LONG TERM OUTCOME FOLLOWING DECOMPRESSIVE CRANIECTOMY FOR SEVERE TRAUMATIC BRAIN INJURY

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Decompressive Craniectomy for Traumatic brain injury

An Inconvenient Truth

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The Monroe Kellie Doctrine

- In 1783 Alexander Monro deduced that the cranium was a "rigid box" filled with a "nearly incompressible brain" and that its total volume tends to remain constant. The doctrine states that any increase in the volume of the cranial contents (e.g. brain, blood or cerebrospinal fluid), will elevate intracranial pressure.
- Further, if one of these three elements increase in volume, it must occur at the expense of volume of the other two elements. In 1824 George Kellie confirmed many of Monro's early observations.

In adults, the intracranial volume - 1400 to 1700 ml
- Brain parenchyma — 80 percent
- Cerebrospinal fluid — 10 percent
- Blood — 10 percent

<table>
<thead>
<tr>
<th>Glial tissue</th>
<th>Neuronal Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>44%</td>
<td>36%</td>
</tr>
</tbody>
</table>

Blood 10%    CSF 10%
The Monroe Kellie Doctrine

Normal Physiology

ICP range 0 –15 mm Hg

Glial tissue 44%
Neuronal Tissue 36%
Blood 10%
CSF 10%

Normal Physiology

Intracranial volume

ICP
The Monroe Kellie Doctrine

*Partially compensated intracranial hypertension*

ICP range 15 – 25 mm Hg
Poor compliance

ICP

Intracranial volume

Glial tissue 49%
Neuronal Tissue 41%
Blood 5%
CSF 5%
The Monroe Kellie Doctrine
Uncompensated intracranial hypertension

ICP range > 25 mm Hg
No compliance

ICP

Intracranial volume

Glial tissue 50%
Neuronal tissue 42%
Blood 4%
CSF 4%
Decompressive Craniectomy

The Monroe Kellie Doctrine

In 1783 Alexander Monro deduced that the cranium was a "rigid box" filled with a "nearly incompressible brain" and that its total volume tends to remain constant. The doctrine states that any increase in the volume of the cranial contents (e.g. brain, blood or cerebrospinal fluid), will elevate intracranial pressure.
ICP 25-26 despite a fluid challenge

I have explained that ICP's are 25-26 despite therapy that far exceeds maximal medical therapy. She has opted for medical management.

0730
D2 100
20.8.12
035
Feb
ICH
This morning: ICP 40
Not responding to simple measures of boluses + paralysis + head up 30°
Theraputic ICP 250 + 250 + 250 + infusion 1-7L/hr
Hyper ventilation target pCO2 ~ 30
For urgent head scan
Nursing made aware

[Signature]
Decompressive craniectomy for diffuse traumatic brain injury

Evidence

The NEW ENGLAND JOURNAL of MEDICINE

Decompressive Craniectomy in Diffuse Traumatic Brain Injury

D. James Cooper, M.D., Jeffrey V. Rosenfeld, M.D., Lynnette Murray, B.App.Sci., Yaseen M. Arabi, M.D., Andrew R. Davies, M.B., B.S., Paul D’Urso, Ph.D., Thomas Kossmann, M.D., Jennie Ponsford, Ph.D., Ian Seppelt, M.B., B.S., Peter Reilly, M.D., and Rory Wolfe, Ph.D., for the DECRA Trial Investigators and the Australian and New Zealand Intensive Care Society Clinical Trials Group*
Decompressive craniectomy

Intervene

- 29 yr old male
- Isolated head injury following fall
- GCS 9 (E2M5V2)
- Reactive pupils
- ICU day 1 – CVS stable
- ICP > 40mmHg despite maximal medical management

Obliteration of basal cisterns
Non-evacuated haematoma
Midline shift
Petechial haemorrhage
Subarachnoid blood
Decompressive craniectomy

? Intervene?

18 year old male

BIBA

Pushed down stairs by friend at nightclub.

Isolated head injury

Fixed pupil at scene. Second pupil fixed in emergency department

EVD in ICU – 40 mmHg despite maximal medical management

Obliteration of basal cisterns

Petechial haemorrhage

Subarachnoid blood

Non-evacuated haematoma

Midline shift

At 18 months

• Wheelchair
• Severe contractures
• Transfers with two
• Follows single stage commands
• Self feeds with help
• Incontinent
Traumatic Brain Injury
Western Australia
Traumatic Brain Injury
Western Australia
Neurotrauma admissions in WA
2004 / 2012

Decompressive craniectomies (n = 270)
Total neurosurgical admissions (n = 3,231)
Decompressive craniectomy
Surgical Technique / Indications - 2004/2012

n = 120

n = 123

n = 27
Decompressive Craniectomy
Western Australia 2004/12
Outcome at 6, 12 and 18 months

Good: 85, 100, 117
Moderate: 68, 64, 51
Severe: 56, 51, 50
Vegetative: 18, 11, 7
Dead: 43, 44, 45

n = 270
MRC Crash Trial

Outcome prediction

CRASH collaborators – Lancet (2005) Corticosteroid randomisation after significant head injury – Outcome at 6 months

- 10,008 patients
- GCS 14 or less
- Randomised within 8 hrs
- 48hr infusion – Methylprednisolone or matching placebo
- 6 month outcome achieved for 9673 pts (96.7%)

Results

Risk of death higher in CORTICOSTEROID group
- 1248 (25.7%) vs 1075 (22.3%)

Risk of death or severe disability higher in CORTICOSTEROID group
- 1828 (38.1%) vs 1728 (36.3%)
MRC Crash Trial

Multivariable predictive models

Basic model
- Age
- Glasgow coma score
- Pupil reactivity
- Major extracranial injury

CT model
- Presence of petechial haemorrhages
- Obliteration of the III ventricle or basal cisterns
- Subarachnoid haemorrhage
- Midline shift
- Non-evacuated haematoma

High or low-middle income country

Prognostic model
- Mortality at 14 days
- Unfavourable outcome at 6 months
MRC Crash Trial
Web based predictive model
MRC Crash Trial
Web based predictive model

Head injury prognosis

These prognostic models may be used as an aid to estimate mortality at 14 days and death and severe disability at six months in patients with traumatic brain injury (TBI). The predictions are based on the average outcome in adult patients with Glasgow coma score (GCS) of 14 or less, within 8 hours of injury, and can only support - not replace - clinical judgment. Although individual names of countries can be selected in the models, the estimates are based on two alternative sets of models (high income countries or low & middle income countries).

Prediction

Risk of 14 day mortality (95% CI)
48.6% (34.3 - 63.1)

Risk of unfavourable outcome at 6 months
72.9% (60.9 - 82.3)

Risk of 14 day mortality (95% CI)
14.6% (9.3 - 22.3)

Risk of unfavourable outcome at 5 months
43.6% (32.8 - 54.9)
Validation of the CRASH model in the prediction of 18-month mortality and unfavorable outcome in severe traumatic brain injury requiring decompressive craniectomy

Clinical article


n = 270
Decompressive craniectomy

Intervene?

- 29 yr old male
- Isolated head injury following fall
- GCS 9 (E2M5V2)
- Reactive pupils
- ICU day 1 – CVS stable
- ICP > 40mmHg despite maximal medical management

Obliteration of basal cisterns
Non - evacuated haematoma
Midline shift
Petechial haemorrhage
Subarachnoid blood
MRC Crash Trial
Web based predictive model

Head injury prognosis

These prognostic models may be used as an aid to estimate mortality at 14 days and death and severe disability at six months in patients with traumatic brain injury (181). The predictions are based on the average outcome in adult patients with Glasgow coma score (GCS) of 14 or less, within 8 hours of injury, and can only support - not replace - clinical judgment. Although individual names of countries can be selected in the models, the estimates are based on two alternative sets of models (high income countries or low & middle income countries).

Country: Australia
Age, years: 40
Glasgow coma score: 9
Pupil react to light: Both
Major extra-cranial injury?: No
CT scan available?: Yes

- Presence of potential haemorrhages: Yes
- Obliteration of the third ventricle or basal cisterns: Yes
- Subarachnoid bleeding: Yes
- Midline shift: Yes
- Non-evacuated haematoma: Yes

Prediction

Risk of 14 day mortality (95% CI) 44.6% (30.6 - 59.5)
Risk of unfavourable outcome at 6 months 69.6% (56.9 - 79.9)
Decompressive Craniectomy WA 2004/12

Predicted vs Observed Outcome at 18 months
Decompressive craniectomy

Intervene?

03.00 am
18 year old male BIBA
Pushed down stairs by friend at nightclub.
Isolated head injury, GCS 4
Fixed pupil at scene. Second pupil fixed in emergency department

EVD in ICU – 40 mmHg despite maximal medical management

Obliteration of basal cisterns
Non - evacuated haematoma
Midline shift
Petechial haemorrhage
Subarachnoid blood
Head injury prognosis

These prognostic models may be used as an aid to estimate mortality at 14 days and death and severe disability at six months in patients with traumatic brain injury (TBI). The predictions are based on the average outcome in adult patients with Glasgow coma score (GCS) of 14 or less, within 8 hours of injury, and can only support - not replace - clinical judgment. Although individual names of countries can be selected in the models, the estimates are based on two alternative sets of models (high income countries or low & middle income countries).

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<th>Country</th>
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<tbody>
<tr>
<td>Age, years</td>
<td>≤40</td>
</tr>
<tr>
<td>Glasgow coma score</td>
<td>4</td>
</tr>
<tr>
<td>Pupils react to light</td>
<td>None</td>
</tr>
<tr>
<td>Major extra-cranial injury?</td>
<td>No</td>
</tr>
<tr>
<td>CT scan available?</td>
<td>☑</td>
</tr>
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<td>Presence of petechial haemorrhages</td>
<td>Yes</td>
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**Prediction**

<table>
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<tr>
<th>Risk of 14 day mortality (95% CI)</th>
<th>87.9% (79.3 - 93.2)</th>
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<tr>
<td>Risk of unfavourable outcome at 6 months</td>
<td>93.6% (88.6 - 96.5)</td>
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Decompressive Craniectomy WA 2004/12

Predicted vs Observed Outcome at 18 months
Decompressive craniectomy

Uncertainty

- **Legal**
- **Ethical**
  - Surrogates
- **Moral**
  - Descriptive – code of conduct (society, philosophy, religion)
  - Prescriptive - ideal code of conduct espoused in preference to alternatives
    - *Murder is immoral*
- **Philosophical**
  - Existence, knowledge, truth, beauty, justice, validity, mind, and language.
  - Distinguished by is critical systematic approach and its reliance on reasoned argument
Survival with severe disability

Ethical issues

Surgical intervention for severe head injury: ethical considerations when performing life-saving but non-restorative surgery

Stephen Honeybul, Kwok M. Ho, Christopher R. P. Lind, Grant R. Gillett

Ethical considerations for performing decompressive craniectomy as a life-saving intervention for severe traumatic brain injury

Stephen Honeybul, Grant Gillett, Kwok Ho, Christopher Lind

Futility and neurotrauma: can we make an objective assessment?

Decompressive Craniectomy for Diffuse Cerebral Swelling After Trauma: Long-Term Outcome and Ethical Considerations

Stephen Honeybul, FRACS, Kwok M. Ho, FRACA, PhD, Christopher R. P. Lind, FRACS, and Grant R. Gillett, DPhil (Oxford), FRAC

Neurotrauma and the RUB: where tragedy meets ethics and science

G R Gillett, S Honeybul, K M Ho, C R P Lind
Decompressive Craniectomy for Traumatic brain injury

An Inconvenient Truth

S Honeybul* KM Ho** CRP Lind*†
GR Gillett FRACS‡

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Whilst we have an obligation to act in what we feel to be the patient’s best interests, feeling is not enough.

Our actions need to be not only reasonable but informed by the evidence.

Any decision to be ethical, must be one that can be included in the narratives of those involved with integrity so that for the person whose life may end and for those who are left grieving there is closure and a sense of having done what is right in a tragic situation.
Decompressive Craniectomy

An Inconvenient Truth

“...What changed in the US with Hurricane Katrina was a feeling that we have entered a period of consequences...”

Al Gore
What is the most difficult ethical dilemma facing science today?

**Sir David Attenborough:** How far do you go to preserve an individual human life?

**Stephen Hawking:** That’s a good one, yes