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Traumatic Brain Injury (TBI)

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Geisinger Holy Spirit

No disclosures

What is TBI?

- Disruption of normal brain **FUNCTION** caused by a bump, blow, or jolt to the head.
- Not all head injuries result in TBI.
- The severity of TBI may range from “mild” to “severe.”

Overview



- TBI is responsible for 30% of all injury related deaths.
- 153 people die from injuries which include TBI each day.
- TBI survivors face effects that last a few days or remainder of their lives.

How big is the problem?

(CDC 2013)

- 2.8 million TBI-related emergency room visits, hospitalizations, and deaths occurred in the United States.
- Between 2007 and 2013, while rates of TBI related ED visits increased by 47%, hospitalization rates decreased by 2.5% and mortality rates decreased by 5%

How big is the problem in Pennsylvania?

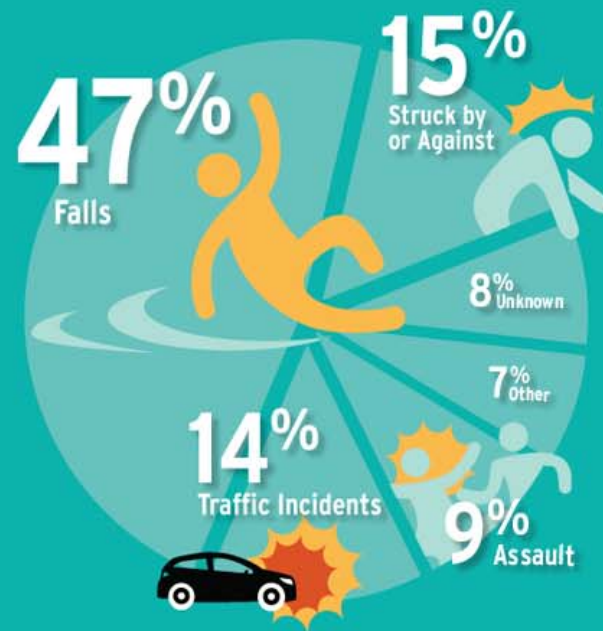
(Brain Injury Association of Pennsylvania)

- 245,621 people are **living with** TBI
- 2,223 **die from** brain injury annually
- 10,463 are **hospitalized** annually following TBI
- 49,505 are **seen in the ED** following TBI annually
- 25,975 Pennsylvanian **children** sustain brain injuries each year
- 8,612 Pennsylvanians each year **sustain life long disability** from TBI

Leading causes of TBI

(CDC 2013)

Leading Causes of Traumatic Brain Injury in the United States (2013)



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BRAIN TRAUMA

IMMEDIATE

Primary Damage

- Scalp laceration
- Skull fracture
- Cerebral contusions
- Cerebral lacerations
- Intracranial hemorrhage
- Diffuse axonal injury



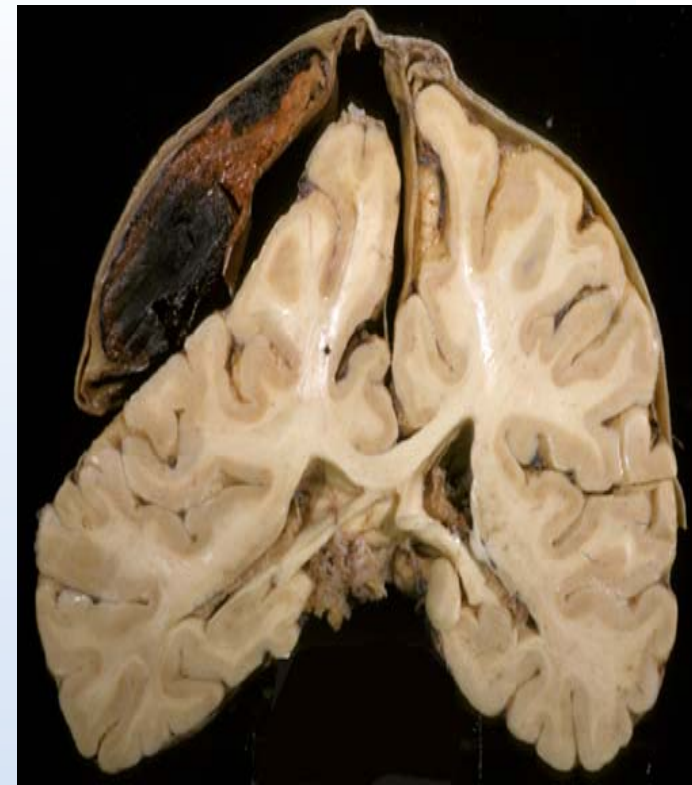
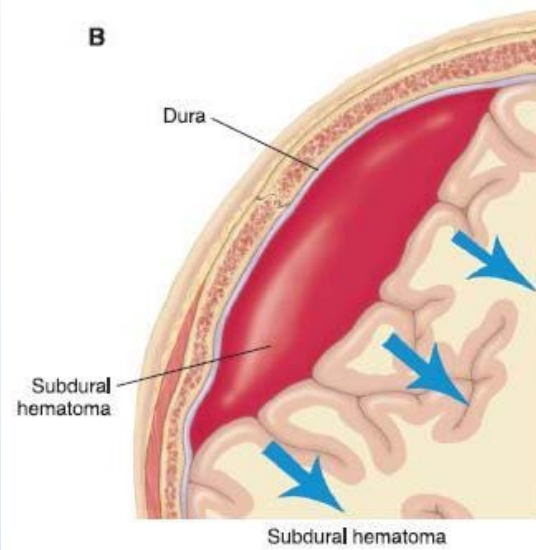
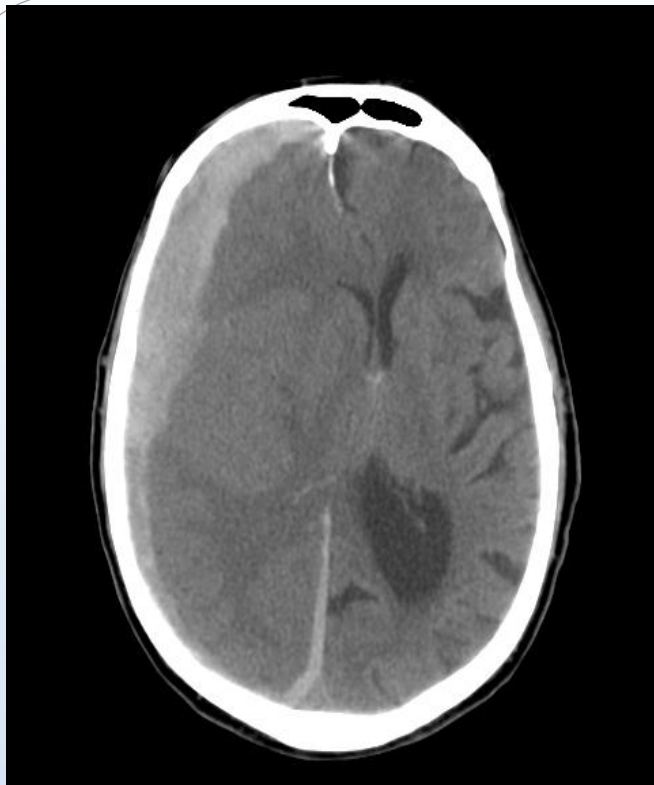
DELAYED

Secondary Damage

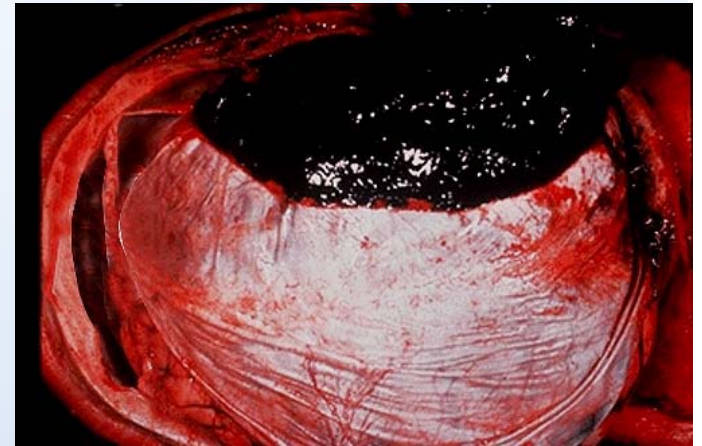
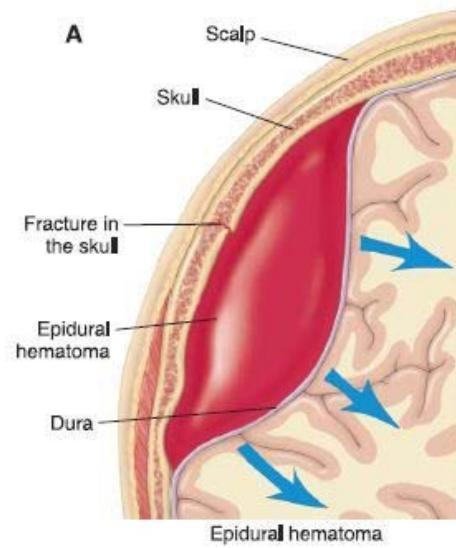
- Ischemia
- Hypoxia
- Cerebral swelling
- Infection

Primary Injury

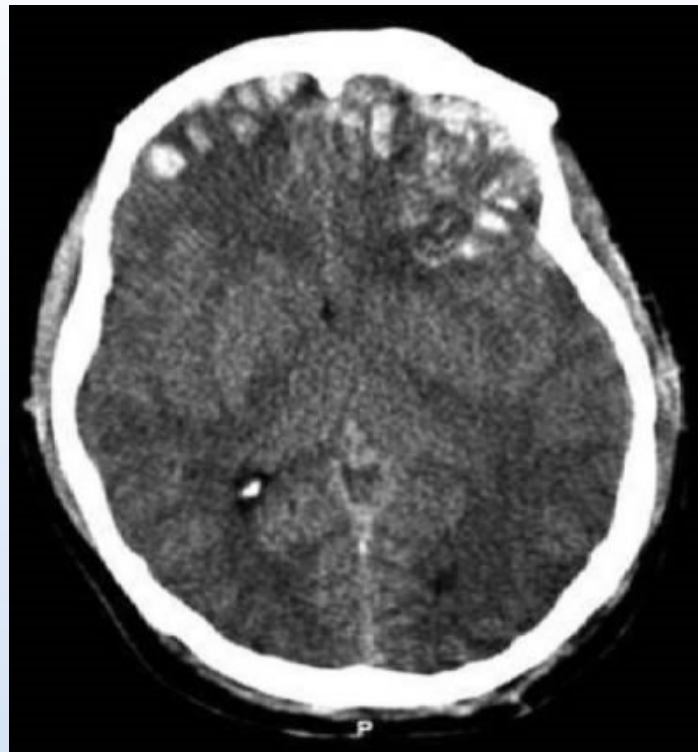
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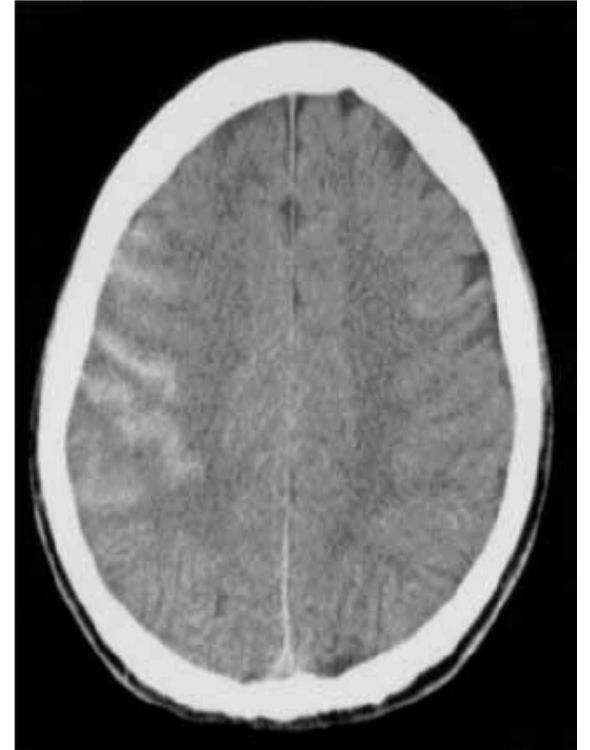
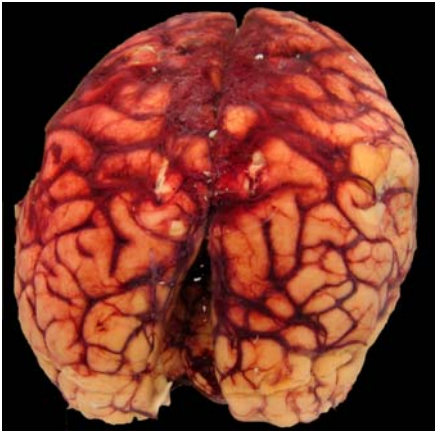
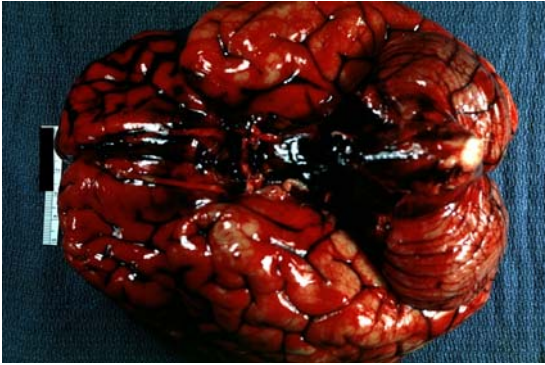
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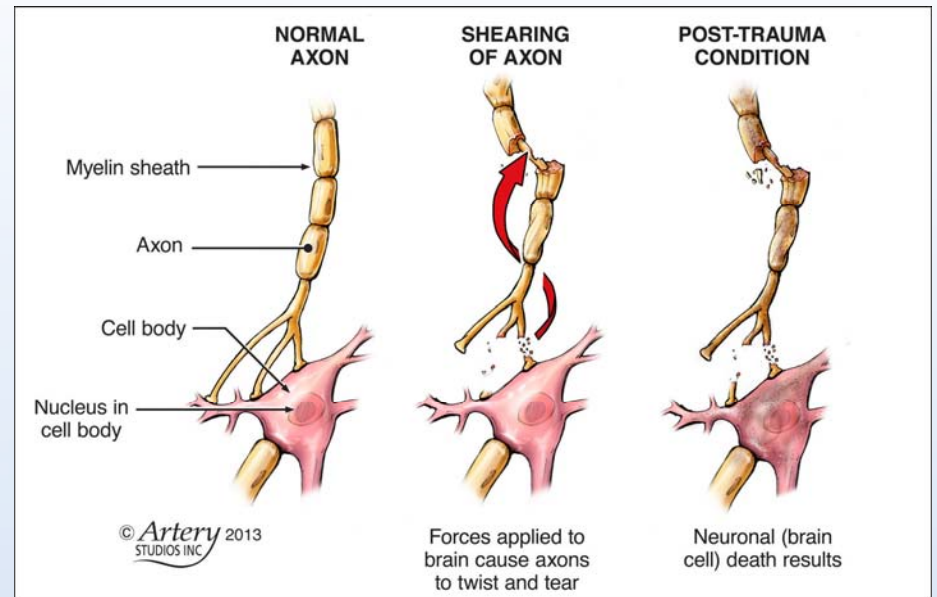
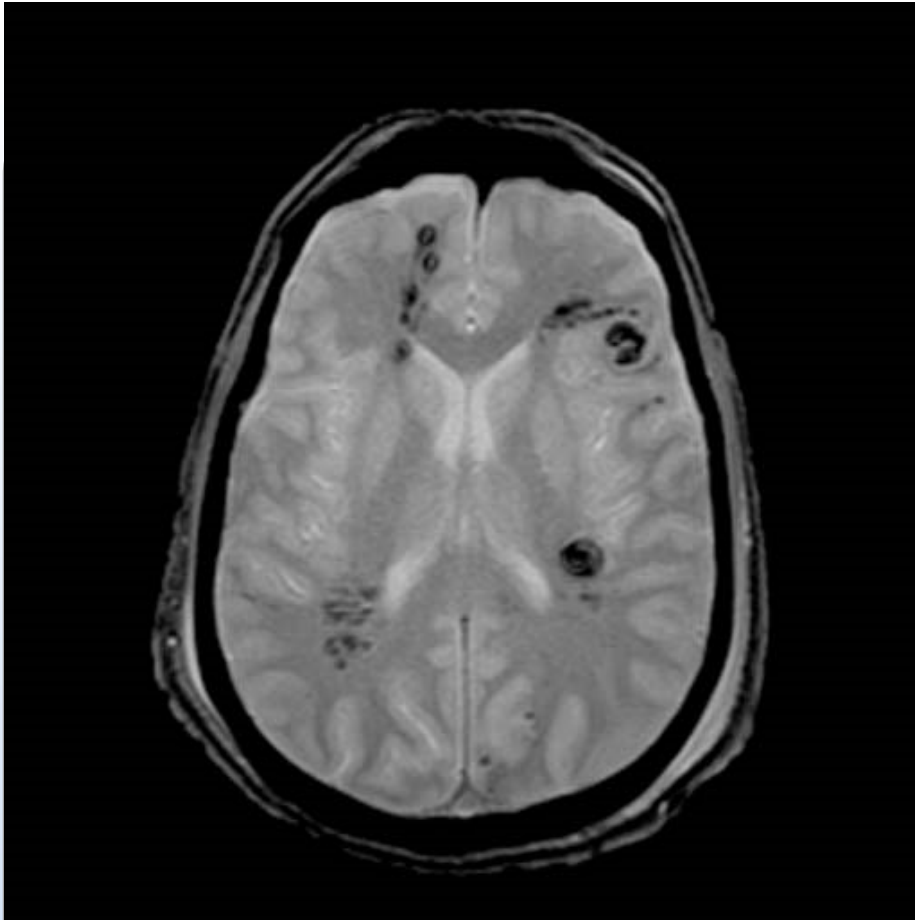


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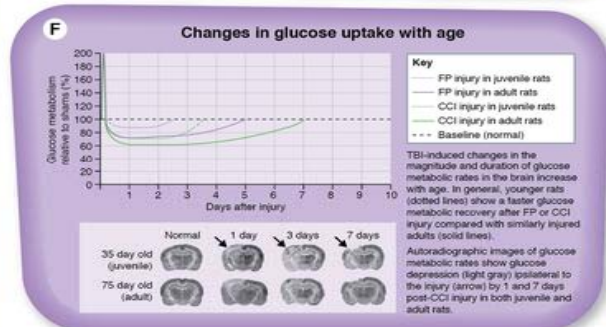
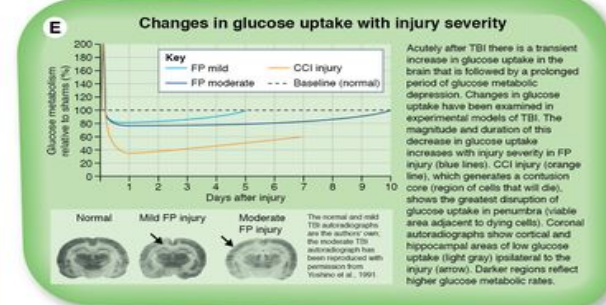
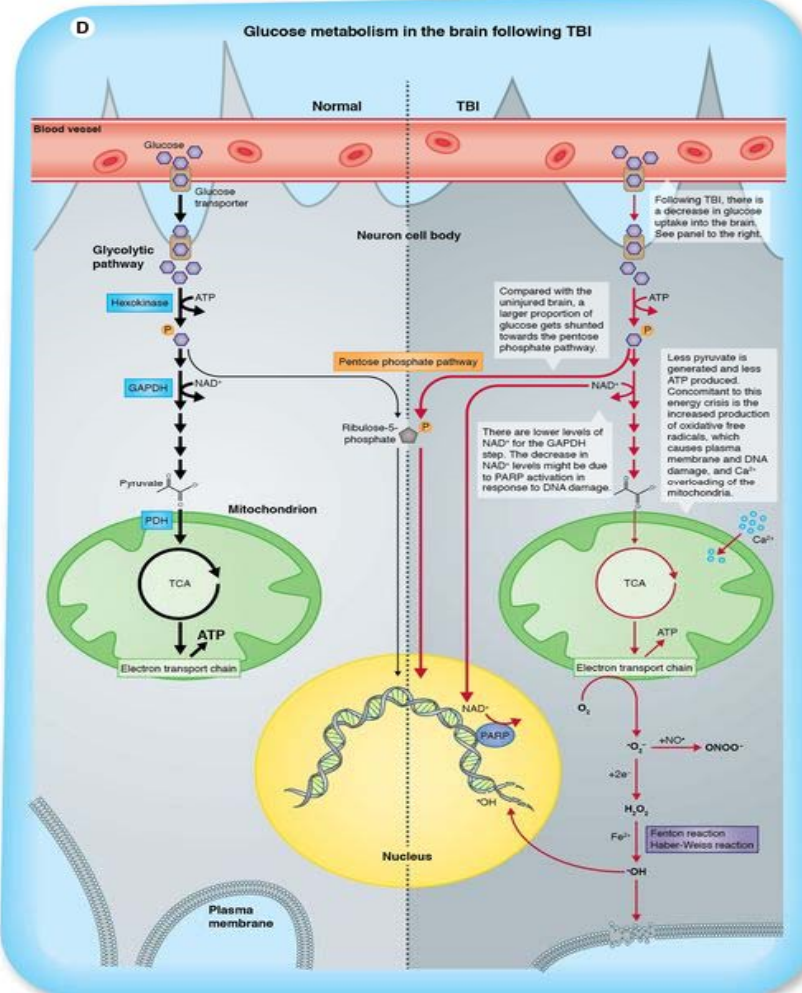
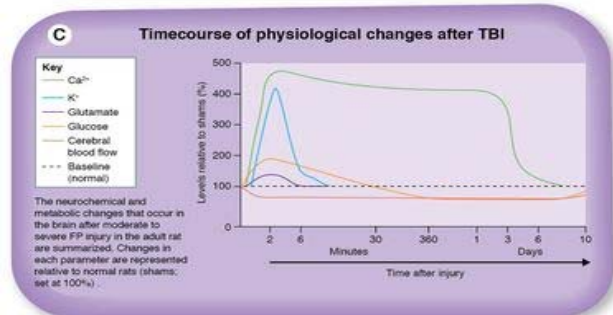
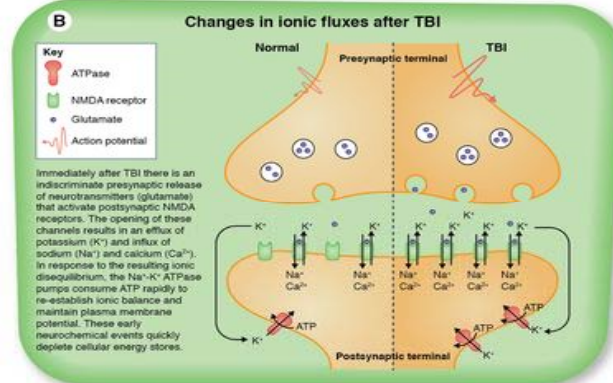
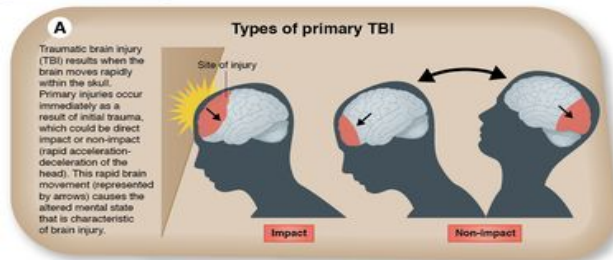
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Secondary Injury

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The pathophysiology of traumatic brain injury at a glance

Mayumi Prins, Tiffany Greco, Daya Alexander and Christopher C. Giza



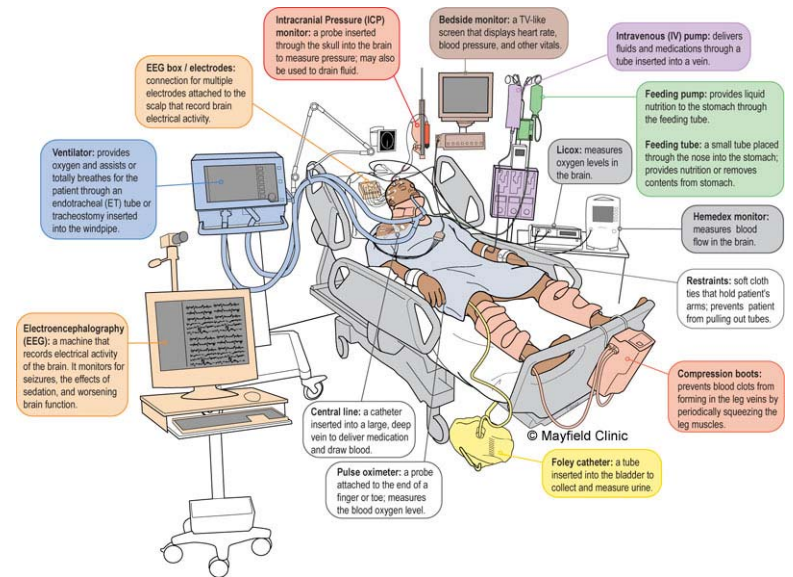
G **Potential metabolic therapies to treat TBI**

Metabolic therapy	Age of rat model	Injury model	Outcome	References
Lactate	Adult	FP	Increased brain lactate uptake and improved cognitive performance	Chen et al., 2000; Bao et al., 2002; Hillway et al., 2007
Sodium pyruvate	Adult	CCI	Decreased cell loss, and neurobehavioral recovery	Fukushima et al., 2009; Moro and Sutton, 2010; Moro et al., 2011
Ketogenic diet	Adolescent and adult	CCI	Decreased cell loss, and improved motor and cognitive deficits and ATP levels	Prins et al., 2005; Prins, 2006; Appobeggs et al., 2009; Ding-Dryant et al., 2011
Ketogenic diet	Adolescent	CCI	Decreased cytochrome c release and cell death	Hu et al., 2009a, 2009b
Fasting ketosis	Adult	CCI	Decreased oxidative stress and improved mitochondrial function	Davis et al., 2008
Aceyl-L-carnitine	Immature	CCI	Decreased cell loss and improved behavioral outcome	Scaddif et al., 2010

Abbreviations: CCI, controlled cortical impact; FP, fluid percussion; GAPDH, glyceraldehyde 3-phosphate dehydrogenase; NAD⁺, nicotinamide adenine dinucleotide; NMDA, N-methyl-D-aspartate; PARP, poly-ADP-ribose polymerase; PDH, pyruvate dehydrogenase; TBI, traumatic brain injury; TCA (cycle), tricarboxylic acid cycle.

See accompanying text for references.

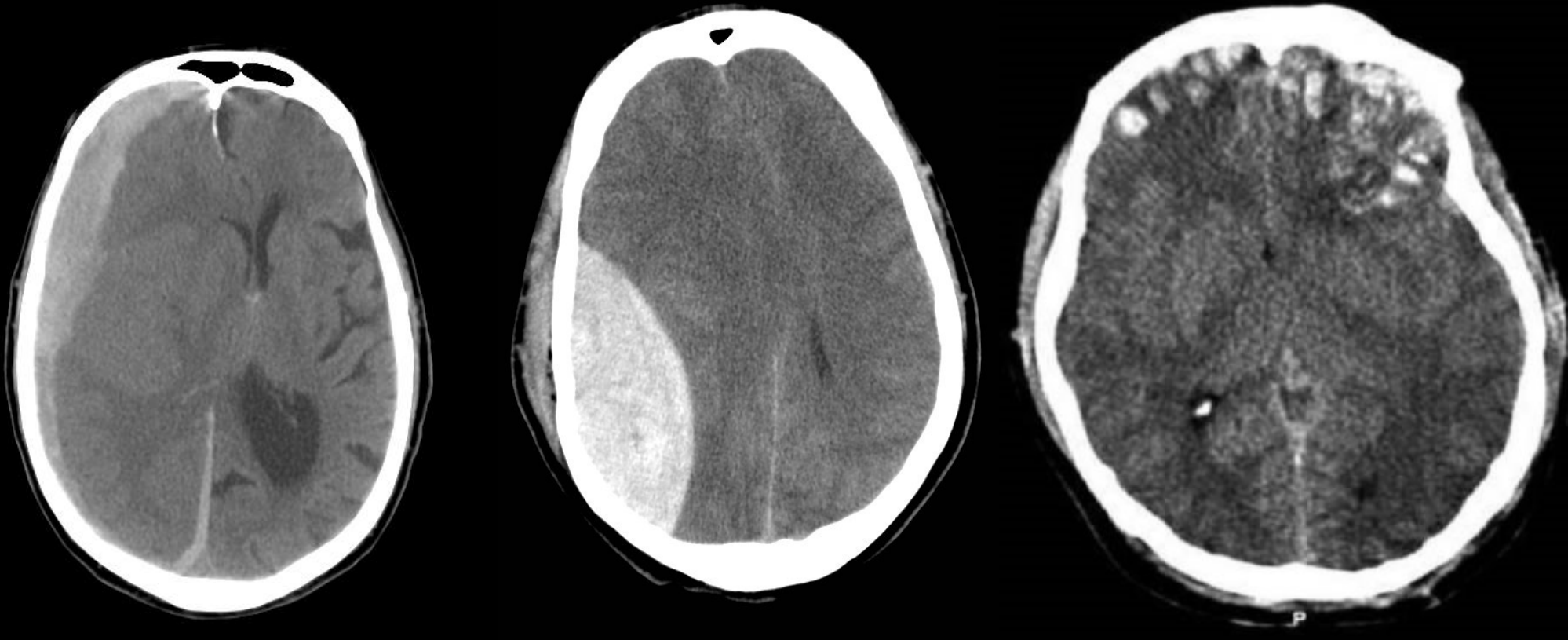
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Treatment

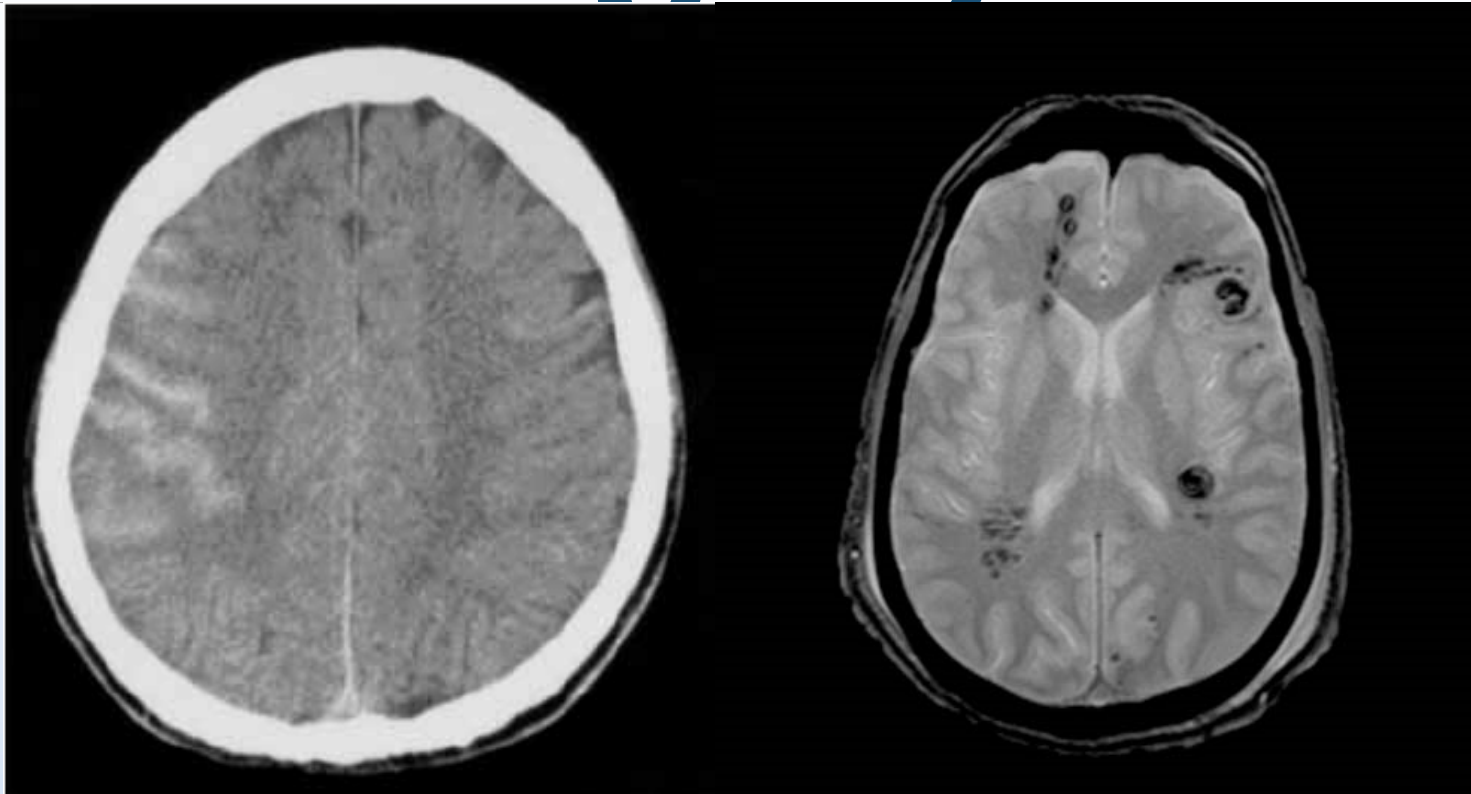
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Surgery?



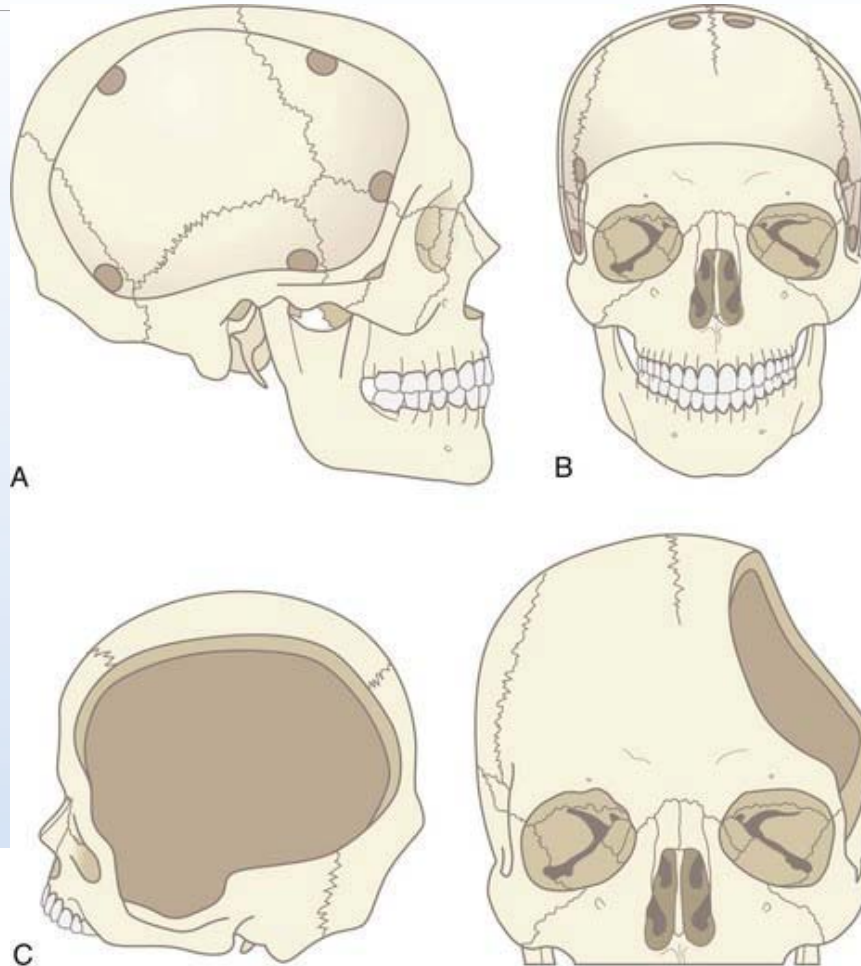
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Surgery?



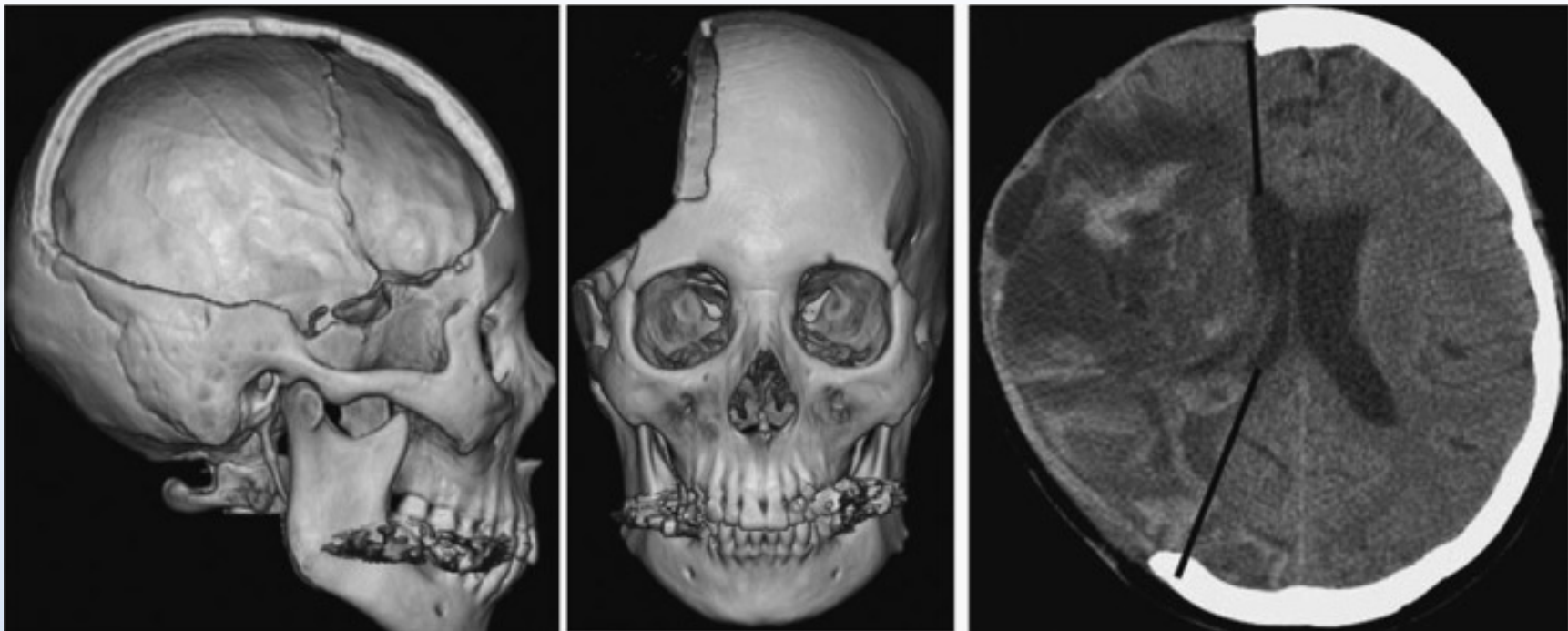
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Craniectomy

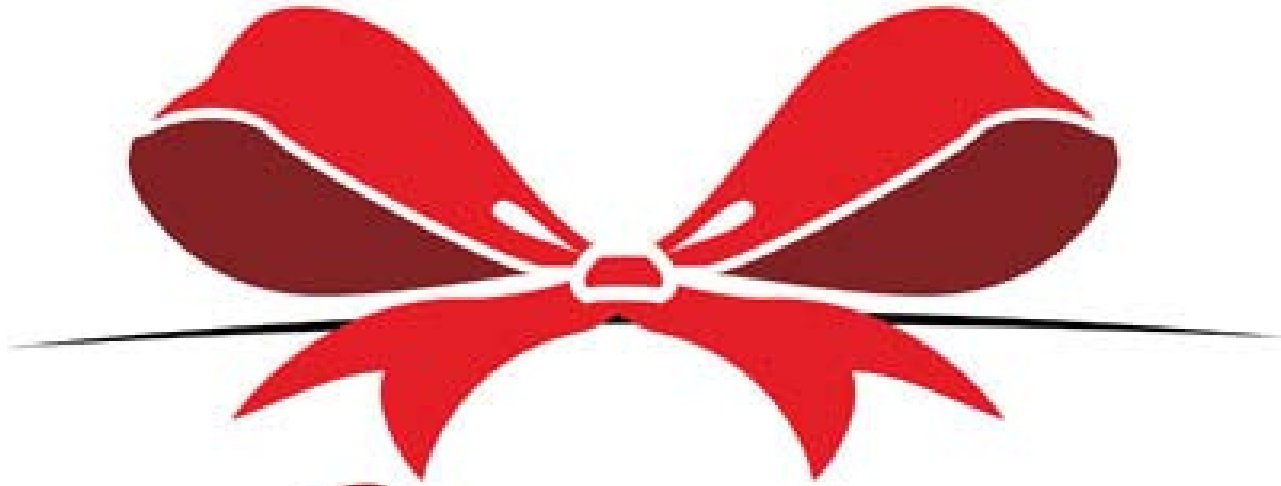


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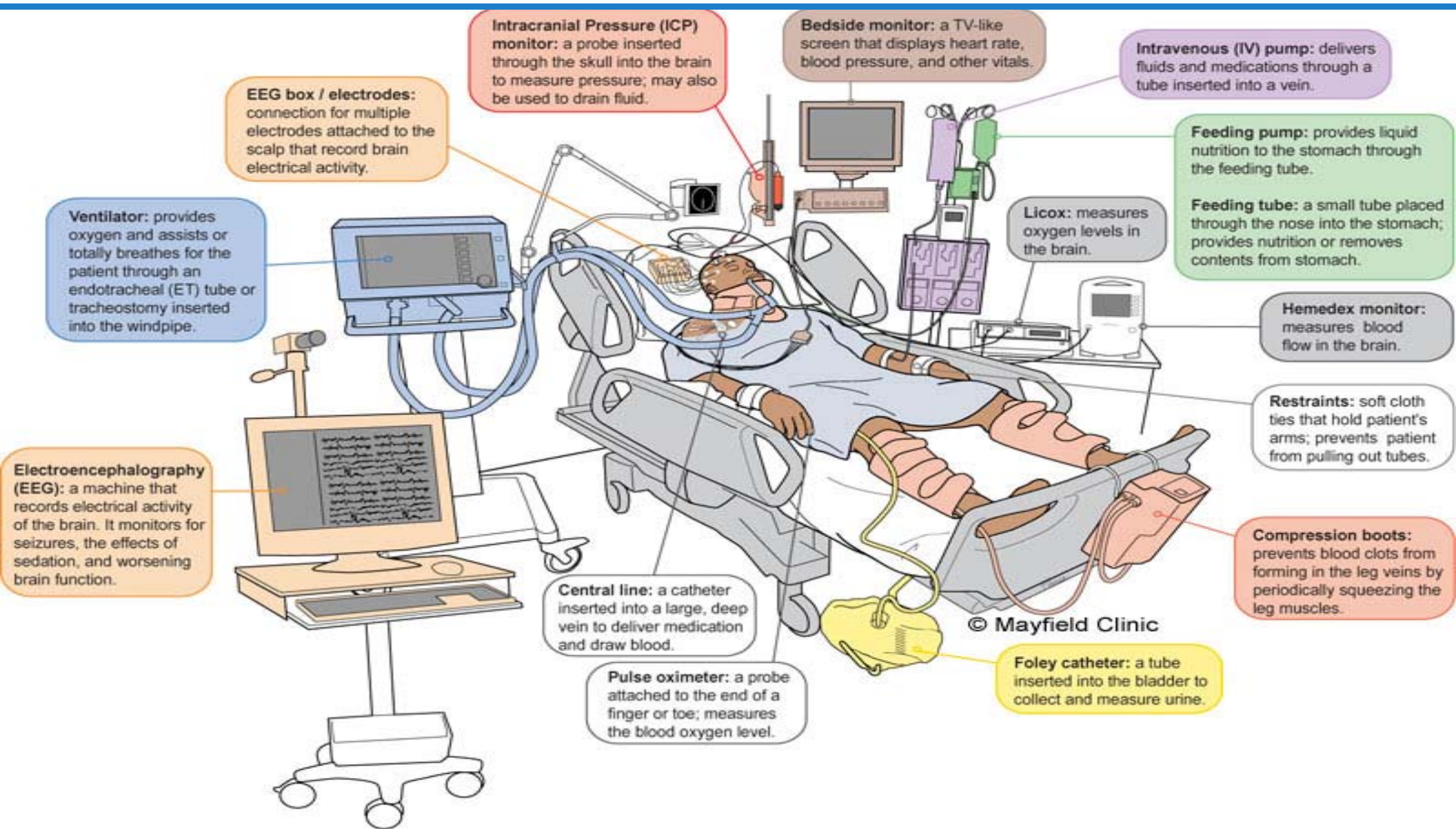
s/p Craniectomy

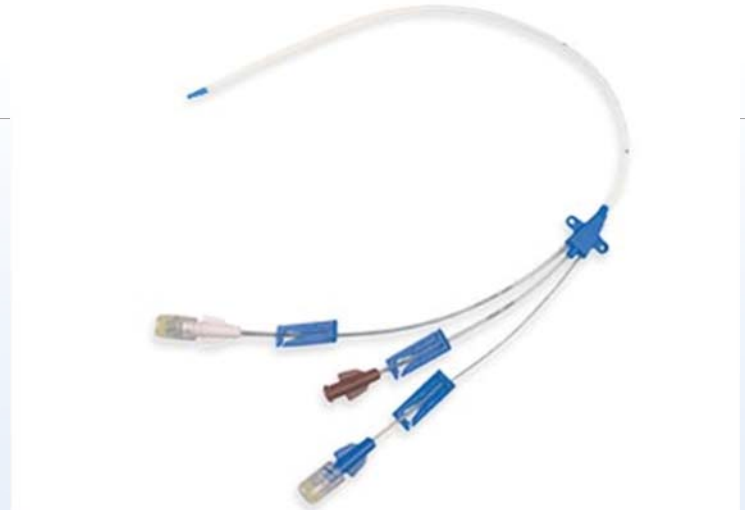


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Season
of GIVING





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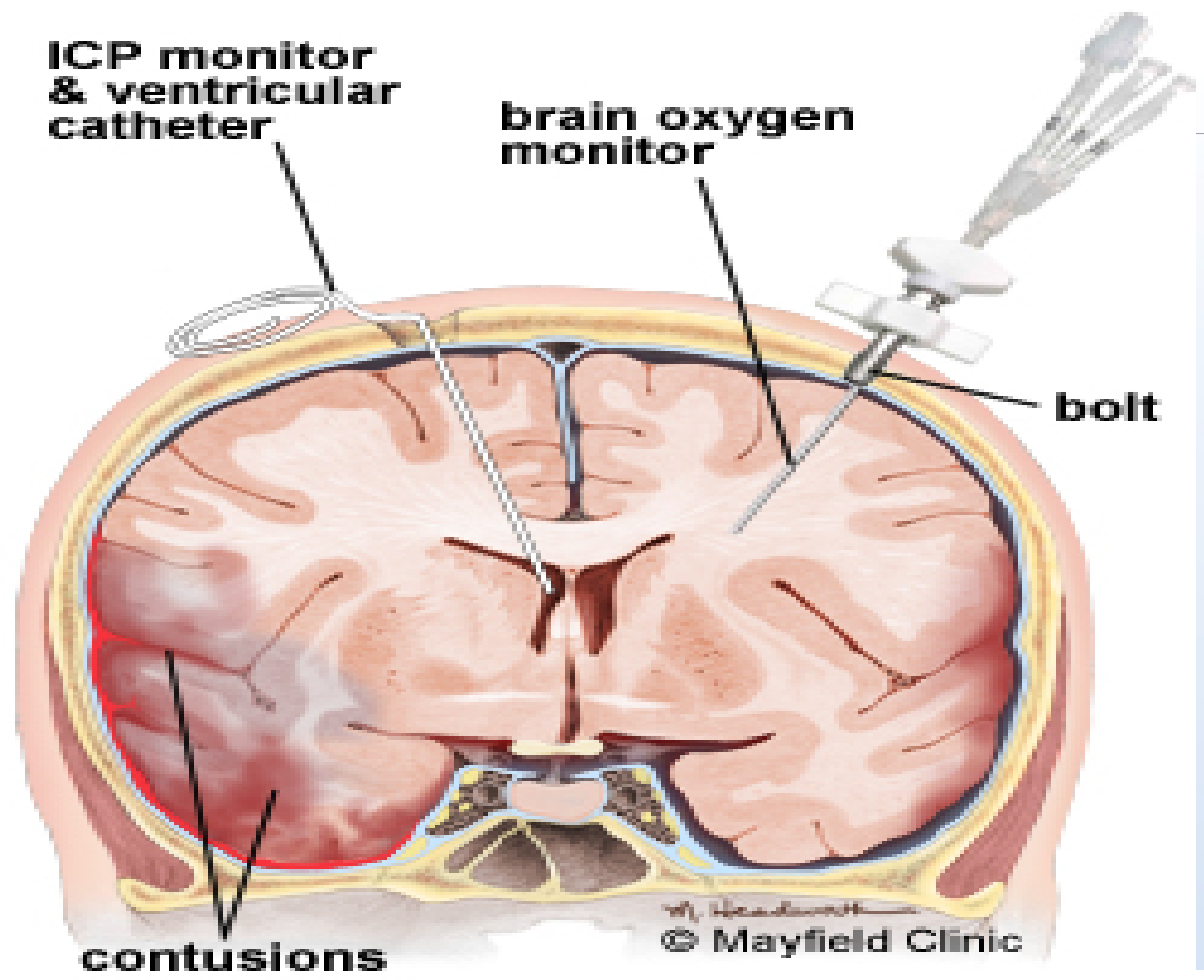


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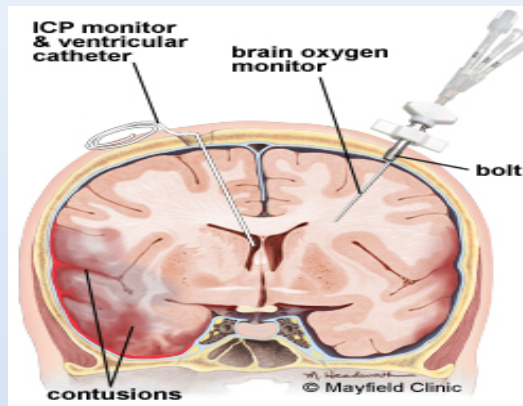


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Monroe-Kellie Doctrine

$$\text{MAP} - \text{ICP} = \text{CPP}$$

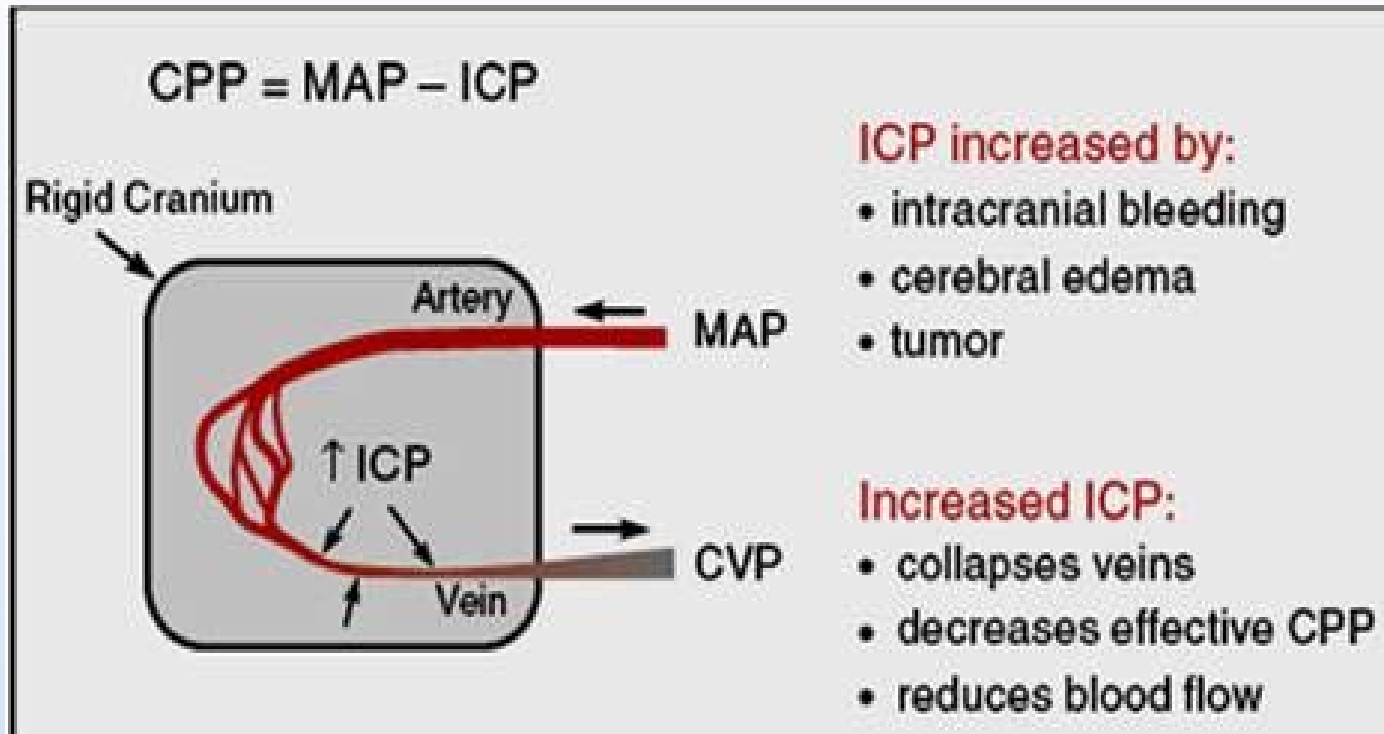
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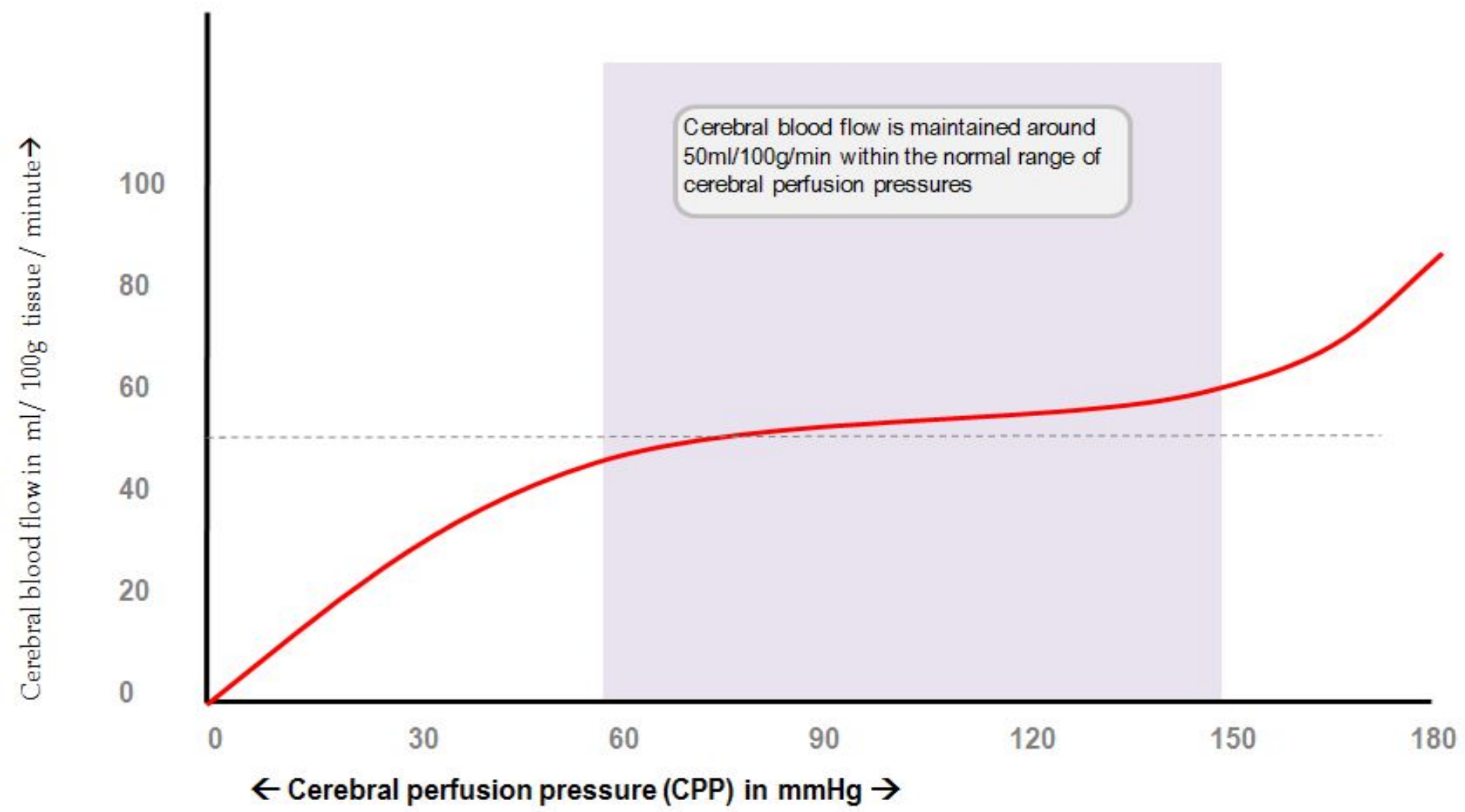


$$= \text{CPP}$$

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Monroe-Kellie Doctrine





Practical Knowledge

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Glasgow Coma Scale (GCS)

Glasgow Coma Scale		
Response	Scale	Score
Eye Opening Response	Eyes open spontaneously	4 Points
	Eyes open to verbal command, speech, or shout	3 Points
	Eyes open to pain (not applied to face)	2 Points
	No eye opening	1 Point
Verbal Response	Oriented	5 Points
	Confused conversation, but able to answer questions	4 Points
	Inappropriate responses, words discernible	3 Points
	Incomprehensible sounds or speech	2 Points
	No verbal response	1 Point
Motor Response	Obeys commands for movement	6 Points
	Purposeful movement to painful stimulus	5 Points
	Withdraws from pain	4 Points
	Abnormal (spastic) flexion, decorticate posture	3 Points
	Extensor (rigid) response, decerebrate posture	2 Points
	No motor response	1 Point
Minor Brain Injury = 13-15 points; Moderate Brain Injury = 9-12 points; Severe Brain Injury = 3-8 points		

Where GCS can be misleading...

Table 3c. Age and sex adjusted odds ratios and 95% confidence intervals for known altered level of consciousness etiologies in past medical history by Glasgow Coma Scale (GCS) category.

	GCS 13-14	GCS 9-12	GCS 3-8
Alcohol	3.11 (2.28-4.25)*	2.55 (1.59-4.08)*	0.80 (0.32-1.97)
Diabetes	0.95 (0.79-1.14)	1.53 (1.22-1.91)*	1.91 (1.48-2.45)*
Psychiatric	1.40 (1.04-1.89)*	0.84 (0.49-1.43)	0.88 (0.47-1.63)
Seizure	3.84 (2.96-4.97)*	3.10 (2.12-4.52)*	2.95 (1.89-4.61)*
Stroke/TIA	1.67 (1.28-2.18)*	2.40 (1.76-3.27)*	1.25 (0.78-2.01)
Substance use	1.99 (1.27-3.13)*	2.30 (1.23-4.28)*	0.79 (0.25-2.53)

**Indicates statistically significant result, (p<0.05)*

TIA, transient ischemic attack

Practical Knowledge...

GCS
Temperature
Na
PaCO₂
HOB @ 30
Analgesia
Sedation
Paralytics
AEDs (x7days)
DVT/GI prophylaxis
Caloric requirements
ICP Management
Road Trips

American Association of Neurological Surgeons (AANS)
Congress of Neurological Surgeons (CNS)
AANS/CNS Joint Section on Neurotrauma and Critical Care



Guidelines for the Management of
Severe Traumatic Brain Injury
4th Edition

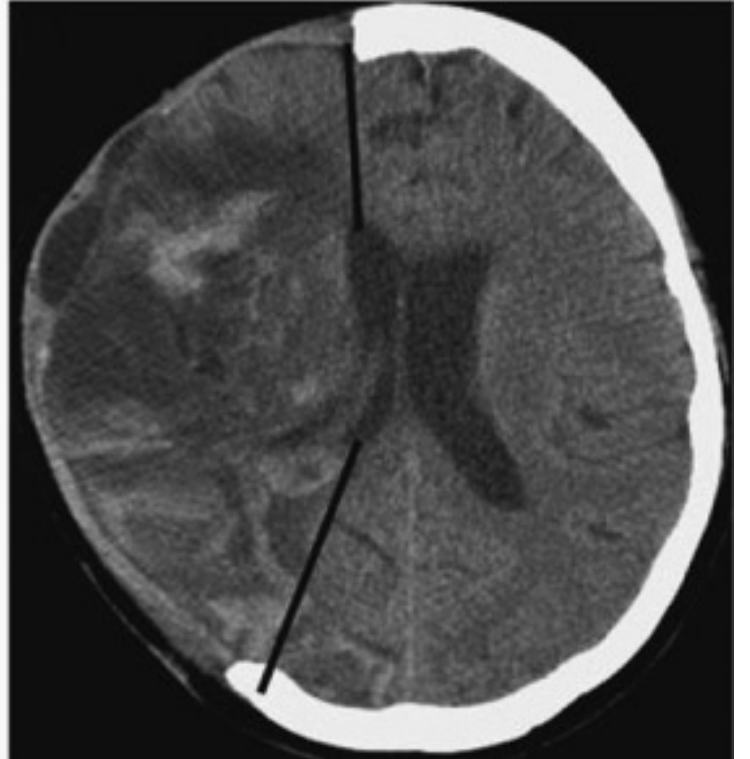
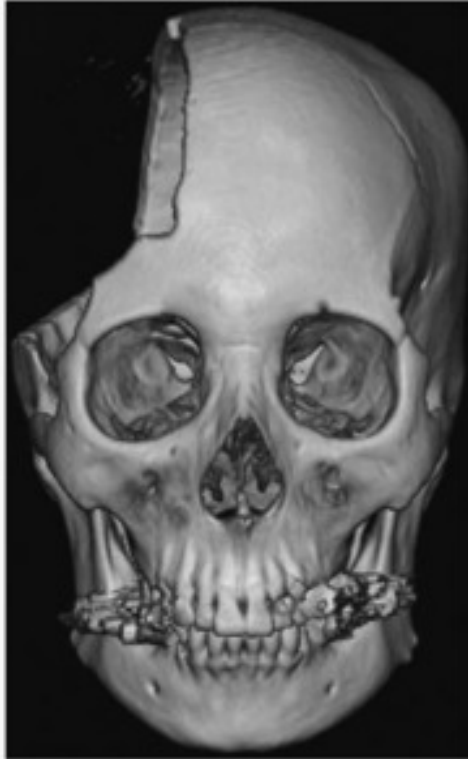
Decompressive Craniectomy

IIA Recommendation:

- Bifrontal DC does not lead to improved neurological outcome (6mos GOS-E score) in patients with severe TBI with diffuse injury who have ICP elevations >20mmHg for more than 15mins within a 1hr period which are refractory to first-line therapies. It does however reduce ICP and LOS in the ICU.

IIA Recommendation:

- A large flap (not less than 12cm x 15cm or 15cm diameter) reduces mortality and improved neurological outcome.



Prophylactic Hypothermia

IIB Recommendation:

- Early (within 2.5hrs), short term (48hrs post injury) prophylactic hypothermia is not recommended to improve outcomes in patients with diffuse TBI.

CSF Drainage

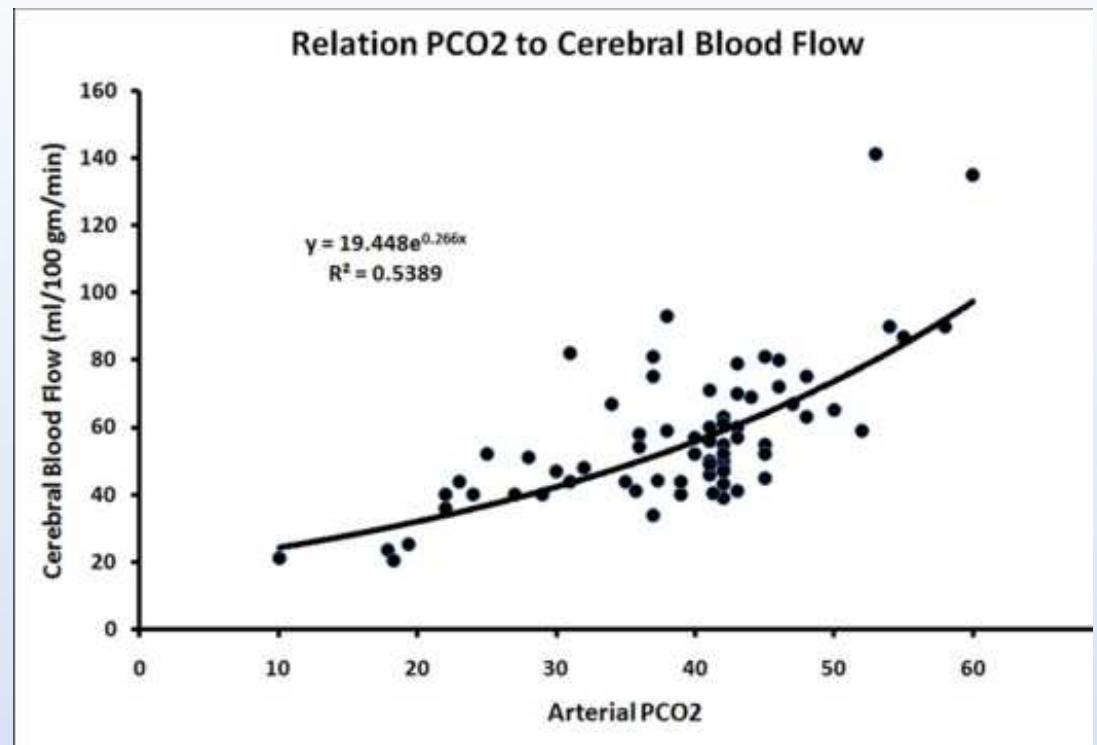
III Recommendation:

- An EVD system continuous drainage of CSF may be considered to lower ICP burden more effectively than intermittent use.
- Use of CSF drainage to lower ICP in patients with an initial Glasgow Coma Scale (GCS) <6 during the first 12 hours after injury may be considered.

Ventilation Therapies

IIB Recommendation:

- Prolonged prophylactic hyperventilation with partial pressure of carbon dioxide in arterial blood (PaCO₂) of 25 mm Hg or less is not recommended.
- **No longer being recommended as a temporizing measure.**



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Anesthetics, Analgesics, and Sedatives

IIB Recommendation:

- Administration of barbiturates to induce burst suppression measured by EEG as **prophylaxis** against the development of intracranial hypertension is not recommended.
- High-dose barbiturate administration is recommended to control elevated ICP refractory to maximum standard medical and surgical treatment. Hemodynamic stability is essential before and during barbiturate therapy.
- Although propofol is recommended for the control of ICP, it is not recommended for improvement in mortality or 6-month outcomes.

Steroids (Seriously).



I Recommendation:



- The use of steroids is not recommended for improving outcome or reducing ICP.
- In patients with severe TBI, high-dose methylprednisolone was associated with increased mortality and is contraindicated.

Nutrition

IIA Recommendation:

- Feeding patients to attain basal caloric replacement at least by the 5th day and, at most, by the 7th day post-injury is recommended to decrease mortality.



IIB Recommendation:

- Transgastric jejunal feeding is recommended to reduce the incidence of ventilator-associated pneumonia.



Antimicrobial Prophylaxis

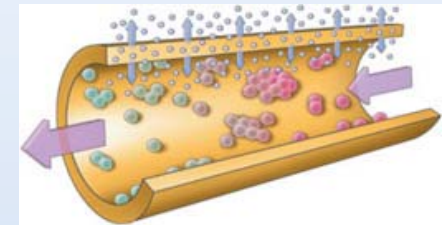
IIA Recommendation:

- Early tracheostomy is recommended to reduce mechanical ventilation days when the overall benefit is felt to outweigh the complications associated with such a procedure. However, **there is no evidence that early tracheostomy reduces mortality or the rate of nosocomial pneumonia.**
- The use of povidone-iodine (PI) oral care is not recommended to reduce ventilator-associated pneumonia and may cause an increased risk of acute respiratory distress syndrome.

Antimicrobial Prophylaxis

III Recommendation:

- Antimicrobial-impregnated catheters may be considered to prevent catheter-related infections during EVD.



DVT Prophylaxis

III Recommendation:

- Low molecular weight heparin (LMWH) or low-dose unfractionated heparin may be used in combination with mechanical prophylaxis. However, there is an increased risk for expansion of intracranial hemorrhage.

My favorite question...

Do you think it is safe to start Lovenox?

--Everybody



My response...

There is no possible way for me to predict whether or not the hemorrhage will expand as a result of being on blood thinning medication. I encourage you to have a serious discussion with the patient's family regarding the risks, benefits, and alternatives to proceeding with blood thinning medication especially for prophylactic reasons.

--Me

Seizure Prophylaxis

IIA Recommendation:

- Prophylactic use of phenytoin or valproate is not recommended for preventing **late** PTS.
- Phenytoin is recommended to decrease the incidence of early PTS (within 7 days of injury), **when the overall benefit is felt to outweigh the complications associated with such treatment.** However, early PTS have not been associated with worse outcomes.

Seizure Prophylaxis

- At the present time there is insufficient evidence to recommend levetiracetam over phenytoin regarding efficacy in preventing early post-traumatic seizures and toxicity.

ICP Monitoring

IIB Recommendation:

- Management of severe TBI patients using information from ICP monitoring is recommended to reduce in-hospital and 2-week post-injury mortality.

ICP Monitoring

Recommendations from the Prior (3rd) Edition ***Not Supported by Evidence Meeting Current Standards:***

- Intracranial pressure (ICP) should be monitored in all salvageable patients with a severe traumatic brain injury (TBI) (GCS 3-8 after resuscitation) and an abnormal computed tomography (CT) scan.
- ICP monitoring is indicated in patients with severe TBI with a normal CT scan if two or more of the following features are noted at admission: age over 40 years, unilateral or bilateral motor posturing, or systolic blood pressure (BP) <90 mm Hg.
- *These are the characteristics of patients with increased ICP however*

CPP Monitoring

IIB Recommendation:

- Management of severe TBI patients using guideline-based recommendations for CPP monitoring is recommended to decrease 2-week mortality.

Advanced Cerebral Monitoring

III Recommendation:

- Jugular bulb monitoring of arteriovenous oxygen content difference (AVDO₂), as a source of information for management decisions, may be considered to reduce mortality and improve outcomes at 3 and 6 months post-injury.

Blood Pressure Thresholds

III Recommendation:

- Maintaining SBP at ≥ 100 mm Hg for patients 50 to 69 years old or at ≥ 110 mm Hg or above for patients 15 to 49 or over 70 years old may be considered to decrease mortality and improve outcomes.

ICP Thresholds

IIB Recommendation:

- Treating ICP above 22 mm Hg is recommended because values above this level are associated with increased mortality.

III Recommendation:

- A combination of ICP values and clinical and brain CT findings may be used to make management decisions.

CPP Thresholds

IIB Recommendation:

- The recommended target cerebral perfusion pressure (CPP) value for survival and favorable outcomes is between 60 and 70 mm Hg. Whether 60 or 70 mm Hg is the minimum optimal CPP threshold is unclear and may depend upon the patient's autoregulatory status.

III Recommendation:

- Avoiding aggressive attempts to maintain CPP above 70 mm Hg with fluids and pressors may be considered because of the risk of adult respiratory failure.

Advanced Monitoring Treatment Thresholds

III Recommendation:

- Jugular venous saturation of $<50\%$ may be a threshold to avoid in order to reduce mortality and improve outcomes.