Traumatic brain injury: a neurosurgical perspective

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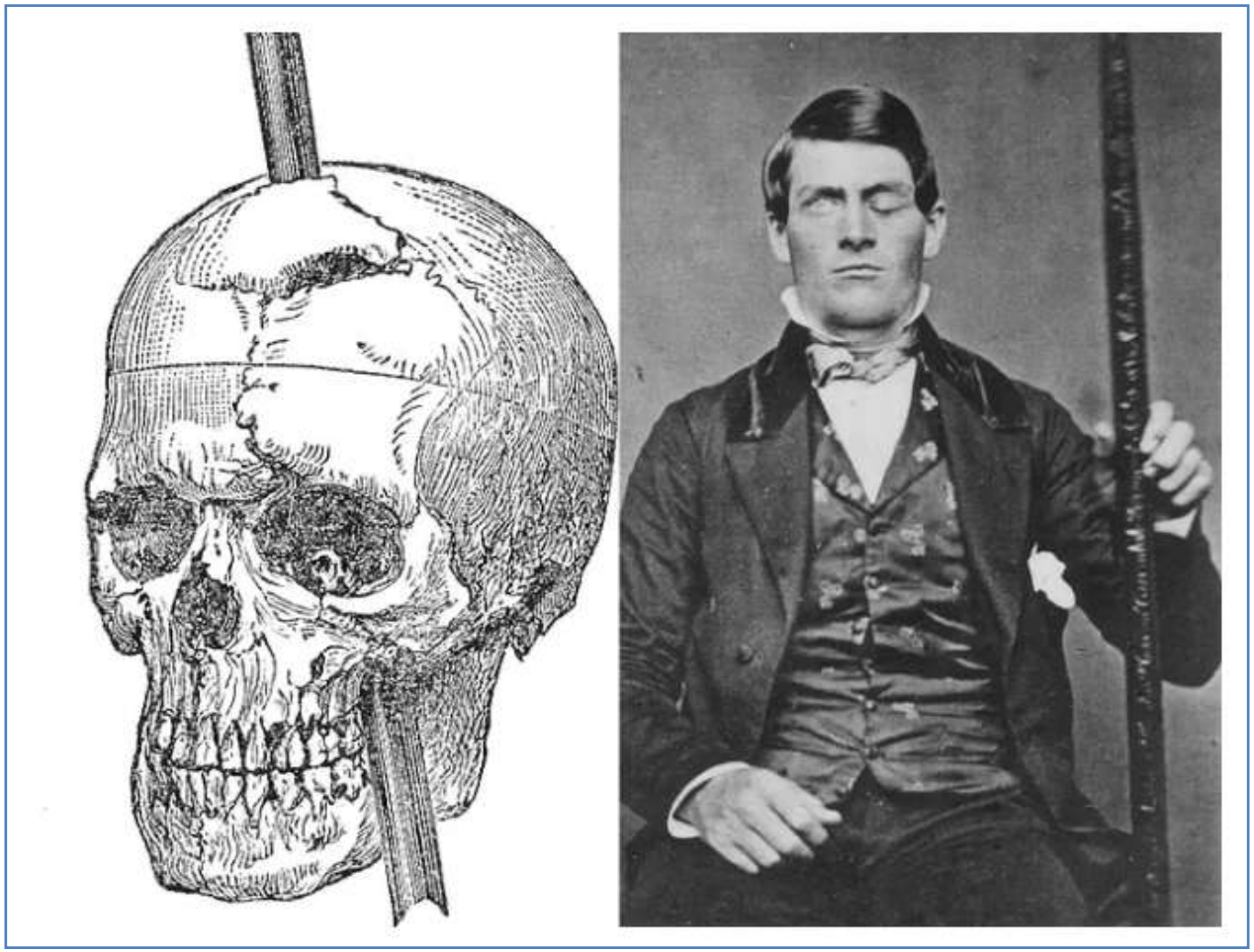
ROYAL COLLEGE OF PHYSICIANS AND SURGEONS OF GLASGOW

NHS Greater Glasgow and Clyde

Content

- History
- Facts and figures
- Coma and unconsciousness
- Skull fractures
- Primary and secondary brain injury
- Management of brain injury
- Surgical management of brain injury

Phineas Gage

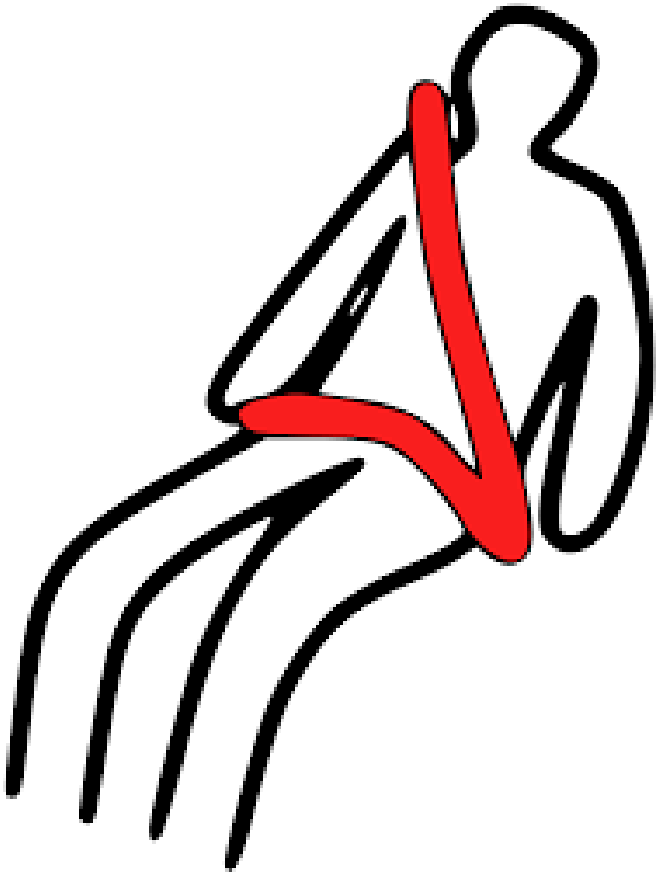


Trepanning

Head injury- the figures

- 1 million patients present to hospital
- 130,000 admitted (~300/100,000)
- Causes (age-dependent)
  - RTA ~50%
  - Falls
  - Assaults
  - Sports
  - (Alcohol)
- Consequences
  - Death ~ 5000 (9/100,000)
  - Disability

Biggest impact?

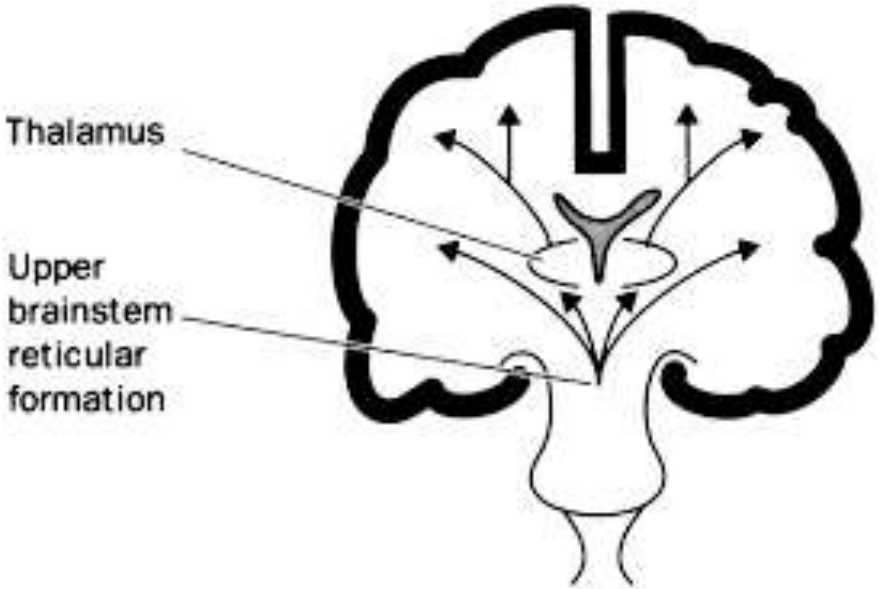


What is consciousness? (Mechanism)

- Interaction between grey matter of cerebral hemispheres and reticular activating system

- Wakefulness ↔ Content

- Decreased consciousness
  - Diffuse lesions of the cerebral hemispheres
  - Lesions of the R.A.S.



What is coma?

- *Koma* – deep sleep
- Impaired conscious level/Inability to be awakened
- Many differing descriptions
- No consistent, objective patient assessment method
- Need for objective scale for management and research purposes.

A practical problem…

Unrousable

Drowsy

Insensible

Obtunded

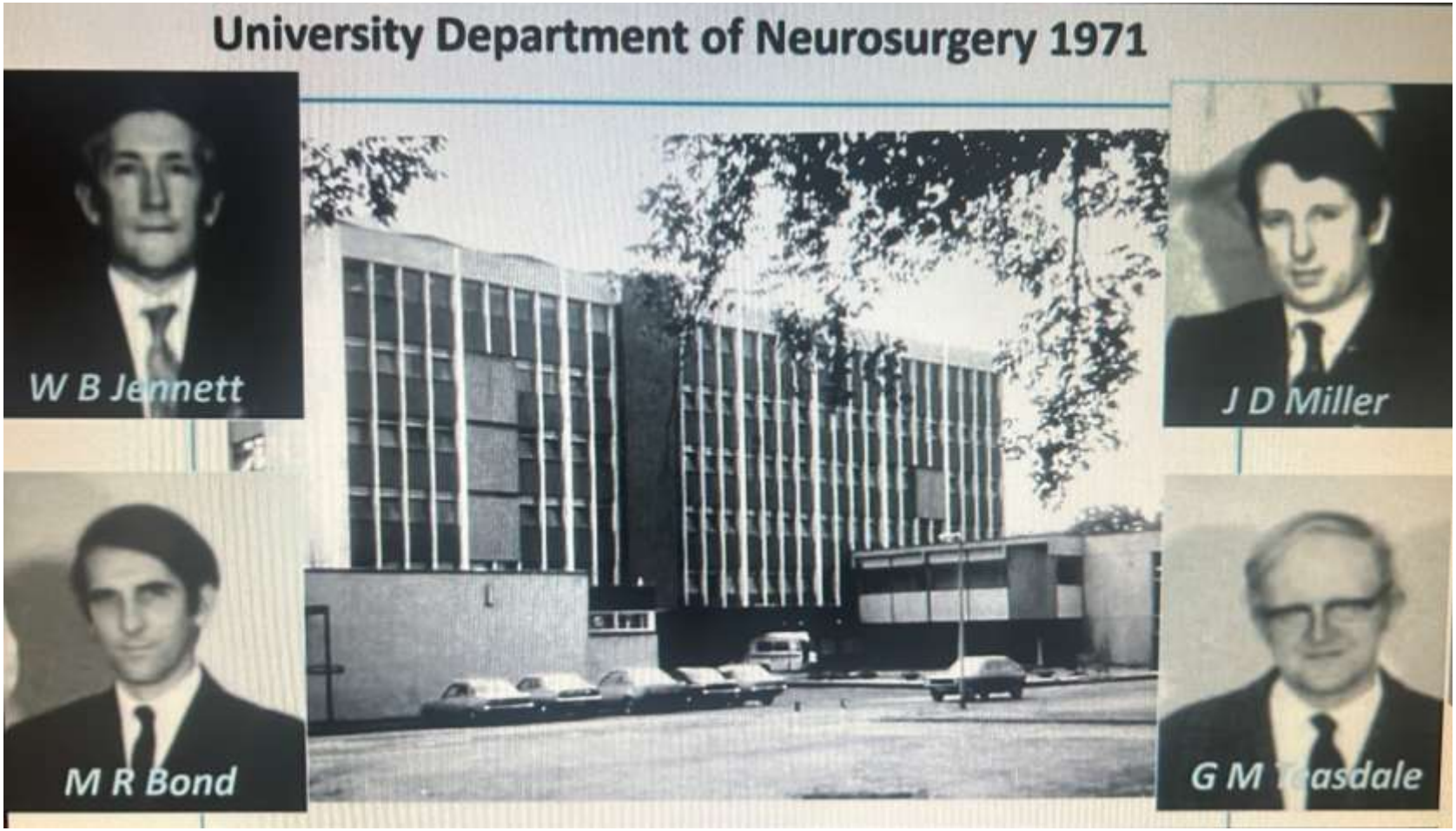
Comatose

Lifeless

Stuporose

Torpid

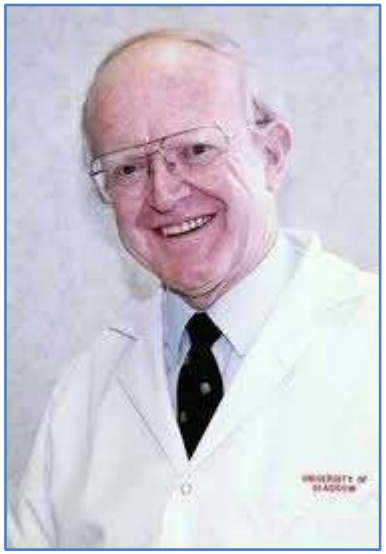
Institute of Neurological Sciences, Glasgow



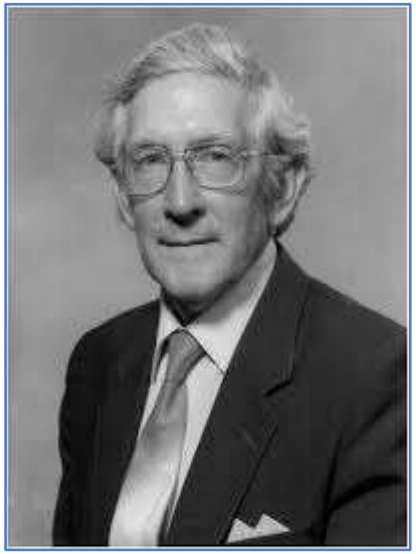
The aim of the GCS

'*A wide range of conditions may be associated with coma or impaired consciousness. Apart from acute brain damage due to traumatic, vascular, or infective lesions, there are metabolic disorders such as hepatic or renal failure, hypoglycaemia or diabetic ketosis, and also drug overdose. In gauging deterioration or improvement in the acute stage of such conditions, as well as in predicting the ultimate outcome,* ***the degree and duration of altered consciousness usually overshadow all other clinical features in importance. It is therefore vital to be able to assess and to record changing states of altered consciousness reliably.***'

Teasdale & Jennett, 1974



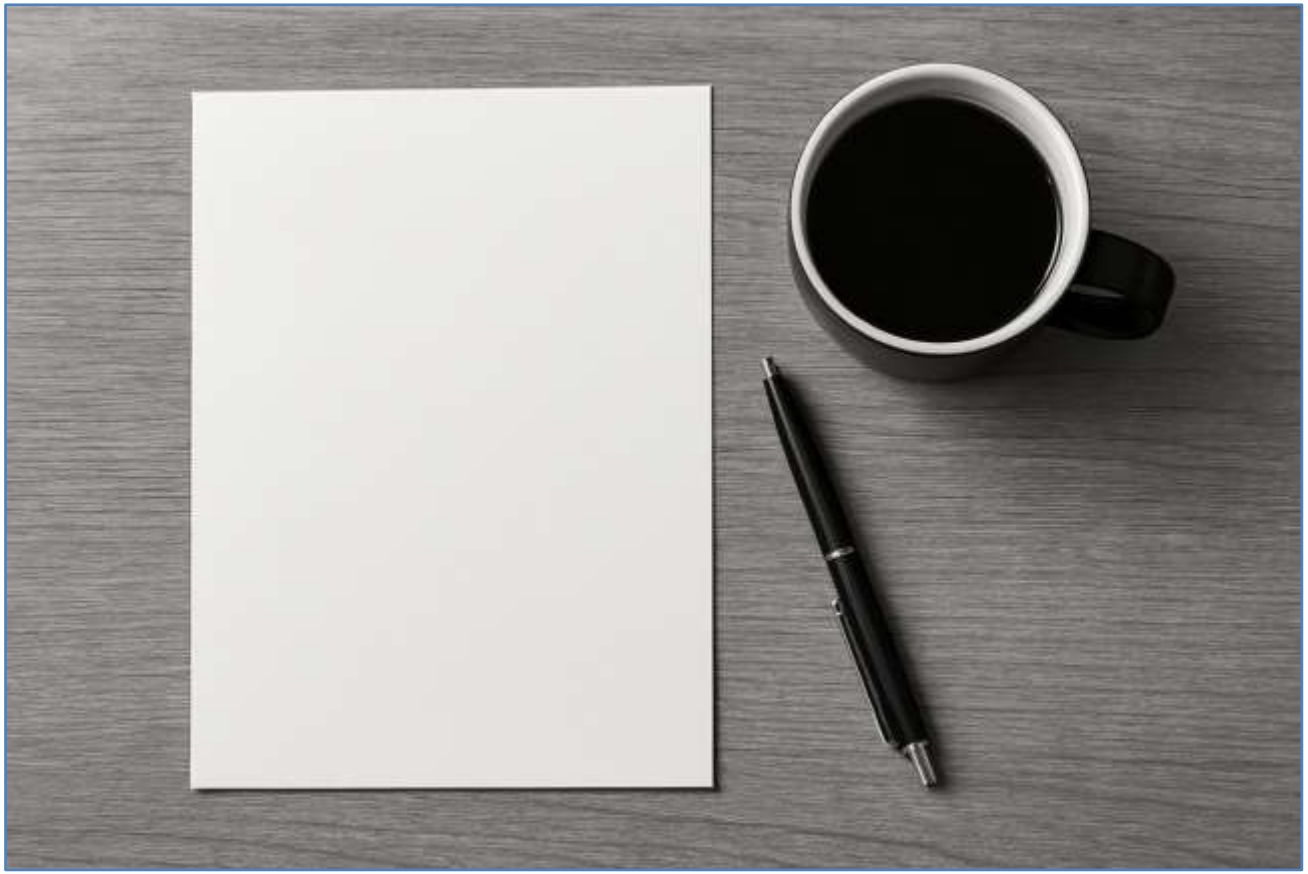
Graham Teasdale



Bryan Jennett

University of Glasgow

Equipment required



Glasgow Coma Scale

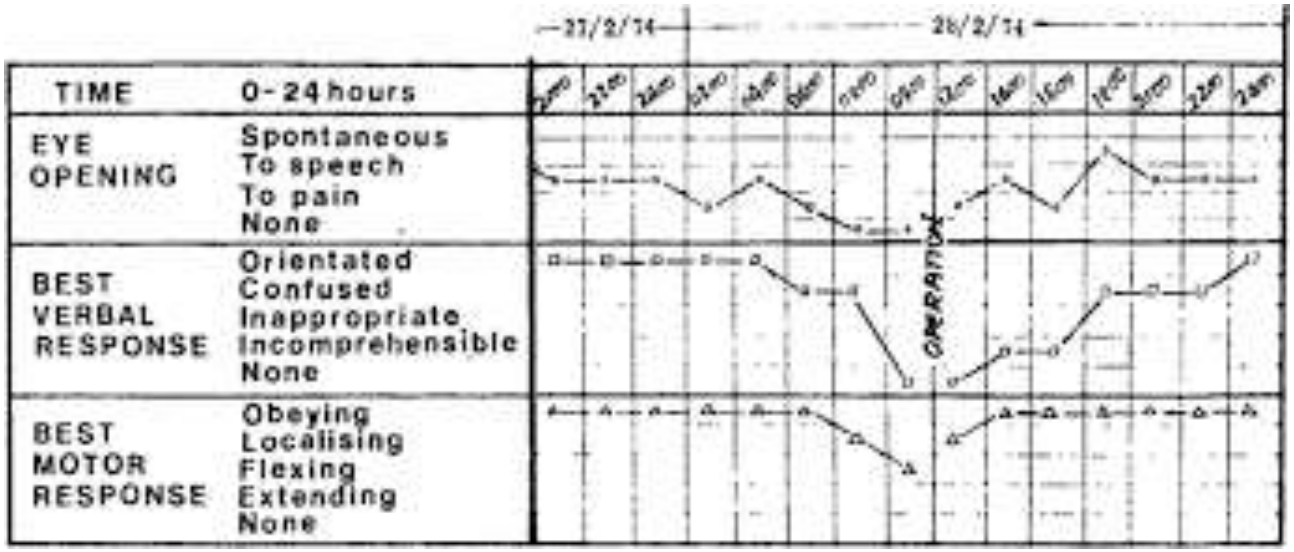
The Lancet, 1974

ASSESSMENT OF COMA AND IMPAIRED CONSCIOUSNESS

A Practical Scale

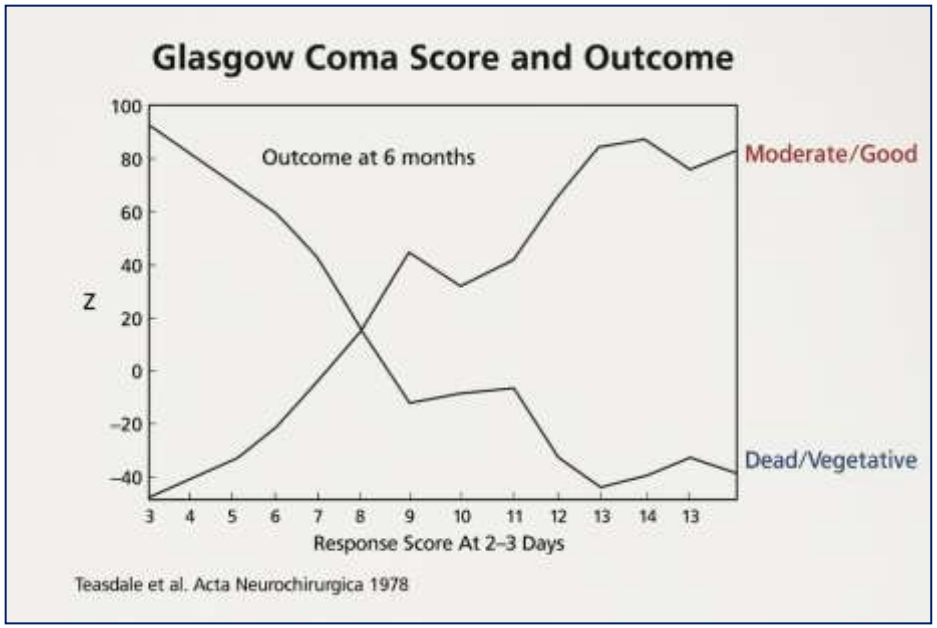
GRAHAM TEASDALE BRYAN JENNETT

University Department of Neurosurgery, Institute of Neurological Sciences, Glasgow G51 4TF



From scale to score

- Why 3 to 15?
  - Quantitative data required
  - No option to input ‘0’
  - Utility of a summed score
- Assesses initial severity
- Accurately predicts outcome
- Champions
  - Langfitt
  - ATLS
  - NTCD



‘*Measuring the outcome from head injuries*’
Journal of Neurosurgery,
Editorial, 1978, **May;48(5):673-8**

Thomas Langfitt

Brain injury severity

Severity of TBI	GCS
Mild	13 - 15
Moderate	9 -12
Severe	3 - 8

Mayo classification

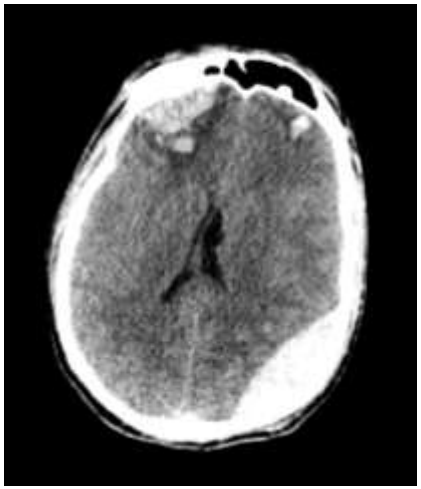
Table 1. Mayo TBI Severity Classification System

A. Classify as Moderate-Severe (Definite) TBI if one or more of the following criteria apply:
1. Death due to this TBI
2. Loss of consciousness of 30 minutes or more
3. Post-traumatic anterograde amnesia of 24 hours or more
4. Worst Glasgow Coma Scale full score in first 24 hours <13 (unless invalidataed upon review, e.g., attributable to intoxication, sedation, systemic shock)
5. One or more of the following present:
   - Intracerebral hematoma
   - Subdural hematoma
   - Epidural hematoma
   - Cerebral contusion
   - Hemorrhagic contusion
   - Penetrating TBI (dura penetrated)
   - Subarachnoid hemorrhage
   - Brain Stem Injury

B. If none of Criteria A apply, classify as Mild (Probable) TBI if one or more of the following criteria apply:
1. Loss of consciousness of momentary to less than 30 minutes
2. Post-traumatic anterograde amnesia of momentary to less than 24 hours
3. Depressed, basilar or linear skull fracture (dura intact)

C. If none of Criteria A or B apply, classify as Symptomatic (Possible) TBI if one or more of the following symptoms are present:
- Blurred vision
- Confusion (mental state changes)
- Dazed
- Dizziness
- Focal neurologic symptoms
- Headache
- Nausea

TBI, traumatic brain injury.



Skull fractures

Skull fractures

Brain injury

- Primary
  - Contusions
    - Frontal & temporal
    - *Coup*
    - *Contre-coup*
    - Possible SOL
  - Diffuse axonal injury
    - Mechanical shearing
    - CT scan often ‘normal’
    - Coma, death
    - Often non-surgical
- Secondary
  - Haematoma
    - Extradural
    - Intradural
    - Parenchymal
  - Cerebral swelling
  - Cerebral ischaemia
  - Infection
  - Seizure
  - ‘Brain shifts’

Management of *secondary* brain injury

- Primary brain injury not treatable

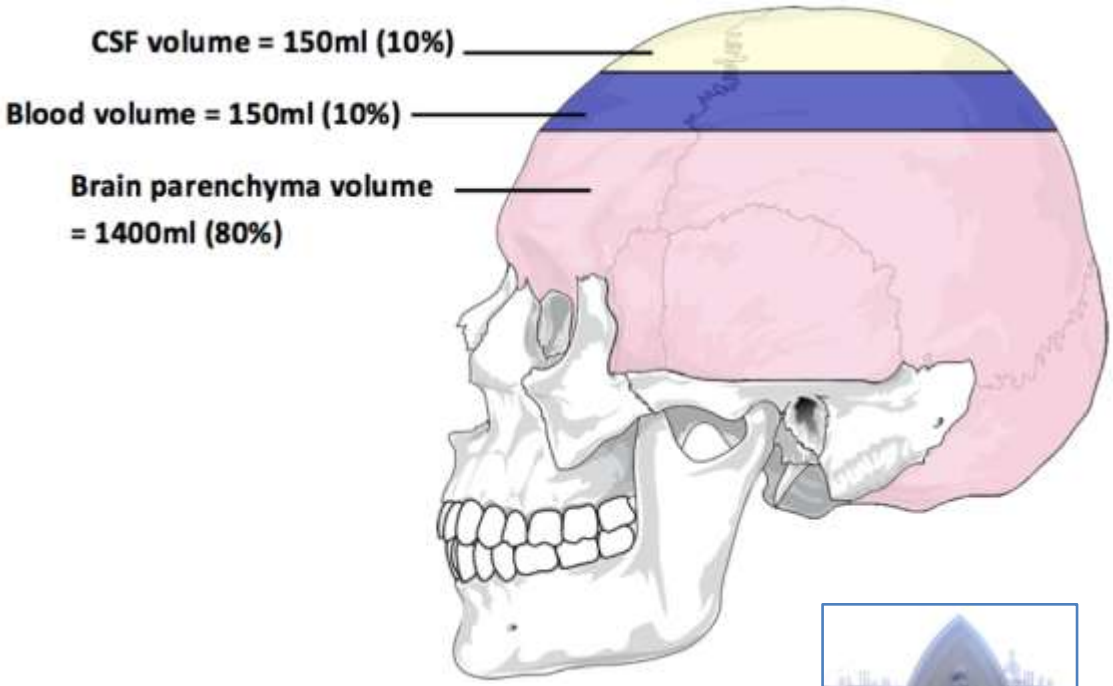
- Medical and surgical management aimed at preventing secondary brain injury

Management of secondary brain injury

- ABC
- Anticonvulsants (if seizures)
- ICP monitoring
- Brain protective agents
- Surgery

Monro-Kellie doctrine

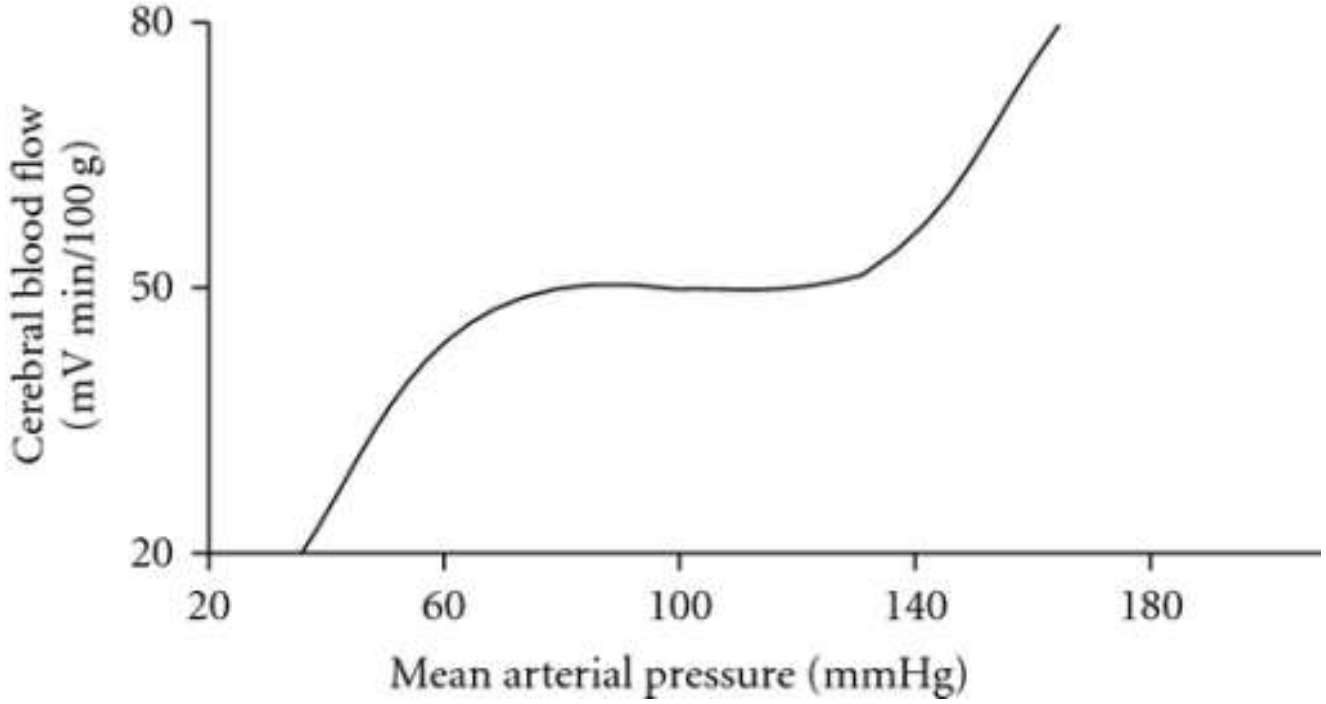
- The skull is a 'closed box' (in the adult)
- The contents of the skull are:
  - Blood
  - Brain
  - CSF
- If the volume of one increases, another must decrease by the same volume, or ICP will rise



Alexander Monro

George Kellie

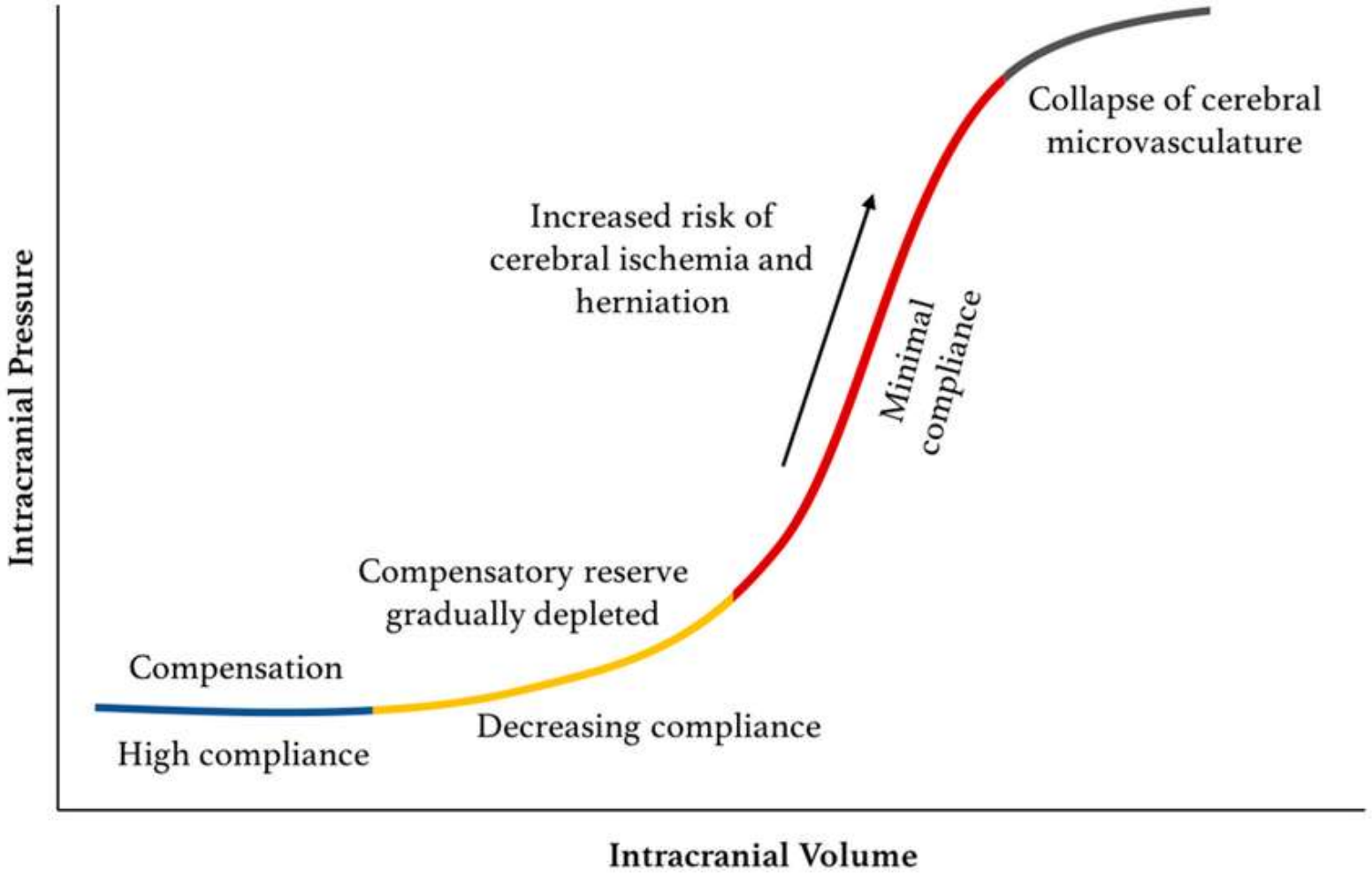
Cerebral autoregulation



CPP = MABP – ICP

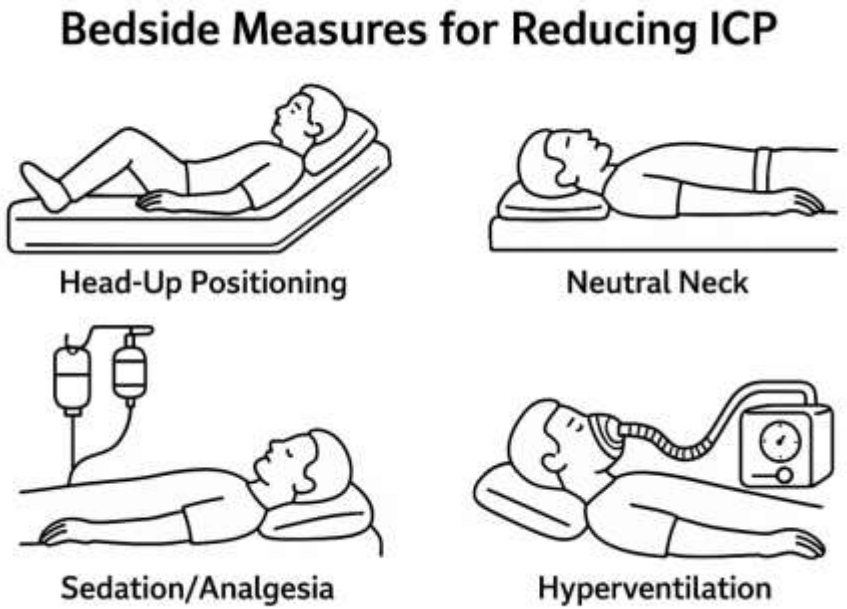
CPP or ICP?

Intracranial pressure

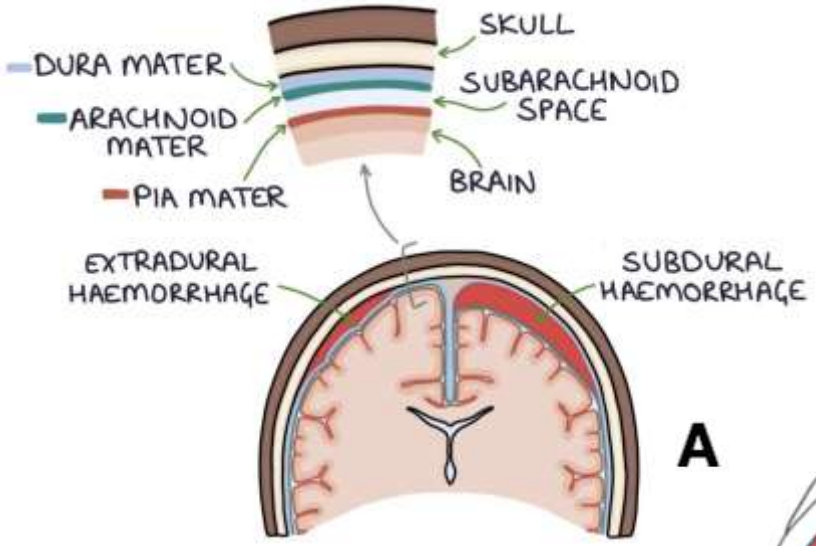


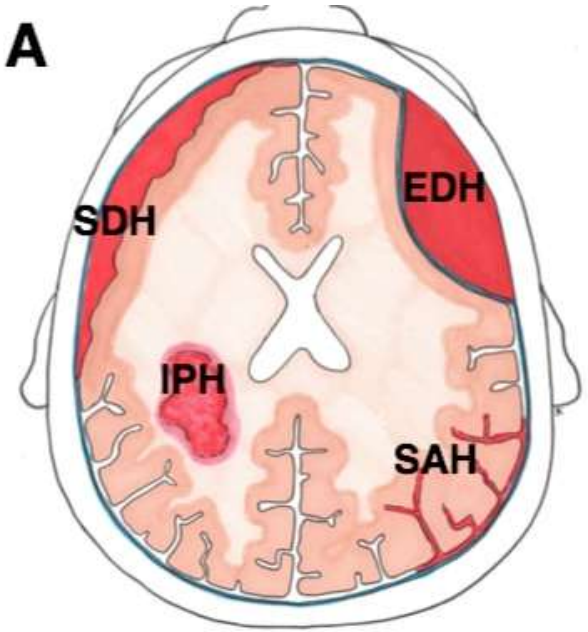
Management of high ICP

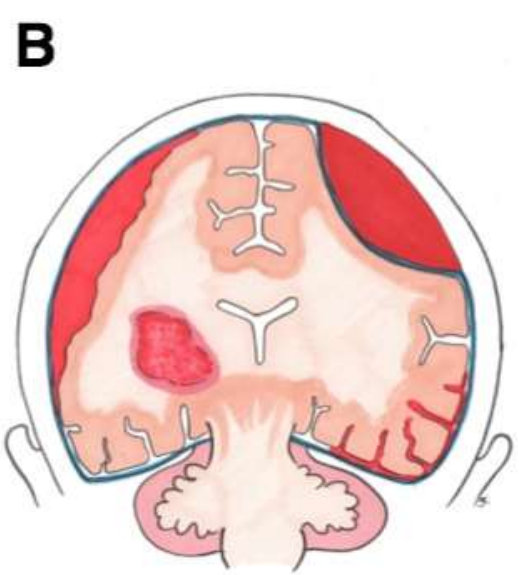
- Sedation
- Elevate head, remove collar
- Ventilation (low normal CO_2)
- Osmotic diuresis
- Barbiturate coma
- Surgery
  - Remove mass lesion
  - CSF withdrawal
  - Decompressive craniectomy



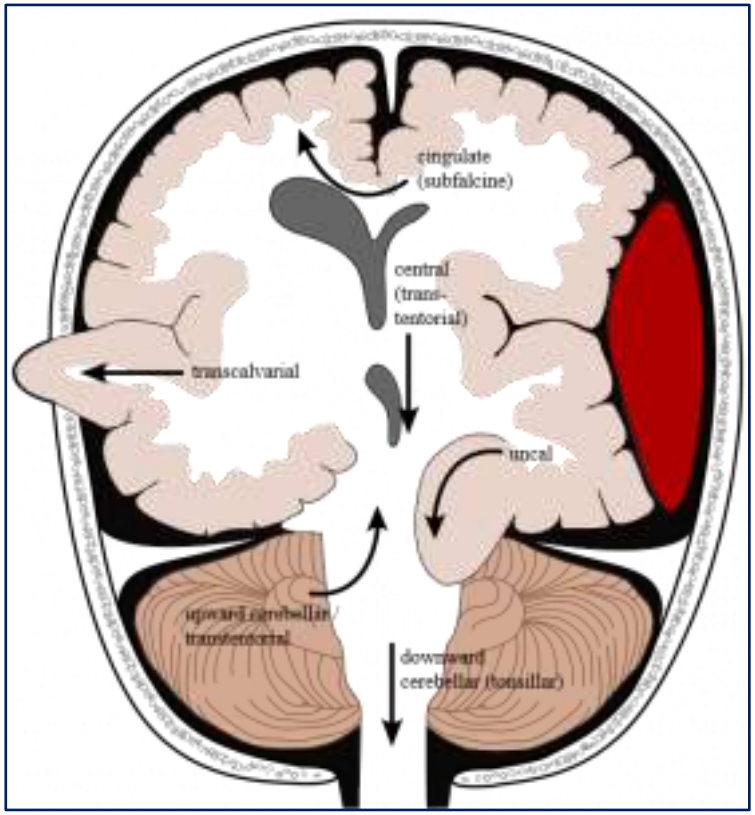
Mass lesions



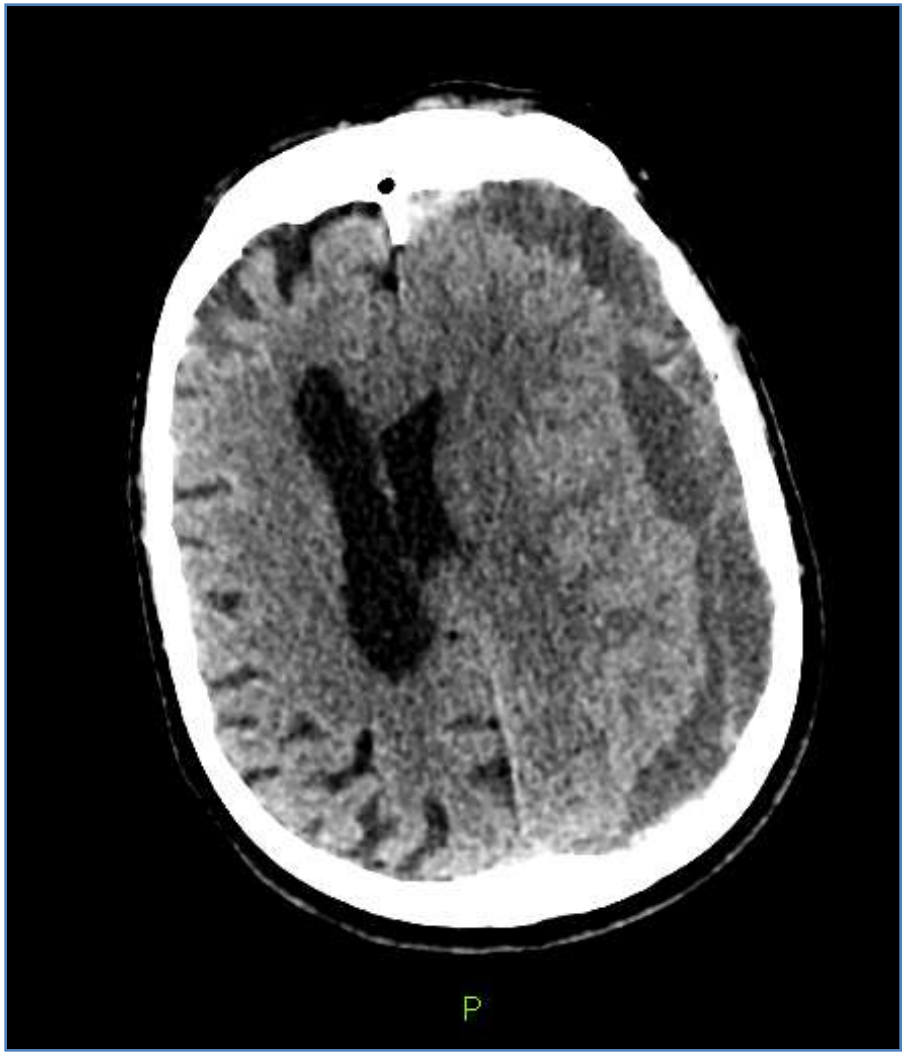




Brain shifts



Mass lesions
Chronic subdural haematoma (CSDH)

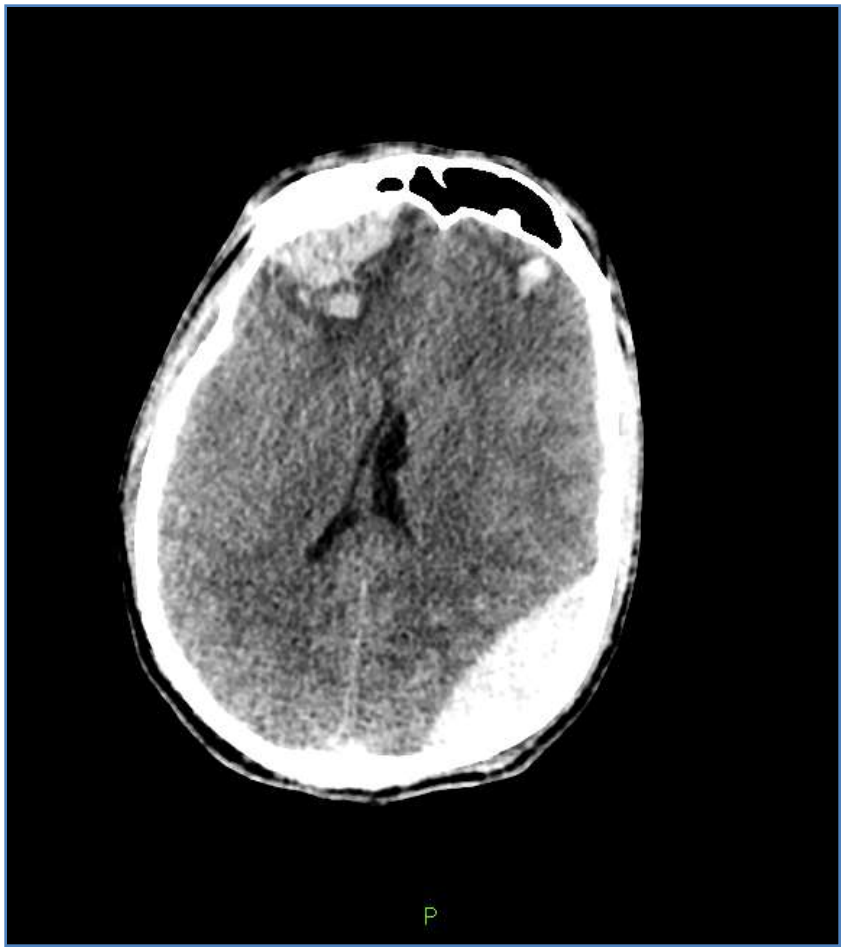


- Pre-op
  - 80 year-old M
  - HA
  - Falls
  - Confused
  - Mild weakness
- Burrholes
- Post-op
  - Initially better
  - More drowsy
  - Further evacuation

Mass lesions
Acute subdural haematoma(ASDH)

- Pre-op
  - 50 year-old M
  - Alcohol, fall
  - GCS 3
  - F+D R pupil
- Trauma craniotomy
- Post-op
  - Long term rehabilitation
  - Fully conscious
  - Left hemiplegia
  - Ongoing care

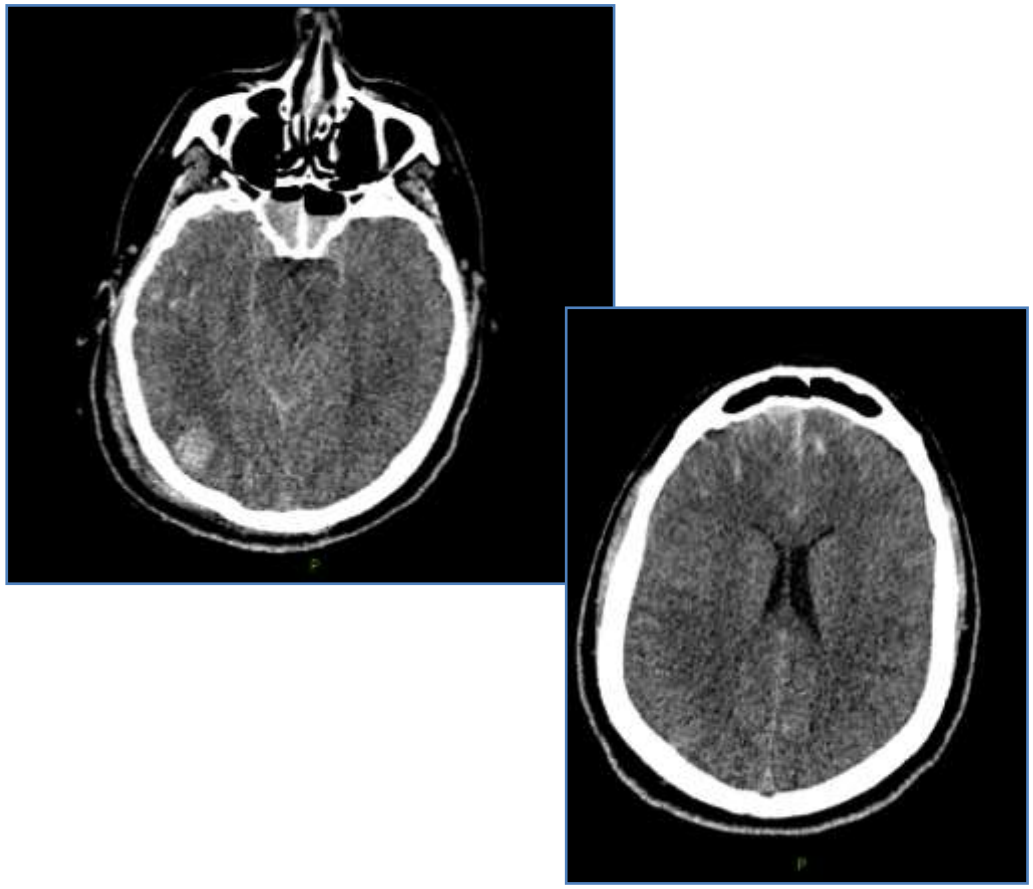
Mass lesions
Extradural haematoma (EDH)



- Pre-op
  - 32 year-old sailor
  - Fall on ship
  - Reduced GCS
- Trauma craniotomy
- Post-op
  - Initial mild confusion
  - Fit to fly home 2/52 later

Decompressive craniectomy

- 23 year-old
- Fall from 3rd floor
- Local A&E
  - GCS 11
  - E3, M5, V3
- I+V
- CT scan
- INS transfer



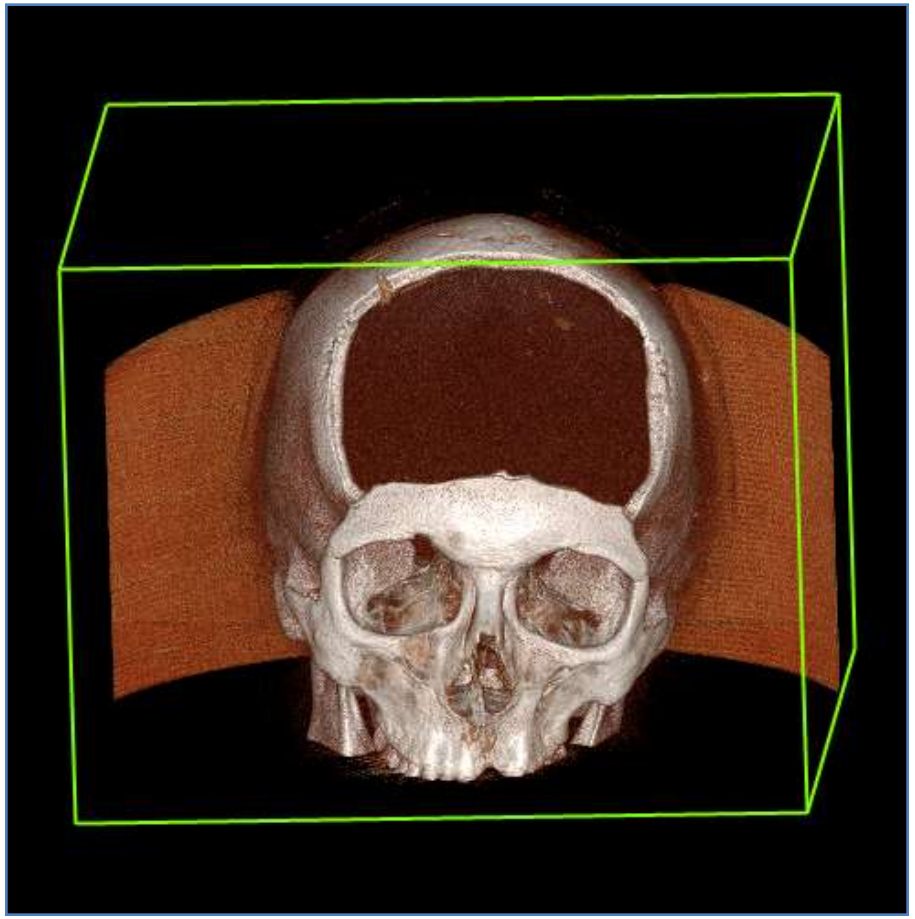
Decompressive craniectomy

- Haemodynamically stable
- Pupils E+R
- ICP > 25
- Mannitol
- Repeat CT scan

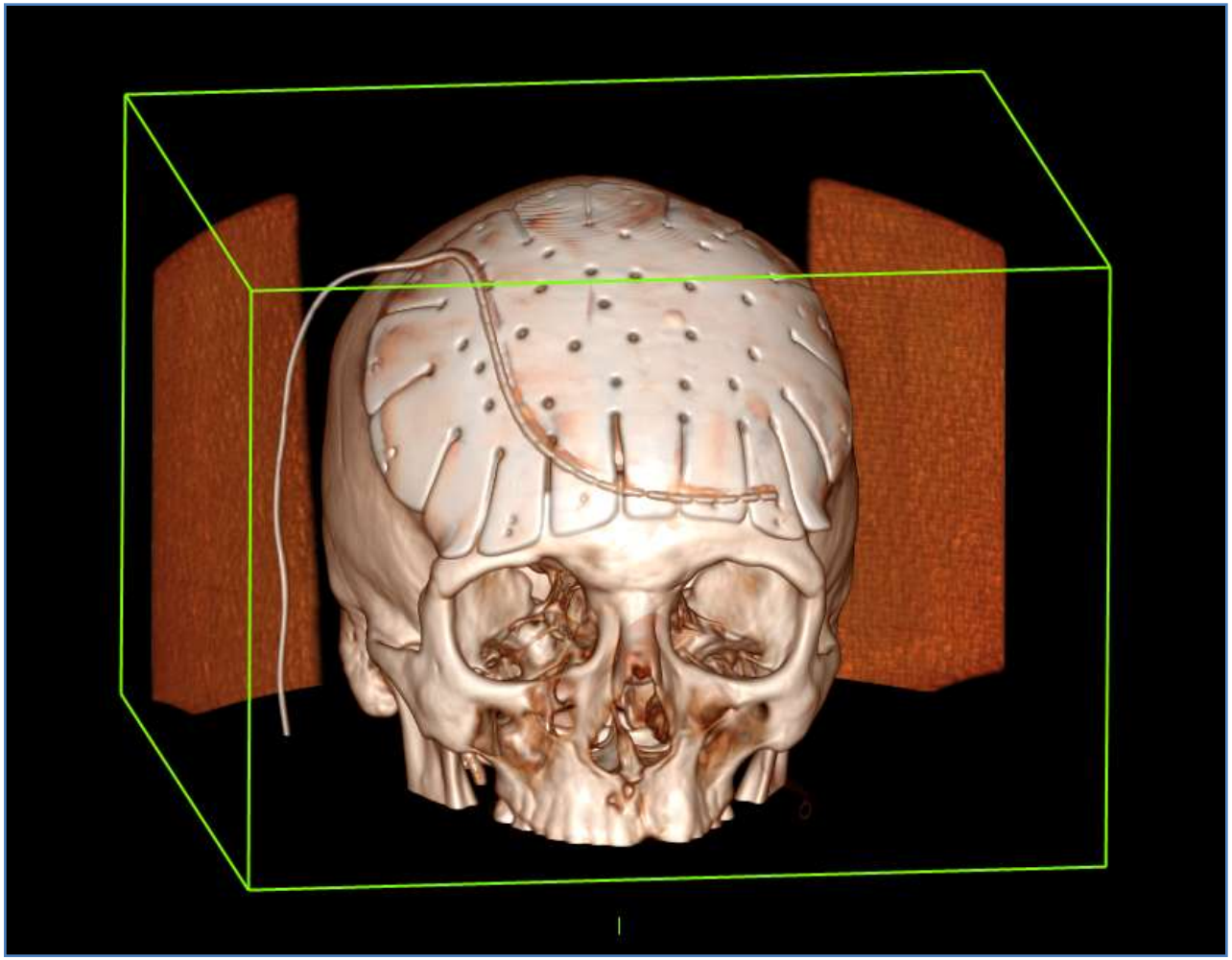
Decompressive craniectomy

- Theatre
  - Decompressive craniectomy
  - Contusionectomy
- 1 week ITU
- Several weeks INS
- Longer term rehabilitation
- Cranioplasty planning scan

Decompressive craniectomy



Cranioplasty

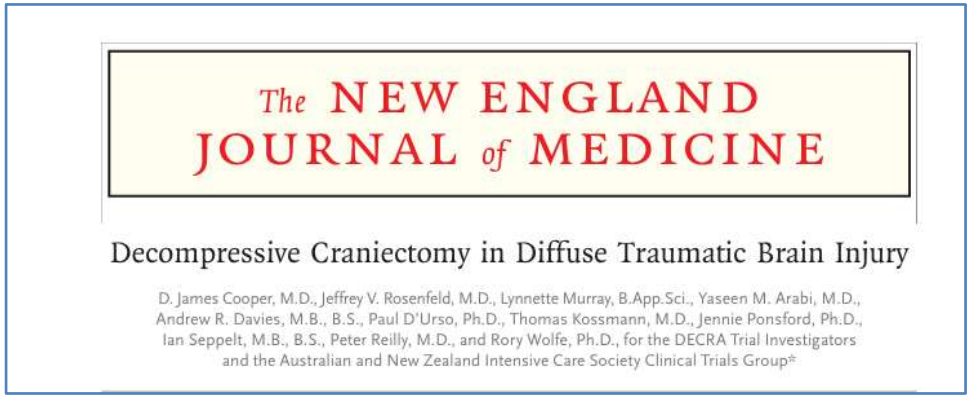


Decompressive craniectomy

- Longer term:
  - Not fully independent
  - Significant cognitive and psychological difficulties
  - Seizures
  - No prospect of working again
  - But in many respects a good outcome(!)

DECRA

- 155 patients
- Diffuse traumatic brain injury
- Refractory ICP
- Decompressive craniectomy v standard care
- Primary outcome
  - Unfavourable GOS 6 months
    - Death, PVS, severe disability



Glasgow Outcome Scale (GOS) and GOS-E

GOS	GOSE	Interpretation
1 = Dead	1 = Dead	Dead
2 = Vegetative state	2 = Vegetative state	Absence of awareness of self and environment
3 = Severe disability	3 = Lower severe disability	Needs full assistance in ADL
	4 = Upper severe disability	Needs partial assistance in ADL
4 = Moderate disability	5 = Lower moderate disability	Independent, but cannot resume work/school or all previous social activities
	6 = Upper moderate disability	Some disability exists, but can partly resume work or previous activities
5 = Good recovery	7 = Lower good recovery	Minor physical or mental deficits that affects daily life
	8 = Upper good recovery	Full recovery or minor symptoms that do not affect daily life

ADL = activities of daily living.

'Assessment of outcome after severe brain damage'
B Jennett, M Bond, Lancet 1975 Mar 1;1(7905):480-4.

DECRA

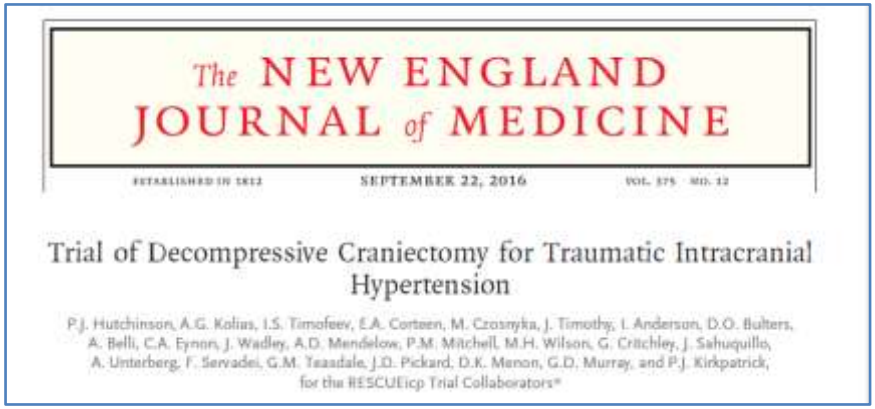
- Craniectomy group
  - GOS Worse (OR 1.84,p =0.03)
  - Greater risk of unfavourable outcome (OR 2.21, P =0.02)
- But
  - Reduced time with high ICP
  - Fewer interventions
  - Fewer ICU days
- Conclusion
  - Decompressive craniectomy associated with an unfavourable outcome

Rescue ICP

- Cambridge
- Differences to DECRA
  - ICP threshold 25mmHg not 20mmHg
  - Timing (any time v first 72 hours)
  - Patients with contusions
  - Follow up 2 years v 6 months

Rescue ICP

- 408 patients randomised
- Traumatic brain injury
- Refractory ICP (>25 mmHg)
- Decompressive craniectomy v medical care
- Primary outcome
  - GOS-E at 6 months



Rescue ICP

- Conclusion

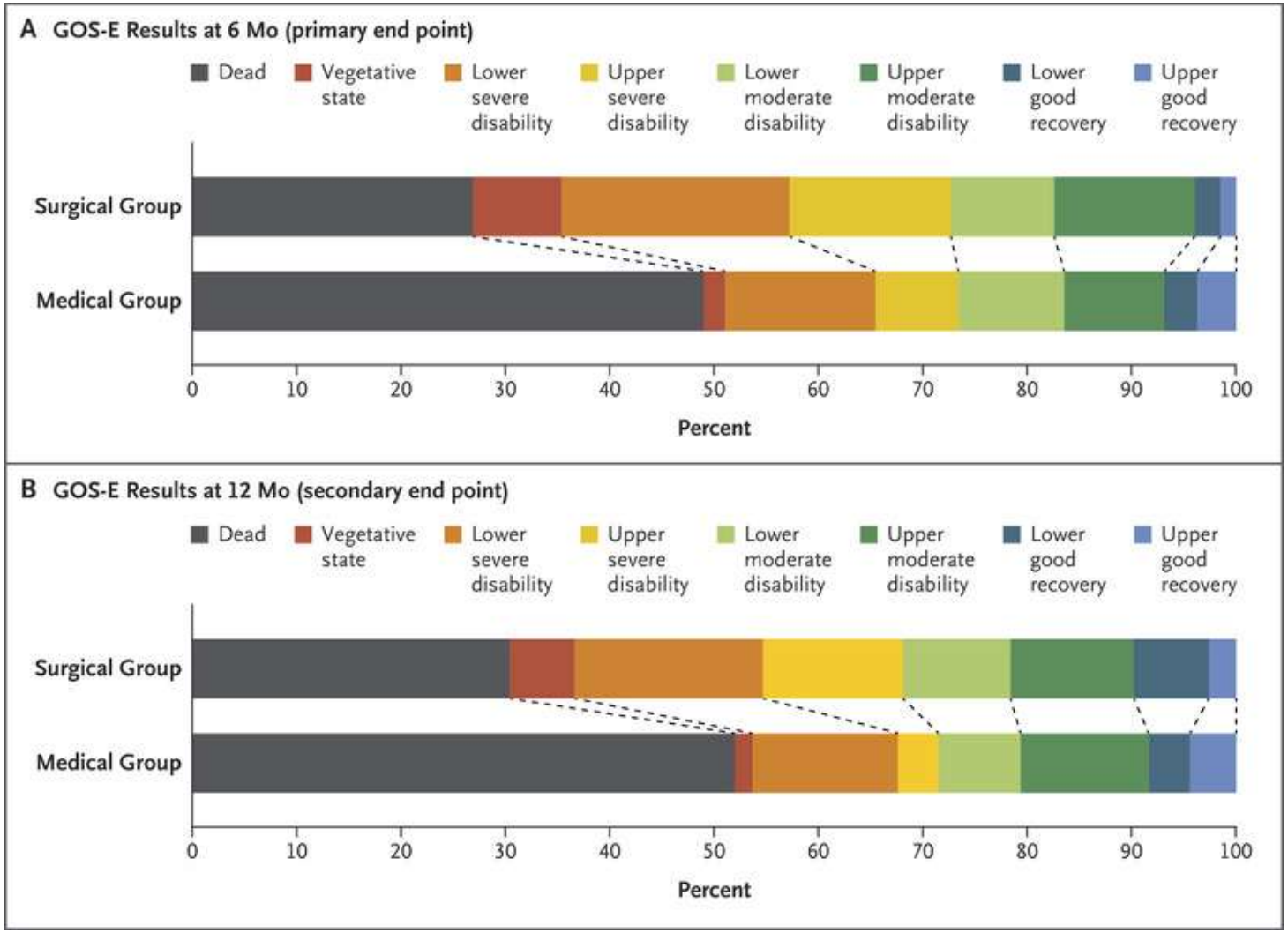
  'At 6 months, decompressive craniectomy in patients with traumatic brain injury and refractory intracranial hypertension resulted in lower mortality and higher rates of vegetative state, lower severe disability, and upper severe disability than medical care. ***The rates of moderate disability and good recovery were similar in the two groups.'***

RESCUE ICP v DECRA

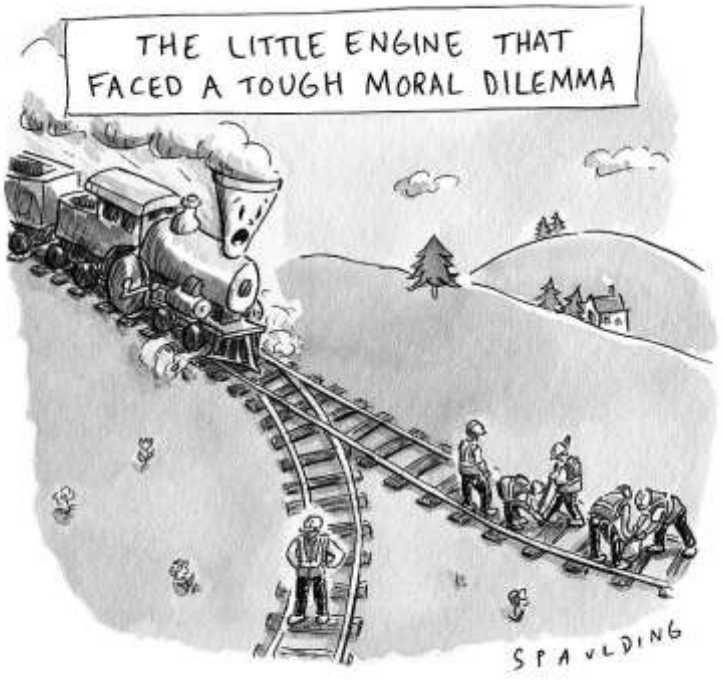
TABLE 1. Comparison of RESCUEicp[1] and DECRA[2] Trials

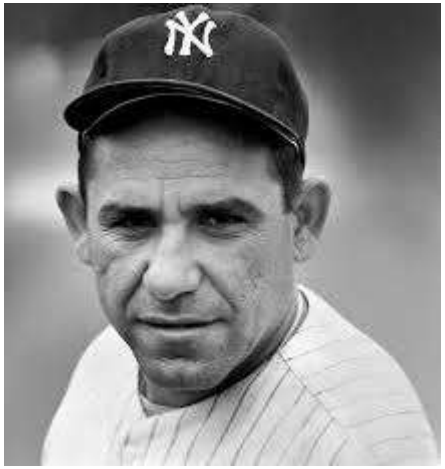
RESCUEicp trial	DECRA trial
Aimed to assess the effectiveness of decompressive craniectomy offered as a last-tier treatment (stage 3).	Aimed to assess the effectiveness of early craniectomy offered as a stage 2 treatment.
Recruitment: 2004 to 2014, 52 centers in 20 countries underwent randomization; of these patients, 291 (71.1%) were recruited in the United Kingdom	Recruitment: 2002 to 2010, 15 tertiary centers in Australia, New Zealand, and Saudi Arabia
ICP threshold: >25 mm Hg for 1 to 12 h	ICP threshold: >20 mm Hg for 15 min within a 1-h period (continuous or cumulative)
44% of patients enrolled >72 h after injury	All patients enrolled within 72 h after injury
Patients with intracranial hematomas (evacuated or nonevacuated) accounted for 20% of the subjects	Patients with intracranial hematomas excluded
37% of patients underwent unilateral craniectomy	Only bifrontal decompressive craniectomy was part of the protocol

Rescue ICP


A GOS-E Results at 6 Mo (primary end point)
Dead
Vegetative state
Lower severe disability
Upper severe disability
Lower moderate disability
Upper moderate disability
Lower good recovery
Upper good recovery
Surgical Group
Medical Group
0
10
20
30
40
50
60
70
80
90
100
Percent
B GOS-E Results at 12 Mo (secondary end point)
Dead
Vegetative state
Lower severe disability
Upper severe disability
Lower moderate disability
Upper moderate disability
Lower good recovery
Upper good recovery
Surgical Group
Medical Group
0
10
20
30
40
50
60
70
80
90
100
Percent

Ethical dilemma

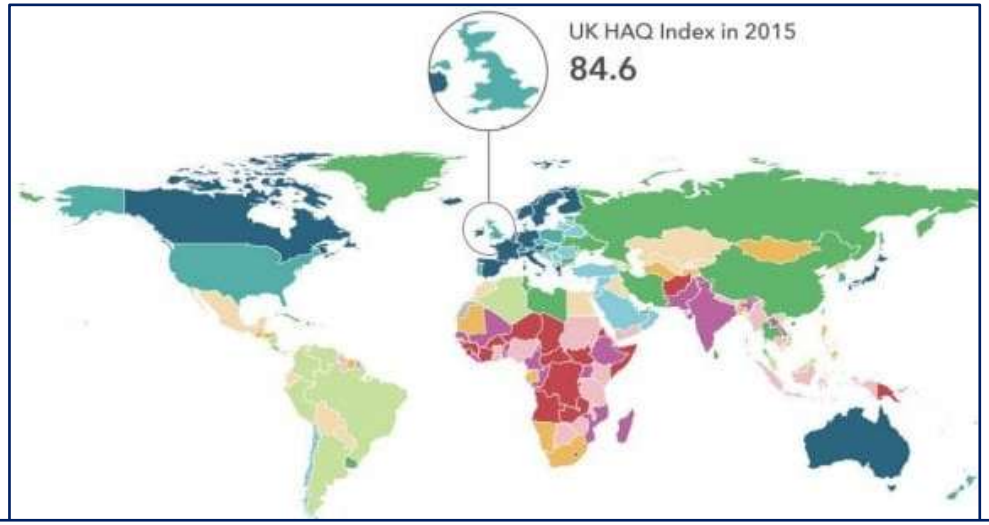




‘When you come to a fork in the road, take it’

A fate worse than death?

Global Inequality in Traumatic Brain Injury (TBI)



69 million TBIs occur globally each year; 90% of deaths occur in LMICs.
Disproportionately affects young adults.

LMICs face major gaps in prevention, emergency services, early resuscitation, access to CT (1–2 scanners per million vs 40+ per million in HICs).

Neurosurgeon density differs dramatically:
1 per 60000 (HICs) vs 1 per 1–10m (LMICs)

Rehabilitation scarce to non-existent

Global initiatives (WFNS, WHO) aim to reduce structural inequities.

Thank you

Douglas Adams

‘The brain is a wonderful organ; it starts working the moment you get up in the morning and doesn’t stop until you get into the office.’