Current concepts on Neurotrauma and Neurocritical care

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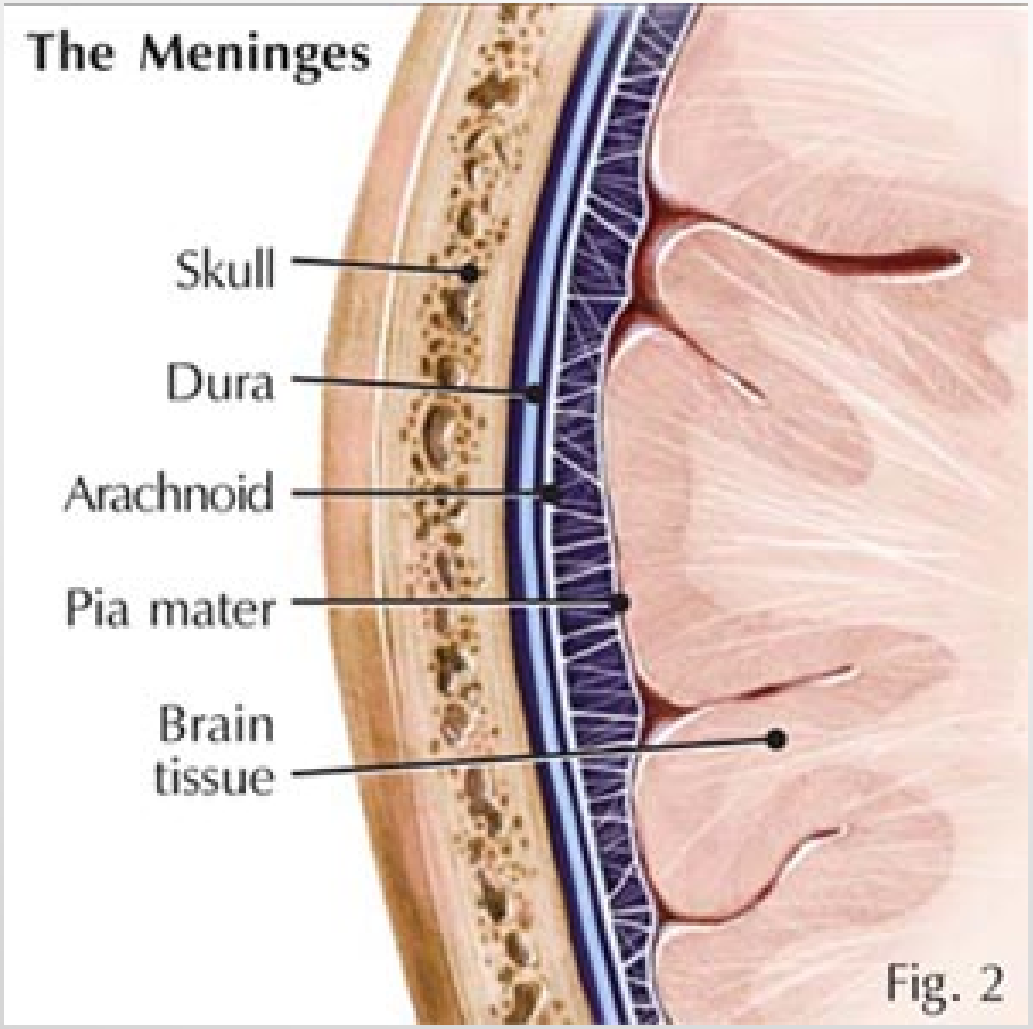
Objectives

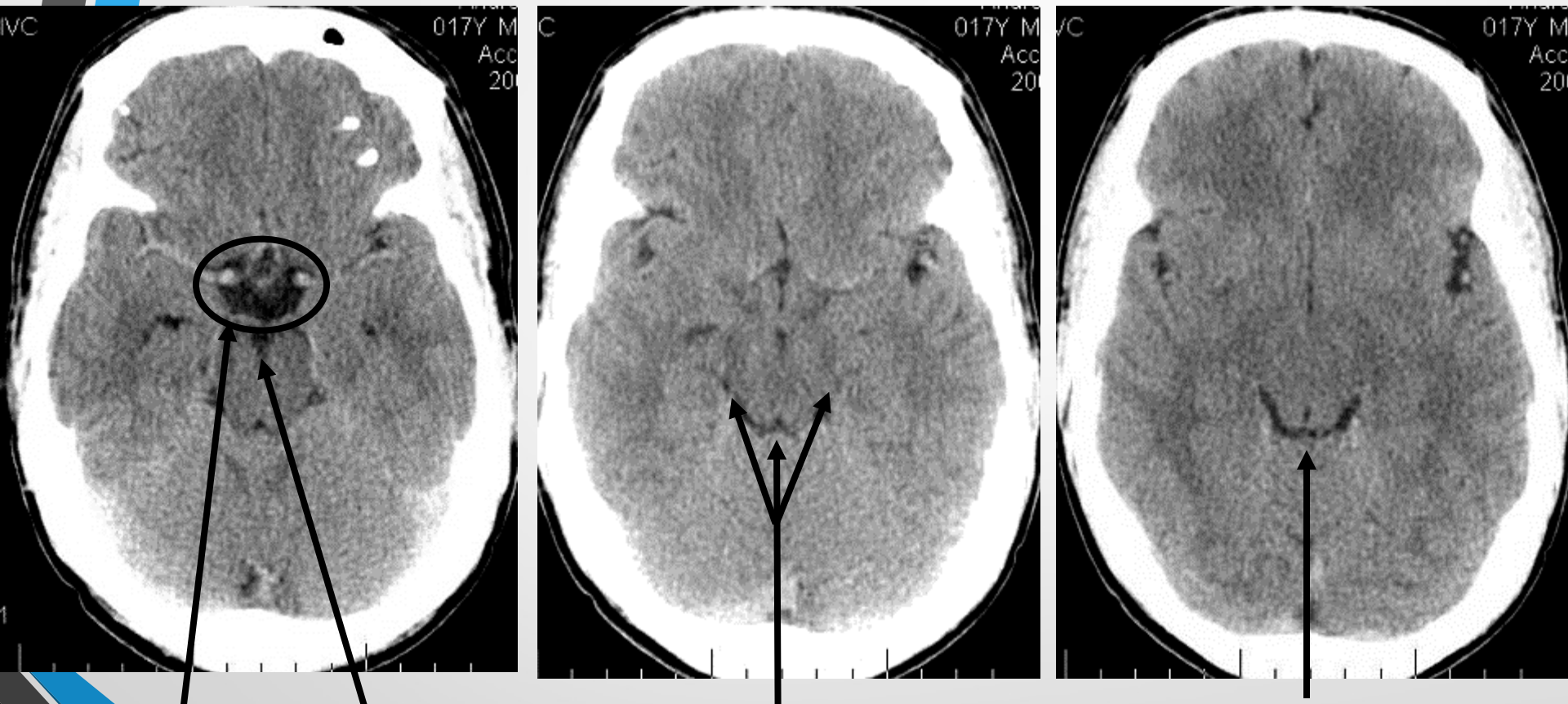
- Should be able to recognize the CT features of intracranial hematoma
- Understand the physiology of TBI
- Understanding the principles of ICP monitoring
- Understand the management cascade for TBI

Normal Anatomy

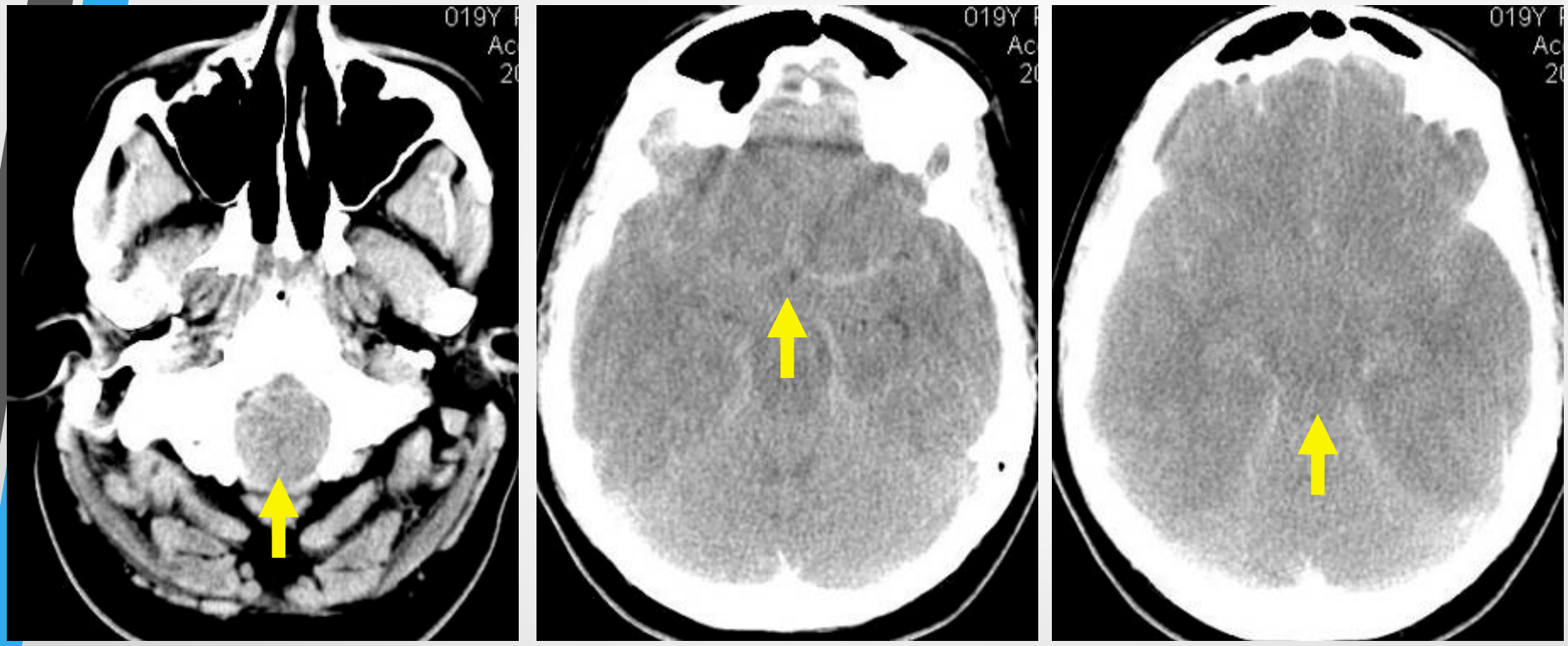


Traumatic Brain Swelling

Know your basal cisterns!



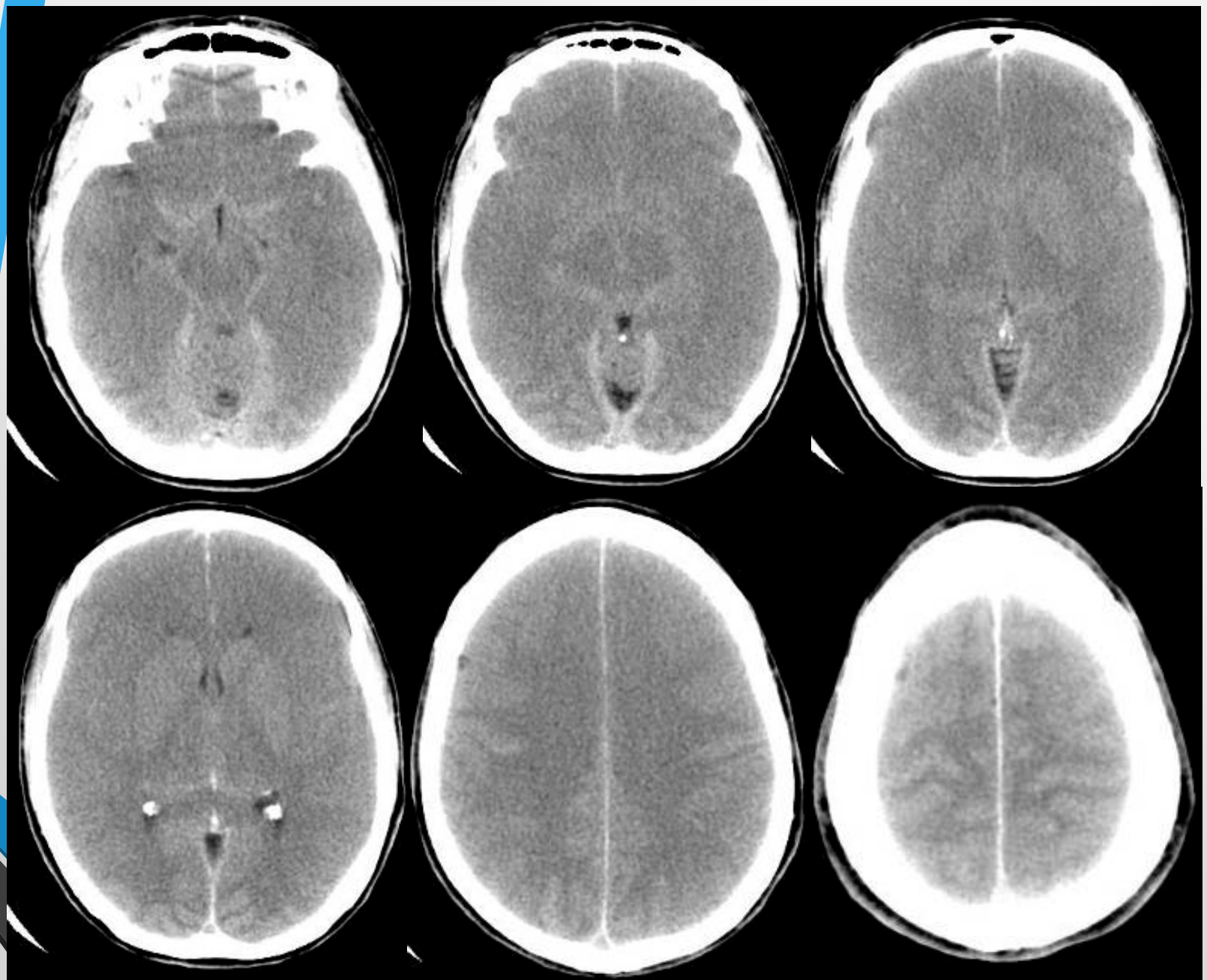
Traumatic Brain Swelling



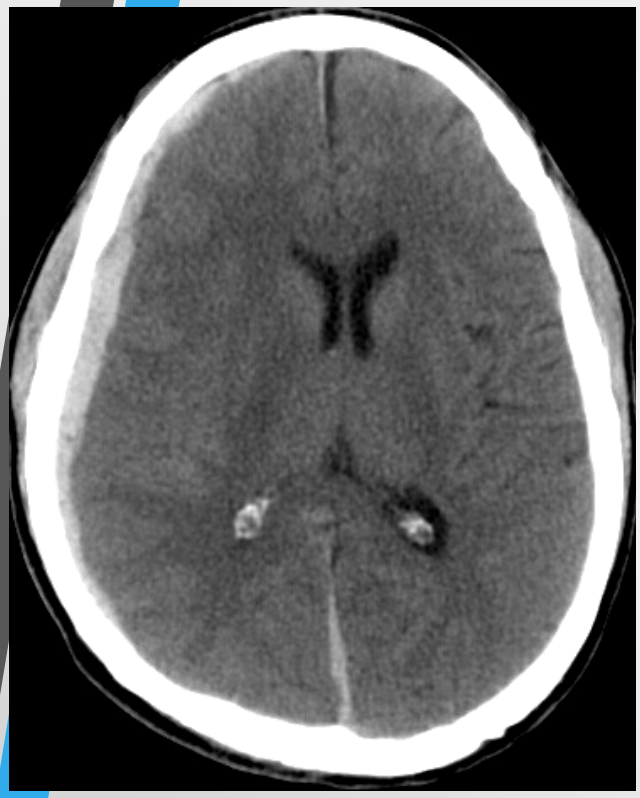
Effacement of basal cisterns

Traumatic brain swelling with herniation

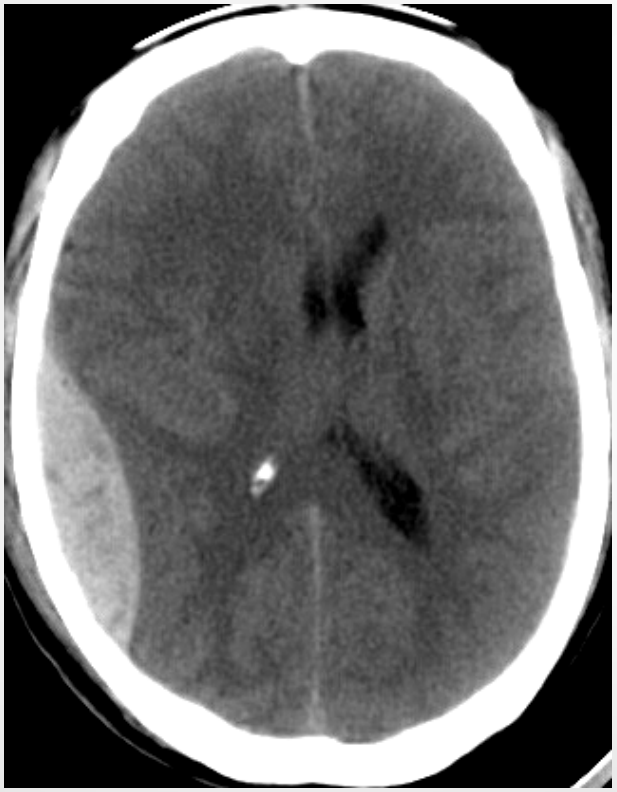
Diffuse cerebral edema



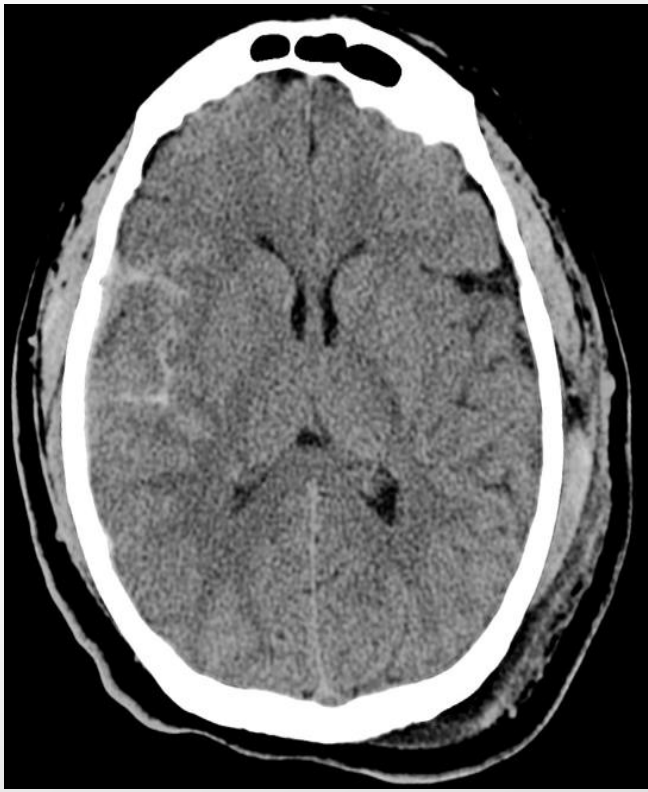
Extra-axial Hemorrhage



Subdural



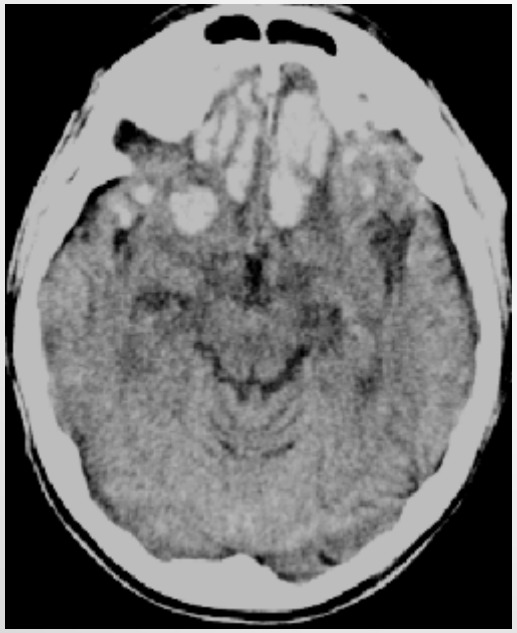
Epidural

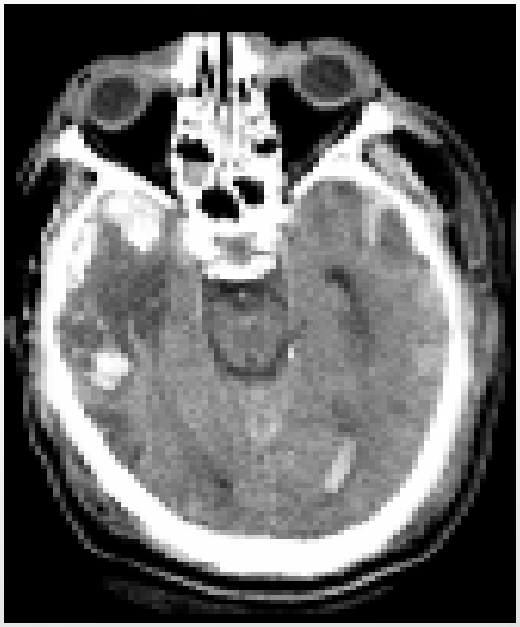


Subarachnoid

Intra-axial Hemorrhage

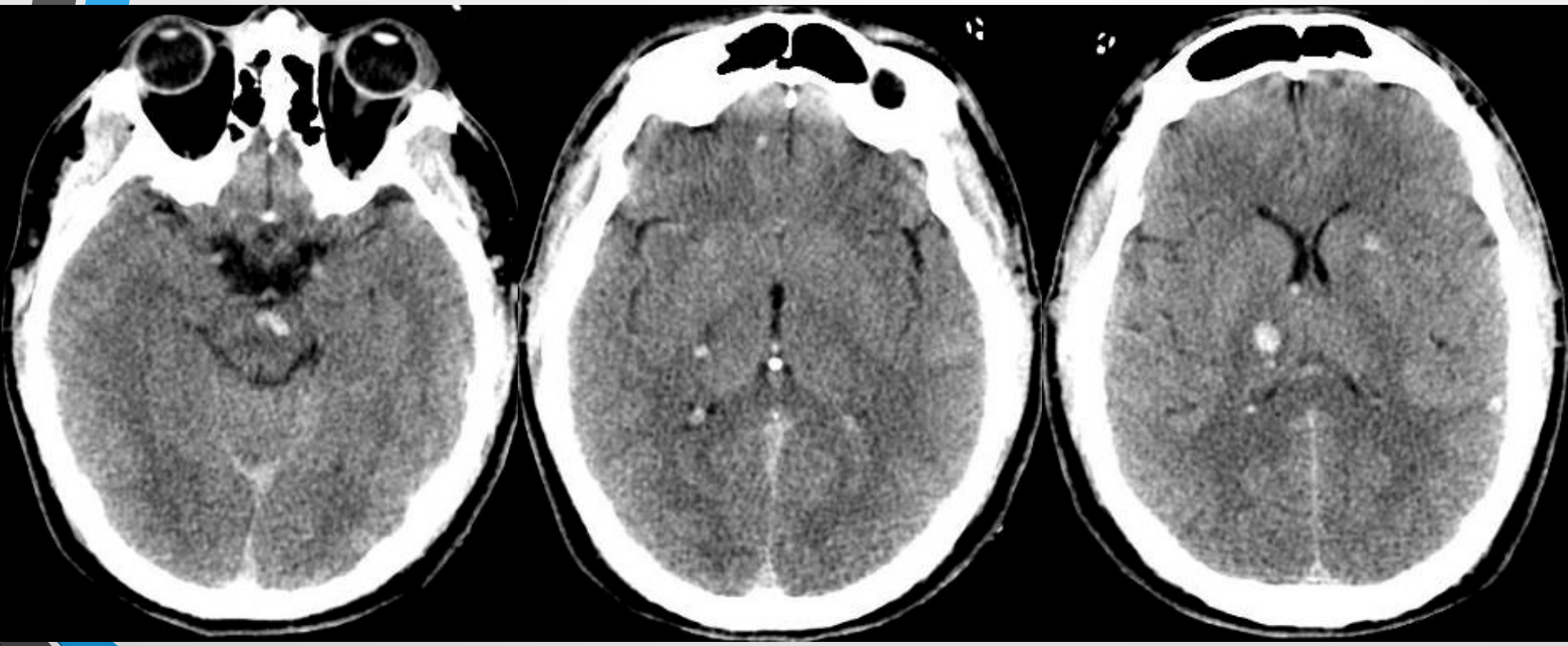
Hemorrhagic contusions



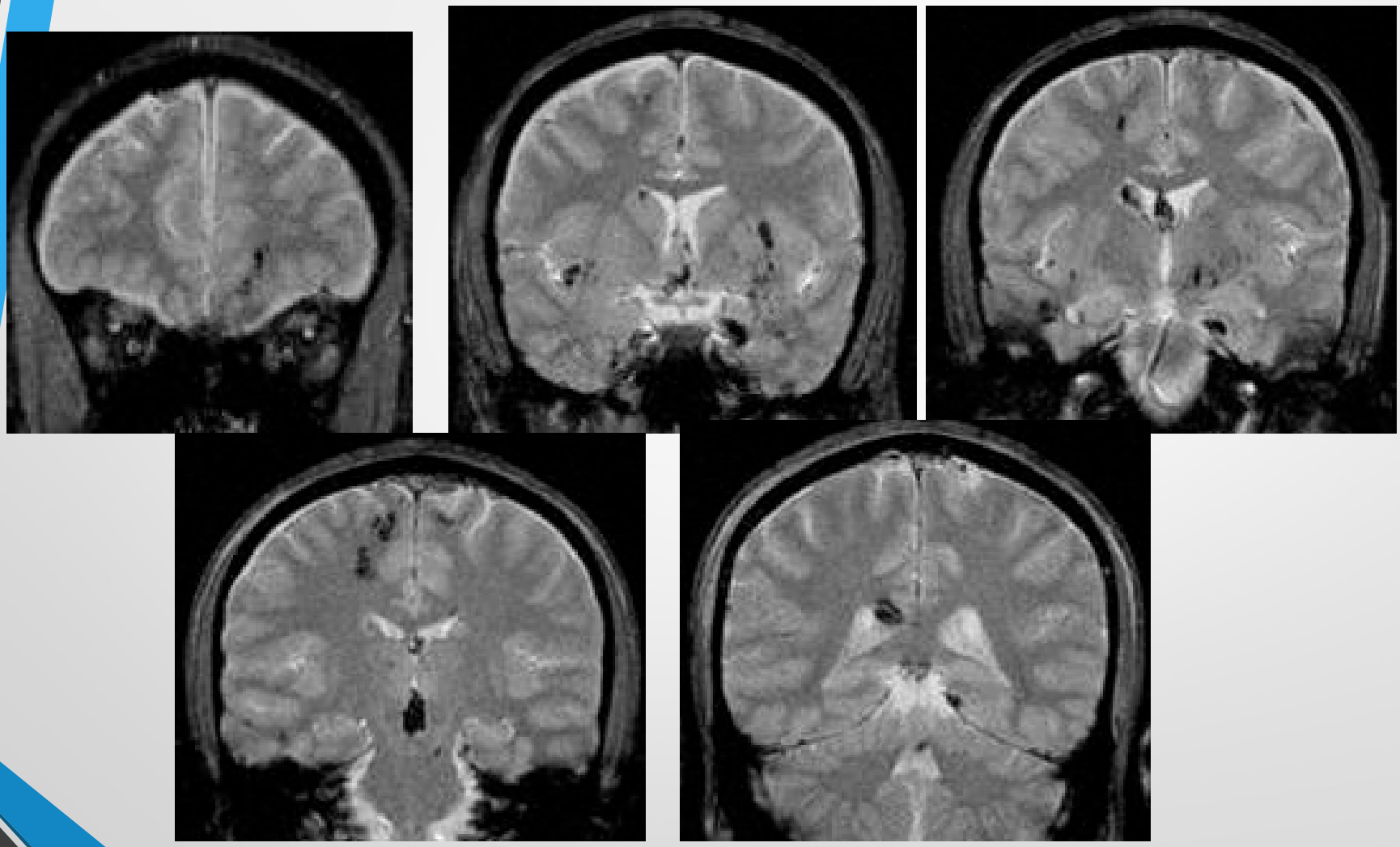


Intra-axial Hemorrhage

Diffuse Axonal Injury (DAI)



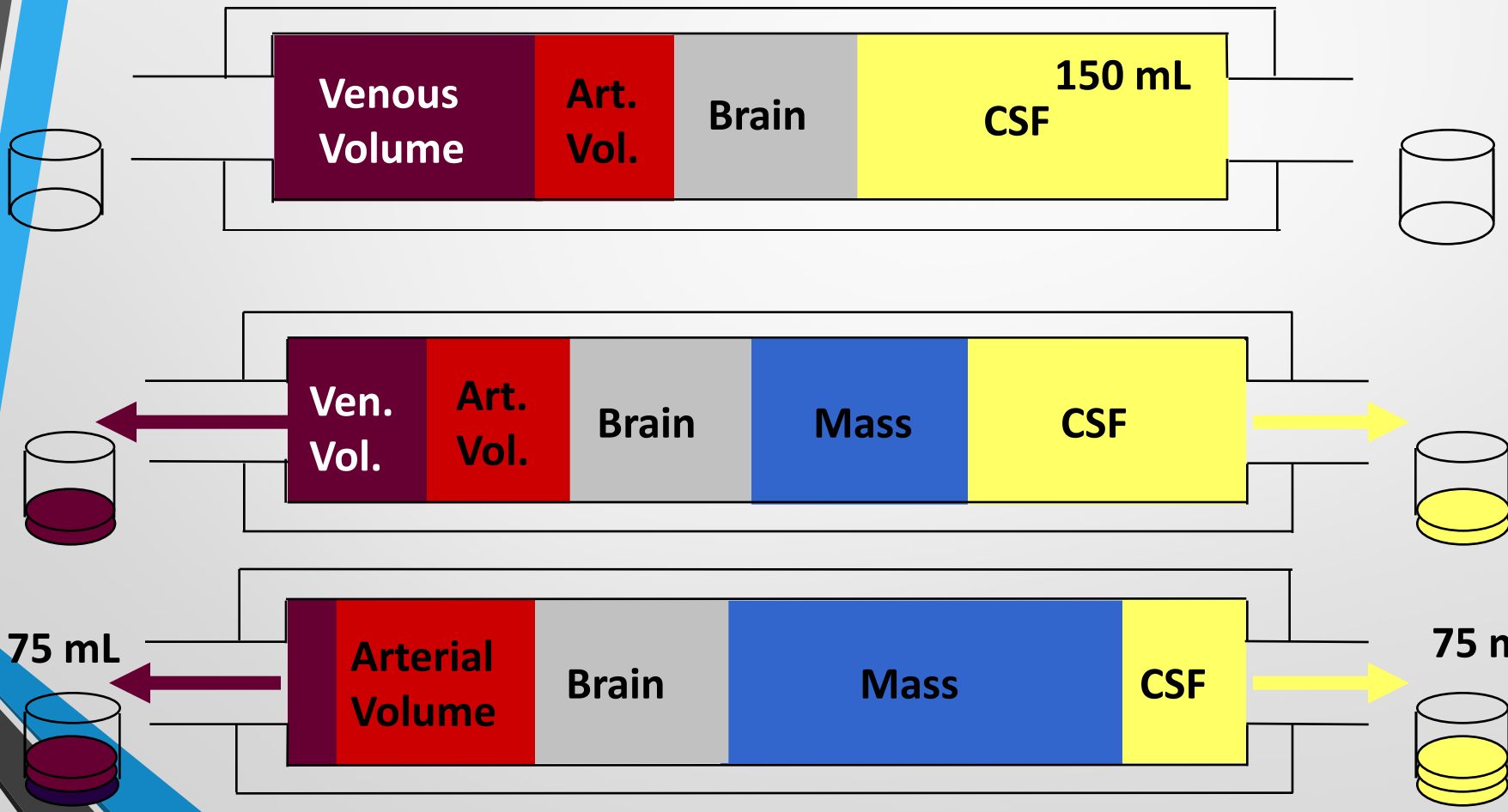
Diffuse Axonal Injury (DAI)



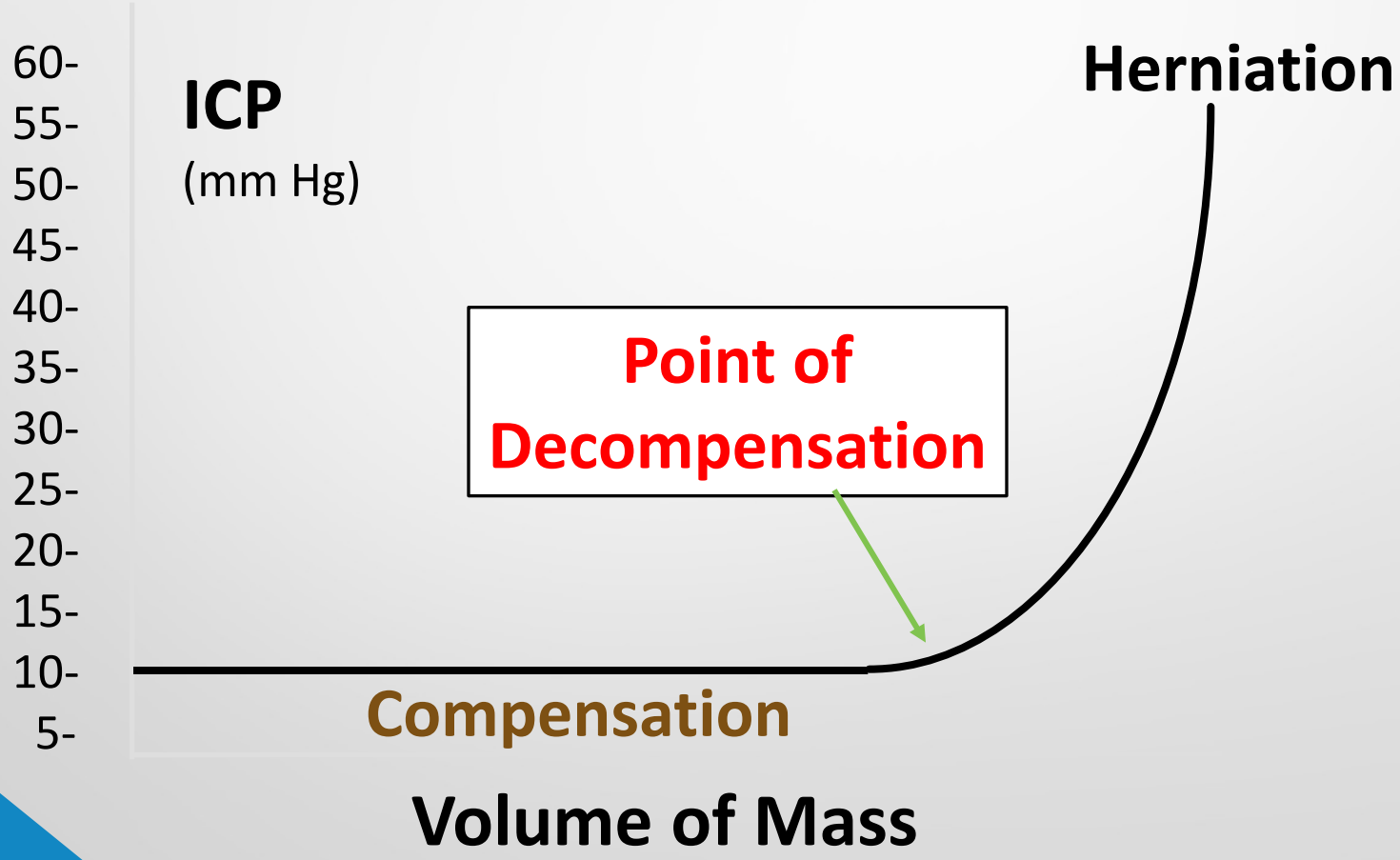
T2*: Increased sensitivity to hemorrhage

Physiology and Management of TBI

Monro-Kellie Doctrine



Volume – Pressure Curve



Intracranial Pressure (ICP)

- 10 - 15 mm Hg = Normal
- **> 22 mm Hg = Poor neurological outcome**
- Sustained ↑ ICP leads to ↓ brain function and outcome

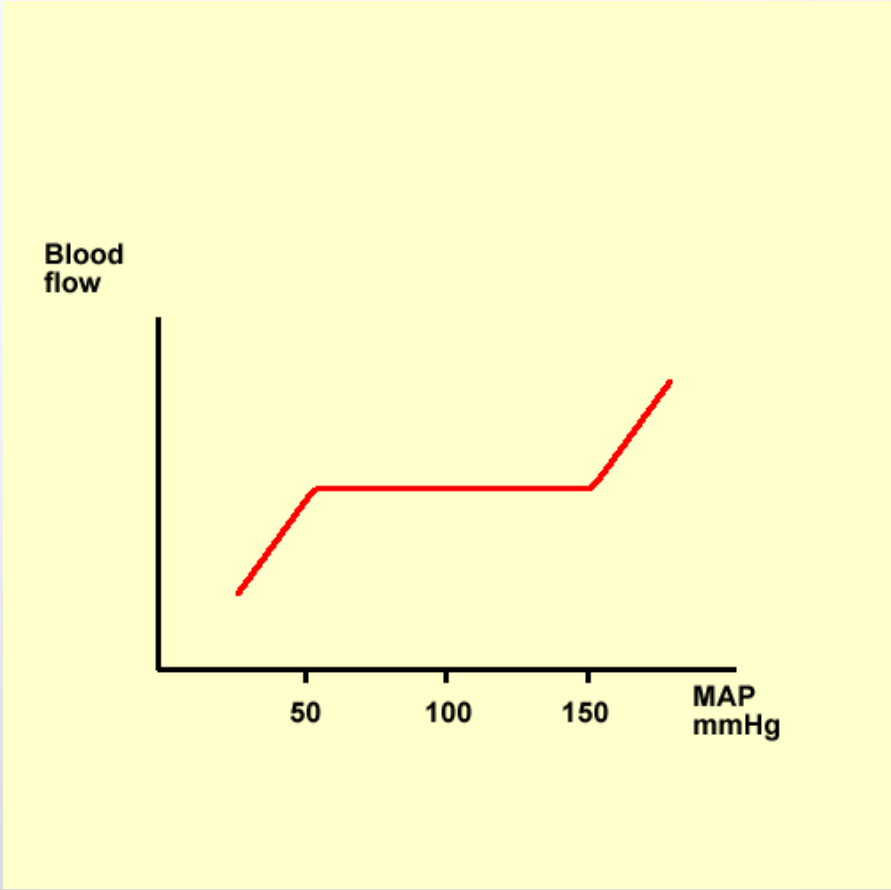
Cerebral Perfusion Pressure

	MAP − ICP = CPP		
Normal	90	10	80
Cushing's Response	100	20	80
Hypotension	50	20	30

CPP: Keep 50mmHg to 70mmHg

Impaired Autoregulation

- Autoregulation often impaired with significant brain injury
- **Secondary brain insult**



CO_2 reactivity

- Decrease in $PaCO_2$ causes cerebral vasoconstriction
- Decrease 3% CBF per mmHg drop of $PaCO_2$
- **Most rapid and effective in rapidly lowering ICP**
- **However prolonged hyperventilation → cerebral ischemia → harmful!**

Injury Severity: Glasgow Coma Score (GCS)

Motor

6- Follows commands

5- Localizes to pain

4- Withdraws to pain

3- Flexion

2- Extension

1- No movement

Verbal

5- Oriented

4- Confused

3- Inappropriate

2- Incomprehensible

1- None

Eyes

4- Opens spontaneously

3- Opens to voice

2- Opens to pain

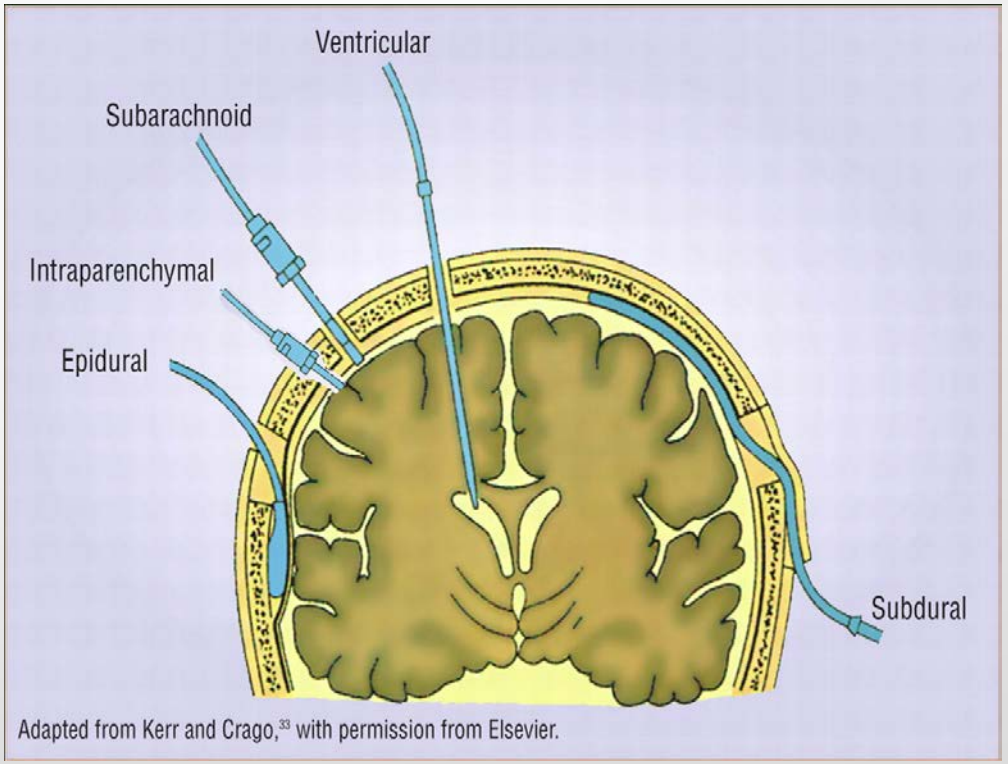
1- None

Teasdale et al. Lancet, 1976

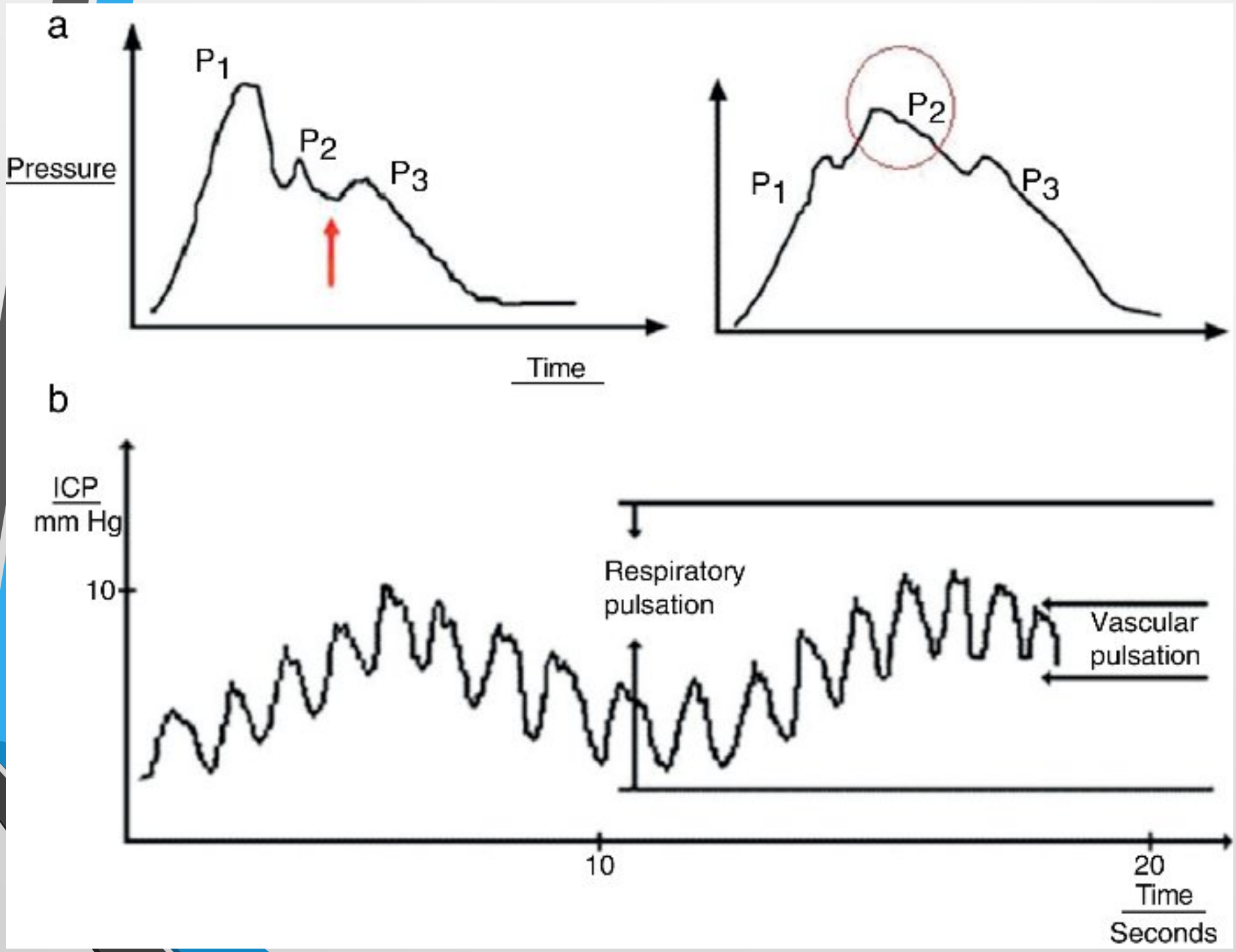
ICP Monitoring – when?

- GCS <8
- CT scan with pathology
  - ICH
  - Swelling
  - Herniation
- Normal CT scan
  - Age >40
  - Posturing
  - Sys BP <90 mmHg

  (Narayan 1982)



Adapted from Kerr and Crago,[33] with permission from Elsevier.


a
P1
P2
P3
Pressure
Time
P1
P2
P3
b
ICP
mm Hg
10
Respiratory
pulsation
Vascular
pulsation
10
20
Time
Seconds

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A Trial of Intracranial-Pressure Monitoring in Traumatic Brain Injury

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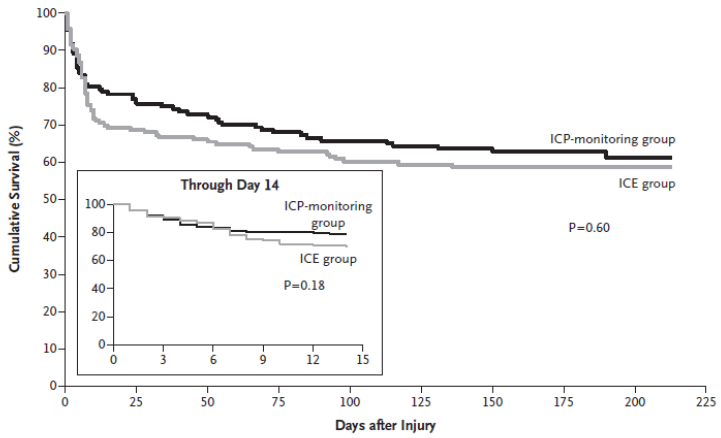


Figure 1. Cumulative Survival Rate According to Study Group.

A Kaplan–Meier survival plot based on the prespecified analysis shows the cumulative survival rate at 6 months among patients assigned to imaging and clinical examination (ICE) as compared with those assigned to intracranial-pressure (ICP) monitoring (hazard ratio for death, 1.10; 95% confidence interval [CI], 0.77 to 1.57). The inset shows the results of the post hoc analysis at 14 days (hazard ratio, 1.36; 95% CI, 0.87 to 2.11).

BACKGROUND

Intracranial-pressure monitoring is considered the standard of care for severe traumatic brain injury and is used frequently, but the efficacy of treatment based on monitoring in improving the outcome has not been rigorously assessed.

METHODS

We conducted a multicenter, controlled trial in which 324 patients 13 years of age or older who had severe traumatic brain injury and were being treated in intensive care units (ICUs) in Bolivia or Ecuador were randomly assigned to one of two specific protocols: guidelines-based management in which a protocol for monitoring intraparenchymal intracranial pressure was used (pressure-monitoring group) or a protocol in which treatment was based on imaging and clinical examination (imaging–clinical examination group). The primary outcome was a composite of survival time, impaired consciousness, and functional status at 3 months and 6 months and neuropsychological status at 6 months; neuropsychological status was assessed by an examiner who was unaware of protocol assignment. This composite measure was based on performance across 21 measures of functional and cognitive status and calculated as a percentile (with 0 indicating the worst performance, and 100 the best performance).

RESULTS

There was no significant between-group difference in the primary outcome, a composite measure based on percentile performance across 21 measures of functional and cognitive status (score, 56 in the pressure-monitoring group vs. 53 in the imaging–clinical examination group; P=0.49). Six-month mortality was 39% in the pressure-monitoring group and 41% in the imaging–clinical examination group (P=0.60). The median length of stay in the ICU was similar in the two groups (12 days in the pressure-monitoring group and 9 days in the imaging–clinical examination group; P=0.25), although the number of days of brain-specific treatments (e.g., administration of hyperosmolar fluids and the use of hyperventilation) in the ICU was higher in the imaging–clinical examination group than in the pressure-monitoring group (4.8 vs. 3.4, P=0.002). The distribution of serious adverse events was similar in the two groups.

CONCLUSIONS

For patients with severe traumatic brain injury, care focused on maintaining monitored intracranial pressure at 20 mm Hg or less was not shown to be superior to care based on imaging and clinical examination. (Funded by the National Institutes of Health and others; ClinicalTrials.gov number, NCT01068522.)

Table 3. (Continued.)

Variable	Pressure-Monitoring Group (N=157)	Imaging–Clinical Examination Group (N=167)	P Value†	Proportional Odds Ratio (95% CI)‡
Post hoc comparisons¶				
Integrated brain-specific treatment intensity			<0.001	2.36 (1.60–3.47)
Median	69	125		
Interquartile range	13–181	45–233		

How to manage TBI?
Management

- **<u>Prevent secondary brain damage</u>**
- Immediate
  - “Time is brain”
- Intensive care / Acute Care
  - Monitors
  - ICP and CPP
  - Brain oxygenation, metabolites
  - Management
- Rehabilitation

ICP <=22 mmHg

CPP: 50 - 70mmHg

Immediate

- Manage Resuscitation: A B C
- Prevent secondary damage
  - Anoxia
  - Hypotension
- 25% Increased Mortality
  - Individually
- 75% Increased Mortality
  - Combined

ICP Management

- Step 1
  - Head up 30 degrees, avoid neck veins kinking
  - AVOID hyperthermia, hypo/hypertension, hypoxia, hypercapnia (high CO2)
- Step 2
  - CSF drainage
  - Sedation (Dormicum) and muscle relaxant
  - Hyperosmolar therapy (Mannitol, HS)
  - CT brain to r/o SOL
- Step 3
  - Decompressive craniectomy
  - Induced coma (propofol / barbiturates)

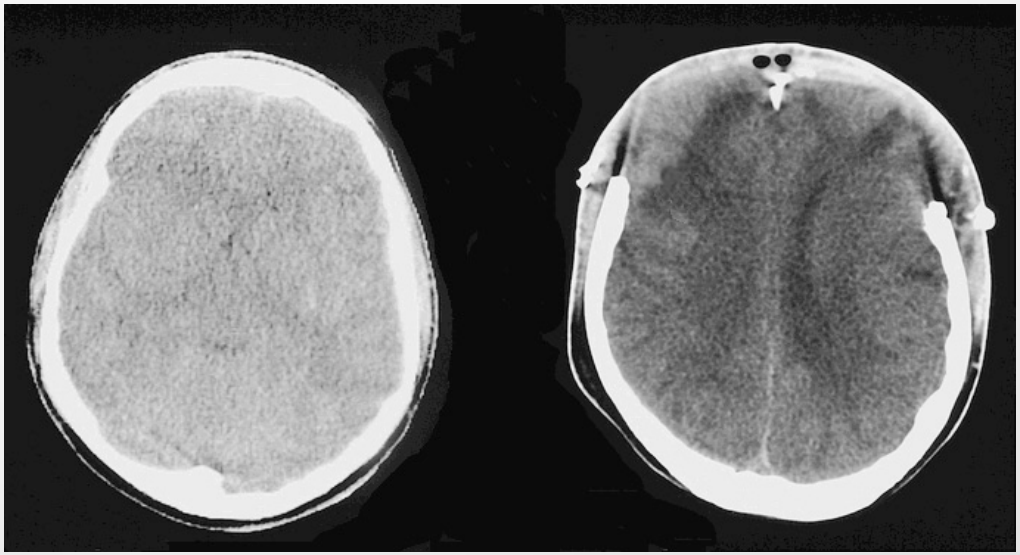
Hyperosmolar Therapy

- Hyperosmolar Therapy
  - Mannitol
  - Hypertonic Saline
- Criteria:
  - Refractory high ICP
  - Na 145-155, Osm 320-330
  - Repeat CT without surgically treatable lesion

Decompressive Craniectomy

- Indications: elevated ICP refractory to medical management

- Abolishing the Monro Kellie Doctrine



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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*

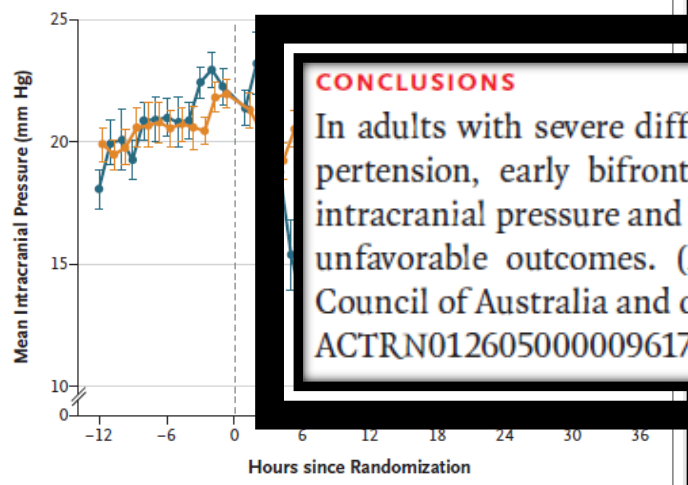


Figure 1. Intracranial Pressure before and after Randomization.
Shown are the mean measurements of intracranial pressure in the two study groups during the 12 hours before and the 36 hours after randomization. The I bars indicate standard errors.

CONCLUSIONS

In adults with severe diffuse traumatic brain injury and refractory intracranial hypertension, early bifrontotemporoparietal decompressive craniectomy decreased intracranial pressure and the length of stay in the ICU but was associated with more unfavorable outcomes. (Funded by the National Health and Medical Research Council of Australia and others; DECRA Australian Clinical Trials Registry number, ACTRN012605000009617.)

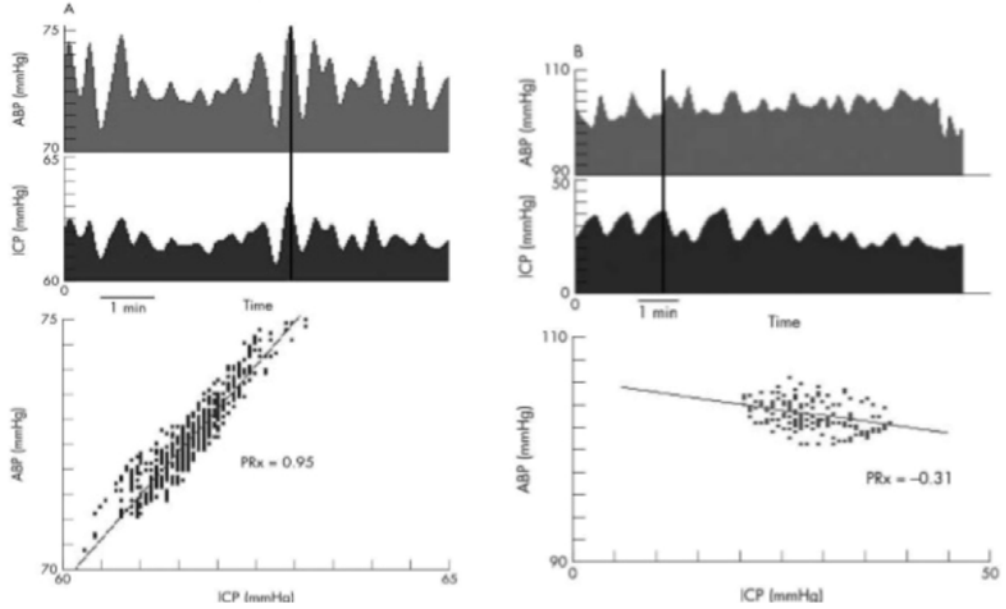
Table 2. Primary and Secondary Outcomes.*

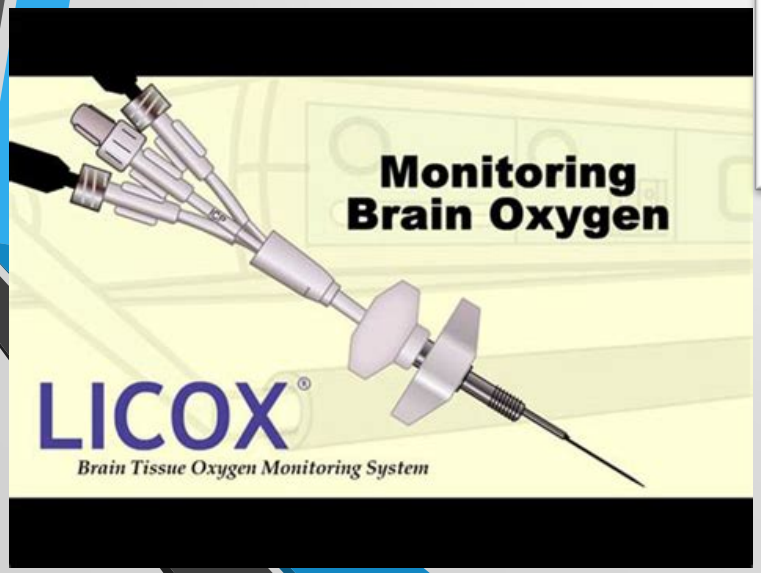
	Decompressive	Standard Care (N=82)	P Value†
		15 (18)	
		2 (2)	
		17 (21)	
		8 (10)	
5 (lower moderate disability)	13 (18)	20 (24)	
6 (upper moderate disability)	6 (8)	13 (16)	
7 (lower good recovery)	2 (3)	4 (5)	
8 (upper good recovery)	1 (1)	3 (4)	
Median score (IQR)	3 (2–5)	4 (3–5)	0.03
Unfavorable score of 1 to 4 — no. (%)	51 (70)	42 (51)	0.02

Personalized TBI management

PRx

- Pressure Reactivity Index: Correlation coefficient between time averaged slow waves of ABP and ICP.





Brain Trauma FOUNDATION

Guidelines for the Management of Severe Traumatic Brain Injury

4th Edition

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Reviewed for evidence-based integrity and endorsed by the American Association of Neurological Surgeons and the Congress of Neurological Surgeons.

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