Brain and Cervico-Medullary Injury: Patterns and Mechanisms

P. Ellen Grant MD
Associate Professor of Radiology, HMS
Director, Center for Fetal-Neonatal Neuroimaging & Developmental Science
Children’s Hospital Boston Chair in Neonatology
Children’s Hospital Boston
Radiological Manifestations of Abusive Head Trauma

- Skull Fractures
- Subdural Collections
- Brain Injury
- Spinal Injury
Patterns of Brain Injury

- Cardiorespiratory Arrest
- Respiratory Arrest
- Anoxia
- Normal imaging
- Contusional Tears
- Big Black Brain
- Associated Spinal Injury

Infant Brain is different
Delayed cell death
Infant Brain Very Different

- Relative size head to body (10% vs 2% wt)
- Weak neck
- Soft pliable calvarium
- Open sutures and fontanelles
- Lack of myelination
- Cell death mechanisms
- Receptors, biochemical cascades
2 year old choked on candy, no one knew Heimlich maneuver. Imaging suggests minimal injury? ....
Cardiorespiratory Arrest

8.5h

18h

46h

57h

4d 14.5h

Mechanisms of Cell Death

1. Acute Necrosis
2. Necrosis like
3. Apoptosis (Type I)
4. Autophagic (Type II)

Programmed Cell Death

REALLY A SPECTRUM...

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ADC Evolution

18hrs
~2d (59h)
~4d (93h)
~8d (184h)

2 month F/U

Respiratory Arrest

ADC T2
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Abusive Head Trauma

CT at Presentation
6 mo old, Seizures, Unresponsive
Abusive Head Trauma

un-responsive

~12h
Abusive Head Trauma

Initial ADC
~12 hrs

ADC
3 Days

ADC
4 Days
On Admission

Confessed

Shaking

Hypoxic Ischemic Pattern

18 Days Later
Abusive Head Trauma

MRI 6 Months Later

Acute DWI can miss injury
Mechanisms of Cell Death

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3D Surface Reconstruction

CT Scan at Presentation
Injured tissue

blood

Injured tissue
Evolution of Injury

Presentation  3 days  14 days  20 days
Mechanisms of Cell Death

- Cell death
- Inflammation
- Repair

- Oxidative stress
- Excitotoxicity

Response: Hours, Days, Weeks

Contusional Tears

- Confusing if pathology not known
- Characteristic of blunt head trauma in infants < 5 months
- Slit-like cleft in white matter +/- hemorrhage
- Horizontal cortical tears at gyral crests
- May be associated with diffuse white matter injury

Associated Spinal Injury

- >60% of children with abusive head trauma who underwent spinal imaging have associated spinal injury

Abusive Head Trauma

Admission 24 hrs later

5 weeks old
Metaphyseal and multiple rib #, suspicion of liver laceration
Evidence of Spinal Trauma

Later the same day
Patterns of Brain Injury

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“Big Black Brain”

CT concerning Hypoxic Ischemic Pattern

15 mo “fall from couch”
Abusive Head Trauma

MRI Confirms Hypoxic Ischemic Pattern
MRI Confirms Hypoxic Ischemic Pattern
BBB + Spinal Trauma

courtesy Michelle Silvera
Secondary Impact Syndrome

• Class IV, case series
• 10 cases
• Initial head injury +/- LOC leading to post concussive symptoms
• Second direct or indirect (acceleration) impact while still symptomatic (hours to weeks) leads to rapid decline
• CT shows thin SDH, massive swelling

Does repetitive injury affect presentation in AHT?

Cantu and Gean. J of Neurotrauma 2010;27:1557
Neurometabolic Cascade

- Ionic shifts
- Altered brain metabolism
- Impaired neuronal connectivity
- Disruption of normal neurotransmission

Giza and Hovda. J Athle Train 2001;36:228-35
Can ASL Improve Detection?

Normal routine MRI, 67 d, visual tracking concerns but normal on follow-up.

Normal routine MRI, 101 d, multiple rib # of at least 2 ages, bruising in multiple regions. Skull fracture.
Can ASL Improve Detection?

Mean Cerebral Perfusion
27.2 mL/100g/min

Mean Cerebral Perfusion
71.1 mL/100g/min
Can NIRS Improve Detection?

Frequency Domain (FD) NIRS

Diffuse Correlation Spectroscopy (DCS)

NIRS detected brain injury in neonatal hypoxic ischemic injury

What about NAT?

Quantitative

StO₂

CBV

CBFᵢ

CMRO₂

Grant, Franceschini
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Mechanisms of Abusive Brain Injury

Mechanical Forces

Hypoxia - Immature Brain - Ischemia

Image multiple times? DTI, MRS, ASL Screen with NIRS?

Window of Opportunity

Delay

COMPLEX SECONDARY CASCADES