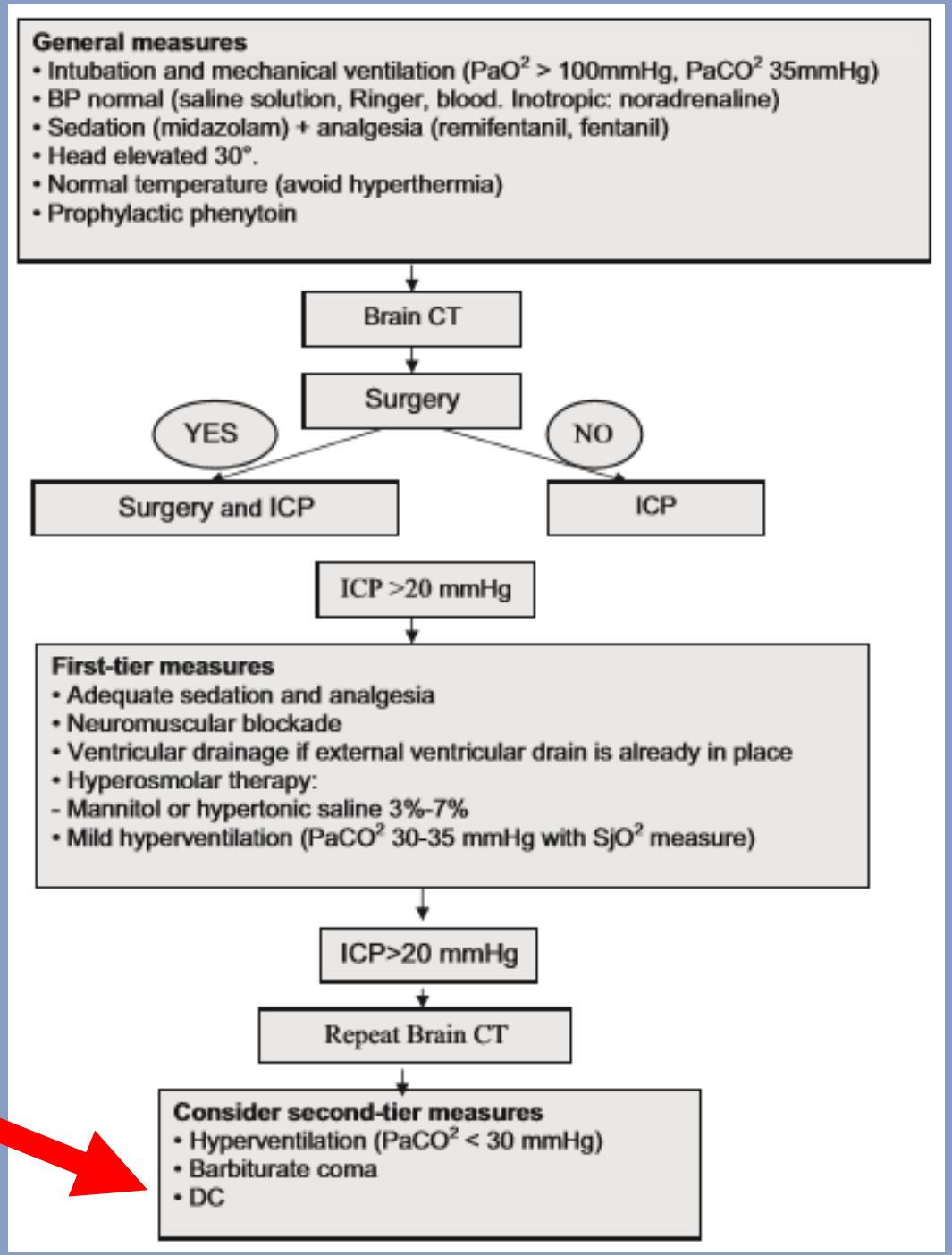
That Early Decompressive Craniectomy in Children with TBI Improves Outcome: Con

Gary Williams

ANZICS Adelaide Oct 12 2028


General measures
• Intubation and mechanical ventilation (PaO^2 > 100mmHg, $PaCO^2$ 35mmHg)
• BP normal (saline solution, Ringer, blood. Inotropic: noradrenaline)
• Sedation (midazolam) + analgesia (remifentanil, fentanil)
• Head elevated 30°.
• Normal temperature (avoid hyperthermia)
• Prophylactic phenytoin
Brain CT
Surgery
YES
NO
Surgery and ICP
ICP
ICP >20 mmHg
First-tier measures
• Adequate sedation and analgesia
• Neuromuscular blockade
• Ventricular drainage if external ventricular drain is already in place
• Hyperosmolar therapy:
- Mannitol or hypertonic saline 3%-7%
• Mild hyperventilation ($PaCO^2$ 30-35 mmHg with SjO^2 measure)
ICP>20 mmHg
Repeat Brain CT
Consider second-tier measures
• Hyperventilation ($PaCO^2$ < 30 mmHg)
• Barbiturate coma
• DC

Decompressive Craniectomy 1950-2000

- Large no of isolated case reports and small series, limited evidence
- Marked variation
  - Indication
  - Technique (where, how complete, ± durotomy)
  - Measures of success / failure

- After 2000 (Trauma Guidelines → more uniform algorithms, ICP-based decision making, better imaging tools)

Decompressive Craniectomy in Diffuse Traumatic Brain Injury

N Engl J Med 2011;364:1493-502.

- 155 adult patients with severe non-penetrating TBI & Refractory ICP
- Randomised to continuing standard care OR standard care +DC
- Primary outcome: odds analysis of score on Extended Glascow Outcome Scale at 6mos and large number of secondary outcomes

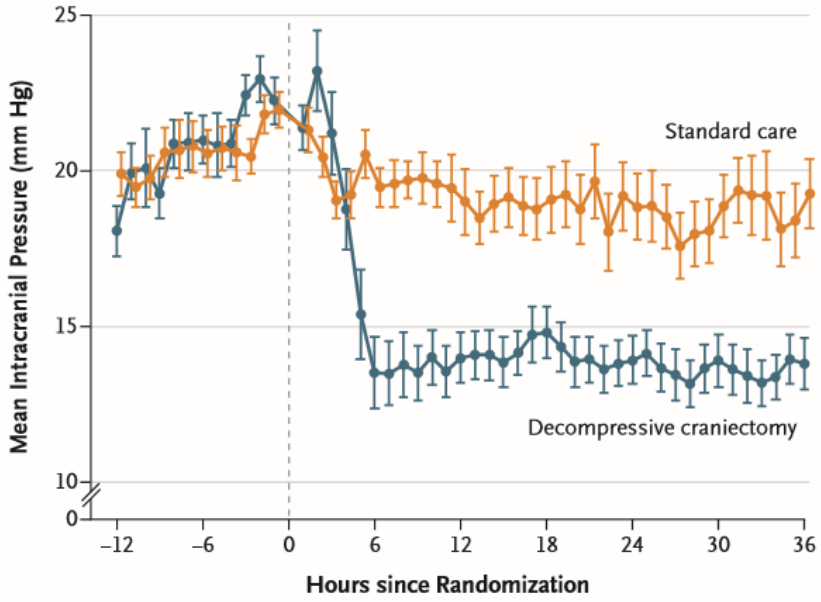


Figure 1. Intracranial Pressure before and after Randomization.
Shown are the mean measurements of intracranial pressure in the two study groups during the 12 hours before and the 36 hours after randomization. The I bars indicate standard errors.

Table 2. Primary and Secondary Outcomes.*

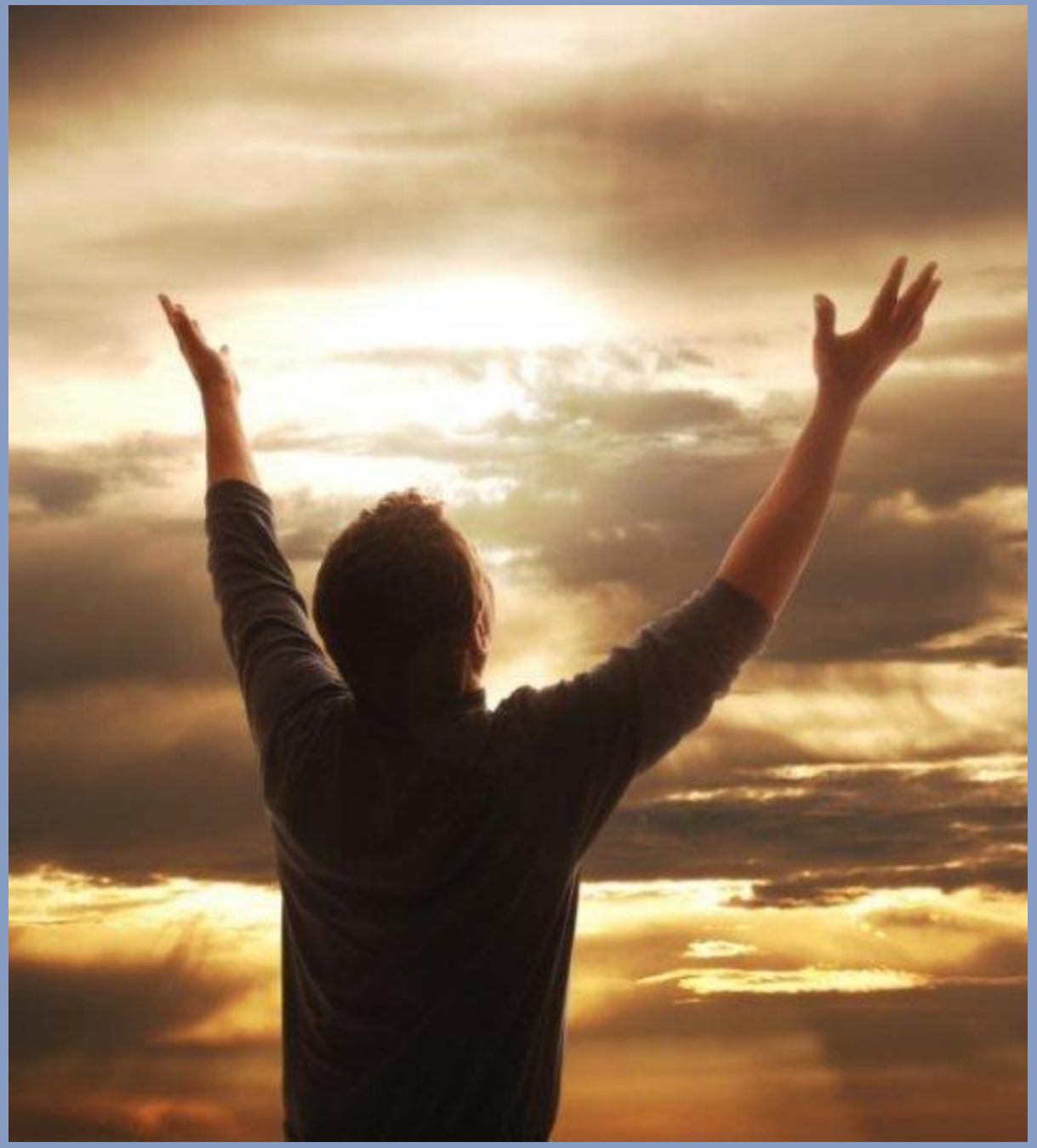
Outcome	Decompressive Craniectomy (N=73)	Standard Care (N=82)	P Value†
Extended Glasgow Outcome Scale			
Score — no. (%)			
1 (dead)	14 (19)	15 (18)	
2 (vegetative state)	9 (12)	2 (2)	
3 (lower severe disability)	18 (25)	17 (21)	
4 (upper severe disability)	10 (14)	8 (10)	
5 (lower moderate disability)	13 (18)	20 (24)	
6 (upper moderate disability)	6 (8)	13 (16)	
7 (lower good recovery)	2 (3)	4 (5)	
8 (upper good recovery)	1 (1)	3 (4)	
Median score (IQR)	3 (2–5)	4 (3–5)	0.03
Unfavorable score of 1 to 4 — no. (%)	51 (70)	42 (51)	0.02

DECRA: Criticisms

1. More severe primary TBI sustained in pts of the DC arm

2. ICP treatment threshold of >20mmHg for >15´ not reflective of clinical practice

3. High crossover rate from the standard care to the DC group



Why should result with DC be worse?

1. Exacerbation of oedema locally by the DC
2. Impairment of venous drainage at border of craniectomy
3. Expansion of brain tissue (and the stretch involved) actually injurious
4. Inability to correct locally altered tissue metabolism

Enhancement of Experimental Cerebral Edema after Decompressive Craniectomy: Implications for the Management of Severe Head Injuries

Paul R. Cooper, M.D., Herbert Hagler, Ph.D., W. Kemp Clark, M.D., and Peggy Barnett

Division of Neurosurgery and Department of Pathology, University of Texas, Southwestern Medical School, Dallas, Texas

10 dogs given standard cryo injury (4mm probe at -110^{o}C applied to the dura for 3') and then randomised to ipsilateral craniectomy or control surgical procedure…….8h later, animals euthenased and oedema assessed

TABLE 2

Volume of Evans Blue Staining Measured in Control and Craniectomized Dogs

Dog No.	Volume of Evans Blue Staining (ml)
Control animals	
8	0.53
11	0.40
13	0.11
15	0.09
17	0.21
Mean ± SD	0.27 ± 0.19
Craniectomized animals	
12	0.43
14	0.58
16	5.12
19	1.68
20	1.98
Mean ± SD	1.96 ± 1.89

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Mild Axonal Stretch Injury *In Vitro* Induces a Progressive Series of Neurofilament Alterations Ultimately Leading to Delayed Axotomy

JOURNAL OF NEUROTRAUMA
Volume 22, Number 10, 2005

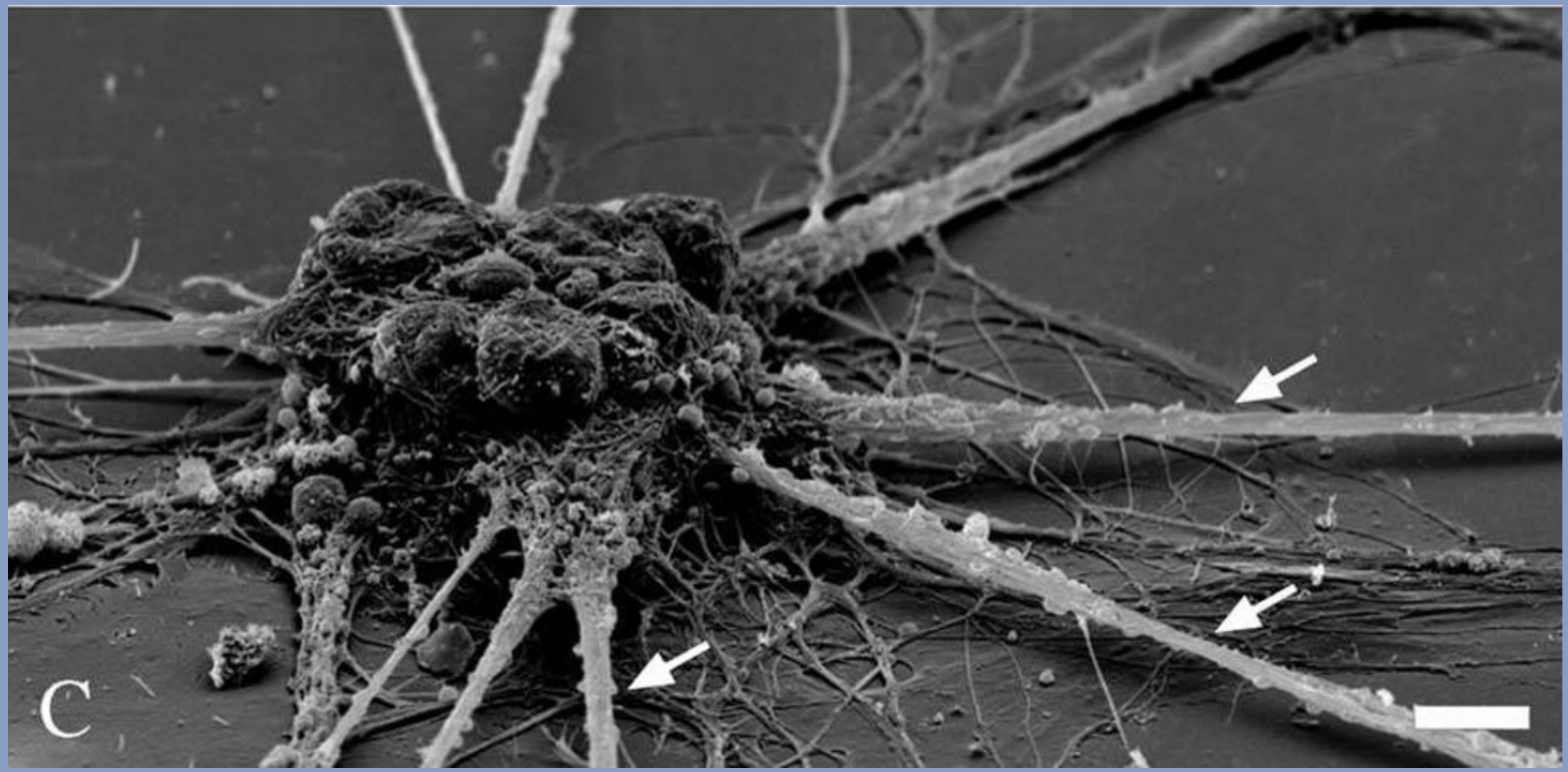

FIG. 1. Neuronal cultures at 21 days *in vitro* had formed large clusters, interconnected by fasciculated bundles of axons

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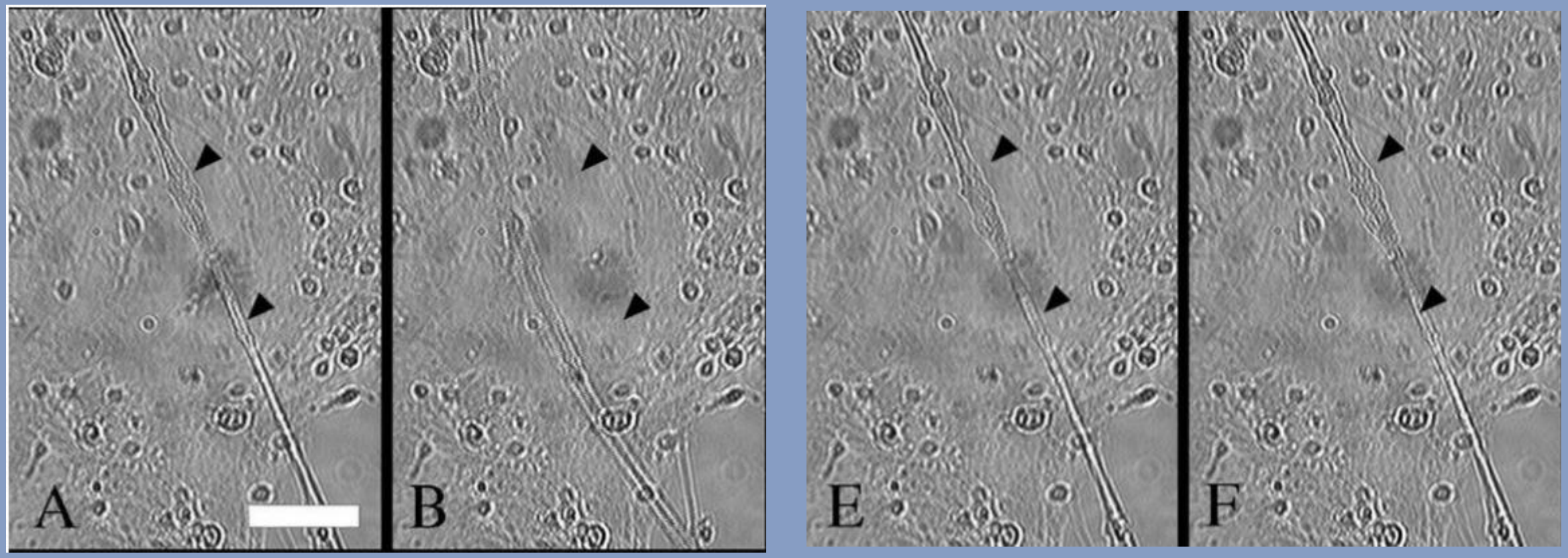

FIG. 2. An individual bundle of axons was targeted with a single blast of sterile air, and the resultant deflection was captured

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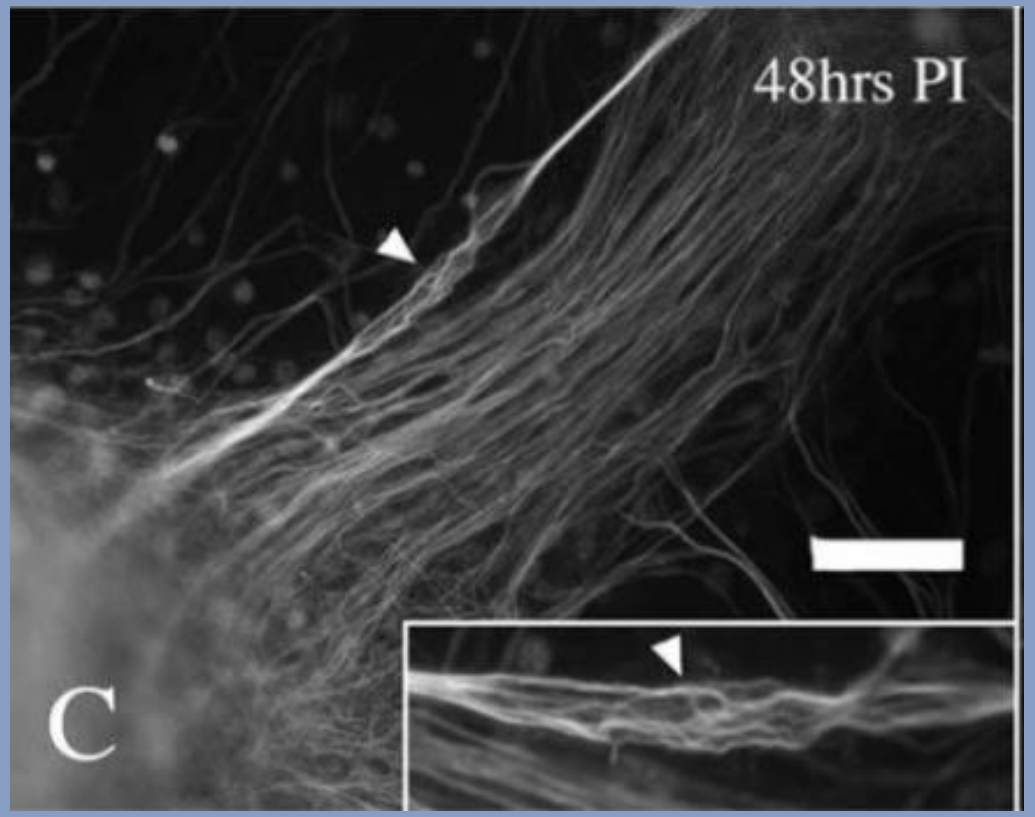

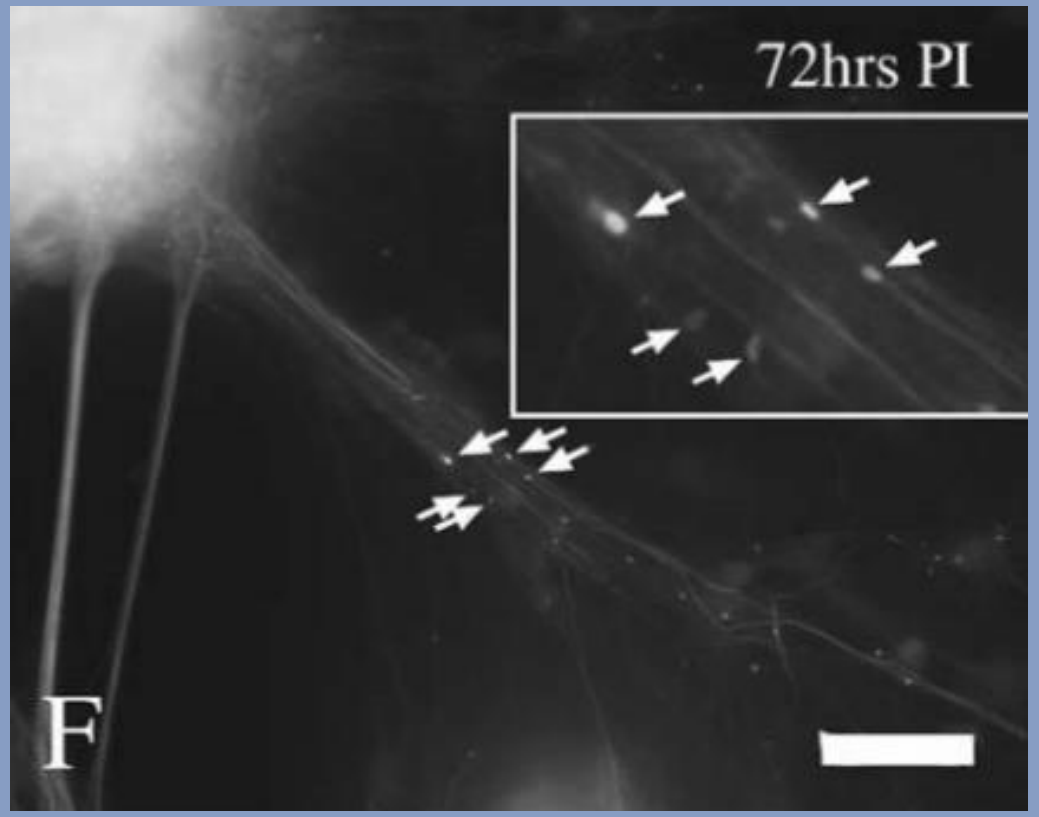

Mild Axonal Stretch Injury *In Vitro* Induces a Progressive Series of Neurofilament Alterations Ultimately Leading to Delayed Axotomy

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TABLE 2. INCREASED NEUROFILAMENT IMMUNOREACTIVITY

Strain level	*24 h PI*	*48 h PI*	*72 h PI*
100–103%	0.5%	66%	26%
103–106%	8%	83%	8%
106%+	28%	33%	6%

TABLE 4. RING-LIKE NEUROFILAMENT IMMUNOREACTIVE STRUCTURES

Strain level	*24 h PI*	*48 h PI*	*72 h PI*
100–103%	0.5%	8%	78%
103–106%	0.5%	16%	12%
106%+	2%	2%	1%

Hemodynamic and metabolic effects of decompressive left hemicraniectomy in normal brain
An experimental PET-study in cats

Brain Research 982 (2003) 31–37

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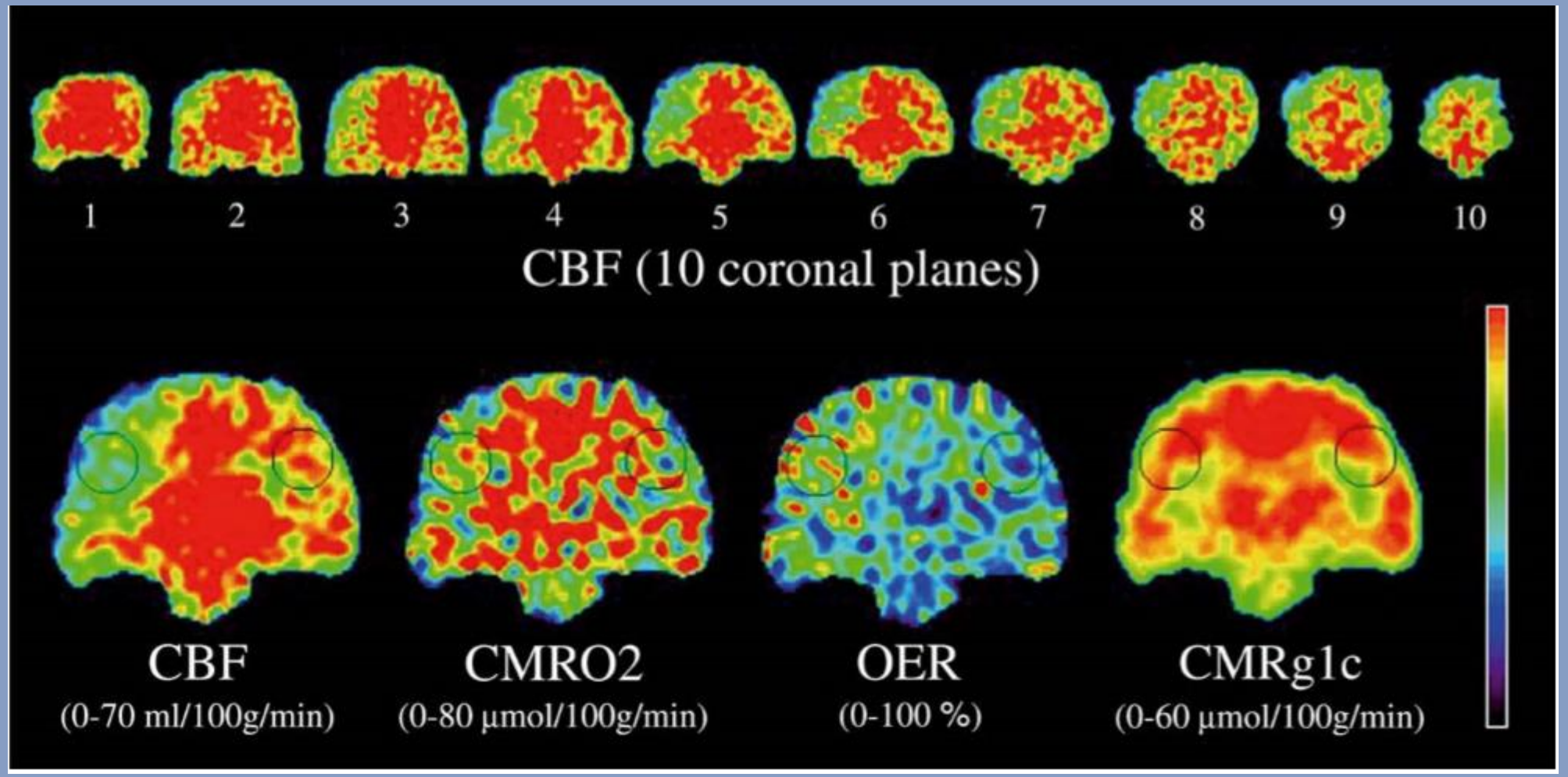

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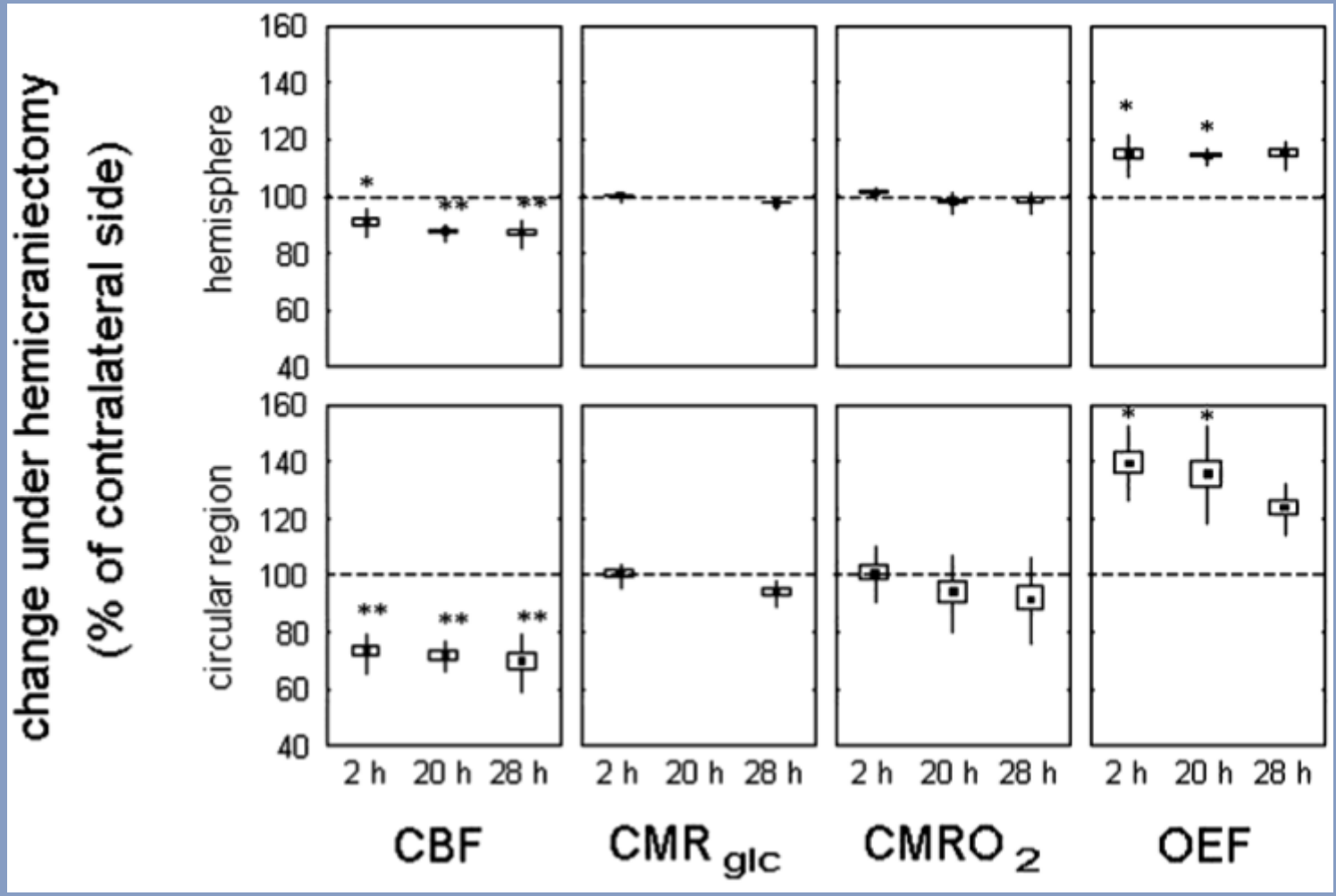
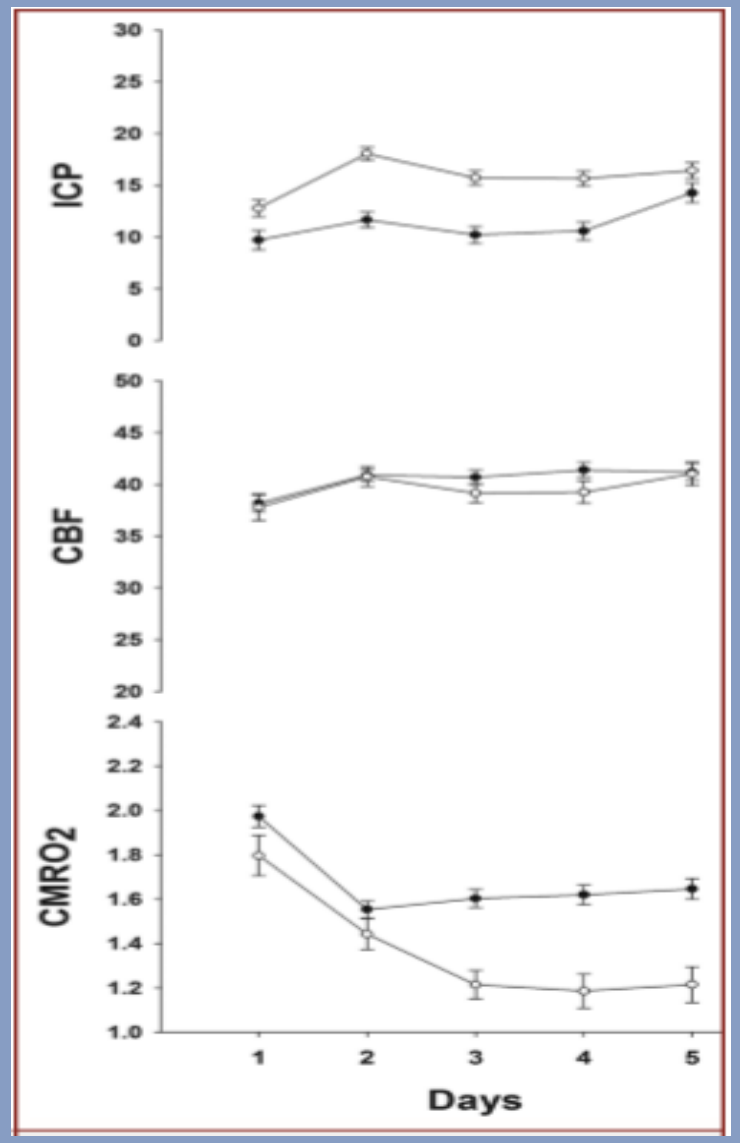


Cerebral Blood Flow and Metabolism Following Decompressive Craniectomy for Control of Increased Intracranial Pressure

Neurosurgery 67:65-72, 2010

- 122 adults with severe TBI, 1/3 were treated with DC
- DC patients had higher peak ICPs and worse CT changes but no difference in admission GCS, pupillary changes, other injuries , CMR or CBF at baseline



CONCLUSION: “These results suggest that DC may enhance survival in the presence of severe brain swelling although it is unlikely to represent an adequate answer to mitochondrial damage responsible for cellular energy crisis and oedema”

Complications – DC post TBI

Haemorhagic

- New ipsilateral haemorrhage 12%
- Haemorhagic progression of contusion 12%

Infectious / inflammatory

- Necrosis of flap, subgaleal and skin wound infections 8%
- Abscess / empyema 5%
- Meningitis / ventriculitis 6%

CSF flow probs

- Subdural hygroma 27%
- Hydrocephalus 16%
- CSF leak 7%

Browne DA et al, *Handbook of Clin Neurology*, 2017, Chap 16

A randomized trial of very early decompressive craniectomy in children with traumatic brain injury and sustained intracranial hypertension

Child's Nerv Syst (2001) 17:154–162

- 27 children over 12mo of age admitted RCH Melb between 1991-98 who had sustained ICP elevation during initial 24h after admission
- Definition: ICP 20-24mmHg for 30', 25-29mmHg for 10', ≥ 30mmHg for 1' or a clinical picture of herniation
- Randomised ("by the Zelen method") to DC OR standard ongoing care
- DC: removal of a bitemporal 3-4cm diam disc of bone with no durotomy (performed at a median of 17h after admission (range 6-27h))
- Outcomes
  - Impact on ICP
  - GOS at 6mo

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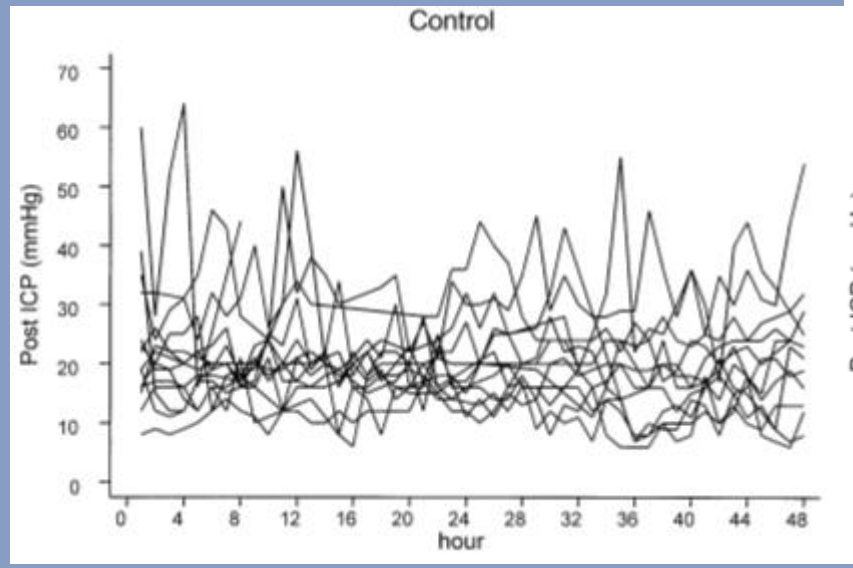

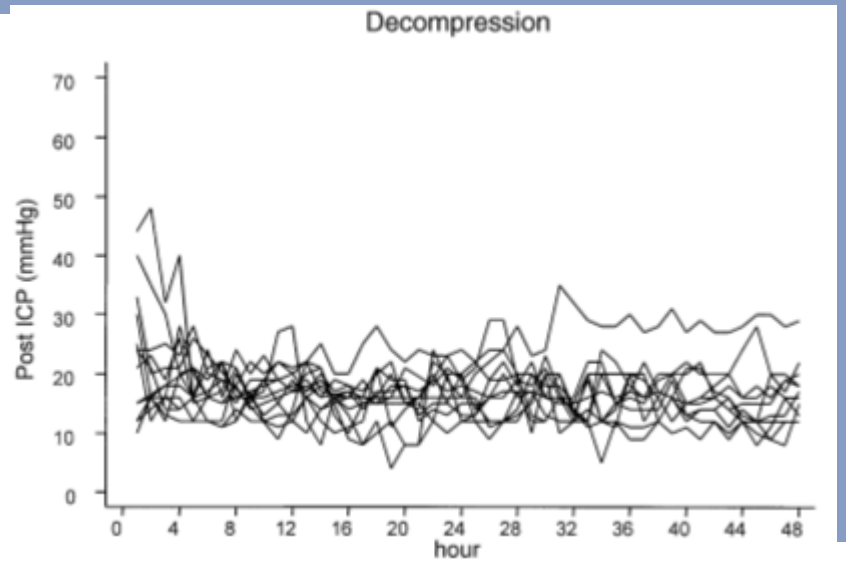

Compared with the ICP before randomization, the mean ICP was 3.69 mmHg lower in the 48 h after randomization in the control group, and 8.98 mmHg lower in the 48 hours after craniectomy in the decompression group (P=0.057).

	Control (n=14)	Decompression (n=13)
ICP (mmHg) mean	21.9 (SD 8.5)	17.4 (SD 3.4)
Range (mmHg)	11–44	11–25
ICP >20 mmHg Number of episodes	223	107
ICP >30 mmHg Number of episodes	59	9

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Table 2 Outcome 6 months after injury

	Control (n=14)	Decompression (n=13)
Glasgow Outcome Score		
Favourable	2	7
Unfavourable	12	6
Health State Utility Index		
Favourable	1	6
Unfavourable	13	7

P=.046 , p req for stat sig , .022

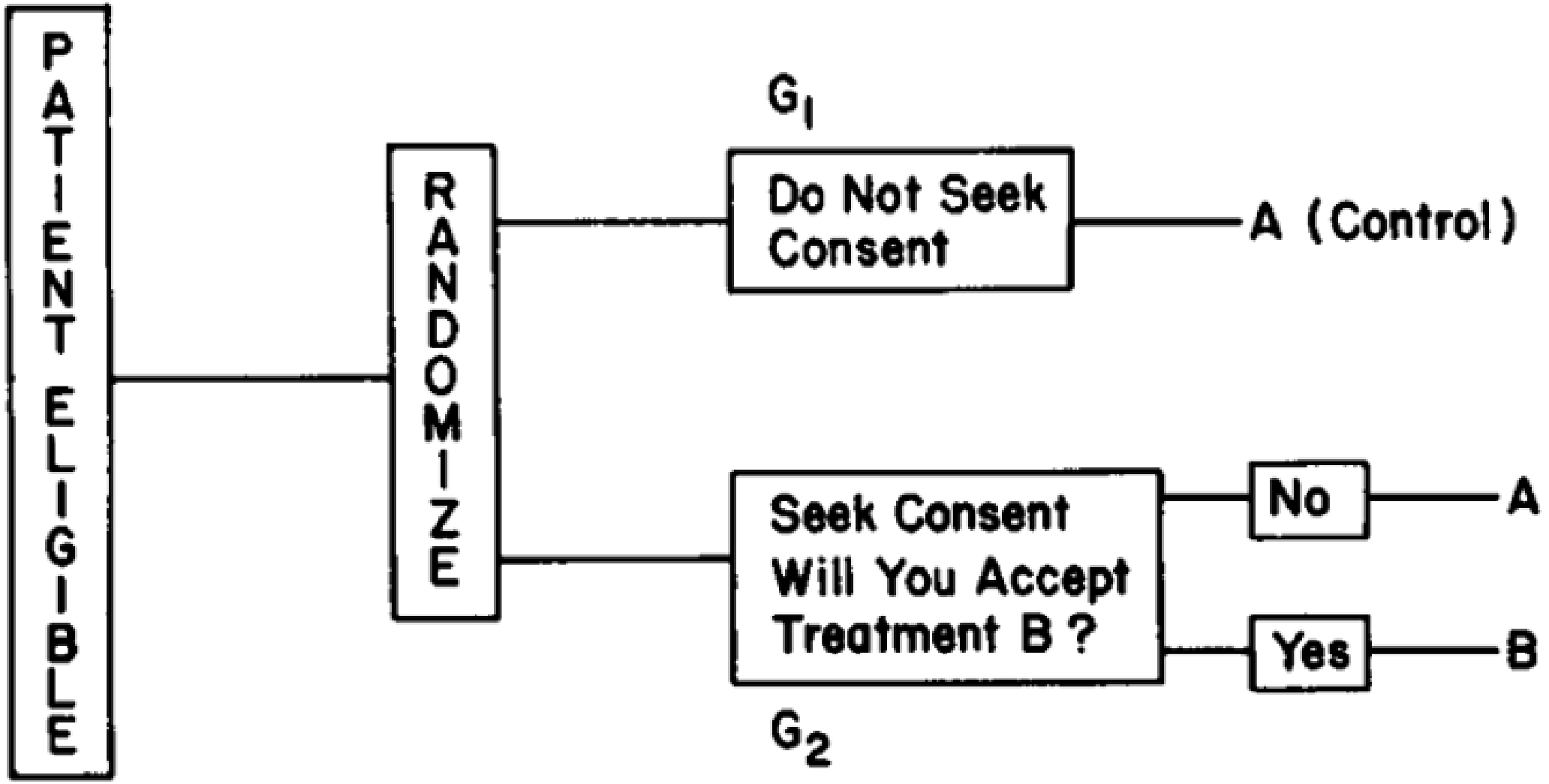

Figure 3. New Design — Patient Is Asked If New Treatment Is Acceptable after Both Options Are Discussed.

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Child's Nerv Syst (2001) 17:154–162

CPP Targets

Years	1-4y	5-8y	9-12y	>12y
91-93	>50	>50	>50	>50
93-96	>35	>40	>45	>50
97-98	>50	>60	>70	>70

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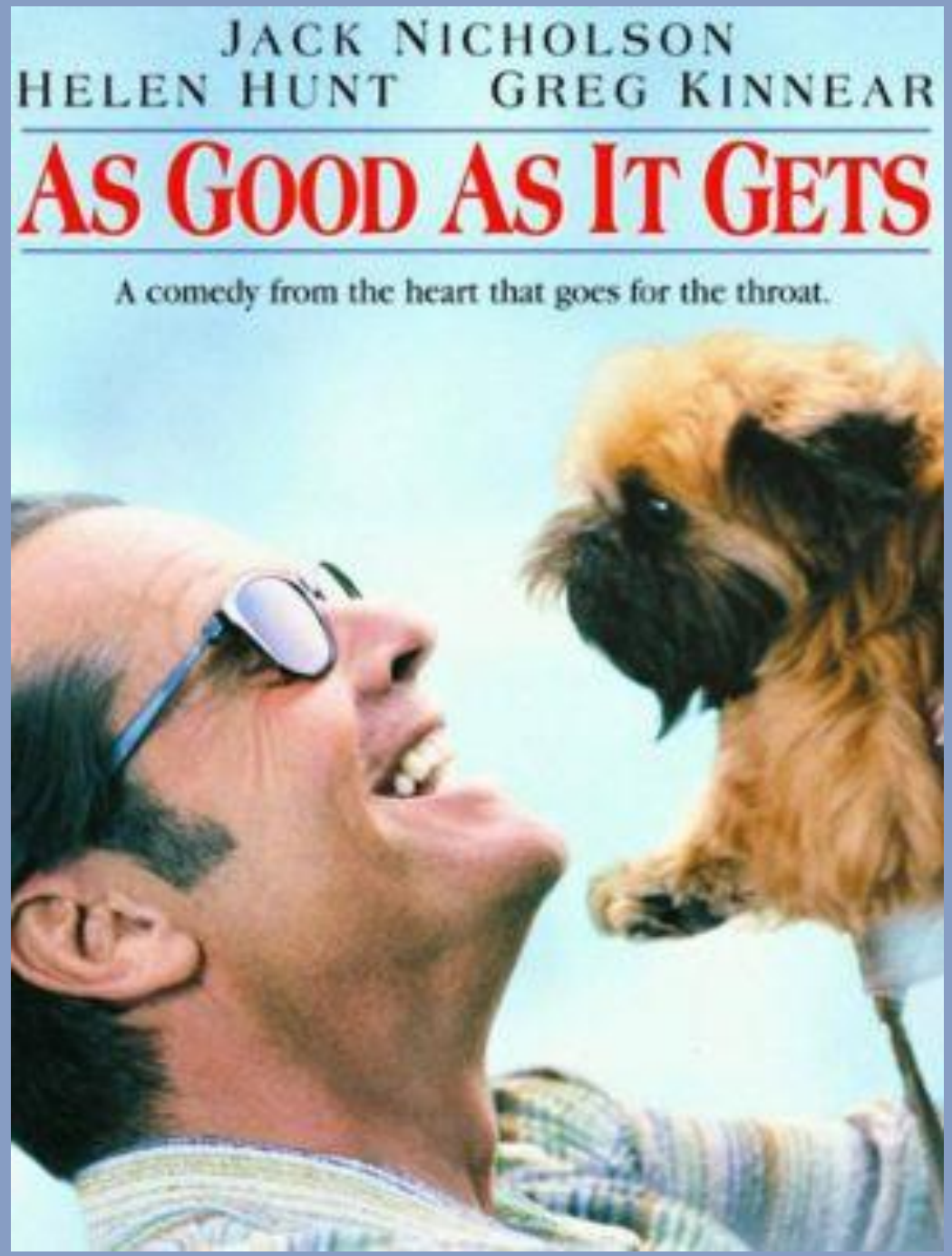
Problems

1. Method of randomisation (necessary for low numbers)
2. Mx targets, specifically CPP, changed 3 times during course of study
3. Dura not opened
4. ICP fall not statistically significant


JACK NICHOLSON
HELEN HUNT
GREG KINNEAR
AS GOOD AS IT GETS
A comedy from the heart that goes for the throat.

Author	Year	N	Op	Follow-up	Outcome
Ruf, Giesen	2003	6	Wide unilat or bilat F/T/P + durotomy	6mo	Good outcome for all but details sketchy
Figaji, Capetown	2003	5	Wide unilat F/T/P + durotomy	14-42mo	GOS 4 or 5/5 for all though “some ongoing concerns”
Jagannathan, Virginia	2007	23	Bilateral frontal or uni F/T/P + durotomy	1-10y	GOS 4 or 5 in 13 of 16 long-term survivors though most “some resid deficit”
Adamo, Albany NY	2009	7	Unilat F/T/P + durotomy	1.5mo-2y	KOSCHI 3b or 4a, resolving hemi and ongoing carer dep
Perez Suarez, Madrid	2011	14	Wide bilat F/T/P + durotomy	2y	GOS in 12 survivors 4-5 (mean 4.5) but “behav, emot or school perf issues”

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Outcome following decompressive craniectomy in children with severe traumatic brain injury: a 10-year single-center experience with long-term follow up

J Neurosurg (4 Suppl Pediatrics) 106:268–275, 2007

- 23 children with severe TBI with ICP > 20
- CT findings primarily DAI (in 90%)
- DC: bilat frontal or unilateral F/T/P craniectomy plus durotomy (median 48h)

- ICP mean 30 pre-procedure ↓ to <20 in 19/23 patients
- Median 48h post trauma BUT 10/23 operations “done immediately”
- 1 intraop death, 5 postop deaths and 17 survivors with a mean GOS at 2y of 4.2/5 (though “most (10/16 or 62%) reported some residual deficit”)

- Conclusion: in view of favourable outcome (GOS 4 or 5) in 13/16 long term survivors that DC “should be considered useful as a salvage procedure for such patients”

So is that all?

Rescue ICP

Trial of Decompressive Craniectomy for Traumatic Intracranial Hypertension

N Engl J Med 2016;375:1119-30

Table 3. Analysis of Primary and Secondary Outcomes.*

Variable	Surgical Group (N = 202)	Medical Group (N = 196)	Absolute Difference (95% CI)† *percentage points*	P Value
GOS-E result — no./total no. (%)‡				<0.001
At 6 mo				
Death	54/201 (26.9)	92/188 (48.9)	–22.1 (–31.5 to –12.7)	
Vegetative state	17/201 (8.5)	4/188 (2.1)	6.3 (2.0 to 10.7)	
Lower severe disability	44/201 (21.9)	27/188 (14.4)	7.5 (–0.1 to 15.1)	
Upper severe disability	31/201 (15.4)	15/188 (8.0)	7.4 (1.1 to 13.8)	
Lower moderate disability	20/201 (10.0)	19/188 (10.1)	–0.1 (–6.1 to 5.8)	
Upper moderate disability	27/201 (13.4)	18/188 (9.6)	3.9 (–2.5 to 10.2)	
Lower good recovery	5/201 (2.5)	6/188 (3.2)	–0.7 (–4.0 to 2.6)	
Upper good recovery	3/201 (1.5)	7/188 (3.7)	–2.2 (–5.4 to 1.0)	

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The survival advantage of decompressive craniectomy in this trial was translated to both dependent and independent living.


YOU CANNOT BE SERIOUS!
made on imgur

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"….conventionally a favourable outcome equates to independence (ie should only include EGOS 1-4) and as such just like the DECRA Trial, the procedure in Rescue ICP increased disability and did not increase full independence in survivors"

Does early craniectomy in children with TBI improve outcome?

- Very weak evidence base in children: stronger in adults but still controversial
- Little strong physiologic proof of concept
- Significant procedural risk
- The answer is NO

Thank You

Does early craniectomy in children with TBI improve outcome?

- **It is what it is** ……..and I don't think there will be any more big trials
- Probably does reduce ICP and make it easier to control
- Shortens ICU LOS and complexity of care
- Probably does increase survival
- Potential for survival with increased morbidity and dependence significant
- Probably reasonable as a salvage measure for paed neurotrauma with refractory ICP provided

  No contraindication

  Family informed of potential for dependent outcome

  Window not lost to assess at earliest time for ischaemic injury (clinical, EEG, MRI) and consider palliation.