



**MIRECC**  
Mental Illness  
Research,  
Education &  
Clinical Center



Post Deployment Mental Health

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## **Windows to the Brain: Neurobiology of Traumatic Brain Injury**

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## **Disclaimer**

The views expressed in this presentation are those of the author and do not reflect the official policy of the Veterans Health Administration, Department of Defense, or U.S. Government.

# Outline of Presentation

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## Intro to TBI

Severity – mild, moderate, severe

Incidence – civilian, military

## Intro to the Brain

Divisions & Functions

Clinical imaging – sections & structure

Neurons

## Traumatic Brain Injuries

Causes & Forces

Injuries – primary, secondary

Mild TBI – diagnostic challenges

# Severity of TBI

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## Mild:

Altered/loss of consciousness < 30 minutes

Post traumatic amnesia < 24 hours

## Moderate:

Altered/loss of consciousness < 6 hours

Post traumatic amnesia < 7 days

## Severe:

Altered/loss of consciousness > 6 hours

Post traumatic amnesia > 7 days

## Incidence of TBI - Civilian

Received medical care = ER + Hospitalized + Deaths

1,565,000 annually

Overall rate = 538.2/100,000

0-4 1188.5/100,000

5-14 520.5/100,000

15-24 917.5/100,000

25-44 386.7/100,000

45-64 327.3/100,000

65+ 524.3/100,000



Rutland-Brown et al. *Journal of Head Trauma Rehabilitation* 2006;21(6):544-548

## Incidence of TBI - Civilian

Did NOT receive medical care

~ 25% do not seek medical care (CDC)

Rutland-Brown et al. *Journal of Head Trauma Rehabilitation* 2006;21(6):544-548

~ 42% did not seek care (Web-based survey)

Did not think I needed care

Setnik et al. *Brain Injury* 2007;21(1):1-9



## Incidence of TBI - Military



### Vietnam war:

- ~ 40% of fatalities were due to head and /or neck wounds
- ~ 14% surviving wounds had head injury

### Operation Desert Storm:

- ~ 20% surviving wounds had head injury

### OEF & OIF:

- ~ 28% evacuated to WRAMC had a TBI

Schwab et al. *Journal of Rehabilitation Research and Development* 2007;44(7):xxiii-xxii

## Incidence of TBI - Military



- ~50% of injuries involve head or neck

- Echelon II medical unit *Mil Med* 2005;170:516-520
- Mechanized Battalion *Mil Med* 2005;170:546-549



- ~88-97% of injuries involve blast

- Echelon II medical unit *Mil Med* 2005;170:516-520
- Mechanized Battalion *Mil Med* 2005;170:546-549



- 59% of soldiers at WRAMC injured by blast had TBI (Jan03-Feb05; 44% mild, 56% mod-severe)

- DVBIC study *N Engl J Med* 2005;352:2043-2047



# Incidence of TBI - Military



- **16.1% of 596 active duty soldiers reported history consistent with TBI**

*Neurology 2006;66:A235*

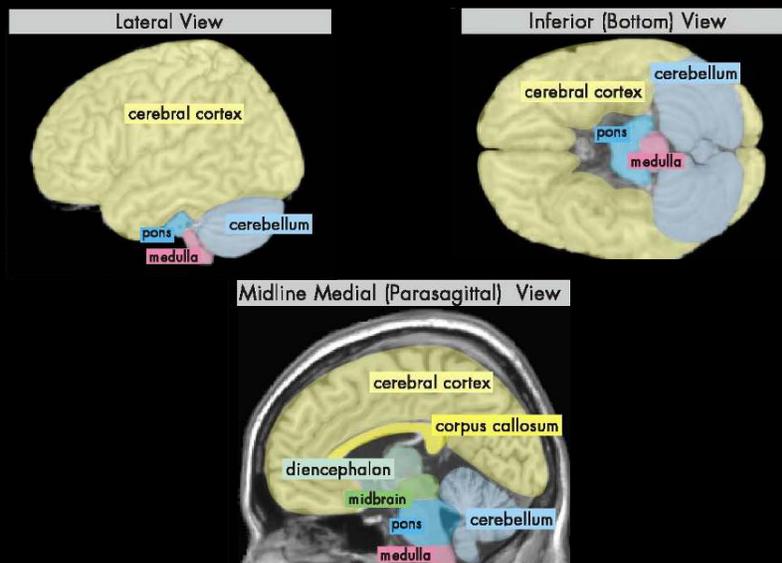
- **15.2% of 2,525 returning soldiers reported history consistent with TBI**

*New England Journal of Medicine 2008;358(5):453-63*

- **17.8% of 13,400 returning soldiers reported history consistent with TBI due to blast**

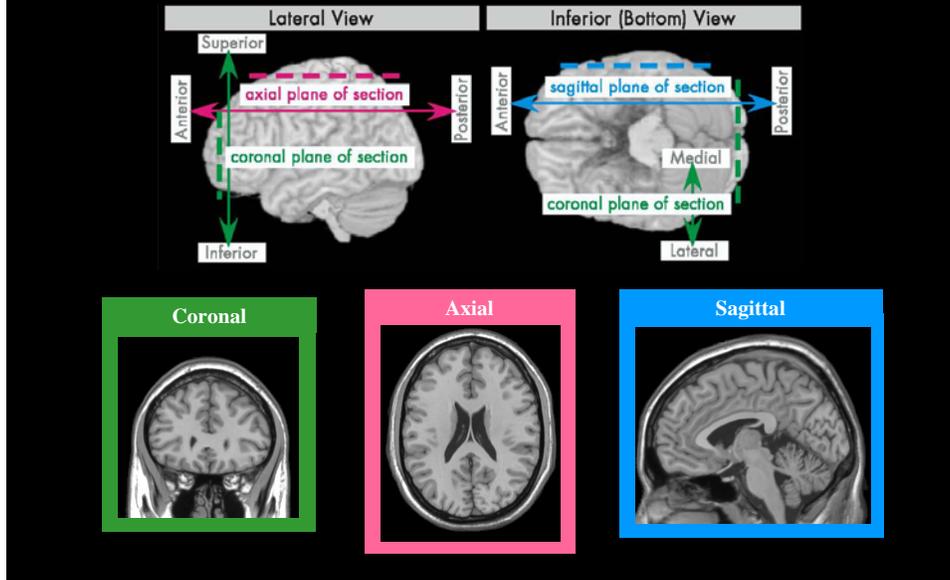
*J Nuc Med 2007;48 (6):24N*

# Intro to the Brain – Divisions

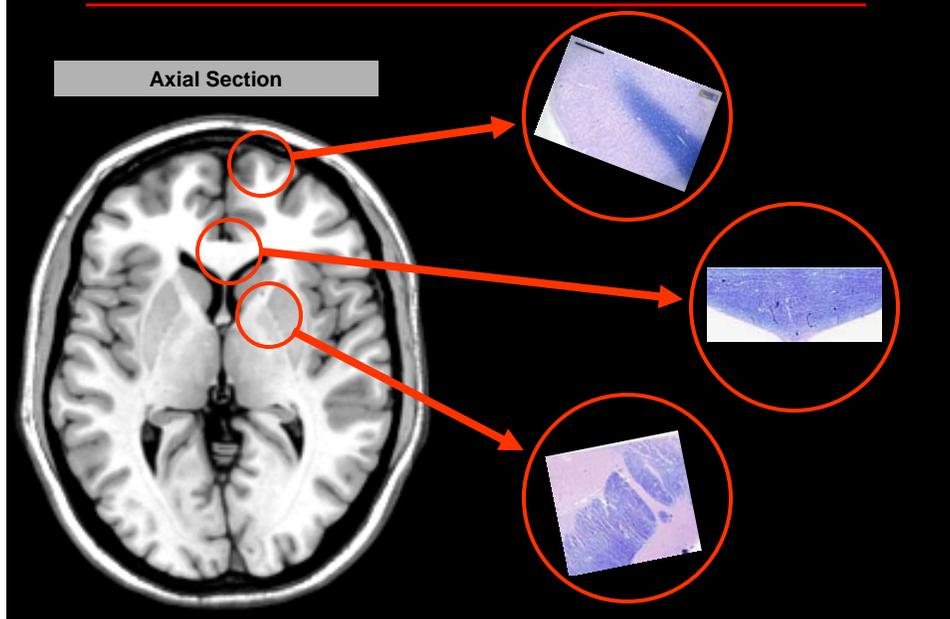




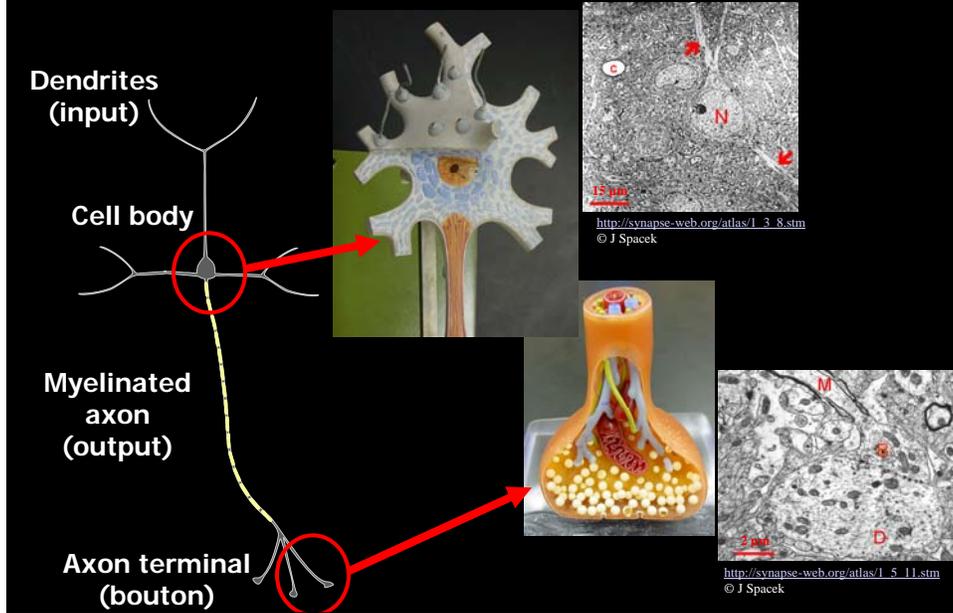
# Intro to the Brain – Sections



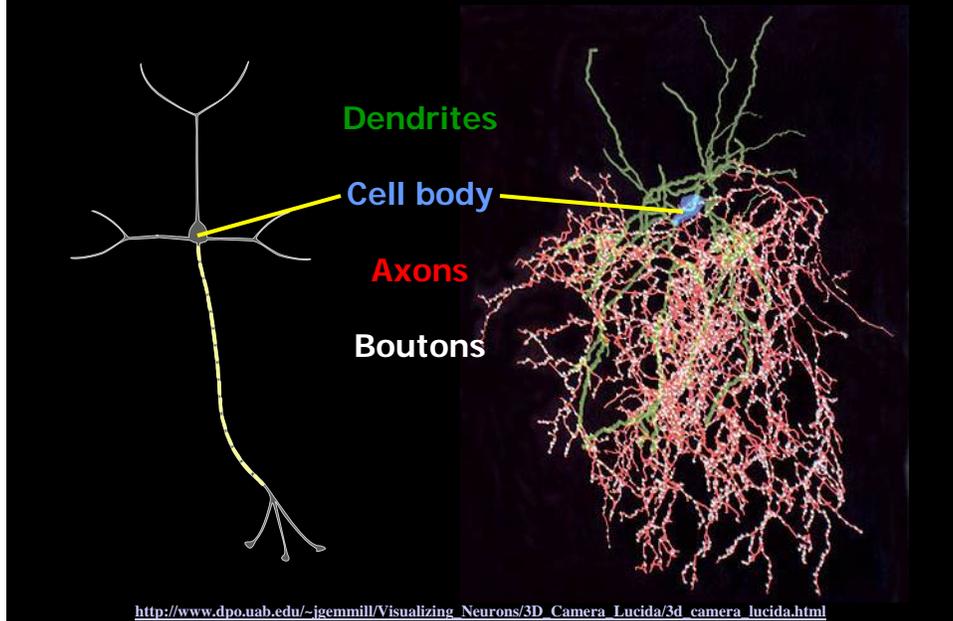
# Intro to the Brain – Structure



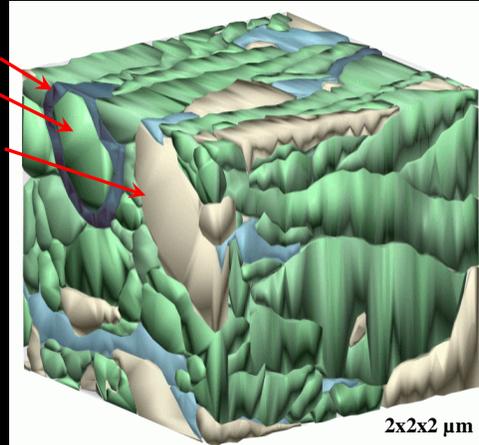
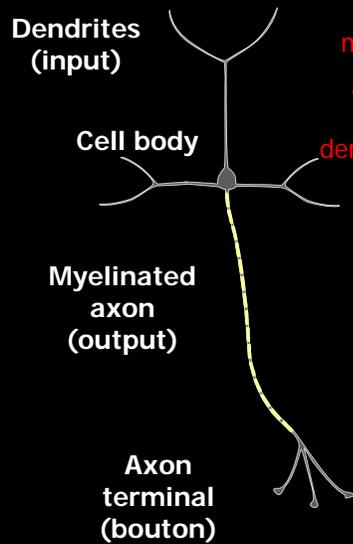
# Intro to the Brain – Neurons



# Intro to the Brain – Neurons



## Intro to the Brain – Neurons



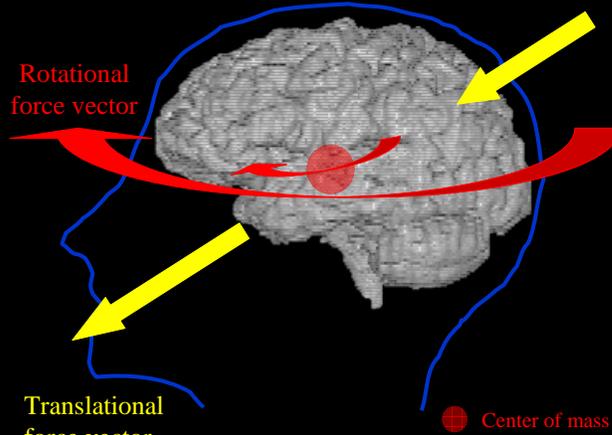
[http://synapse-web.org/atlas/1\\_8\\_4.stm](http://synapse-web.org/atlas/1_8_4.stm) © J Spacek

## What are the common causes?



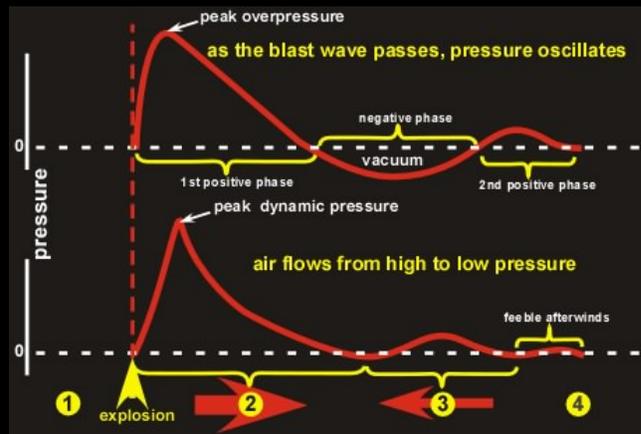
- Motor vehicle accidents
- Assaults
- Sports-related accidents
- Falls
- **Explosions**

# What are the forces?



(Figure adapted from Arciniegas and Beresford 2001)

# What are the forces?



## What are the injuries?

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### Most Common Primary Injuries:

- Subdural hemorrhage
- Contusion
- Diffuse axonal injury

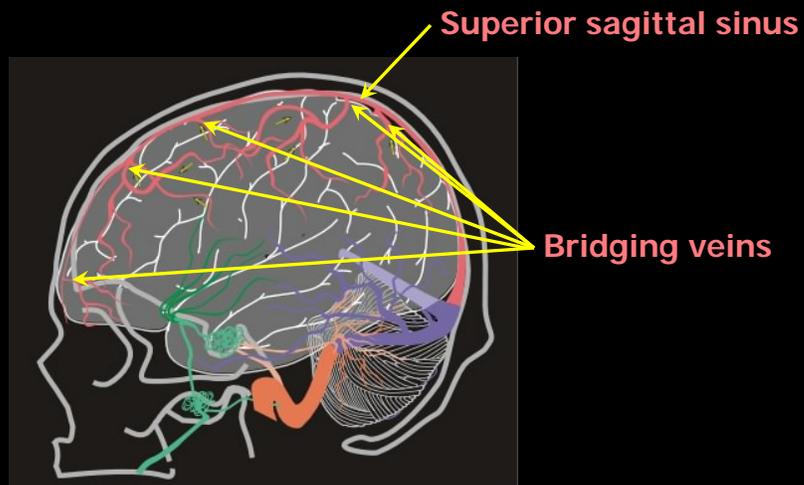
### Most Common Secondary Injuries:

- Excitotoxicity
- Edema
- Ischemia

## What are the injuries?

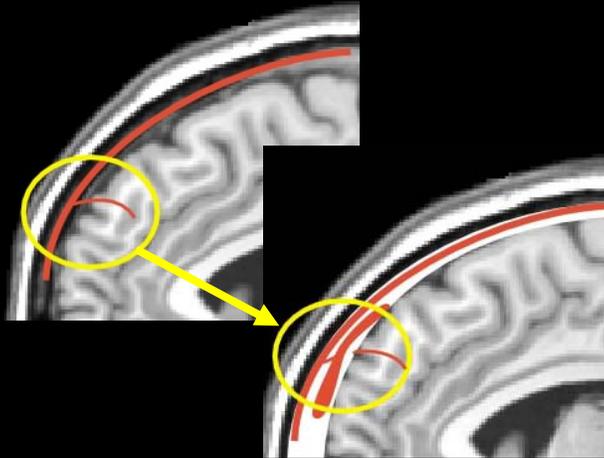
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### Subdural Hemorrhage (SDH)



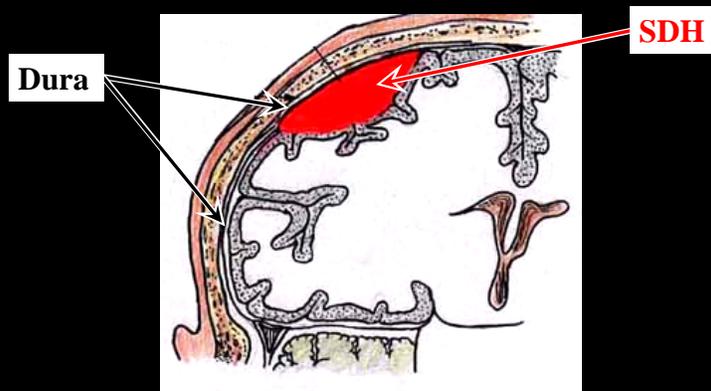
## What are the injuries?

Subdural Hemorrhage (SDH)



## What are the injuries?

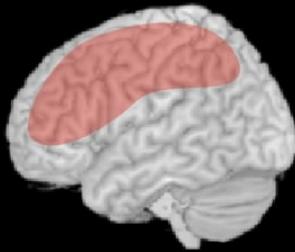
Subdural Hemorrhage (SDH)



# What are the injuries?

## Subdural Hemorrhage (SDH)

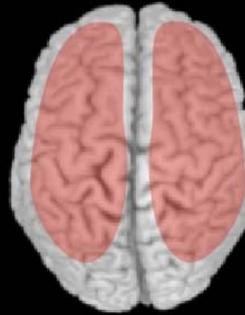
Side View



Front View



Top View



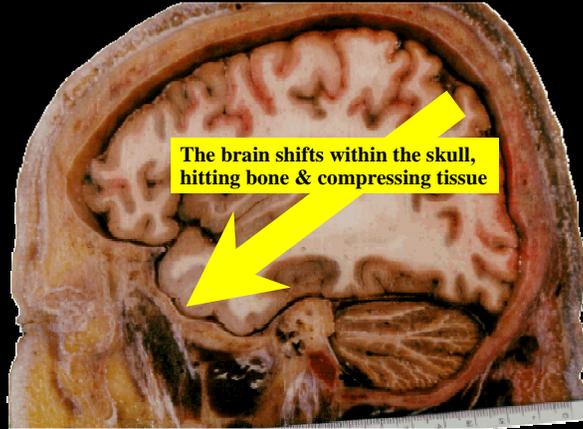
# What are the injuries?

## Subdural Hemorrhage (SDH)



# What are the injuries?

## Contusion



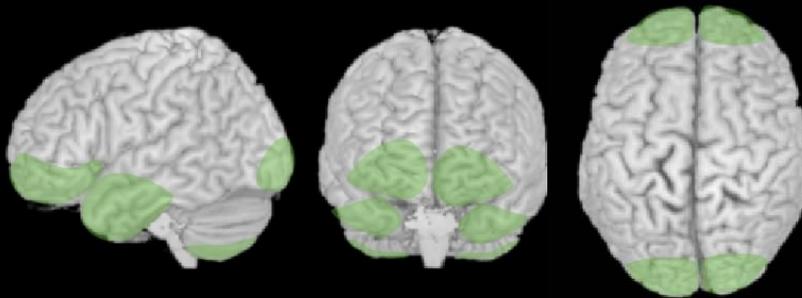
# What are the injuries?

## Contusion

Side View

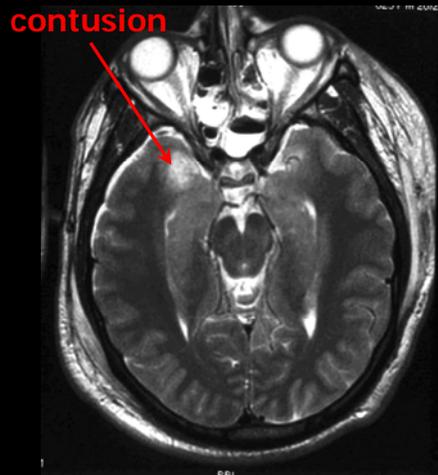
Front View

Top View



## What are the injuries?

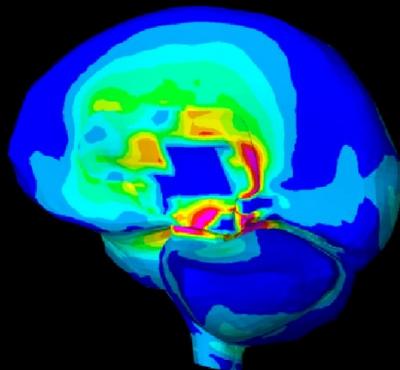
### Contusion



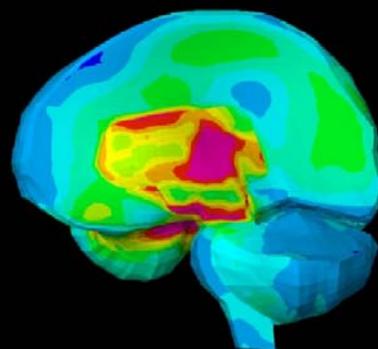
## What are the injuries?

### Diffuse Axonal Injury (DAI)

Predicted Shear Stress



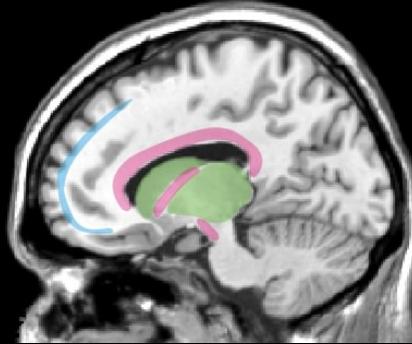
Predicted Strain Stress



# What are the injuries?

## Diffuse Axonal Injury (DAI)

Midline View



# What are the injuries?

## Diffuse Axonal Injury (DAI)

### Old View



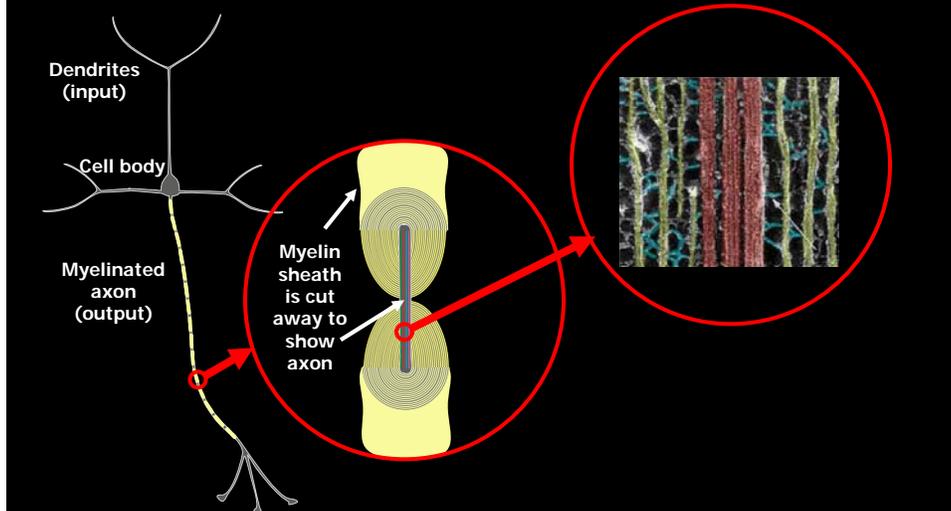
### New View

- Immediate injury
- Axon is torn
- Axon retracts
- Formation of end ball

- Progressive injury
- Axon is stretched
- Increased permeability
- Calcium influx
- Damage to cytoskeleton
- Impaired axoplasmic transport
- Axonal swelling
- Detachment

# What are the injuries?

## Diffuse Axonal Injury (DAI)



# What are the injuries?

## Diffuse Axonal Injury (DAI)

### Old View



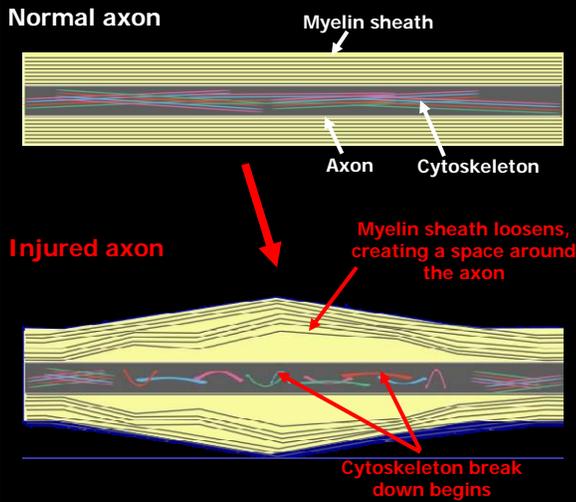
### New View

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# What are the injuries?

## Diffuse Axonal Injury (DAI)

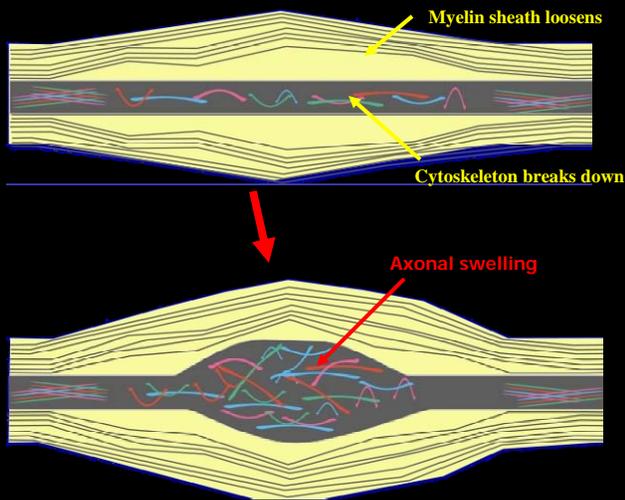


### New View

- Progressive injury
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# What are the injuries?

## Diffuse Axonal Injury (DAI)

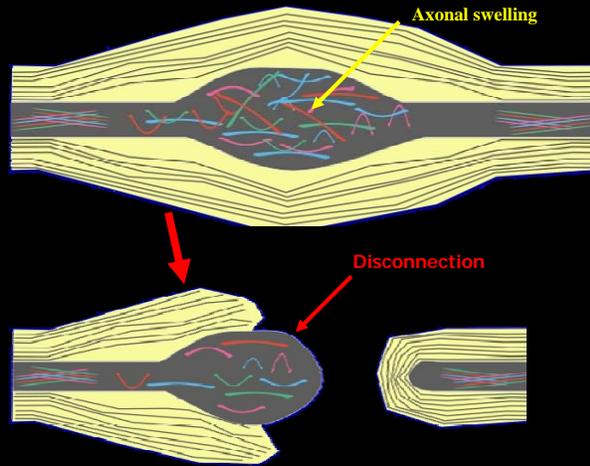


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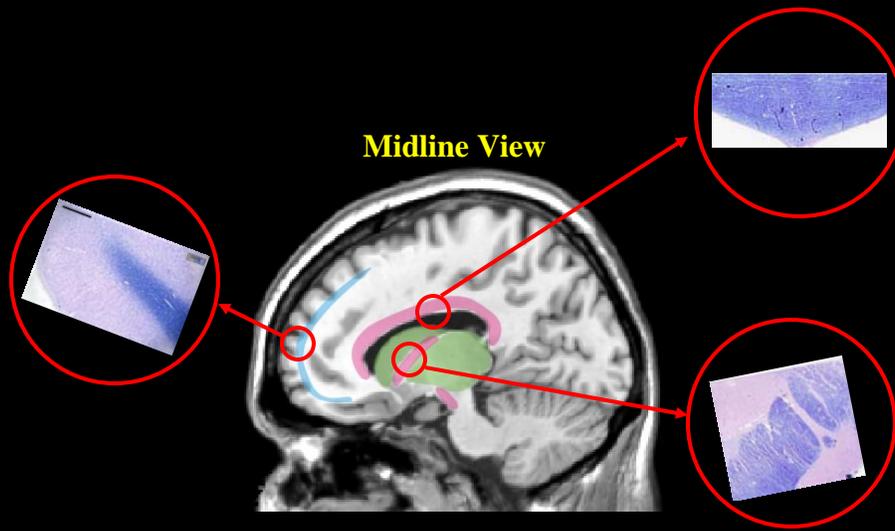


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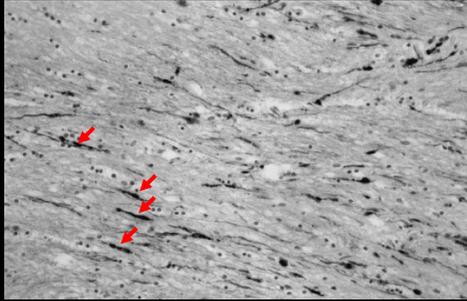
# What are the injuries?

## Diffuse Axonal Injury (DAI)

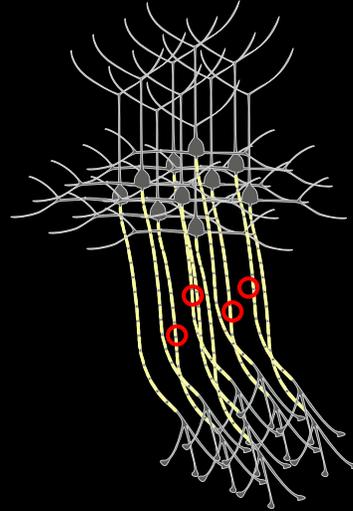


## What are the injuries?

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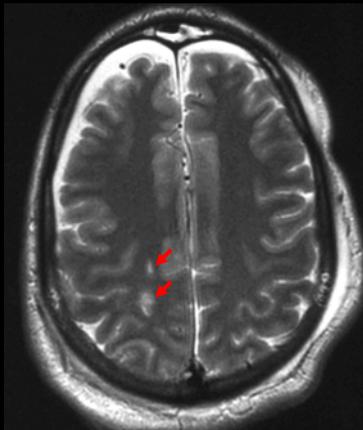
(Oehmichen 1998 Figure 1)



## What are the injuries?

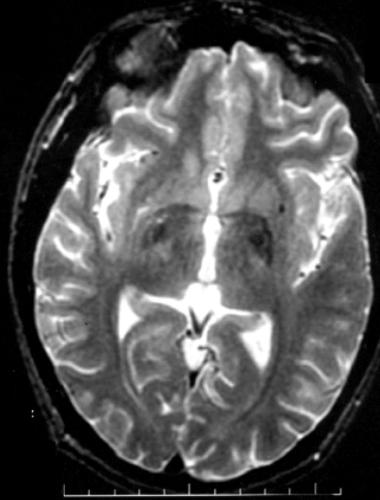
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### Diffuse Axonal Injury (DAI)



# What are the injuries?

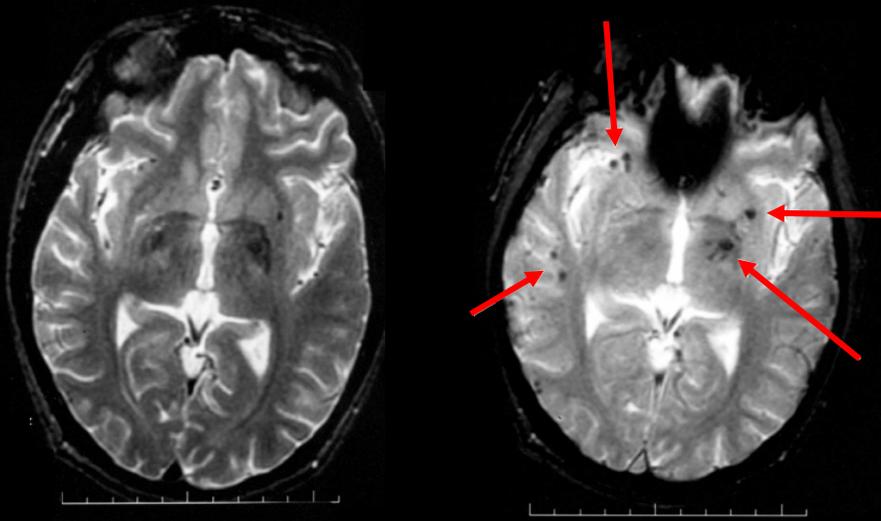
## Diffuse Axonal Injury (DAI)



Gerber et al. Brain Injury 2004; 18(11):1083-1097

# What are the injuries?

## Diffuse Axonal Injury (DAI)



Gerber et al. Brain Injury 2004; 18(11):1083-1097

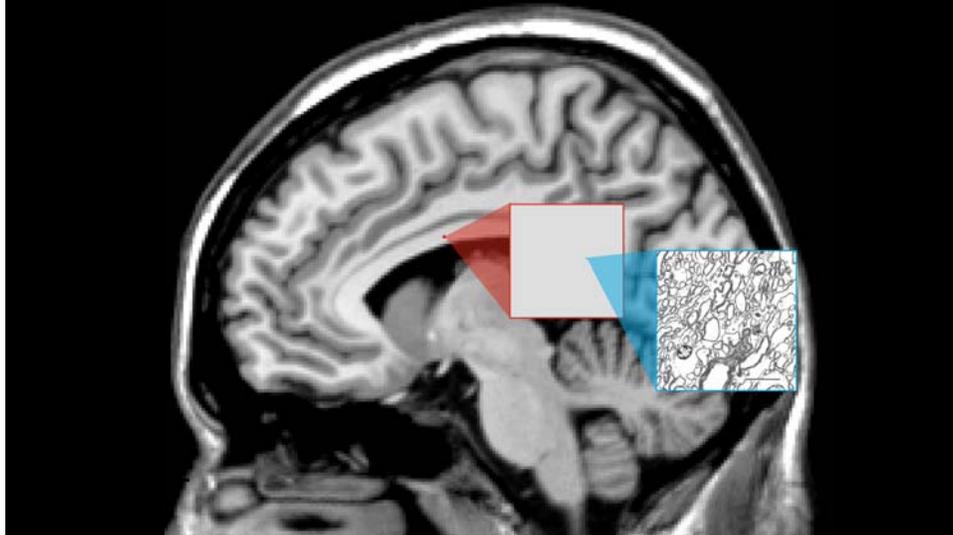
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Diffuse Axonal Injury (DAI)



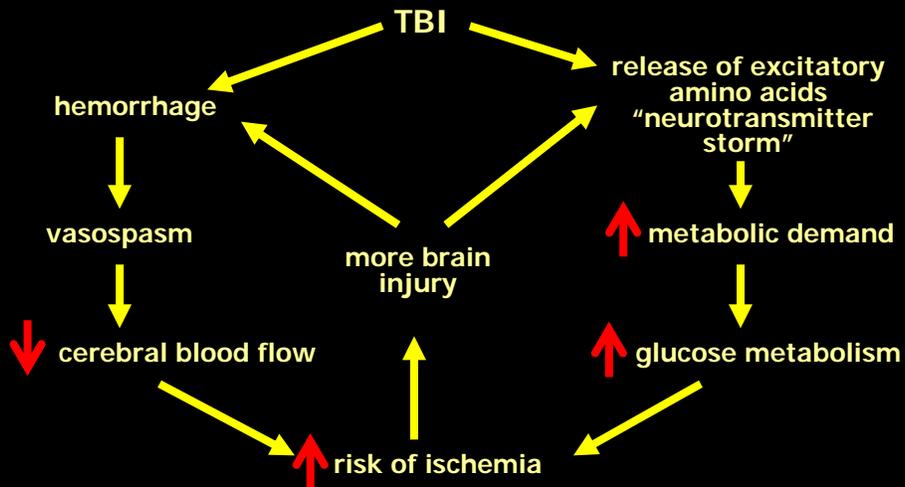
## What are the injuries?

Diffuse Axonal Injury (DAI)



# What are the injuries?

## Evolution



(Figure adapted from Yi and Hazell, 2006)

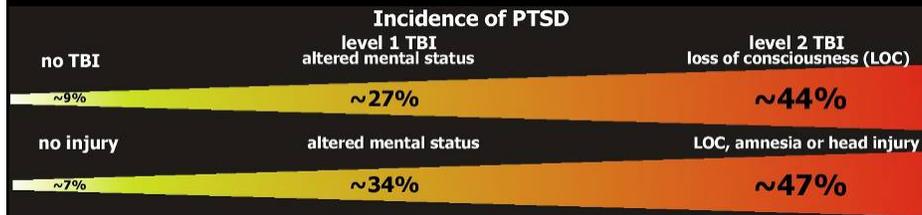
# Mild TBI - Challenges



## Diagnosis

- Neuroimaging
- Neurobehavioral testing
- Self-report

## Mild TBI - Challenges

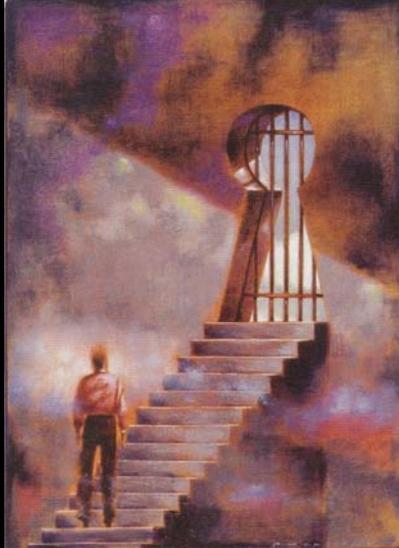


## Mild TBI - Challenges

### PTSD and TBI: Common symptoms

- Decreased concentration
- Agitation/irritability
- Insomnia
- Social isolation/detachment
- Impaired memory
- Affect and Mood disturbances

## What we don't know....



- Is combat-related injury similar to or different from civilian TBI?
- When are the deficits permanent?
- Is there change in judgment/skill after mild combat-related TBI? If so, for how long?
- Can we use the sports-related TBI literature as a guide?
- What are the best assessment strategies/tools for the immediate and long-term evaluation?
- What are the best acute and longer term treatment protocols?
- What is the prognosis?

Thank You