



MIRECC
 Mental Illness
 Research,
 Education &
 Clinical Center
 Post Deployment Mental Health



**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

- 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

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):xiii-xxii

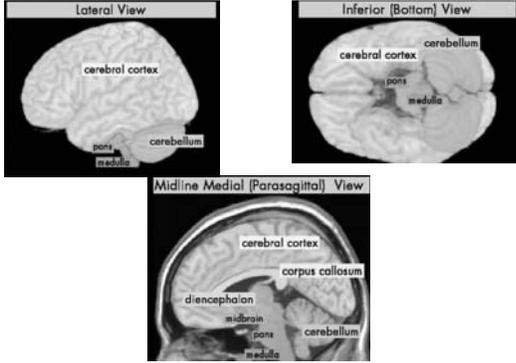
Incidence of TBI - Military

- ~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

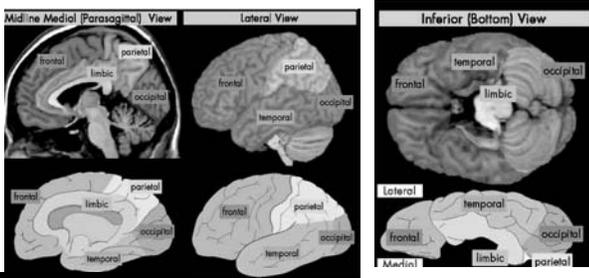
- 16.1% of 596 active duty soldiers reported history consistent with TBI
Neurology 2006;66:A235
- 15.2% of 2,525 returning soldiers reported history consistent with TBI
New England Journal of Medicine 2008;358(5):453-63
- 17.8% of 13,400 returning soldiers reported history consistent with TBI due to blast
J Nuc Med 2007;48 (6):24N

Intro to the Brain – Divisions



Intro to the Brain – Divisions

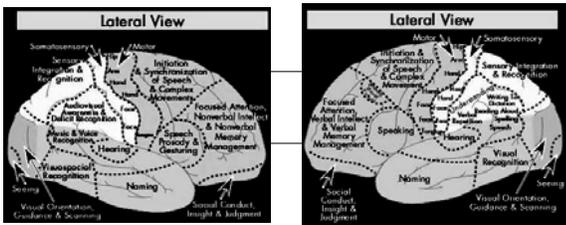
limbic | temporal | occipital | parietal | frontal



Intro to the Brain – Functions

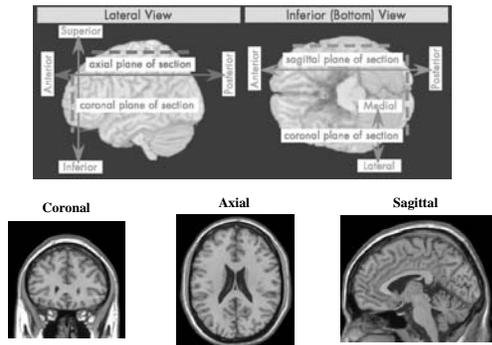
Right Hemisphere

Left Hemisphere

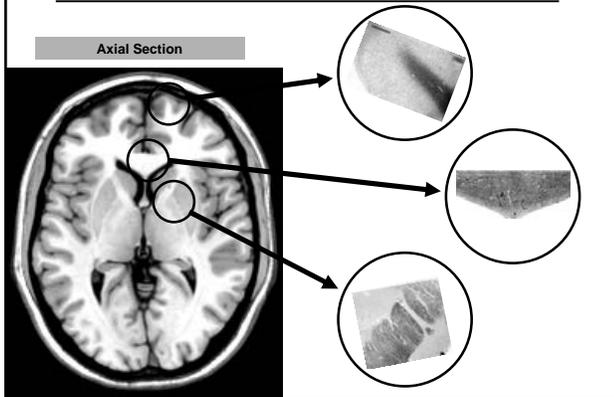


limbic | temporal | occipital | parietal | frontal

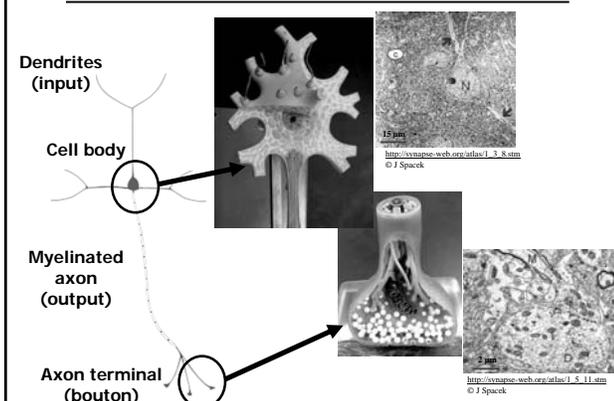
Intro to the Brain – Sections



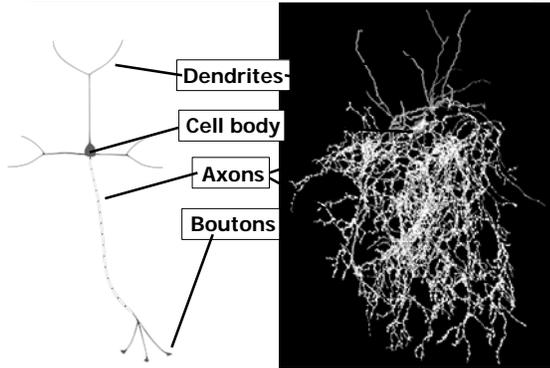
Intro to the Brain – Structure



Intro to the Brain – Neurons

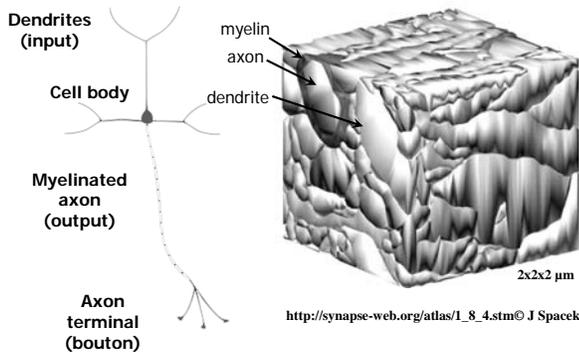


Intro to the Brain – Neurons



http://www.dpo.uab.edu/~jgemmill/Visualizing_Neurons/3D_Camera_Lucida/3d_camera_lucida.html

Intro to the Brain – Neurons

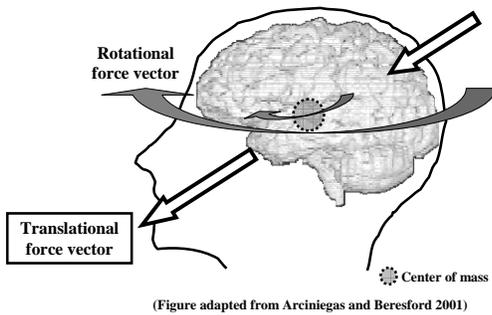


http://synapse-web.org/atlas/1_8_4.stm © J Spacek

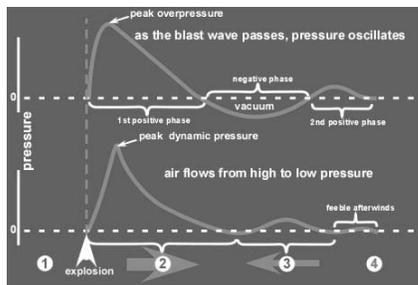
What are the common causes?

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

What are the forces?



What are the forces?



What are the injuries?

Most Common Primary Injuries:

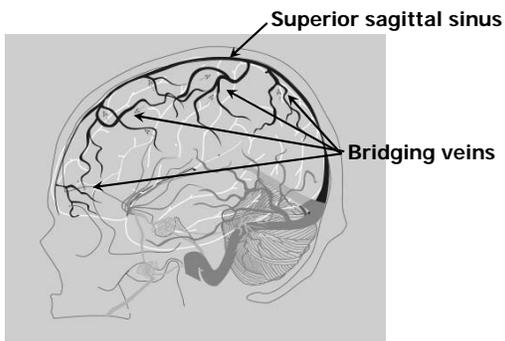
- Subdural hemorrhage
- Contusion
- Diffuse axonal injury

Most Common Secondary Injuries:

- Excitotoxicity
- Edema
- Ischemia

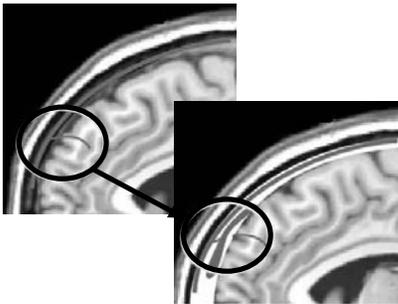
What are the injuries?

Subdural Hemorrhage (SDH)



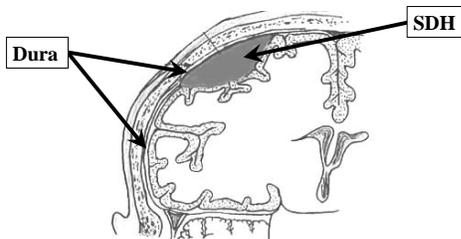
What are the injuries?

Subdural Hemorrhage (SDH)



What are the injuries?

Subdural Hemorrhage (SDH)



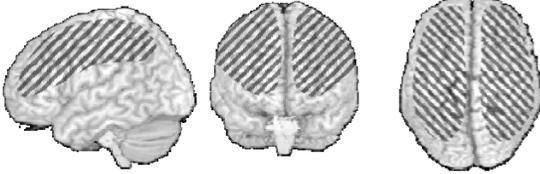
What are the injuries?

Subdural Hemorrhage (SDH)

Side View

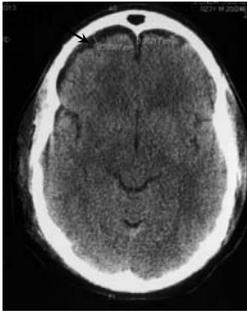
Front View

Top View



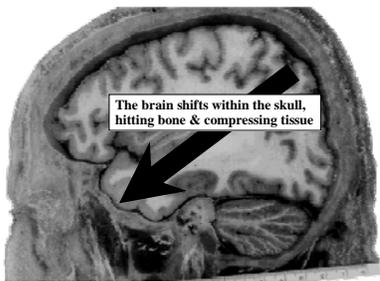
What are the injuries?

Subdural Hemorrhage (SDH)



What are the injuries?

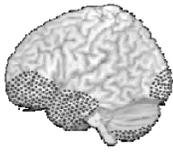
Contusion



What are the injuries?

Contusion

Side View



Front View



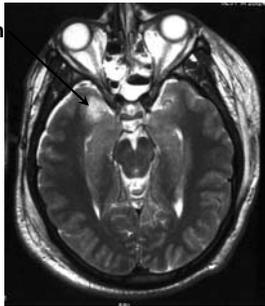
Top View



What are the injuries?

Contusion

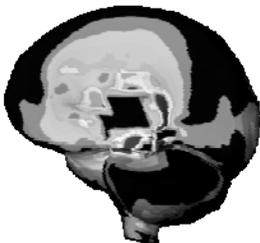
contusion



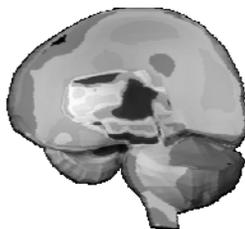
What are the injuries?

Diffuse Axonal Injury (DAI)

Predicted Shear Stress



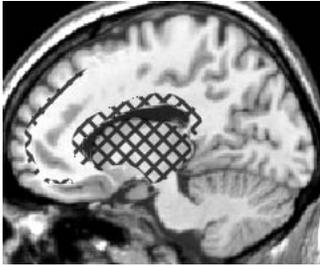
Predicted Strain Stress



What are the injuries?

Diffuse Axonal Injury (DAI)

Midline View



What are the injuries?

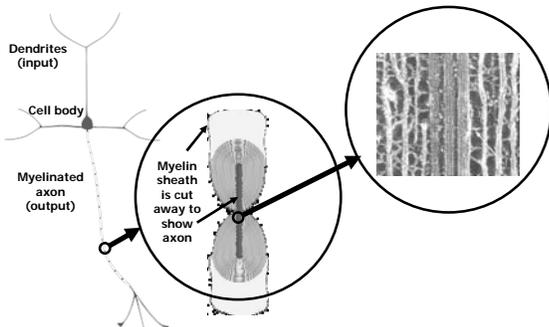
Diffuse Axonal Injury (DAI)

Old View → New View

- | | |
|---|--|
| <ul style="list-style-type: none">• Immediate injury• Axon is torn• Axon retracts• Formation of end ball | <ul style="list-style-type: none">• 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

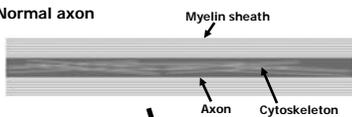
- Immediate injury
- Axon is torn
- Axon retracts
- Formation of end ball

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

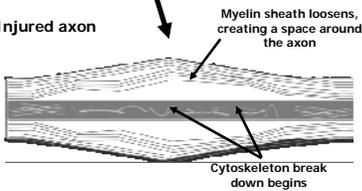
What are the injuries?

Diffuse Axonal Injury (DAI)

Normal axon



Injured axon

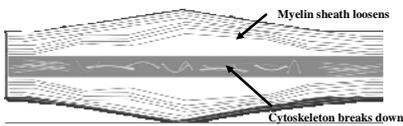


New View

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

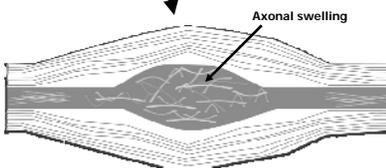
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Diffuse Axonal Injury (DAI)



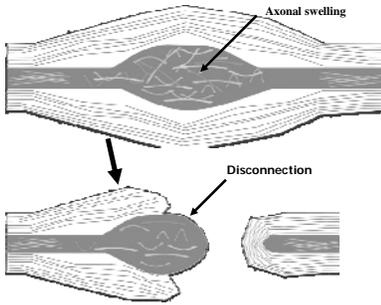
New View

- Progressive injury
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What are the injuries?

Diffuse Axonal Injury (DAI)

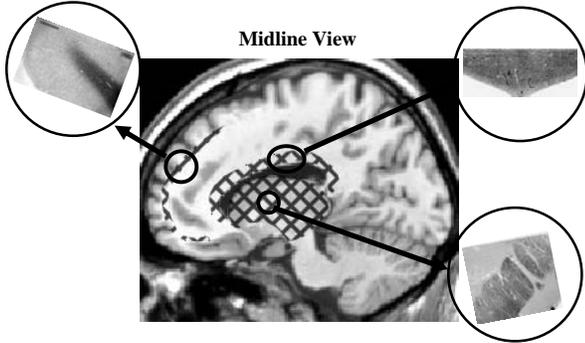


New View

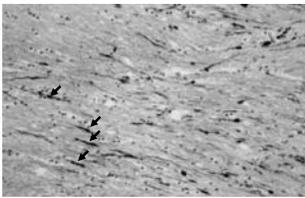
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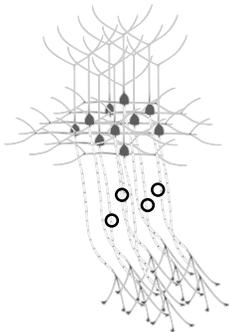
Diffuse Axonal Injury (DAI)



What are the injuries?

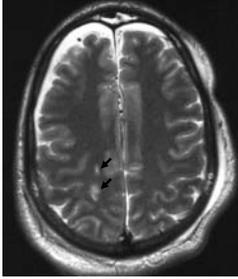


(Oehmichen 1998 Figure 1)



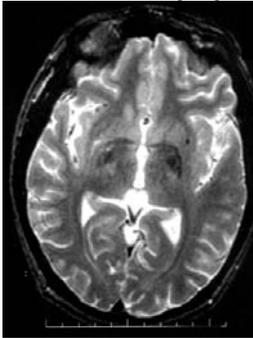
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Diffuse Axonal Injury (DAI)



What are the injuries?

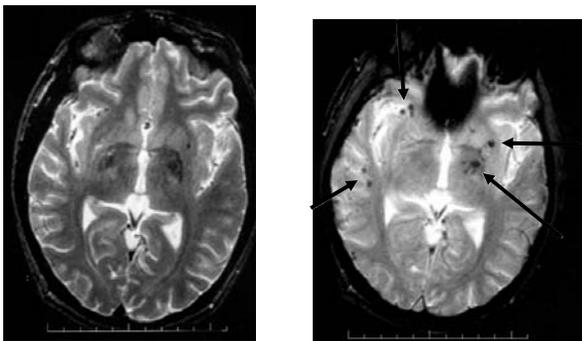
Diffuse Axonal Injury (DAI)



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

What are the injuries?

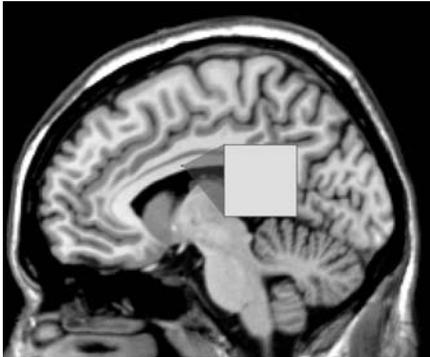
Diffuse Axonal Injury (DAI)



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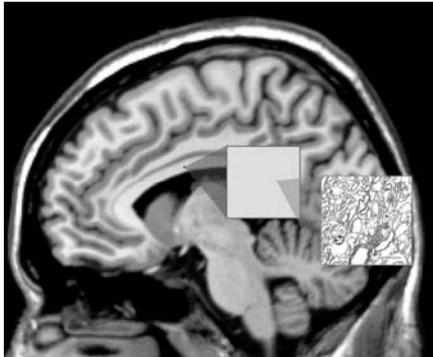
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Diffuse Axonal Injury (DAI)



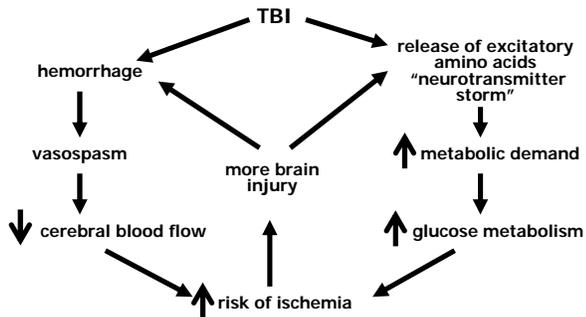
What are the injuries?

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

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?
