May 8th, 10:30 AM - 12:00 PM

Rodent Traumatic Brain Injury as a Model for Human Traumatic Axonal Damage and Neurodegeneration

Nils Henninger
University of Massachusetts Medical School, nils.henninger@umassmed.edu

Follow this and additional works at: http://escholarship.umassmed.edu/cts_retreat

Part of the Animal Diseases Commons, Nervous System Diseases Commons, Neurology Commons, Translational Medical Research Commons, and the Trauma Commons

This work is licensed under a Creative Commons Attribution-Noncommercial-Share Alike 3.0 License.

http://escholarship.umassmed.edu/cts_retreat/2013/presentations/11

This material is brought to you by eScholarship@UMMS. It has been accepted for inclusion in UMass Center for Clinical and Translational Science Research Retreat by an authorized administrator of eScholarship@UMMS. For more information, please contact Lisa.Palmer@umassmed.edu.
RODENT TRAUMATIC BRAIN INJURY AS A MODEL FOR
HUMAN TRAUMATIC AXONAL DAMAGE AND NEURODEGENERATION

Nils Henninger, MD
Department of Neurology
-no disclosures-
OBJECTIVES

- Advantages and disadvantages of mouse trauma models
- Few examples of frequently used mouse models
- Similarities between mouse vs. human mild traumatic brain injury (TBI)
The Neuropathology and Neurobiology of Traumatic Brain Injury

Kaj Blennow,¹* John Hardy,² and Henrik Zetterberg¹,²
¹Clinical Neurochemistry Laboratory, Institute of Neuroscience and Physiology, Sahlgrenska Academy at University of Gothenburg, Sahlgrenska University Hospital, Mölndal, SE-431 80 Mölndal, Sweden
²Department of Molecular Neuroscience and Reta Lilla Weston Laboratories, UCL Institute of Neurology, London WC1N 1PJ, UK
*Correspondence: kaj.blennow@neuro.gu.se
http://dx.doi.org/10.1016/j.neuron.2012.11.021

Figure 1. Molecular Pathophysiology of Concussion
A schematic flow chart of the molecular changes after rotational head injury that leads to concussion and knockout with loss of consciousness. Abbreviations: NMDA, N-methyl-D-aspartate.
Modeling mild TBI with axonal injury in mice is difficult because of their brain’s resilience to accelerational/rotational forces.

**Mouse Brain Trauma**

**Disadvantages:**
- Obvious differences related to developmental speed, brain size, gyration (surface area), gray-white matter ratio, specific compartmentalization, and complexity.
- High resilience to angular acceleration injury (compact, small).

**Advantages:**
- Low cost and ethical concern compared to higher species.
- Models key aspects of human brain injury.
- Genetic versatility.

[Image: Close-up of a human foot over a dead mouse]
Focal injury models:
- Controlled cortical impact
- Head impaction

Diffuse injury models:
- Fluid percussion
- Blast injury models
- Closed head weight drop

?Mild
CCI causes traumatic axonal injury (TAI) at the expense of massive focal damage

**CONTROLLED CORTICAL IMPACT (CCI)**

CCI delivers an impact onto the unprotected brain surface

But, it requires a craniotomy and typically produces TAI in the vicinity of significant focal injury (*).
FLUID PERCUSSION INJURY (FPI)

FPI produces TAI uncomplicated by contusion, major inflammatory response, or significant astrocytic gliosis.

However, it requires an elaborate setup, craniotomy, and is prone to variability (worse with small brains).
Closed head injury model is easy to perform, avoids craniotomy, and adaptable

**CLOSED HEAD TBI(CHI)**

CHI avoids a craniotomy and can be performed very quickly

CHI can easily be tailored to specific needs

Weight 50 g
Height 15 cm
Impact area 3 mm
MILD CHI INDUCES TRANSIENT NEUROLOGICAL DEFICITS

**PROTOCOL**

**TABLE 1 | Neurological severity score (NSS) for mice.**

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Points (success/failure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit circle</td>
<td>Ability and initiative to exit a circle of 30 cm diameter within 3 min</td>
<td>0/1</td>
</tr>
<tr>
<td>Monoparesis/hemiparesis</td>
<td>Paresis of upper and/or lower limb of the contralateral side</td>
<td>0/1</td>
</tr>
<tr>
<td>Straight walk</td>
<td>Alertness, initiative and motor ability to walk straight</td>
<td>0/1</td>
</tr>
<tr>
<td>Startle reflex</td>
<td>Innate reflex; the mouse will bounce in response to a loud hand clap</td>
<td>0/1</td>
</tr>
<tr>
<td>Seeking behavior</td>
<td>Physiological behavior as a sign of 'interest' in the environment</td>
<td>0/1</td>
</tr>
<tr>
<td>Beam balancing</td>
<td>Ability to balance on a beam of 7 mm width for at least 10 s</td>
<td>0/1</td>
</tr>
<tr>
<td>Round stick balancing</td>
<td>Ability to balance on a round stick of 5 mm diameter for at least 10 s</td>
<td>0/1</td>
</tr>
<tr>
<td>Beam walk: 3 cm</td>
<td>Ability to cross a 30-cm long beam of 3 cm width</td>
<td>0/1</td>
</tr>
<tr>
<td>Beam walk: 2 cm</td>
<td>Same task, increased difficulty on a 2-cm wide beam</td>
<td>0/1</td>
</tr>
<tr>
<td>Beam walk: 1 cm</td>
<td>Same task, increased difficulty on a 1-cm wide beam</td>
<td>0/1</td>
</tr>
<tr>
<td>Maximal score</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

Author: the last name of the first author; No. reference marks Study type is coded as follows (per the Oxford Centre for Kidney Research and Medical Education): RCT, randomized trial. Measures refer to specific tests (e.g., SCAT2, BESS). See Table S1 for more details.
Laser Doppler Flowmetry Indicates Transient Posttraumatic Hypoperfusion

Pediatric Sp
Todd A. M
*Pediatri*

Alterations
M. Cecil
2011;

---

a Participants who completed only 2 study visits.
b This value was eliminated from the mean calculation as this participant was an extreme outlier: see discussion section.
BETA AMYLOID PRECURSOR PROTEIN (bAPP)-STAINING MARKS TRAUMATIC AXONAL INJURY

Johnson et al., ExpNeurol 2012
Post-traumatic bAPP-positive neurons are predominantly found in the right hemisphere CA3 and cortex.
SUMMARY AND OUTLOOK

- Mouse closed head TBI mimics several important aspects of human concussion injury:
  - Transient neurological deficits (particularly balance)
  - Posttraumatic hypoperfusion
  - Traumatic axonal injury
  - Neuronal stress and degeneration

- Further detailed histological evaluation
- Impact on cognitive measures
- Evaluating axonal death pathways
- Testing of novel therapeutic strategies to mitigate axonal/neuronal traumatic injury