there was no difference in functional outcome
  - ◆ Study stopped prematurely for futility – highly unlikely that significant difference between the two groups would be detected

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# Rationale - RCTs

- ◆ HeADDFIRST: Hemicraniectomy and Durotomy Upon Deterioration From Infarction-Related Swelling Trial
  - ◆ Randomized pilot study to gain information for the design of a phase III trial
  - ◆ Two step approach for patient selection
    - ◆ Pts 18-75 with unilateral MCAI who were responsive to minor stimulation and had a NIHSS score > 18 points were screened.
    - ◆ If pts met image criteria (> 50% territory infarcted on CT done < 5 hours from sx onset or complete infarction on CT done < 48 hours from sx onset patient were eligible for enrollment
    - ◆ Patient randomized to DC or medical management only if:
      - ◆ Midline shift > 7.5 mm with unchanged or worsening status
      - ◆ Midline shift of the horizontal pineal > 4 mm with depression or arousability to level of effortful waking
    - ◆ 4909 pts screened. Only 26 pts randomized → 10 received best medical care and 14 received medical + DC
    - ◆ 40% of medical arm died versus 21% medical and DC group

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# Rationale - RCTs

- ◇ Pooled analysis from all of the European randomized controlled trials showed improved functional outcomes for patient <60 years of age
- ◇ After this, **Destiny II** trial sought to analyze the effect of DC in patients > 60 years old
  - ◇ Criteria: age > 60, NIHSS score of > 14 (or 19 if non dominant hemisphere involved), reduced consciousness and imaging of infarction in > 2/3 MCA territory
  - ◇ 13 German centers and total 112 patients enrolled
  - ◇ Study stopped at 6 months due to safety concerns: 41% of DC group versus 16% in medical group had mRS 0-4
  - ◇ Mortality was 41% for DC and 76 for medical group

# Rationale – Monocentric studies

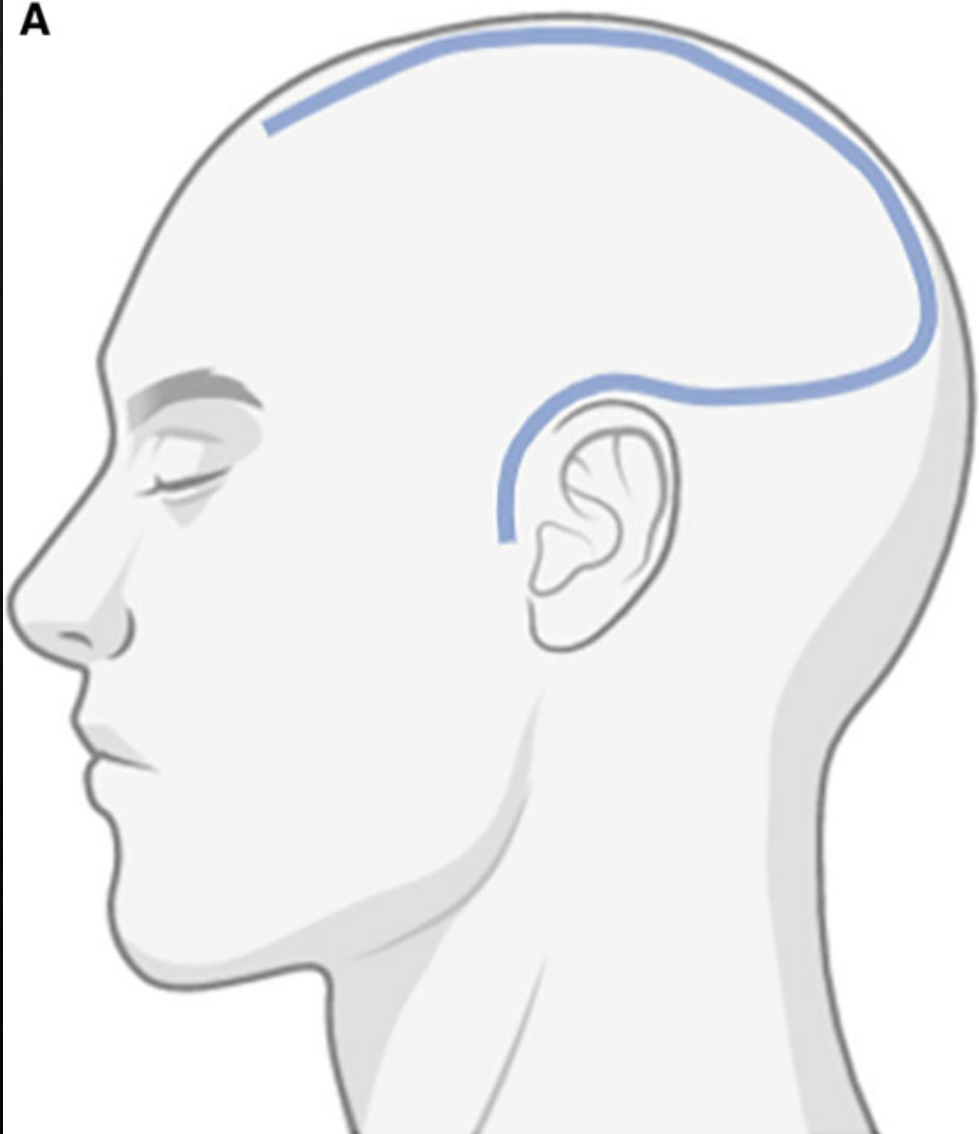
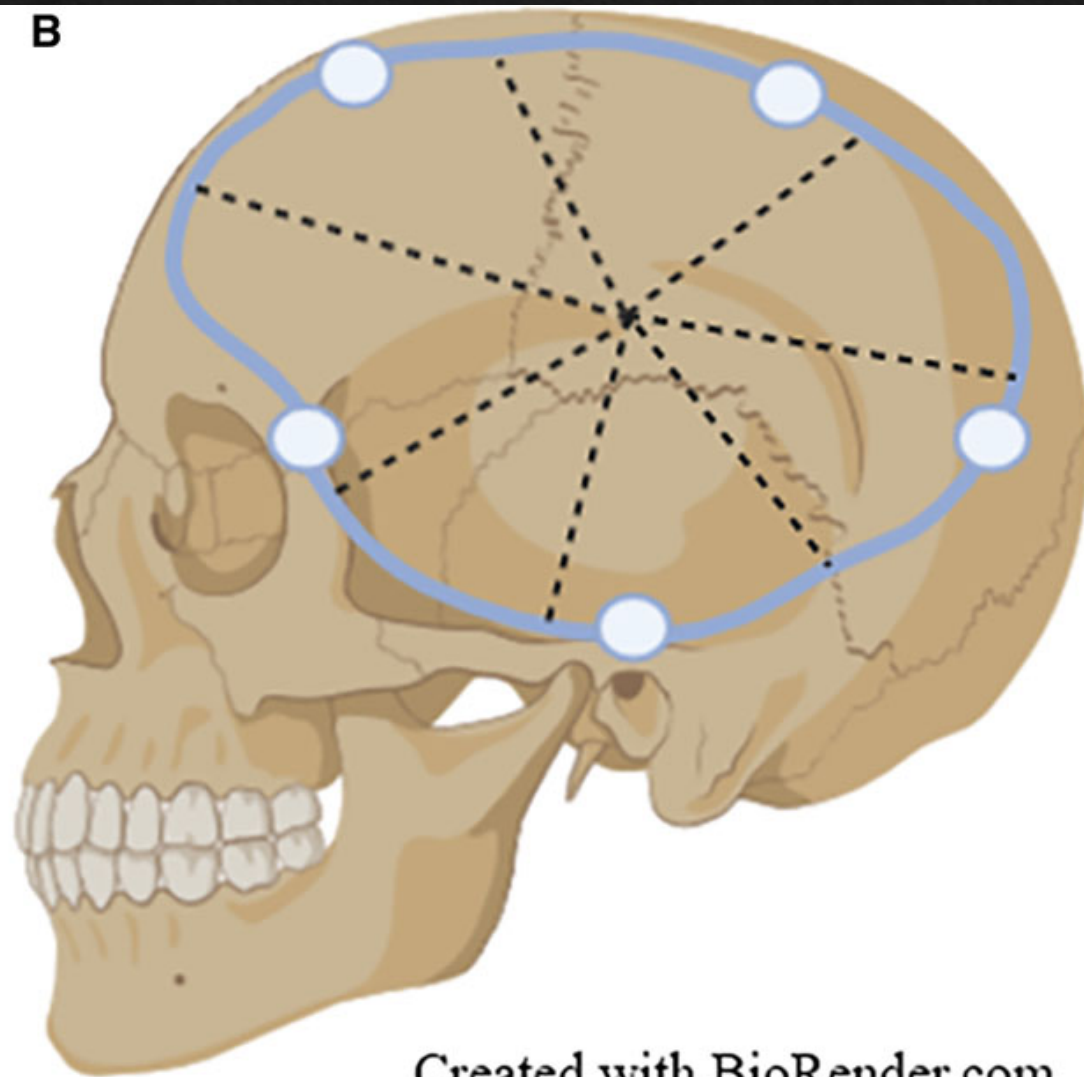
- ◇ Latvian study with 28 patients
  - ◇ 45% of DC vs 7.7% of medical management survived at one year
  - ◇ All DC pts has mRS 2-3 where medical management patients had mRS 4
- ◇ Phillipines study
  - ◇ 24 pts in DC arm and 11 in medical group were analyzed.
  - ◇ No difference in primary and secondary outcome measures (mRS and mortality)

# Bottom Line

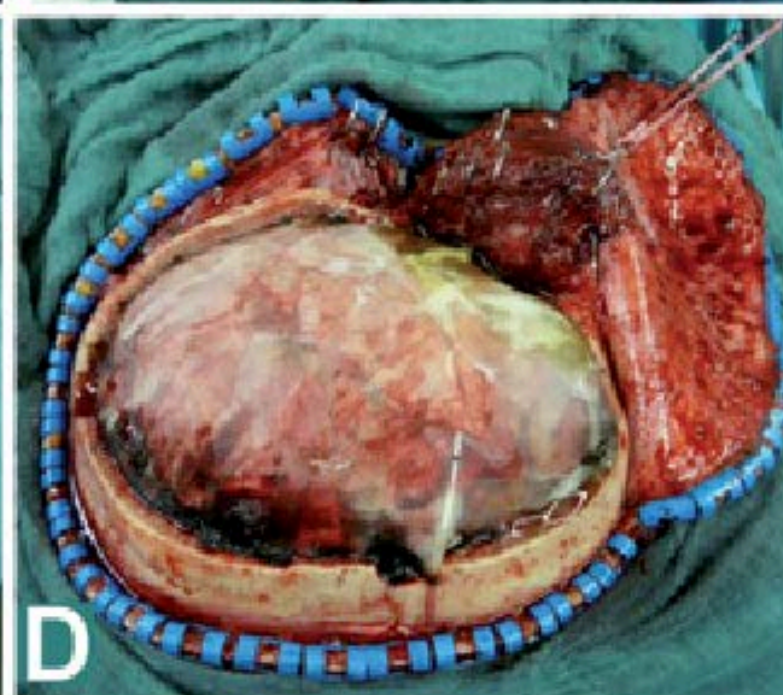
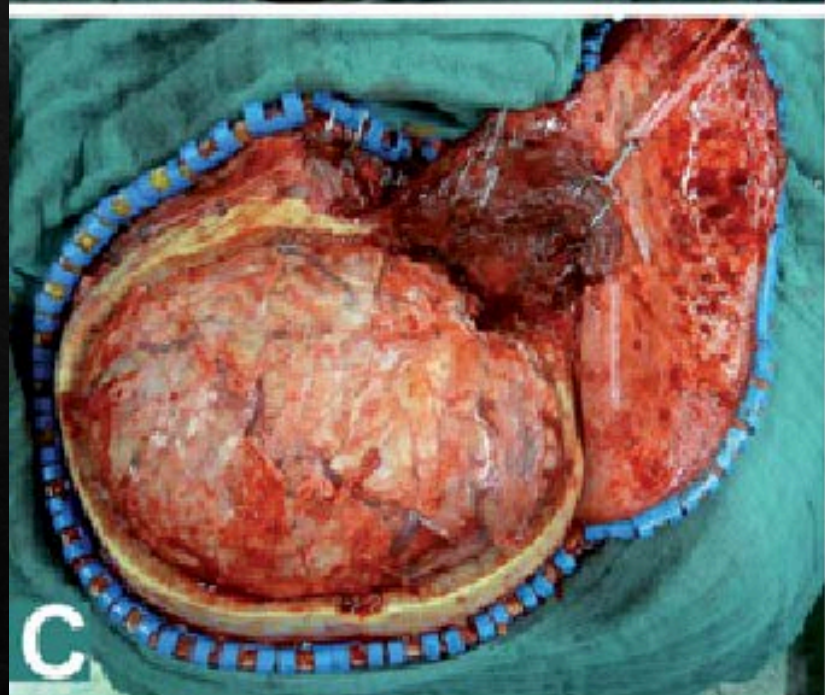
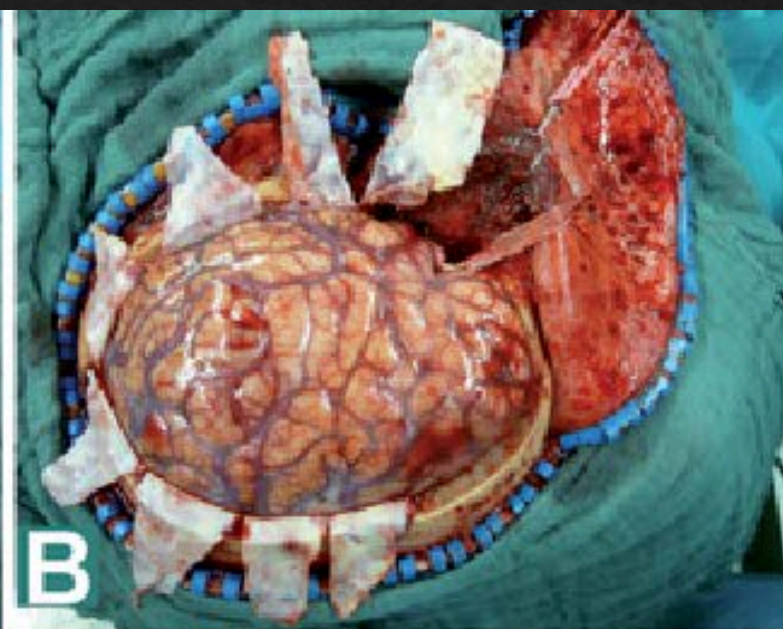
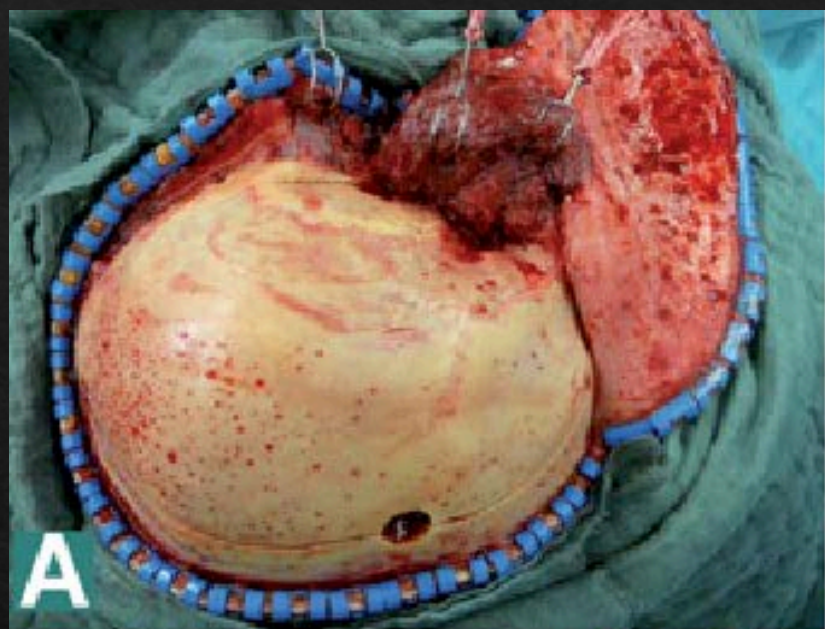
- ◆ Decompressive hemicraniectomy reduces mortality rates in patients with malignant cerebral artery infarction
- ◆ Most recent meta-analysis published in 2016 (included DECIMAL, HAMLET, DESTINY I, and monocentric study in Latvia) demonstrated a clear benefit to DC in terms of lowering mortality and increasing the likelihood of surviving with mRS 0-4
- ◆ Improved functional outcome for pts < 60
- ◆ Patient can be left with significant disability

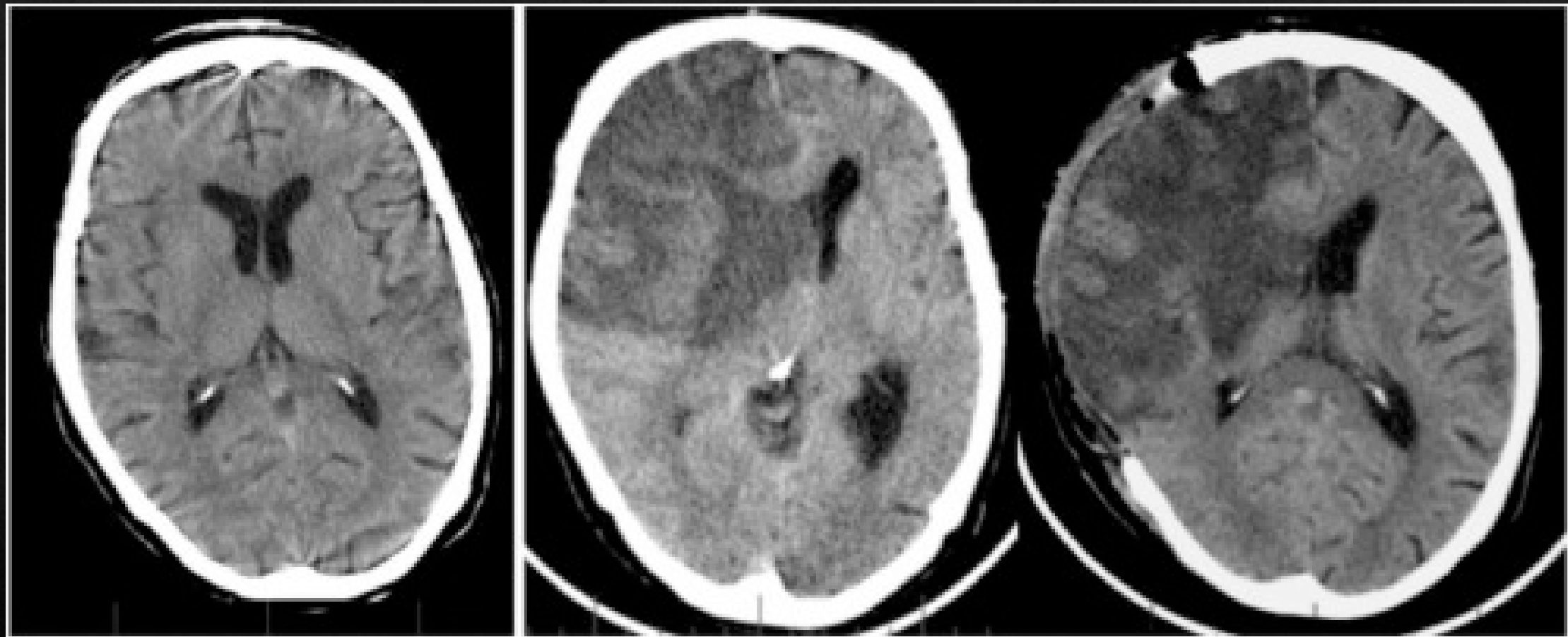
# Procedure



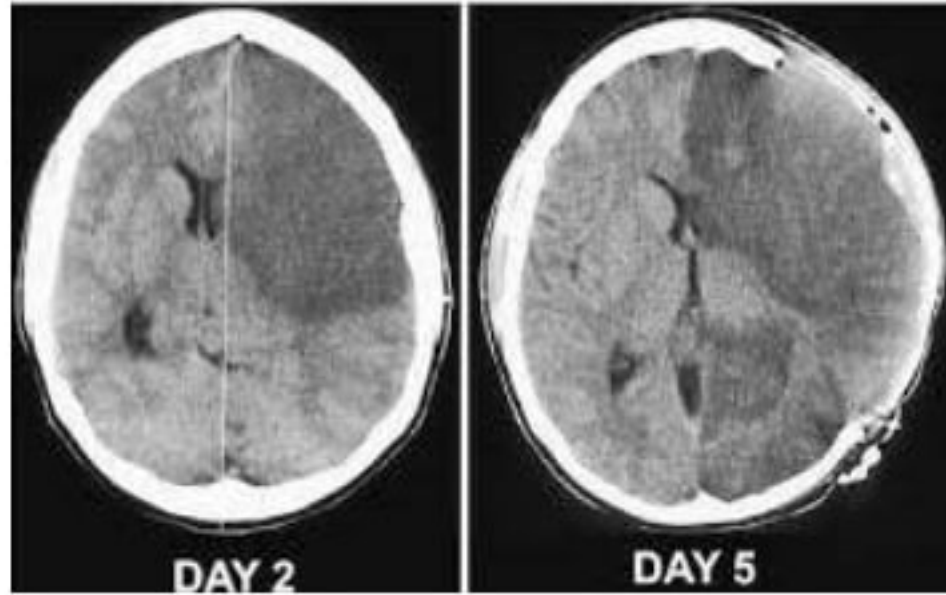
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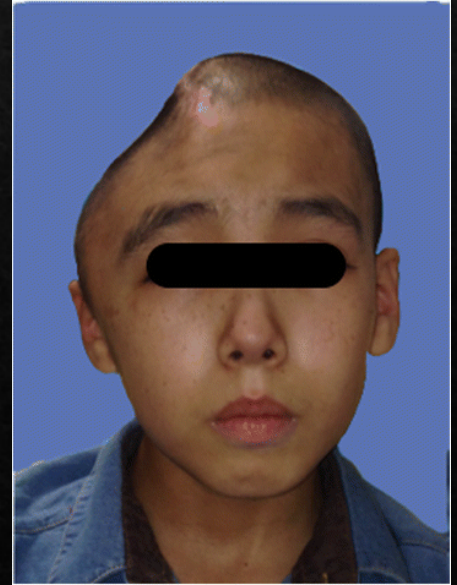
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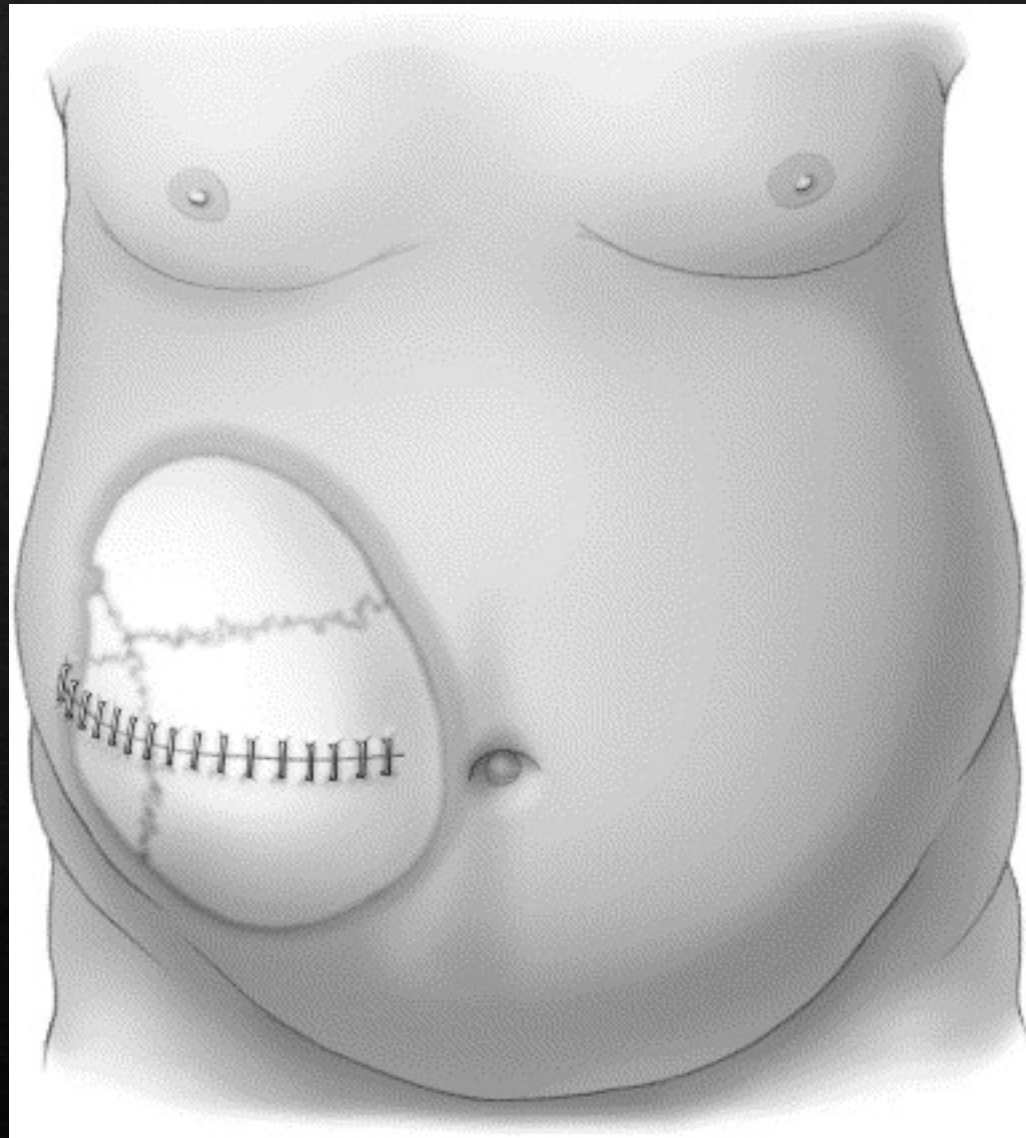




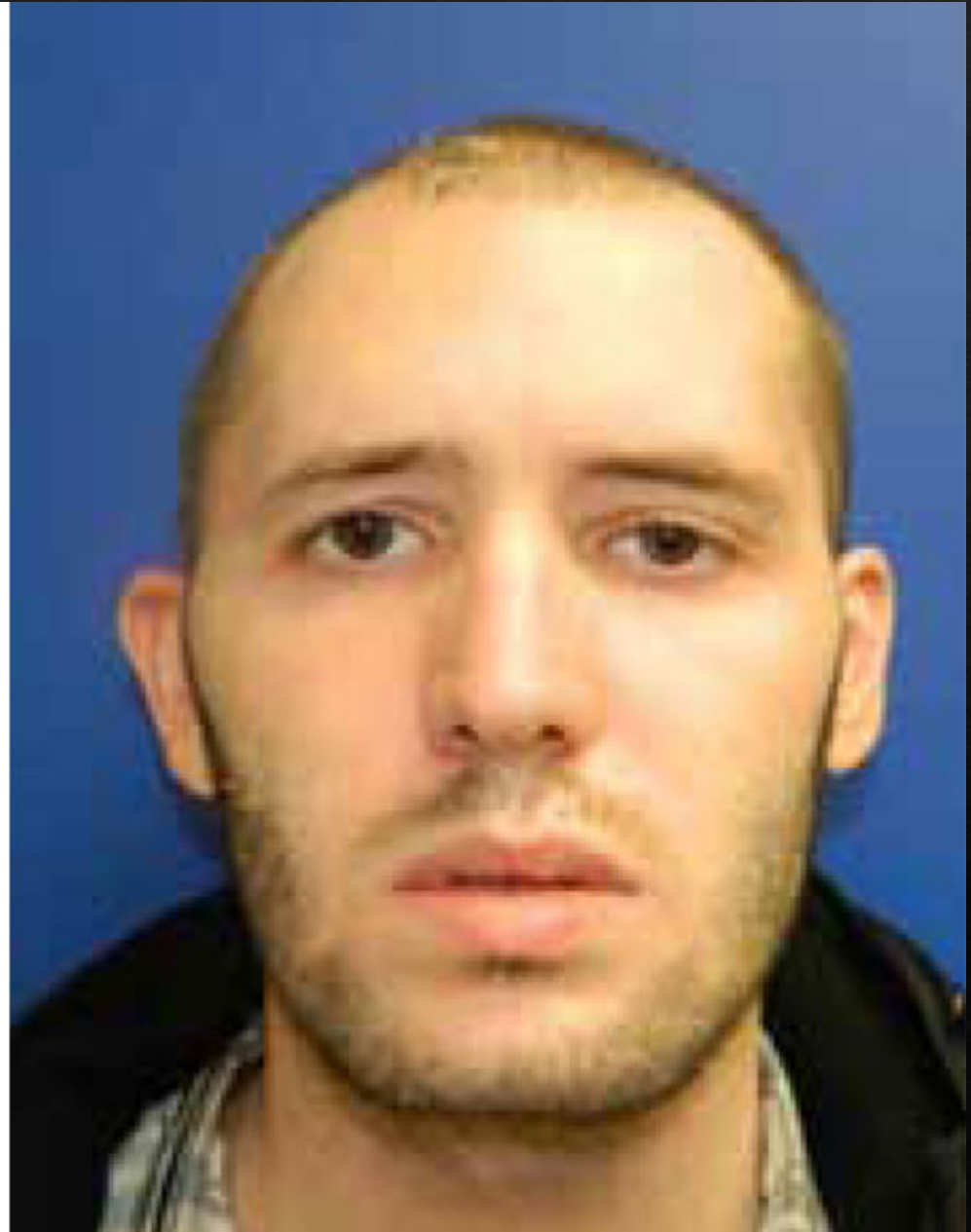
DHC  
resolving  
midline shift













# Timing

- ◆ None of the trials specifically addressed the issue of timing
- ◆ Decimol trial demanded randomization no later than 24 hours after sx onset with surgery no later than 6 hours after randomization
- ◆ Destiny I trial allowed surgery between 12-36 hours after sx onset, with sx done no longer than 6 hours after randomization
- ◆ Hamlet trial allowed randomization up to 96 hours after sx onset, with sx within 3 hours within randomization
- ◆ Hamlet did not show any improvement in functional outcome when delayed > 48 hours and up to 96 hours after stroke onset
- ◆ European meta analysis included only patients with surgery performed no later than 48 hours after sx onset and DESTINY II followed this same pattern
- ◆ Common dilemma: wait until patients deteriorate clinically and risk normal brain tissue OR do prophylactically and risk putting patients through surgery unnecessarily
- ◆ Cerebral edema culminates from 2-5 days. However, 70% of patients deteriorate within 48 hours of stroke
- ◆ In a national inpatient sample analysis in US (from total 1301 DC pts) 22% underwent surgery within 24 hours and 55% underwent within 48 hours and 76% within 72 hours → surgery within 24-48 hours showed no difference in outcomes, but within 72 hours showed more likelihood of discharge to institutional care with poor outcome
- ◆ There is currently no evidence that DC improves functional outcomes when it is delayed for > 48 hours and up to 96 hours
- ◆ Timing for DC in pts > 60 is uncertain
- ◆ In patients < 60 years that deteriorate neurologically within 48 hours despite medical tx, DC with dural expansion is effective. Effect of later SX unknown, but should be strongly considered
- ◆ Although optimal trigger is unknown, it is reasonable to use a decrease in the level of consciousness and its attribution to brain swelling as selection criteria

# Complications

Pneumocephalus

Mushrooming of brain

IPH/Subdural hematomas

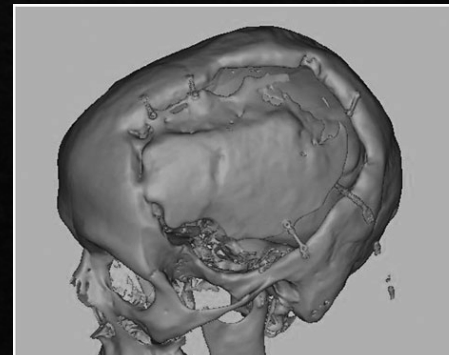
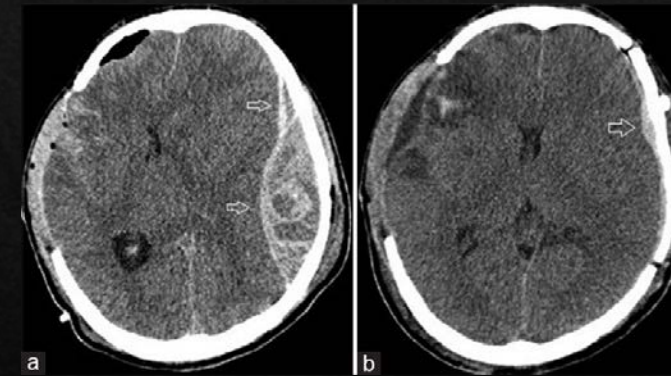
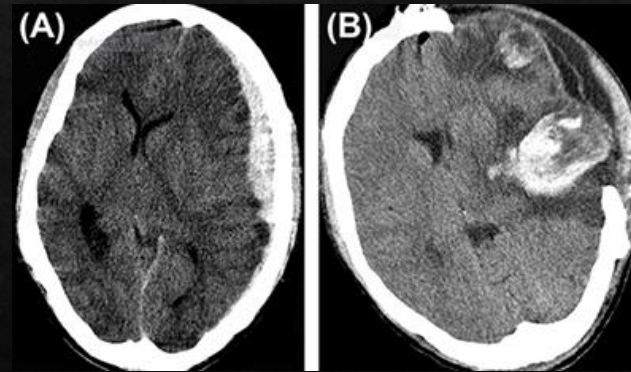
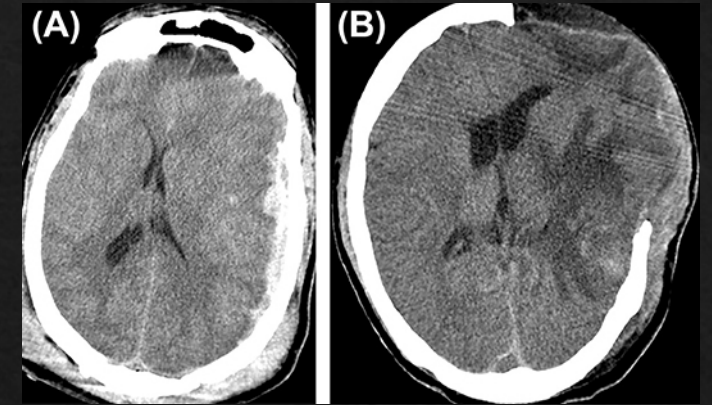
Syndrome of the trephined – atmospheric pressure and gravity overcomes ICP and you get paradoxical herniation

Bone resorption after re-implantation

Infections associated with craniectomy or bone flap implantation site in abdomen

Delayed Hydrocephalus requiring shunting

Seizures

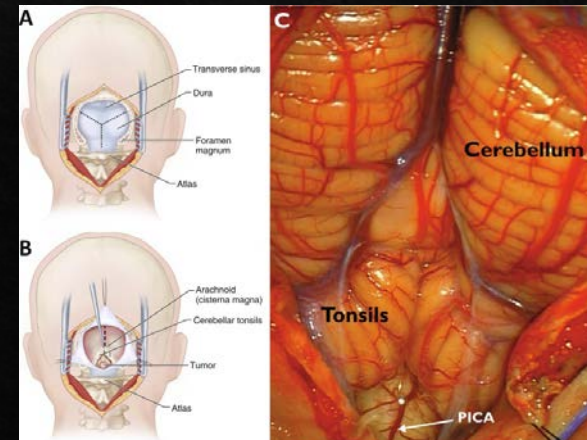
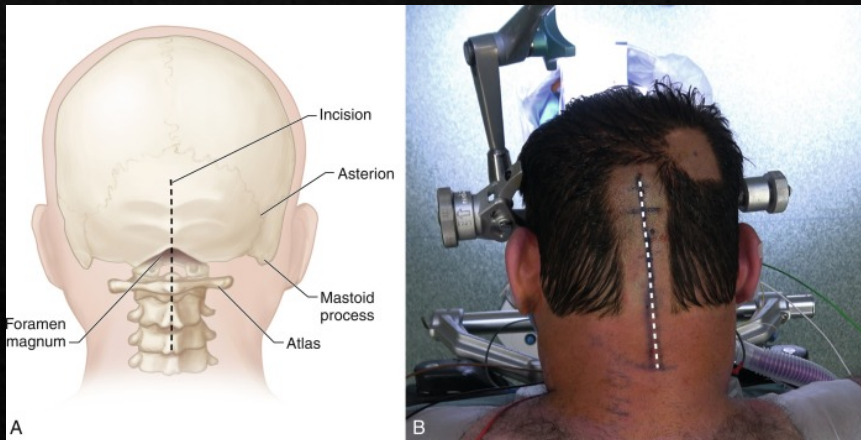


# Decision making

- ◆ What constitutes an acceptable outcome for these patients is controversial and expectations for post operative quality of life should be thoroughly communicated to the patient's family and caregivers before surgery
- ◆ Shared decision making with this information should occur when possible
- ◆ There is inherent complexity in balancing scientific evidence, clinical expertise and patient/family preference when considering this treatment
- ◆ There are ethical considerations when the patient wishes are unknown and family is uncertain about their wishes
- ◆ Communication is key

# Posterior Circulation Strokes

- ◆ 1/5<sup>th</sup> of all strokes in posterior circulation
- ◆ Cerebellar infarction with mass effect on 4<sup>th</sup> ventricle and brainstem compression is main target of SOC and EVD placement
- ◆ These patients tend to have more favorable outcome than other types of strokes
- ◆ Most surgeons decompress early
  - ◆ Some authors wait to do sx for significant decrease in level of consciousness, but some argue this can be too late (in terms of brainstem compression)
  - ◆ Efficacy of SOC in pts without comas is unproven
  - ◆ SOC with dural expansion should be done in pts who deteriorate neurologically, despite maximal medical therapy.



Thank you

◆ 405 410 9894