"I tremble lest I have mankind at large for my enemies, so much doth wont and custom become a second nature. Doctrine, once sown, strikes deep its root, and respect for antiquity influences all men. Still, the die is cast, and my trust is in my love of truth, and the candour of cultivated minds".

William Harvey, “On the motion of the heart...” (1628)
The Mechanics and Mimics for Apparent Head Trauma in Infants and Toddlers

John Plunkett, MD
Bridget McCormack, JD
Differential diagnosis

The conditions known to cause (or) to be associated with the observed clinical, radiographical or pathological findings
Differential diagnosis

• Subdural hemorrhage (SDH)
• Retinal hemorrhage (RH)
• Encephalopathy
Differential diagnosis

• Subdural hemorrhage (SDH)
• Retinal hemorrhage (RH)
• Encephalopathy
Differential diagnosis

- Subdural hemorrhage (SDH)
- Retinal hemorrhage (RH)
- Encephalopathy
What is SDH?

• Bleeding in the “space” between the dura and the arachnoid
Schema of bridging cerebral vein
One problem, *inter alia*

Subdural collections occur *without* trauma
Non-traumatic subdural collections

• The birth process itself, including C-section delivery
• Lumbar puncture resulting in intracranial hypotension
• A variety of infections caused by bacteria and viruses
• Bleeding associated with cortical venous thrombosis (CVT), or sagittal sinus thrombosis (SST) or other large-sinus thrombosis
Non-traumatic subdural collections

• Inborn errors of metabolism such as glutaric aciduria and Menkes Disease
• Inherited or acquired coagulation abnormalities, such as hypofibrinogenemia, Vitamin K deficiency, thrombocytosis, or thrombocythemias
• Structural abnormities such as an arachnoid cyst, increased extra-axial fluid, or subdural hygromas
Non-traumatic subdural collections

- Vascular malformations such as, but not limited to, AV malformations
- Poorly understood inflammatory processes such as hemophagocytic lymphohistiocytosis and post-vaccination reactions
- Anoxia/hypoxia
The DBC is approximately 8 microns thick

The DBC is the “weakest link” in dural/arachnoid interface due to scarcity of tight junctions and prominent interstitial spaces.

Haines, 1993
Differential diagnosis for SDH

- Mechanical
  - Impact
  - Impulsive loading
- Natural diseases
- Anoxia
Differential diagnosis for SDH

- Mechanical
  - Impact
  - Impulsive loading

- Natural diseases

- Anoxia
Impact Loading

Impact from a fall

Impact from an object
Mechanism for impact brain injury

- Focal injury
- Diffuse injury
Infant versus Adult Anatomy

Brain
- Mass/size
- Water Content
- Myelination
- Subarachnoid space
- Vascular development

Skull
- Geometry
- Skull calcification
- Suture fusion
Differential diagnosis for SDH

• Mechanical
  • Impact
  • Impulsive loading

• Natural diseases

• Anoxia
Impulsive Loading

Rear torso loading
Mechanism for impulsive brain injury

- Focal injury
- Diffuse injury
On the road to Damascus...

Pre-impact motion has *nothing* to do with outcome
Shaken-Slammed Baby Syndrome
Differential diagnosis for SDH

• Mechanical
  • Impact
  • Impulsive loading

• Natural diseases

• Anoxia
Non-traumatic subdural collections

- A variety of infections caused by bacteria and viruses
  - Bleeding associated with cortical venous thrombosis (CVT), or sagittal sinus thrombosis (SST) or other large-sinus thrombosis
  - Vascular malformations such as, but not limited to, AV malformations
• 3-year-old with fever/lethargy for 18 hours
• Became unresponsive
• Taken to ED, presumed sepsis
• Developed DIC with right frontal infarct /SAH/SDH secondary to the coagulopathy
• Autopsy: Meningococcemia, Group B
• Fundi: “WNL” (“We never looked”)
Non-traumatic subdural collections

- A variety of infections caused by bacteria and viruses
- Bleeding associated with cortical venous thrombosis (CVT), or sagittal sinus thrombosis (SST) or other large-sinus thrombosis
- Vascular malformations such as, but not limited to, AV malformations
History and clinical findings

- Two-day history of “minor” diarrhea
- Ryan arched his back and raised his arms while being fed, then stopped breathing
- Linda transported him to the local hospital
- He had a single 1 cm x 3 cm bruise on the deltoid surface of his left shoulder
- His eyes and anterior fontanel were sunken, and his urea nitrogen was 25 mg/dl
• Transferred to the Marshfield Clinic
• Bloody CSF with normal carotid and vertebral angiography
• Extensive bilateral retinal hemorrhage with papilledema
• Working diagnosis: Subarachnoid hemorrhage of undetermined etiology, possible abuse
Autopsy

- Ryan weighed 25 pounds, according to the report
- He had no bruises, fractures, or parenchymal organ damage other than the brain
- He had bilateral subarachnoid hemorrhage
- The autopsy face sheet diagnoses include right parietal lobe subdural hemorrhage
Conclusion

• Polygraph
• Manner of death undetermined
Review and outcome

• The local “Medical Examiner” reviewed the Death Certificate in 1997 and concluded that shaking had caused Ryan’s death

• A forensic pathologist reviewed the medical records and autopsy report and concluded that shaking/impact syndrome had caused Ryan’s death

• Linda was charged and convicted of 2nd degree murder, and served six years in prison
Testimony

• “There’s clear evidence of severe... mechanical injury to the brain of a very, very severe nature. In fact, the injury that we see is comparable to the injuries that you see in children who fall out of second- or third-story windows or who are in 50-mile-an-hour motor vehicle crashes and tossed around the car or the inside of the car.”
• “Significant trauma similar to that of a high-speed traffic accident or a fall from a fifth story building caused the retinal hemorrhage.”
On May 1, 1978, infant Ryan A. Wanta was transported by his baby-sitter, Linda T. Sobish, to a Wisconsin hospital with no pulse and not breathing. On May 2, his five-month birthday, Ryan died. Autopsy findings included bloody cerebrospinal fluid, retinal hemorrhages and subdural and subarachnoid hemorrhage. Accidental causes offered in the police interviews ended the investigation. Nineteen years later, the case was reopened. Current medical experts clearly opined SBS as the cause of death. Key people involved with the case will share their experiences and thoughts about the evolution of this case.
Non-traumatic subdural collections

- A variety of infections caused by bacteria and viruses
- Bleeding associated with cortical venous thrombosis (CVT), or sagittal sinus thrombosis (SST) or other large-sinus thrombosis
- Vascular malformations such as, but not limited to, AV malformations
Michael

- 7-month-old
- L&D, and neonatal development normal
- No pre-terminal signs or symptoms
Differential diagnosis for SDH

• Mechanical
  • Impact
  • Impulsive loading

• Natural diseases

• Anoxia
Differential diagnosis

• Impact
• Natural diseases (“mimics”)
• Anoxia
• I don’t know
• Shaken baby syndrome
Take-home messages

• Any head impact may be associated with diffuse as well as focal injury.

• “Diffuse” rather than “focal” injury tells you little about the ultimate mechanism.

• Pre-impact motion rarely has anything to do with the mechanism, morphology, and/or outcome.

• Bridging vein rupture is an unlikely mechanism for most case of infant SDH or TBI.

• The default diagnosis is “I don’t know”, not “NAI”.

People v. Julie Baumer

Venous Sinus Thrombosis mimicking traumatic head injury
Factual background

• Julie takes her 7 week old nephew, Philipp Baumer, to the ER after 12 hours of refusing to eat or keep food down. He is lethargic but not fussy.

• At ER: doctors find he has sepsis, is dehydrated, and having seizures. No signs of abuse.

• Transferred to Children’s Hospital where 24 hours later a CT scan is done revealing significant bleeding throughout the brain and a skull fracture.
First trial: March 2005

- Prosecution experts: Triad; only explanation for injuries is child abuse.
- No defense expert
- Julie did not testify
Motion for Relief from Judgment

- Defense experts Barnes, Krasnokutsky and Ferris independently read the MRI and concluded that Philipp had unequivocal Venous Sinus Thrombosis.

- He had an old skull fracture, most likely representing birth injury.

- The Prosecution called no experts.

- Motion granted.

- Retrial set.
**Prenatal**
- Drugs
- Chorioamnionitis
- Nutrition
- Pre-diabetes
- Illness
- Multiple visits, limited movement.

**Birth**
- 37 weeks
- Pitocin
- Dystocia
- Bruises/blue/cut
- Calcified hematoma
- No notes
- 1 wk. NICU
- Critical low glucose
- Gavage (tube) fed
- No CT/MRI

**October 2**
- With Julie
  - 4:30 pm: Fr. Cooney
  - 8 pm: vomits bottle
  - 10 pm: does not feed

**October 3**
- With Julie
  - 7:30-10 am: does not feed, disc'd w/ father
  - 10:30 am: calls ped., dehydration?
  - 12:17 pm: ped. ret's call, suggests ER

**Mt. Clemens ER**
- October 3, 1:05 pm
  - 1:50 pm: more alert, cooing, moving extremities
  - 2:15 pm: seizures
  - 3:30 pm: stops breathing
  - Dx: sepsis, dehydration; no signs trauma/abuse
  - Labs: anemia, MRSE, other
  - Hi dose antibiotics, IV, phenobarb
  - Children's cancels CT

**Children's**
- October 3
  - 6 pm: sepsis, dehydration, PRBC anemia, ax
  - Night: seizures

**October 4**
- 8 am: US brain abnormal
  - 9:40 pm: brainswelling

**9:46 pm: CT abnormal, old skull fx, missed stroke [shunt]**

**Post-Discharge**
- Cerebral palsy
- Same patterns
- Illness → severe dehydration → hospital, poor feeding, etc.
- Missed stroke thru 2010
extreme sports