The Importance of Trauma in Traumatic Brain Injury

The Injury Event Dictates Injury Outcome

Bryan Pfister, PhD
Professor and Chair, Biomedical Engineering
Associate Director, Center for Injury Biomechanics,
Materials and Medicine
Thanks to colleagues/students and funding agencies
Thanks to millions of soldiers who guard our freedom
Unique Facilities
Traumatic Brain Injury

- Inertial Loading
- Diffuse Injury

Margulies et. al. 1990

Graphs showing time (ms) and shear strain over time for different runs and sensors.
Mechanics of TBI

- Head rotations lead to significant shear deformations of brain tissue.

- Bulk shearing often translates to a localized stretching of individual neurons and their processes.

Magou et al. 2011 J Neurotrauma
Smith and Meaney 2000 Neuroscientist
Meaney et al. 1995 J Neurotrauma
Traumatic Axonal Stretch Injury

Stretch leads to cellular damage.

DAI
Diffuse Axonal Injury
Widespread injury to axons.

mTBI
Repair or Dysfunction?

Smith and Meaney 2000 Neuroscientist
In Vitro TBI Model
Traumatic Axonal Stretch Injury

Magou et.al. 2011 J Neurotrauma
What type of loading and tissue deformation is realistic?
Concussion / Blunt Head Injury Modeling

Drop Tower

Motor Vehicle Accident Simulation

Sports Injury Simulation

Human Scale Model (PMHS)
Blunt Injury Experimental Setup

- Interchangeable body
- Variable impact speed:
  - 3mph
  - 5mph

Skull-Brain-Neck Surrogate
- PVC human skull
- 20% ballistic gel with markers
- Hybrid III anthropomorphic neck
- Adjustable impact orientation:
  - Crown
  - Front

Drop Tower
- Body
- Surrogate
- With markers
- Anthropomorphic neck
- Orientation
Impact Direction Affects Deformation
Analysis: Motion tracking and strain computations
Shear strain - 3mph impact
Contour maps of mean maximum strains

Contour maps of strain rates associated with maximum strains

Data displayed is for 5mph impacts
Different Rates of Deformation

1 second long video

Graph showing strain over time with different rates of deformation.
Modeling Variations in Injury

Comparison of Different Rates From pFPI and vcFPI in Adult Rat Injuries
Distinct Effect of Impact Rise Times on Immediate and Early Neuropathology After Brain Injury in Juvenile Rats

Eric J. Neuberger,¹† Radia Abdul Wahab,²† Archana Jayakumar,¹ Bryan J. Pfister,² and Vijayalakshmi Santhakumar¹,³*  
¹Department of Neurology and Neurosciences, Rutgers New Jersey Medical School, Newark, New Jersey  
²Department of Biomedical Engineering, New Jersey Institute of Technology, Newark, New Jersey  
³Department of Pharmacology and Physiology, Rutgers New Jersey Medical School, Newark, New Jersey

### TABLE I. Summary of Waveform Rise and Immediate Postinjury Response

<table>
<thead>
<tr>
<th></th>
<th>Sham</th>
<th>Fast FPI</th>
<th>Standard FPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>10–90% Rise time (msec)</td>
<td>N/A</td>
<td>4.67 ± 0.3 (n = 9)</td>
<td>11.88 ± 1.11 (n = 9)*</td>
</tr>
<tr>
<td>% Seizure (stage 3 or higher)</td>
<td>0 (n = 7)</td>
<td>0 (n = 16)</td>
<td>72.2% (n = 18)††</td>
</tr>
<tr>
<td>% Mortality (4-hr study)</td>
<td>0 (n = 7)</td>
<td>0 (n = 16)</td>
<td>22.2% (n = 18)††</td>
</tr>
<tr>
<td>% Mortality (1-week study)</td>
<td>0 (n = 14)</td>
<td>0 (n = 16)</td>
<td>22.7% (n = 22)††</td>
</tr>
</tbody>
</table>

*P < 0.05 by Student’s t-test.  
†P < 0.05 compared with sham by χ² test.  
‡P < 0.05 compared with fast FPI by χ² test.
Credits

**In vitro modeling:**
Joshua Berlin
Alexandra Adams
George ‘Dino’ Magou

**In vivo modeling:**
Viji Santhakumar
Kevin Pang
Mathew Long
Aswati Arvind
Eric Neuberger

**Blast Injury:**
Namas Chandra
Maciej Skotak
Rama Rao

**Human surrogate modeling:**
Abdus Ali
Michael Hanna
Brian Swenson

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