Raised ICP in Traumatic Brain Injury
Mortality from Head Injury Over Four Decades in Scotland

- 1974-2012
- Decreased from 503 annually to 339
- Decreased from 9.6 to 6.4 per 100,000 population
- 100,000 A&E attendances a year 15% require admission
- 4% of those GCS 3-8

Hamill et al 2012
Scottish Public Health Network 2015
Causes of Head Injury
Monro-Kellie Hypothesis

To keep the intracranial pressure within normal limits, any change in volume of one of the intracranial contents must be accompanied by a change in one or two of the other components.

The ability of the brain to adjust to changes in volume is called **COMPLIANCE**.

Normal ICP 7-15mmHg in the horizontal position
Cerebral Perfusion Pressure

• This is the CPP is Mean arterial pressure - ICP

• Normal CPP is 80 to 100 mmHg in most adults

• Cerebral blood flow is maintained by autoregulation
Cerebral Perfusion Pressure

- Outside 60 to 150 mmHg autoregulation has failed
- Below 60 mmHg cerebral ischaemia will occur
- Below 30-40 mmHg cell death will occur
Items beginning with C that raise ICP

- Clot
- Contusion
- Cells (tumour, abscess)
- CSF
- Cytotoxic Oedema
- Cerebral Oedema
- Cerebral vasospasm
- Clonic Activity
- Care
Case Study

• 19 year old boy fell off his friends’ shoulders.
• His friend was driving a quad bike in a quarry at the time
• Patient was GCS 9 at the scene
• GCS 14 in A/E
• Then deteriorated to <8
Avoidance of Secondary Brain Injury

• The brain needs blood flow, oxygen and nutrients to survive. There are key things beginning with H that make ICP worse following trauma:
  • Hypoxaemia
  • Hypotension
  • Hypoglycaemia
  • Hypercapnia
  • Hypocapnia
  • Haemoglobin
  • Hyperthermia
Intubation and Ventilation

• **Advantages**
  – Secure and protect the airway
  – Avenue for suction
  – Maintain ABGs through ventilation
  – Deliver high FiO2
  – End TIDAL CO2 monitoring
  – Allows paralysis

• **Disadvantages**
  – Coughing against tube
  – VAP
  – Requires Sedation
  – Hypotension during procedure
Ventilation

• Secure airway
• Avoid hypoxia aim for PaO$_2$ $\geq$ 13kPa
• Avoid hypoxia aim for SpO$_2$ 95%

• Maintain PaCO$_2$ at 4.5-5.0kPa (34-38mmHg)
• Use end tidal CO$_2$ monitoring

• Use with high respiratory rate and moderate breaths as an emergency treatment in the setting of a fixed and dilated pupil
Sedation and Pain Relief

- Sedation will reduce cerebral metabolic requirement and will reduce blood flow

- Sedation will prevent coughing and gagging against the ET tube

- Sedation might prevent seizures

- Allows procedures to be carried out

- Beware hypotension as this will reduce CPP!!

Tier 1 treatment

- Propofol (fast/short)
- Midazolam (long term)
- Alfentanil (opiate)

NMB’s /Muscle relaxants reserved for:
- Transport of patients
- Unstable ICP
Basic care

• Head and Neck in alignment with a straight torso

• Avoid excessive flexion at the hips

• Maintain head up at 30° but some patients like a higher position 45°

• Use of bed tilt

• Tape the ET tube. Do not use ties

• Regular oral care.
Did Nigel have a good B/P

- Initially the MAP was over 90mmHg
- Edinburgh would aim for this figure

- The BTF say > 100mmHg for 50-69 years
- > 110mmHg systolic 15-49yrs

- Hb always above 90g/l
- Platelets never <75x10^9
Nigel’s ICP going

- Up to 30mmHg
- Tier 2 therapy

- However a good CPP was always maintained by the use of fluid and noradrenaline.

- The noradrenaline dose was the equivalent of 24mg% running at 10-15mls per hour on some occasions.
Mannitol

- Guidelines suggest 0.25-1gm per kg bolus
- Edinburgh use 200mls of 20%
- 0.5gm per kg for 80kg patient
- With 250mls of Plasmalyte 148

Tier 2 treatment
Mannitol

- Meaningful entries in the literature appear around 1961
- Transient hypervolaemia
- Transient haemodilution
- Dehydrates brain tissue
- Administer over 15 minutes - 30 minutes
- Effects may last 3 - 6 hours
- Beware fluid overload and rebound hypertension. Excessive use may cause renal failure
- Check pupils frequently
- If no ICP response after 15-20 minutes get a medical review
- What do we measure every 12 hours?
Hypertonic saline

- 1919 Weed and McKibben reduced brain volume by injection of 30% Normal Saline
- 10%
- 29%
- 20%
- 23.4%
- 5%
- 3%
Hypertonic Saline

• 125 mls of 5% over 15 minutes
• Via a central line
Mannitol versus HTS

• Which is better at lowering ICP?

• Which avoids hypotension?

• Which is best at improving overall outcome.

“insufficient evidence about effects on clinical outcomes to support a specific recommendation, or to support use of any specific hyperosmolar agent” Carney et al (2017)
Hypertonic Saline infusion

- Some small recent studies have investigated the use of continuous infusions of hypertonic saline to reduce ICP.

- Asehnoune et al 2017
Nigel’s ICP

- Still up to 30mmHg and a new scan revealed a small temporal haematoma.

- This was surgically evacuated.

- However the ICP was still rising to 30mmHg and 35mmHg during nursing care so he received boluses of neuromuscular blocker
Hyperventilation

• Prophylactic hyperventilation is not recommended as although it transiently reduces ICP it does not improve final outcome in patients with TBI.

• Should be avoided in the first 24 hours
• Used in conjunction with
  • PbtO\textsuperscript{2} from Licox catheter
  • Sjo2

• Transient use for high ICP
Licox
Thiopentone infusion

- Reduces metabolic brain requirement and therefore blood flow.

- ICP reduction should follow

- Often the infusion is titrated to the EEG brain activity.

- The aim is usually 3-5 bursts of brain activity a minute or 75% suppression of activity.
EEG Burst Suppression
Problems with Thiopentone

- May cause hypotension, drop in temperature, dilated pupils, immuno-suppression

- May take 96 hours to wash out of the system.

- Rebound hyperkalaemia up to 48 hours after infusion has stopped so 2-3 hourly potassium levels

- Levels need to be checked before brain stem tests can be carried out.
Therapeutic Hypothermia

Waveforms frozen
Press take snapshot to create a snapshot

ECG
46
40.160

HR
76

ST
-1.4

V5
-0.6

aVL
1.2

-1.9

Art 200

CVP

Pleth

CO2

Resp

NIBP

34.8
20
150/73

Tier 3 treatment
Eurotherm Trial

- Hypothermia for Intracranial Hypertension after Traumatic Brain Injury
- The primary outcome measure was the extended Glasgow Outcome Score at 6 months

<table>
<thead>
<tr>
<th>Hypothermia</th>
<th>Favourable Outcome</th>
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<td>26%</td>
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<table>
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<tr>
<th>Control</th>
<th>Favourable outcome</th>
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<td>37%</td>
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Conclusions

• Titrated hypothermia to reduce raised intracranial pressure in addition to standard care did not achieve better outcomes than standard care alone.

• Hypothermia resulted in higher mortality and poorer outcomes and should not be used to reduce ICP after TBI
Normothermia Instead

• Aim 36°C-38.3°C

• Achieved by anti pyretics, fan, sponging or a cooling blanket.
Craniectomy

Tier 3 treatment
Craniectomy RESCUEicp

• Removal of a bone flap to relieve intracranial pressure.

• Study to compare craniectomy as a third tier treatment for high ICP with medical management including barbiturate coma.

• Primary outcome was GOSe at 6 months
Results

- Deaths in the craniectomy group 26.9%
- Deaths in medical group 48.9%

- Vegetative state in craniectomy group 8.5%
- Vegetative state in medical group 2.1%

- Favourable outcome in craniectomy group 42.8%
- Favourable outcome in medical group 34.6%

- Good recovery in the craniectomy group 4%
- Good recovery in the medical group 6.9%
DVT Prophylaxis

• Graduated compression stockings

• Flowtron boots

• Reassess heparin at one week.
Glucose control

- Nigel’s blood glucose was always around 5-10mmols/l

- Edinburgh would try to keep this at 4.5-10mmols/l
Seizure Activity

• Seizure activity increases metabolic activity and cerebral blood flow.

• ICP will rise

• Phenytoin is given if there are confirmed seizures. Loading followed by 100mg every 8 hours with levels checked the following day.
Outcome for Nigel

• Home after 1 month

• At outpatients he complained of some visual disturbance of peripheral vision on the side of his injury and sore heals.

• Nigel’s mother said he was a bit louder than usual and was not great with numbers and maths

• He could no longer go into the army as planned
Neuropoly
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