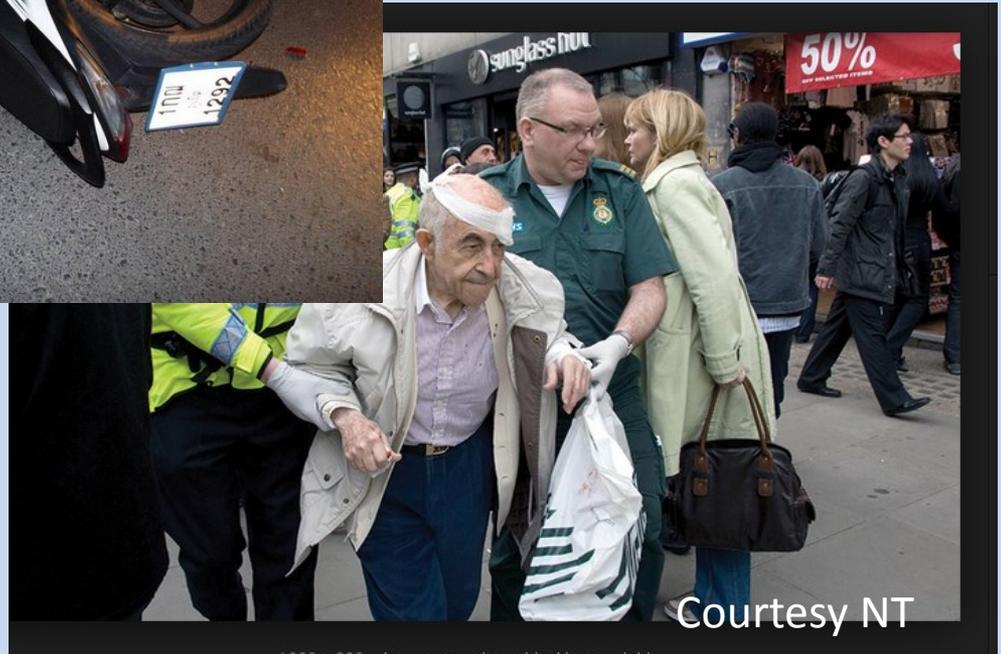


Raised ICP in Traumatic Brain Injury

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

Causes of Head Injury



Courtesy NT



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 $\text{Mean arterial pressure} - \text{ICP}$
- 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

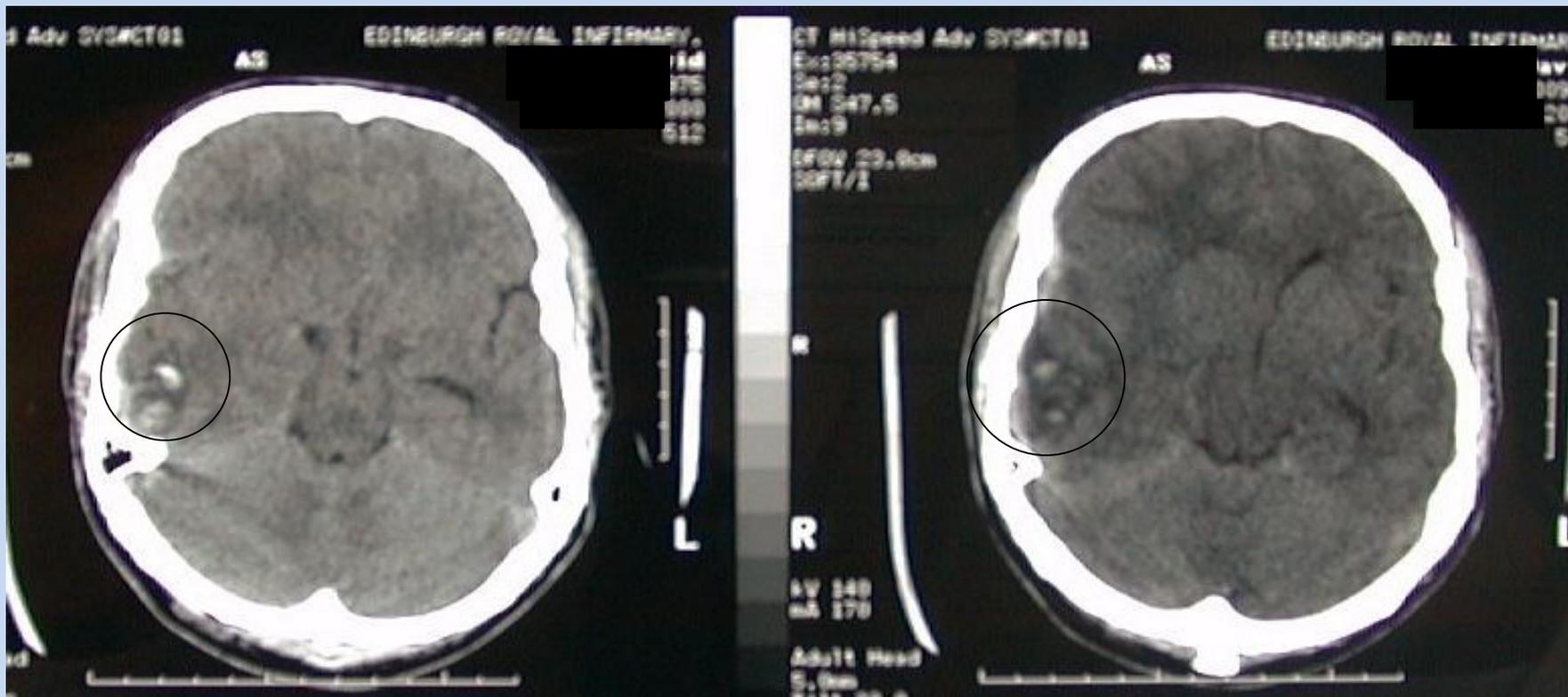
Case Study

- 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 $\text{PaO}_2 \geq 13\text{kPa}$
- 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 !!

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 15-49hrs

- Hb always above 90g/l
- Platelets never <75x10⁹

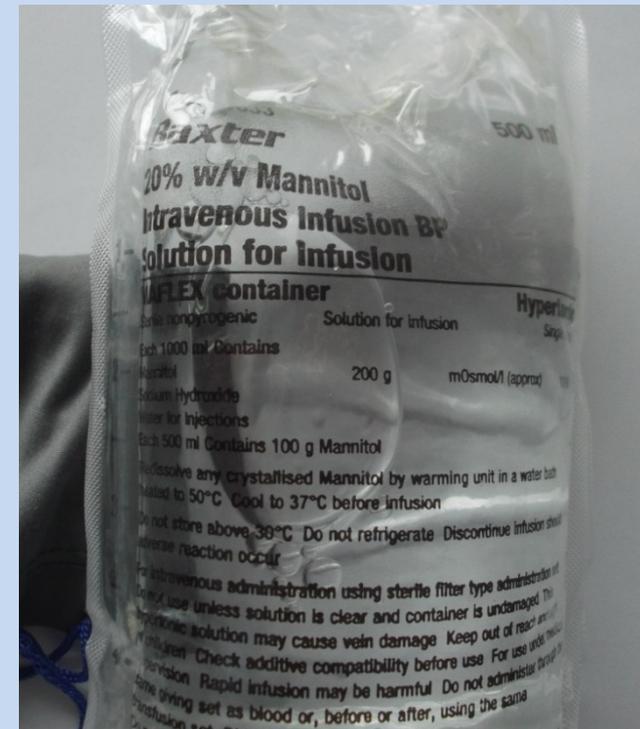


Nigel's ICP going

- 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



Mannitol

- Meaningful entries in the literature appear around 1961
- Transient hypervolaemia
- Transient haemodilution
- Dehydrates brain tissue
- Administer over 15minutes-30minutes
- Effects may last 3-6hours
- 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?

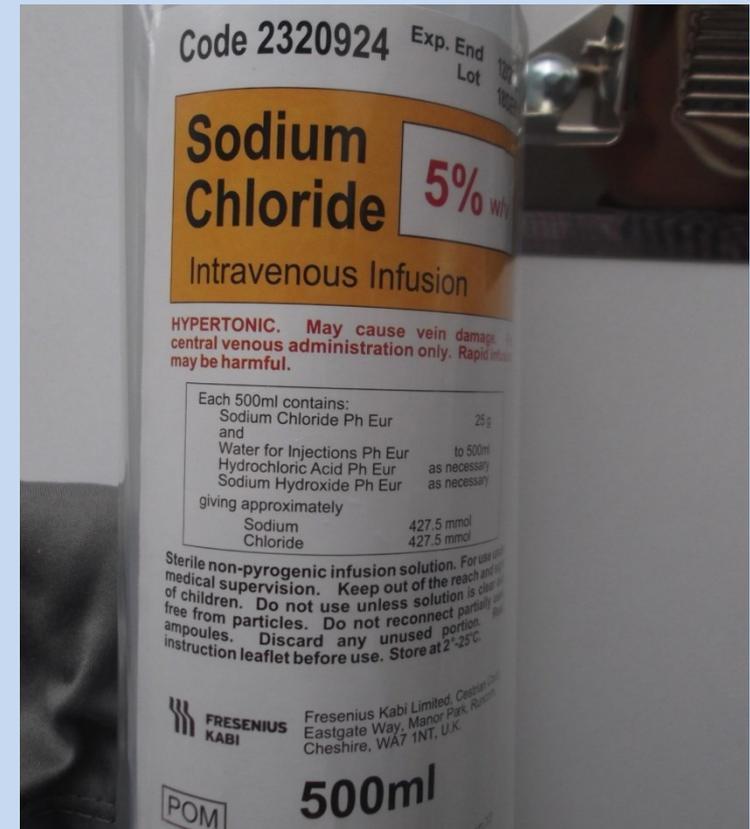
Hypertonic saline

- 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

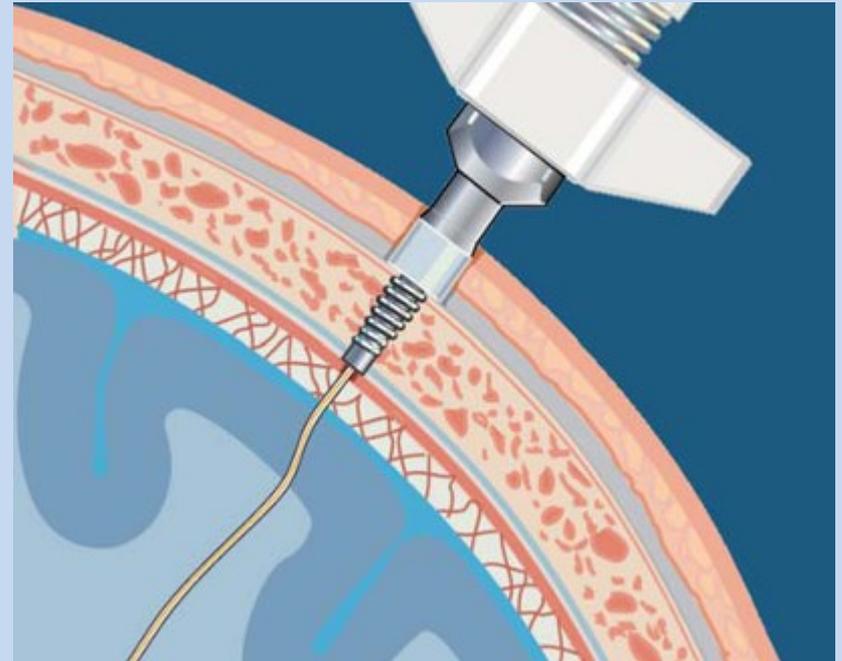
- Still up to 30mmHg and a new scan revealed a small temporal haematoma.
- This was surgically evacuated.
- However the ICP was still rising to 30mmg and 35mmHg during nursing care so he received boluses of neuromuscular blocker

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 24hours
- Used in conjunction with
 - P_{btO_2} from Licox catheter
 - S_{jo_2}
- Transient use for high ICP



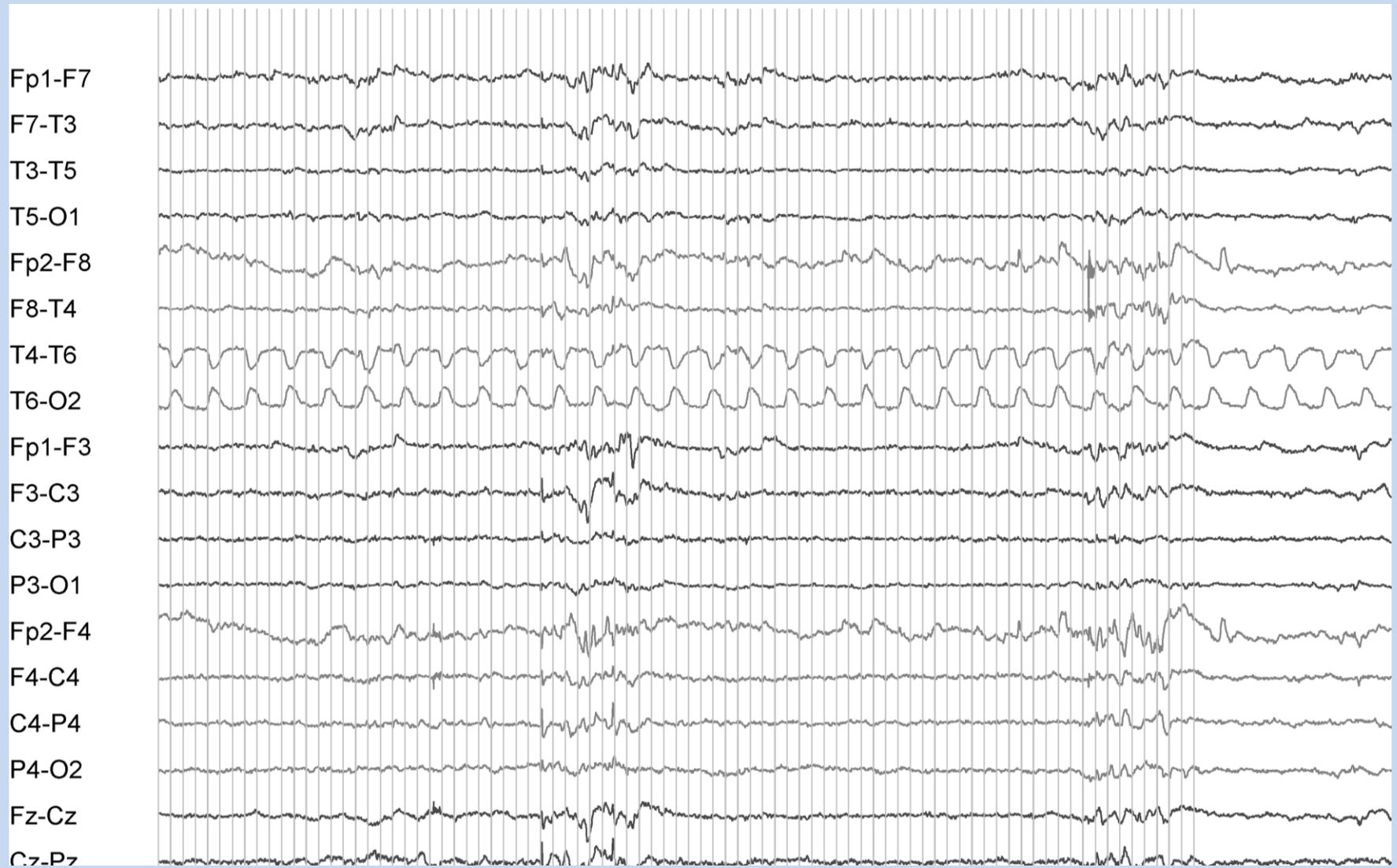
Licox



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



Eurotherm Trial

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

Favourable
Outcome
Hypothermia

26%

Favourable
outcome control

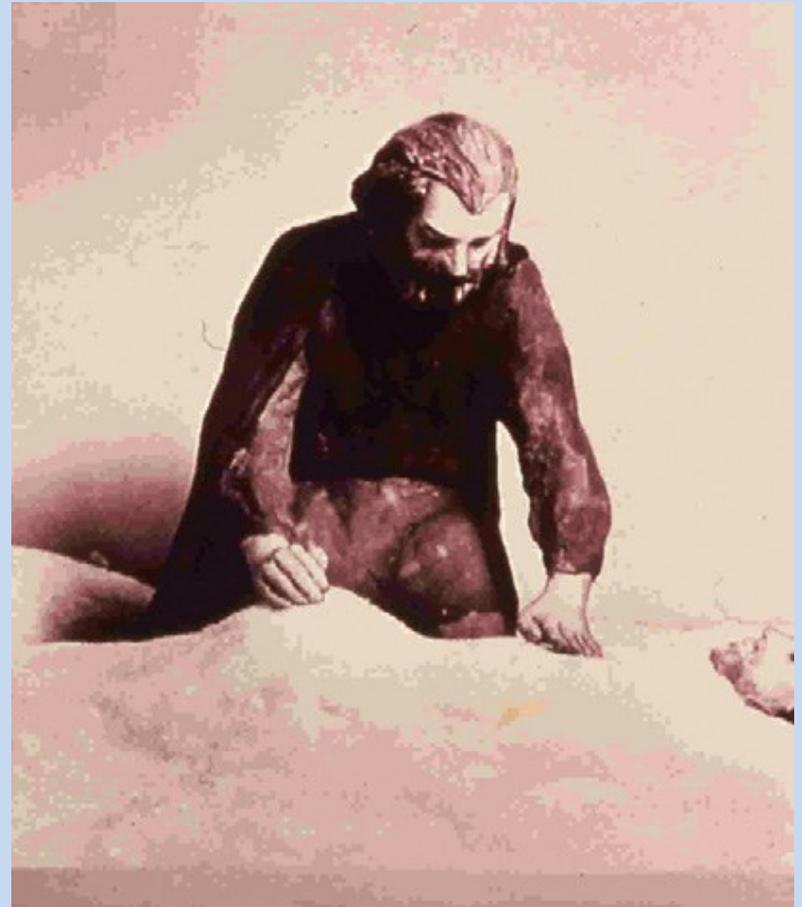
37%

Conclusions

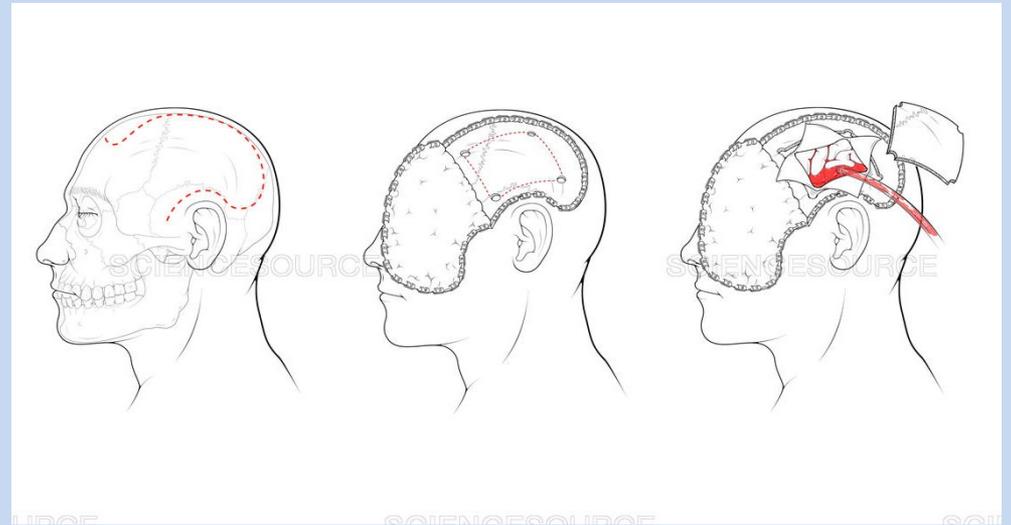
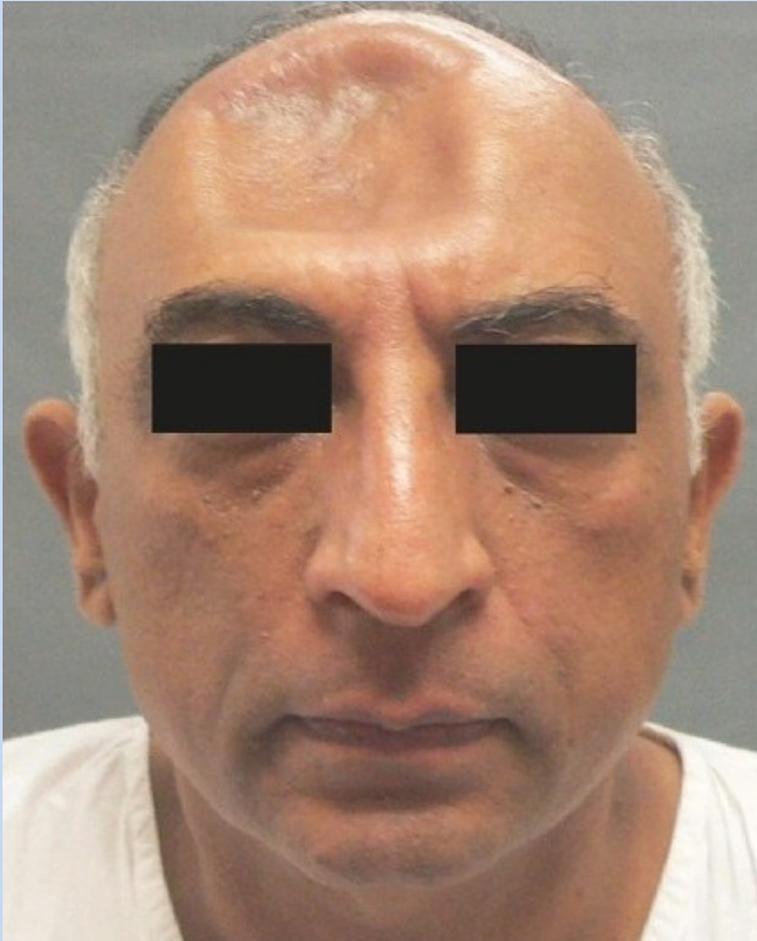
- Titrated hypothermia to reduce raised intracranial pressure in addition to standard care did not achieve better outcomes than standard care alone.
- Hypothermia resulted in higher mortality and poorer outcomes and should not be used to reduce ICP after TBI

Normothermia Instead

- Aim 36° C- 38.3C
- Achieved by anti pyretics, fan, sponging or a cooling blanket.



Craniectomy



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

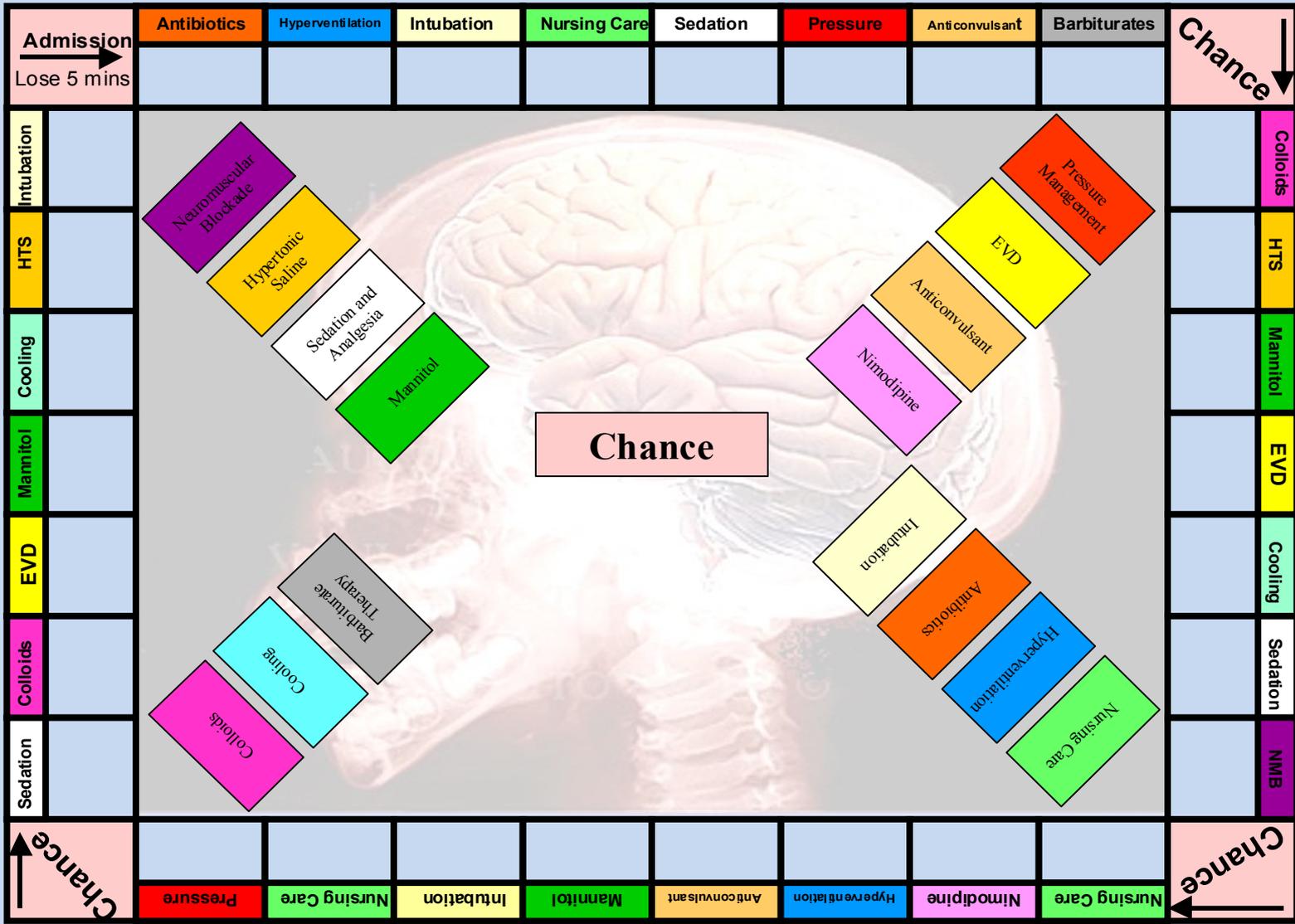
- Seizure activity increases metabolic activity and cerebral blood flow.
- ICP will rise
- Phenytoin is given if there are confirmed seizures. Loading followed by 100mg every 8 hours with levels checked the following day.

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 heels.
- 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

Neuropoly



Neuropoly

Neuropoly

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