

brain is like 3 pound block of tofu stuffed in a sock



1





2

scalp is first protective layer (hair and fat acts like a cushion), when you break the skin of the scalp there will be a lot of bleeding because it's very vascular, muscle in that protective layer (occipital frontalis) that raises and lowers eyebrows



3

the skull is not just one plate, it's a series of plates stuck together by semiridged joints, some of the plates in the skull are flatter than others. the parts where skull changes shape is where fractures are most likely to happen, the more joints we create the more weakness we have

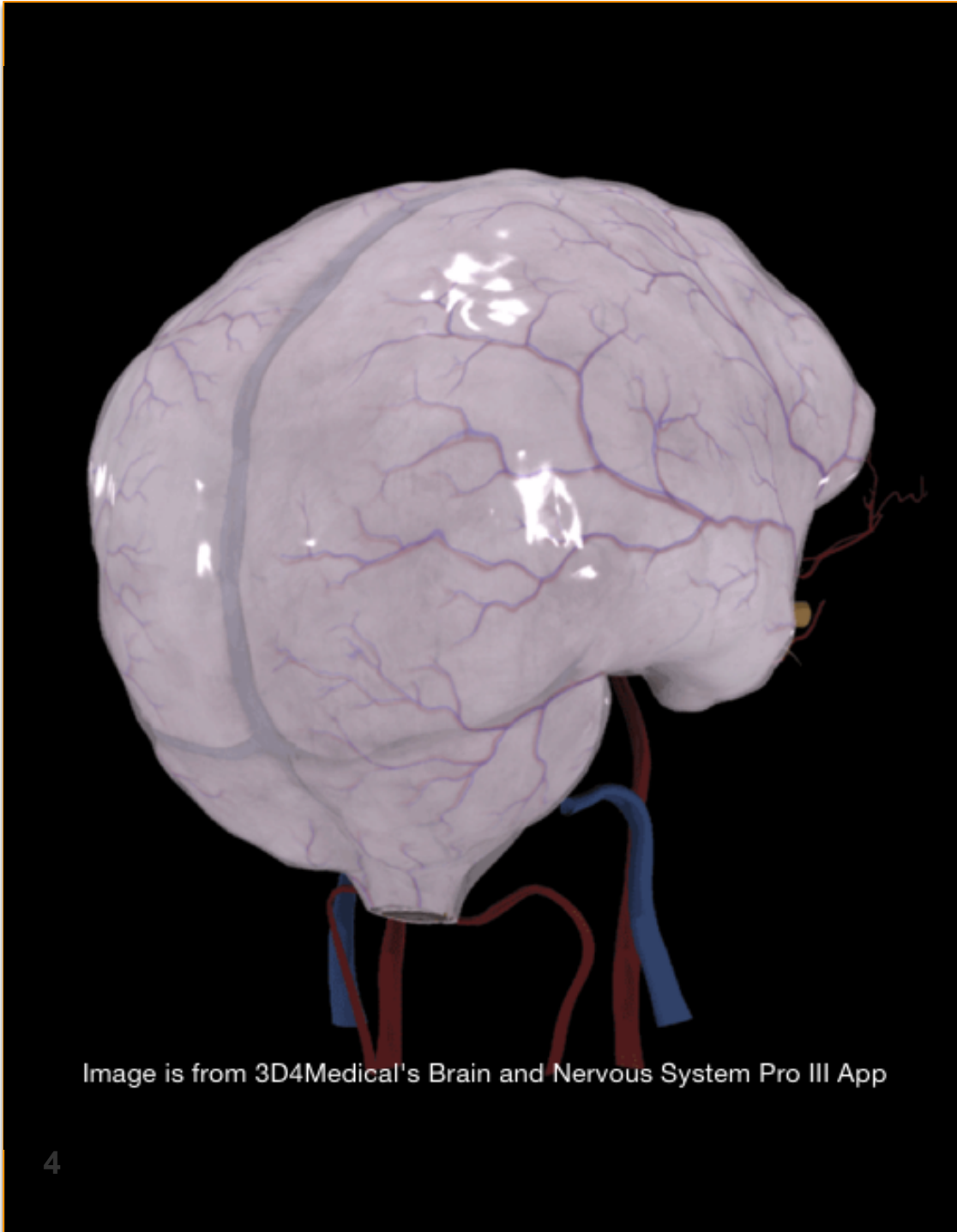


Image is from 3D4Medical's Brain and Nervous System Pro III App

# Meninges And CSF

## Falx Cerebri

outer-coating of dura around the brain that wraps down and in between the two hemispheres  
- falx will then attach to other parts of the skull to anchor the brain

## Tentorium Cerebelli

tent for the cerebellum, sits between the brain and the cerebellum anchoring

meninges wrap around the brain and spinal cord, are continuous with each other.

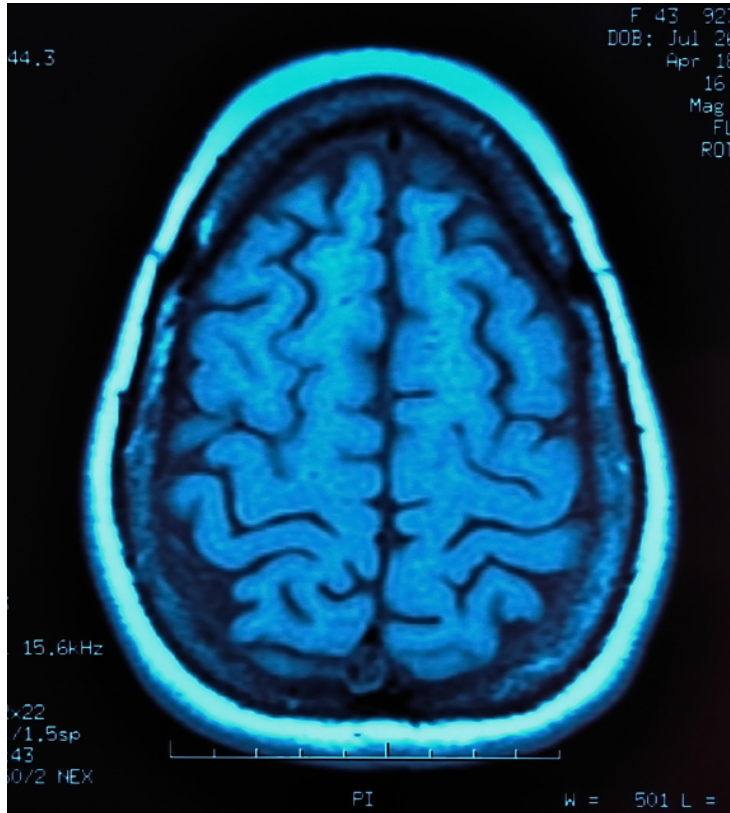
dura is the toughest layer, double layer. one layer is blended with the skull and one layer on top.

arachnoid layer is spongy, and sub-arachnoid space is where the cerebrospinal fluid is

pia wraps around every single groove of the brain

# What is a Concussion?

5



- Zurich consensus (2012)

most recent consensus statement on concussion in sport

- A subset of mTBI

minor traumatic brain injury - there is damage that happens in the brain although everything seems fine

- Typically short-lived

symptoms can disappear within minutes or hours, recover is quick so it's

- Functional impairment

hard to assess, nothing will show up on MRI

- Biomechanical Insult

something had to have hit you (external force) while other brain injuries can happen without external force

because it is just a functional disruption not a structural one

sports with high speed, or with ability to fall from heights will have more possibility of concussion

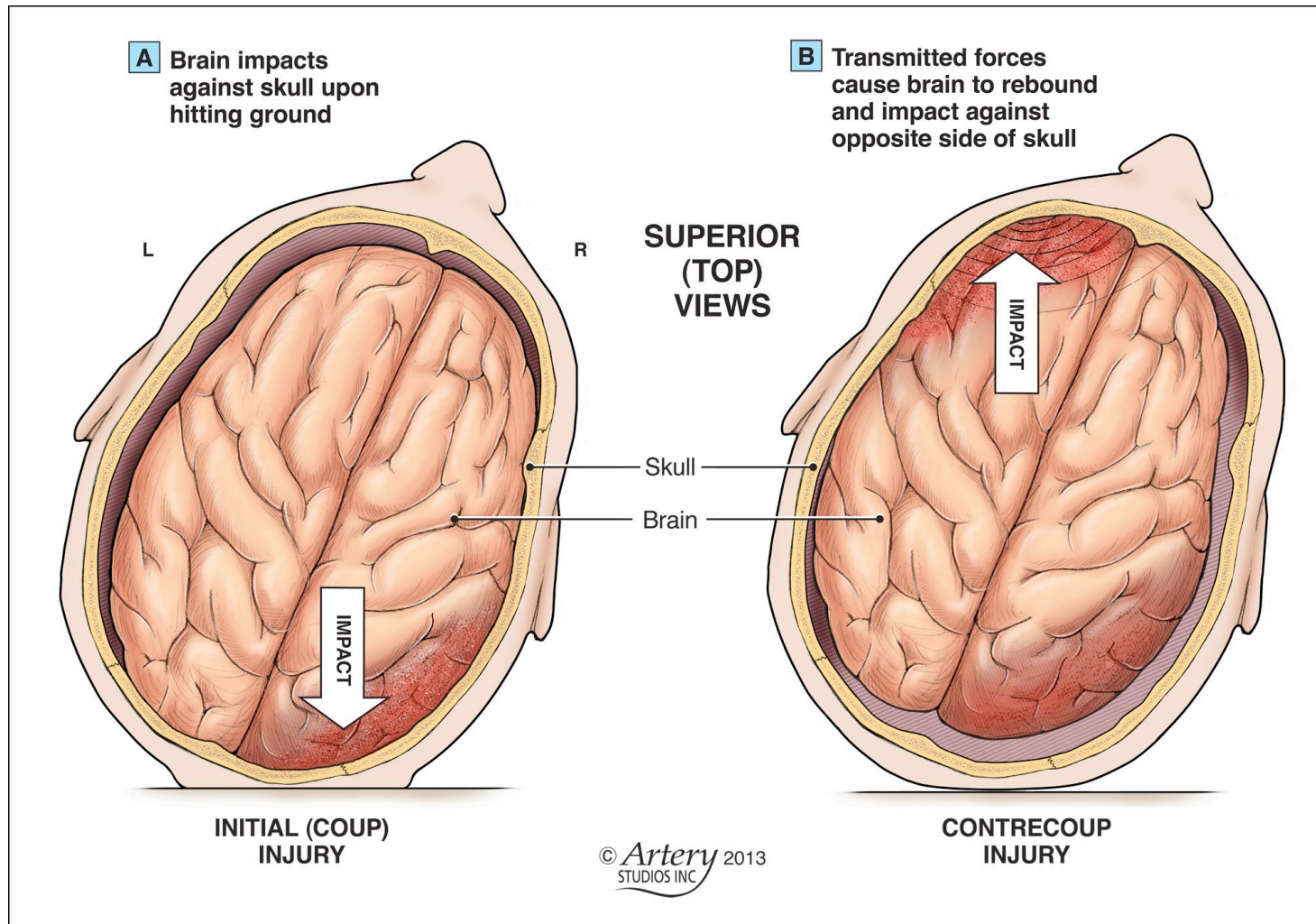
concussion can happen from force applied to the body (chest), not just to the head.

many patients with whiplash can experience concussion (hit in the chest and head flies back)

Concussion can occur  
**with** or **without**  
direct head contact

Brain motion within  
the skull





linear acceleration (brain goes back and forth)  
 angular acceleration (brain moves in angular way)

# Coup-Contrecoup

7

a concussion is not a brain bruise.  
 the coup part of the injury is the initial injury.  
 when the brain bounces up and hits the other side of the skull, might end up with a brain that is impaired on two sides which can bring up many symptoms

when brain goes side to side

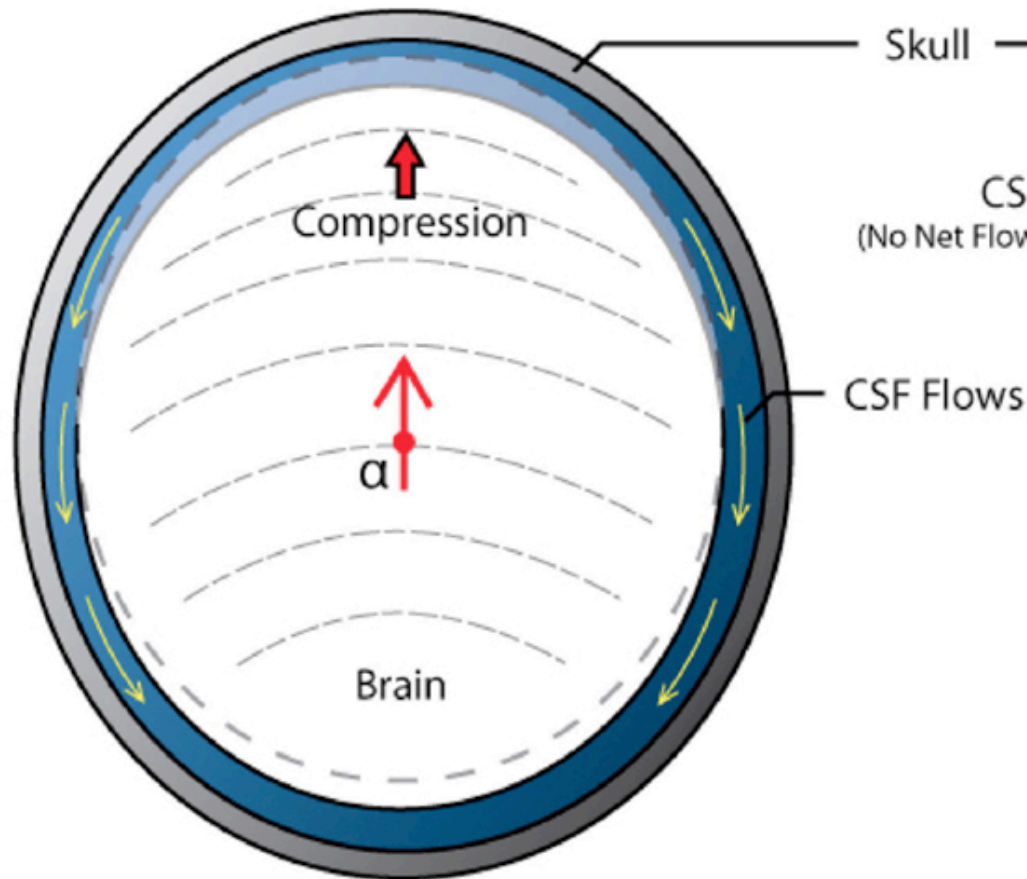
# Compression of brain tissue BUT there is more to the story

brain won't change shape with compression, so what does change it's shape?

- grey matter and white matter have different material properties (densities), so sometimes angular acceleration will cause shearing between the white and grey matter, changing shape of the brain (two surfaces moving from their original position)
- issue isn't about translation, it's about the brain banging around like a tether-ball
- helmets will not stop the brain from moving around within the skull, just protects from skull fracture

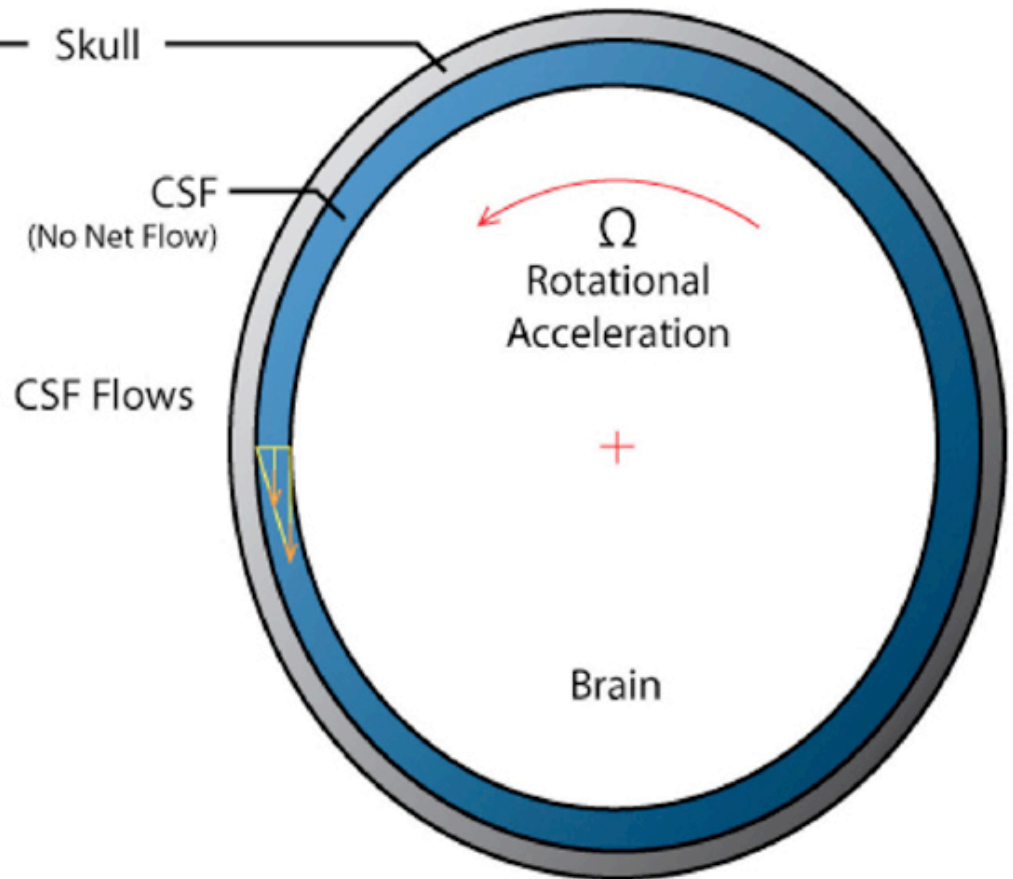
**Two** forms of **acceleration** to consider; they affect brain tissue differently

## Linear Brain Acceleration



forward backward movement, cerebrospinal fluid will protect the brain

## Rotational Brain Acceleration

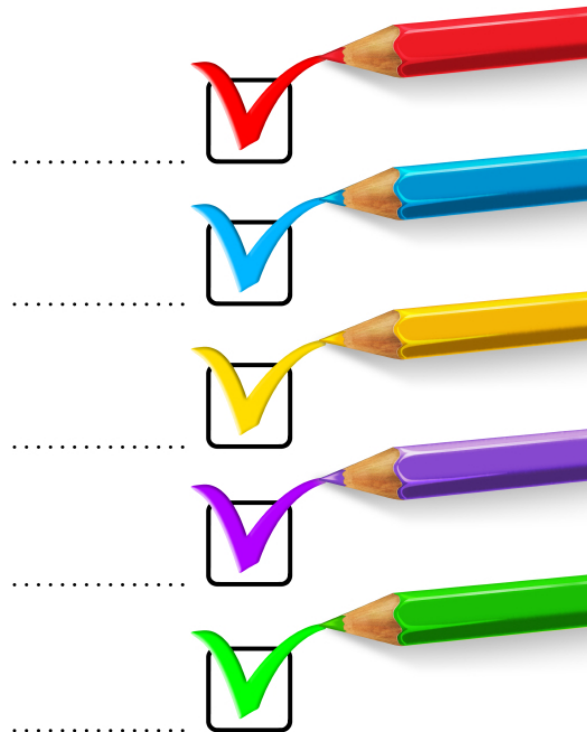


brain spinning inside, the fluid doesn't offer much protection (helmet designers need to figure this out)

concussion is a functional issue, but there are also metabolic issues after impact within the brain

# A Metabolic Issue

10



## ✓ Excitatory neurotransmitters

these get released, depolarization happens and as a response to these neurotransmitters there will be a massive out-flux of potassium. potassium floods out and at the same time, calcium will flood in which is a challenge for the brain.

## ✓ Potassium and Calcium

brain needs to rebalance the resting brain potential. since calcium has flooded the cell, it impairs the cells ability to provide energy, impairs the brain's primary source of energy. sodium potassium pump needs to help with rebalancing, but has no energy. now need to turn to the anaerobic system.

## ✓ Bad news for mitochondria

combination of the work that the Na-K pump has to do and the energy crisis (using an inefficient source) creates a metabolic problem.

## ✓ Na<sup>+</sup>- K<sup>+</sup> pumps need energy

## ✓ Net result?

# A Vascular Issue

11



- Impaired auto-regulation of cerebral blood flow

brain has the capacity to regulate blood flow by itself, however after brain injury, its ability to regulate blood flow becomes impaired, brain will no longer work the way it's supposed to

- Less responsive to CO<sub>2</sub>?

- Conflicting evidence:

blood flow ↑ or ↓

some evidence documents blood flow increase and some documents blood flow decrease  
- most time decrease  
- with less blood flow to the brain, adds to the energy crisis

- Adding to the energy crisis

# SCAT 3

12



- Link on Avenue
- Rested > 10 mins

## 1. Symptoms

list of 22 different symptoms, athlete will rank them on a scale of 1-6  
- dizziness, headache, blurred-vision, nausea, pressure in the head, loss of memory, sensitivity to light, confusion

## 2. Cognitive Function

cognitive function:  
- evaluate their immediate memory (random words to remember, ask them to repeat)  
- ask what the year is, then the month, then the day, then the time (easiest to hardest)  
- if they cant answer the easier ones, something is wrong  
- then test ability to concentrate

## 3. Physical Function

physical component:

- begin with range of motion in the neck
- test balance (standing with one leg, etc)
- upper limb/finger coordination
- last question is "remember those 5 words i gave you, what were they?" (delayed recall)

# Risk Factors and Prognosis

13

□ Finnoff et al. (2011)

□ Risk Factors what makes you higher risk for concussions

□ **Male vs. Female** males will have more concussions than females, however percentage of female athletes experiencing concussion is higher than males

□ **Prior concussion (3)** if you had 3 or more concussions in the past, you are at greater risk

□ **Fatigue from physical exertion** most concussions will happen towards the end of a game when the athlete is tired



# Prognosis

14

## □ Typical recovery vs. Post concussion syndrome (PCS)

most symptoms will disappear within 7 days or sooner, however some may go up to 3 weeks (post-concussion syndrome/disorder)

## □ Prognostic Factors what might cause you to recover slower

- **Pre-existing neurological conditions ie:** people with history of:
  - migranes
  - learning disabilities
  - anxiety and depression
- **Age** children take longer to recover than adults
- **Previous concussion history** more concussions in the past = more chance of longer recovery