

# Pediatric Abusive Head Trauma

## 2015 Rocky Mountain Rural Trauma Symposium

Kathryn Wells, MD  
Medical Director, Denver Family Crisis Center  
Kempe Child Protection Team  
The Children's Hospital  
Instructor in Pediatrics, University of Colorado  
(720) 944-3747  
Kathryn.wells@dhha.org

# Objectives

- Recognize the possible presentations of pediatric abusive head trauma
- Understand the medical evaluation of pediatric abusive head trauma
- Appreciate the complexity of these cases

# Abusive Head Injuries

## Mechanisms

- Direct impact, “blow or throw”
- Penetration
- Asphyxiation/hypoxia
- Ischemia
- Shaking
- Shaking with impact

# Skull Fractures

- Simple linear skull fractures can result from short falls of less than 3 ft
- Usually associated with scalp bruising or swelling
- Abuse should be suspected when history of minor head trauma (i.e. short fall) in children with multiple , complex, diastatic, or occipital skull fractures

(Kleinman PK, ed. Diagnostic Imaging of Child Abuse. St. Louis, MO: Mosby Inc; 1998:295)

# Head Injuries

## Levels of Injury

Scalp: lacerations,  
bruising, hair pulling

Subgaleal: hematomas

Subperiosteal: cephalo-  
hemtoma

Skull: fractures

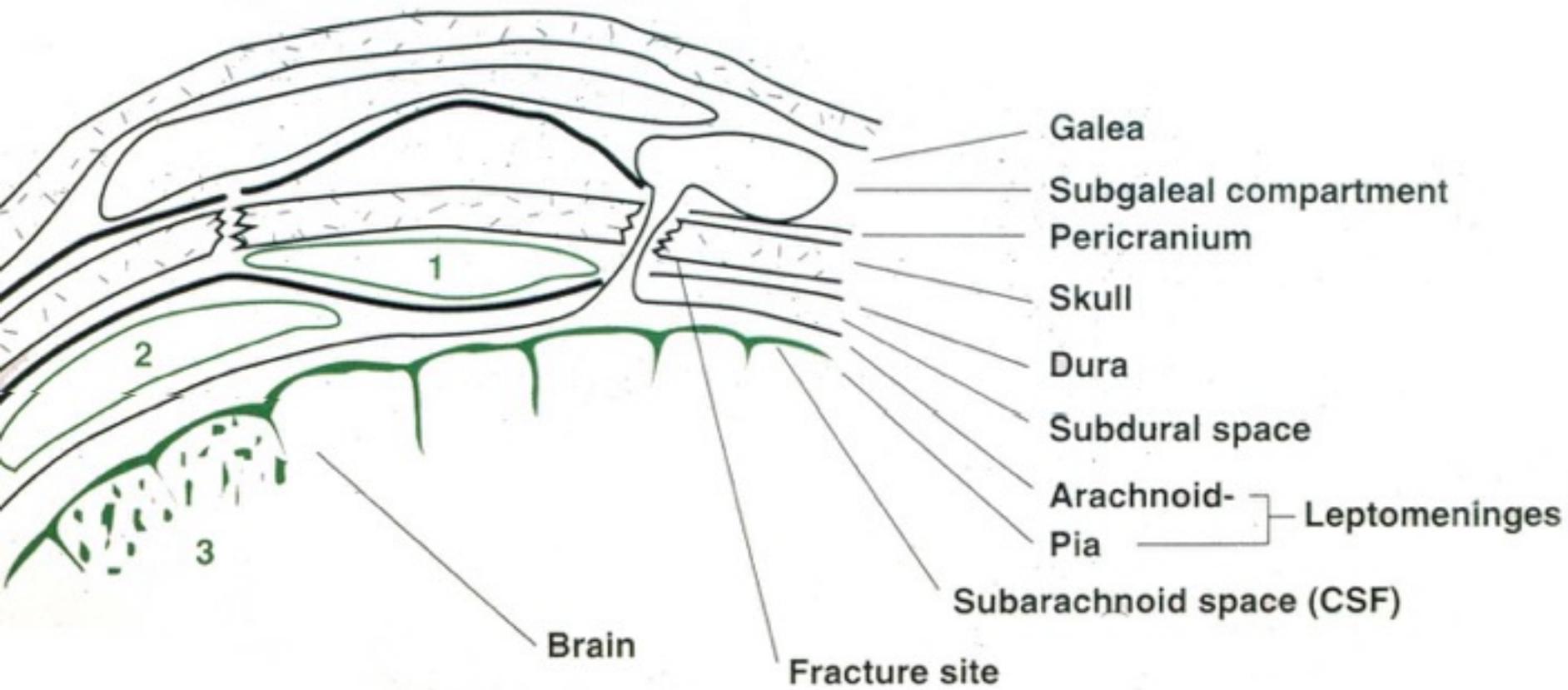
Epidural: hematomas

Subdural: hematomas

Subarachnoid:  
hemorrhage

Parenchymal: shearing  
tears, infarctions,  
axonal injuries, cerebral  
edema,  
encephalomalacia, or  
herniation

Intraventricular:  
hemorrhage



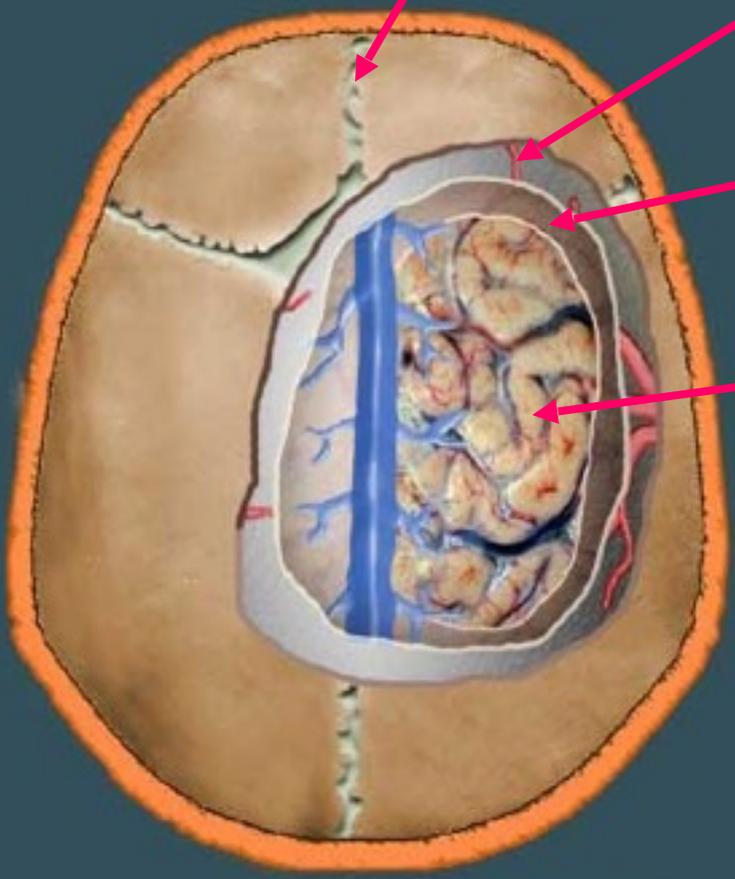
- 1 Epidural hematoma
- 2 Subdural hematoma
- 3 Cerebral contusion

Skull and Sutures

Dura and Meningeal Arteries

Arachnoid

Brain



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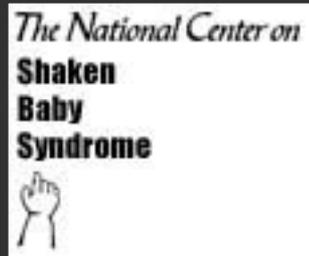
# The Shaken Baby Syndrome:

## A Visual Overview

Version 2.0

Produced by

The National Center on Shaken Baby Syndrome



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# Differential Diagnosis of Seizures

- Seizure disorder
- Infection
- Head trauma
- Metabolic abnormality
- Tumor
- Breath-holding spell
- Febrile seizure
- Anoxia/suffocation
- Ingestion/ poisoning
- Electrolyte abnormalities
- Other seizure-like behaviors

# Physical Examination

- Be thorough and document carefully!
- Skin examination for bruises, Mongolian spots, scratches, rashes, petechiae
- Head exam for bruising, swelling, fontanel (if present) and be sure to get head circumference
- Eye exam for bruising, hemorrhage, fundi
- Mouth for signs of trauma
- Include genital examination
- Musculoskeletal – moves all extremities
- Good neurologic exam

# Child Abuse Misdiagnoses

- In one study, 31% of children and infants with abusive head trauma were initially misdiagnosed
- Misdiagnosed victims likely to:
  - Be younger
  - Be white
  - Have less symptoms
  - Live with both parents

(Jenny C, Hymel KP, Ritzen A, Reinert SE, Hay TC, JAMA. 1999;281:621-626)

# “Sentinel” Injuries

- Perceived “minor” injuries that preceded serious abuse
  - Bruise
  - Intra-oral injury
  - Not clinically significant
- Pre-cruising infant
- Visible or detectable to caregiver
- Poorly explained and unexpected
- Study noted that of the 100 infants (<12 mo old) hospitalized for abusive head trauma, 30% had at least one sentinel injury compared to 0% of 101 infants who were hospitalized with injuries but no concerns of abuse

(Sheets, LK et al. Sentinel Injuries in Infants Evaluated for Child Physical Abuse. Pediatrics 2013;131:710-7.)

# Medical Provider Response

- Of the sentinel injuries known to a medical provider
  - 44% of cases suspected to be abuse
    - BUT...False assumption that abuse is “ruled out” by the workup
  - 56% of cases with no evidence that the medical provider suspected abuse
    - Injury noted without comment
    - Explained as:
      - Unintentional
      - Self-Inflicted

# Differential Diagnosis of Bruising

- Coagulopathy
- Infection
- Vasculitis
- Accidental trauma
- Nonaccidental trauma
- Leukemia
- Birth mark- Mongolian spot
- Cultural practices (coining, cupping)

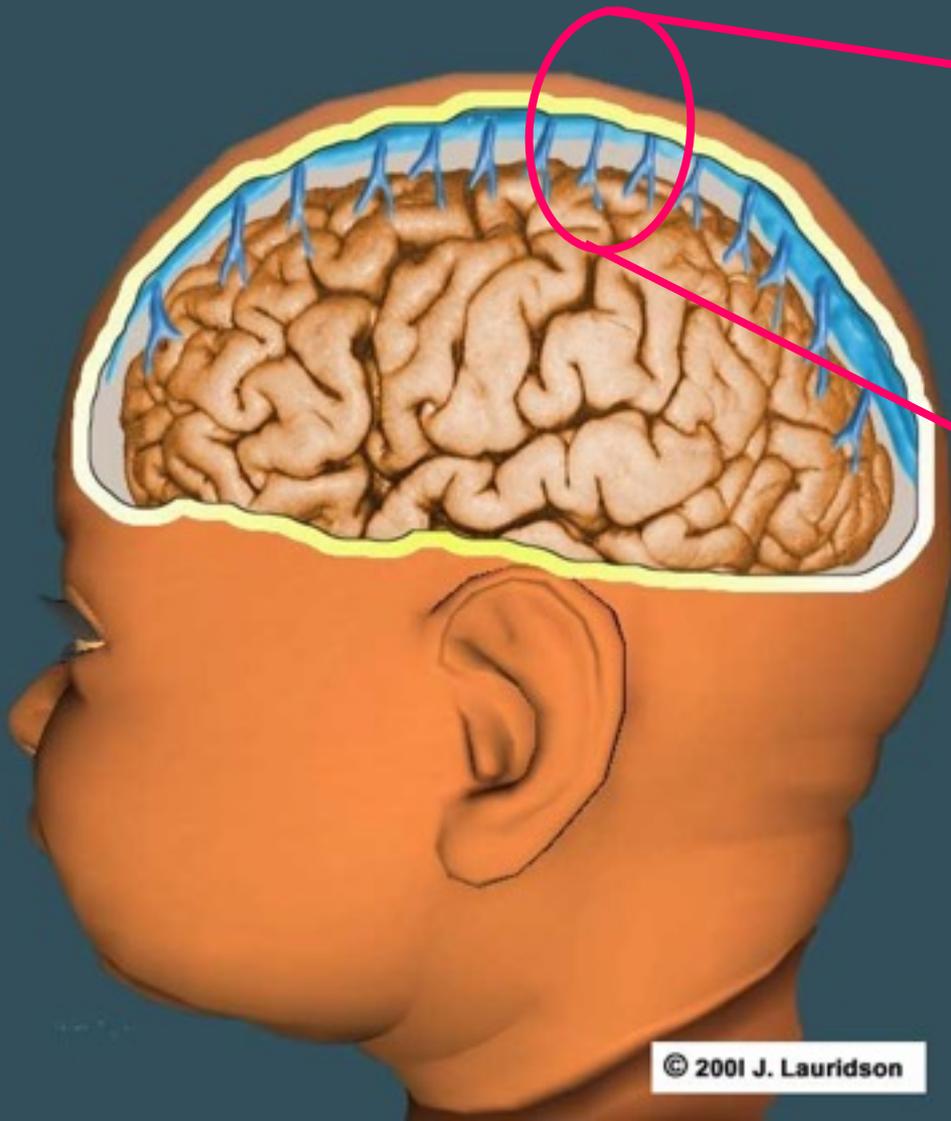
# Radiology / Lab Evaluation

- Head CT scan
- MRI
- Skeletal survey  
(preverbal or nonverbal  
infant /child - <2yr)
- CBC, PT, PTT
- LFT's, amylase/lipase
- Blood and/or CSF  
cultures
- (? urine toxicology)



# Imaging

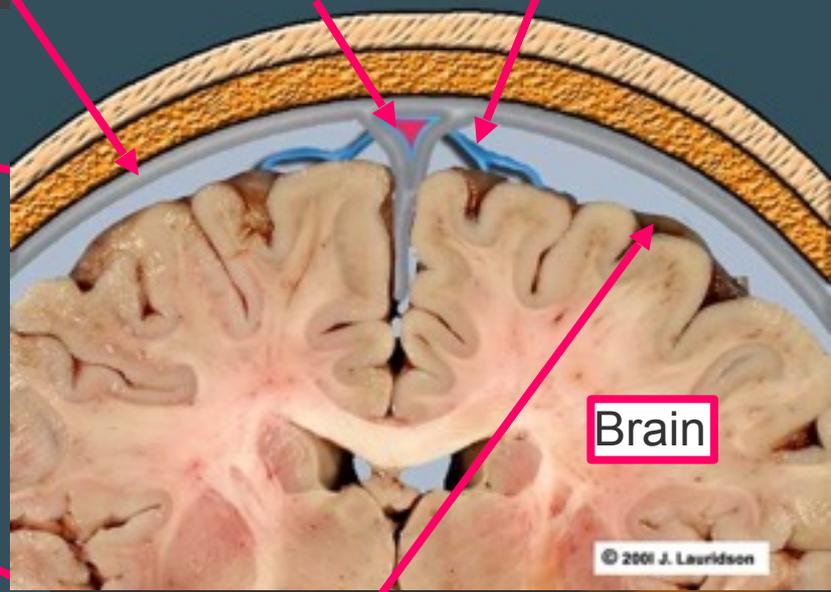
- For traumatic head injuries in general, MRI more sensitive than noncontrast CT
- FLAIR sequence helpful to detect and characterize SDH and SAH
- Diffusion-weighted imaging (DWI) helpful to detect edema, particularly related to ischemia
- Ability to accurately time the injury is limited!



Dura

Sagittal Sinus

Bridging Veins



Brain

Arachnoid

# Other Brain Injuries

- Severe diffuse axonal injury
  - Immediate Clinical Symptoms
  - Seizures
  - Unconsciousness
  - Breathing difficulty
  - Vomiting
  - Other signs of neurological damage
- Brain Laceration
- Brain Contusion
- Parenchymal Hemorrhage
- Spinal Cord Injury

# Hypoxic Ischemic Encephalopathy

- Multifactorial pathophysiology in AHT
  - Traumatic axonal injury to the brainstem and spinal cord
  - Apnea attributable to injury
  - Seizures
  - Alterations in blood flow to the brain after trauma
  - Unmet metabolic demands of the injured brain
  - Secondary cerebral edema
- Other causes
  - Birth asphyxia
  - Accidental or intentional trauma or suffocation
  - Infection
  - Metabolic disease
  - Congenital anomalies
  - Drowning
  - Choking

(Huh JW, Raghupathi R. New concepts in treatment of pediatric brain injury. Anesthesiol Clin 2009;27:213-40)

# Fractures Associated with Physical Abuse

- HIGHLY - metaphyseal chip fractures, bucket handle, posterior ribs, scapula, spinous processes of vertebral bodies, sternum
- MODERATELY - multiple fractures, fractures of different ages, vertebral body fractures and subluxations, epiphyseal separations
- LOW - clavicles, shafts of long bones, linear skull fractures (however, must be carefully reviewed whenever they occur in infants)

# Bone Injury in Abusive Head Trauma

- Rib Fractures
  - Single or Multiple
  - Posterior and Posteriolateral
  - Not caused by minor trauma
  - Not caused by CPR
  - Caused by squeezing
- Skull Fractures
- Long Bone Injury
  - Periosteal Stripping
  - Metaphyseal Fractures
  - Shaft Fractures

# Long Bone Injuries

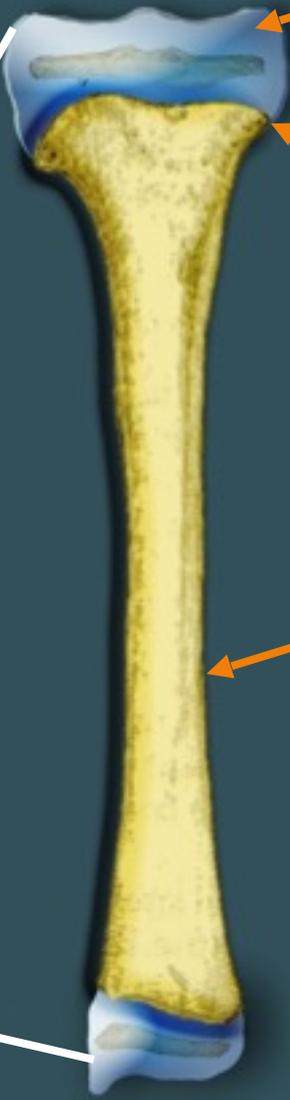
- Bucket Handle and Corner Fractures
- Periosteal stripping
- Shaft Fractures
- Pulling and twisting forces
- Not common in blunt force trauma (except for shaft fractures)



**Cartilage  
(epiphysis)**

**Growth Plate  
(metaphysis)**

**Shaft  
(diaphysis)**

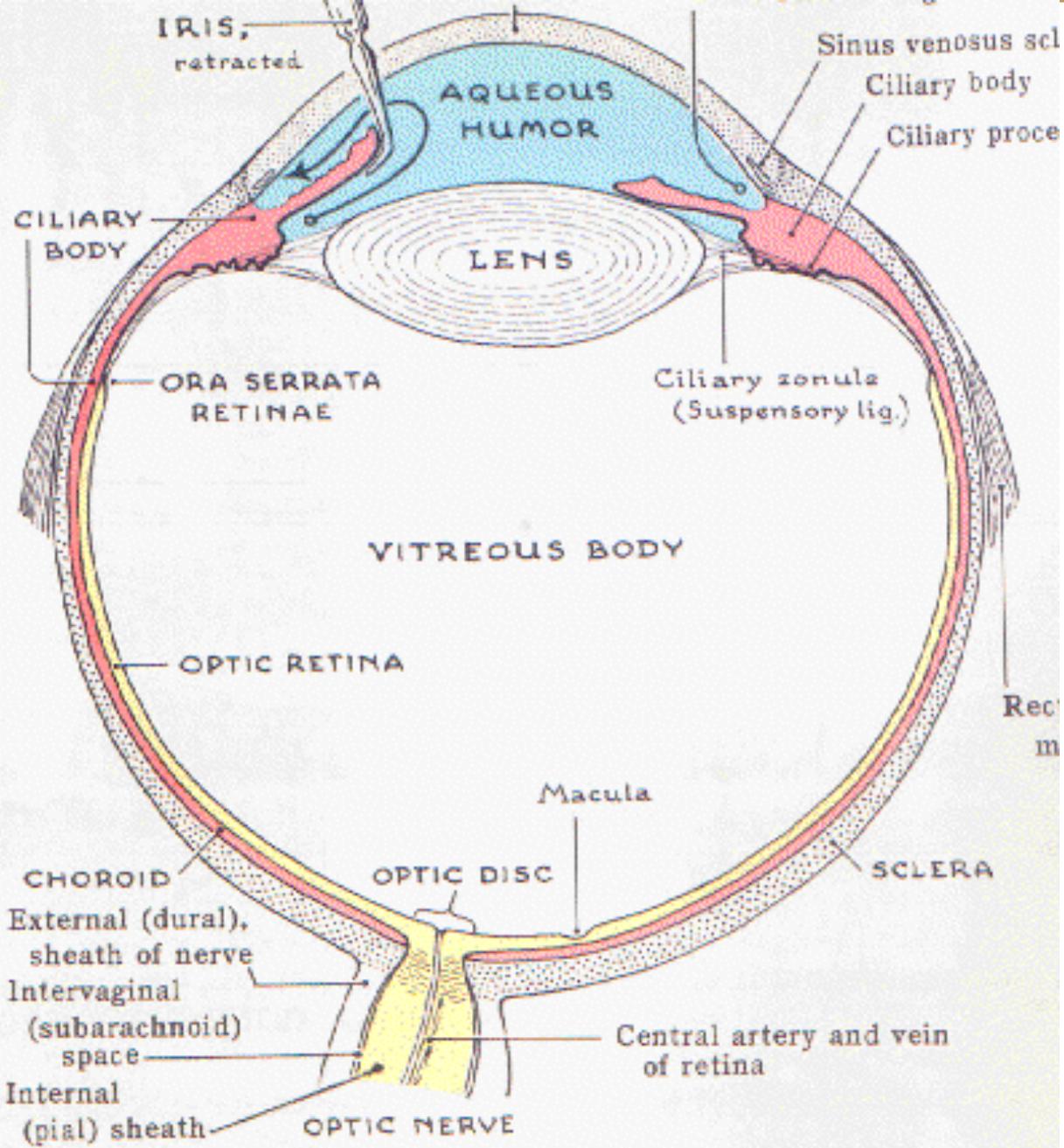


# What to do next??

- Medical photography
- Ophthalmologic exam
- Consults:
  - Pediatric Trauma/Surgery and ? Need for transfer
  - Neurosurgery
  - Child Protection Team
  - Social Work
  - ? Orthopedics
- MRI to evaluate for chronic subdural hematoma
- Obtain medical records (birth, ER visit, EMT trip sheet, transferring ER notes, PCP records)

# Retinal Hemorrhages

- 50% to 100% incidence
- Unilateral or bilateral - can be asymmetric
- Mild, Moderate or severe
- Described by type, location, amount
- Diffuse, severe, multilayered, extending to the retina's edge are not caused by
  - CPR
  - Seizures
  - Coughing and vomiting
  - Short Falls, minor head trauma
  - Elevated ICP
  - Vaccination
  - Most other diseases
- RH cannot be dated



# Short Falls

- Focal vs. Diffuse
- Shaking is often accompanied by impact
- Impact is not required for serious injury
- Fall from a short vertical height (<4 ft) is an UNCOMMON cause of SDH
- Multiple studies that describe injuries in children
  - N = 4,600
    - Short falls - Occasionally sustain simple linear skull fracture
    - Stairway falls - a series of short falls
    - Falls > 1 story
- Pattern of injury seen from short falls is unlike that seen in AHT

# Summary of Literature to Date: Witnessed Falls

<b>Fall Height</b>	Less than 3 ft	Greater than 3 ft and less than 6 ft	Greater than 6 ft
<b>From where or what object</b>	Couch, bed, coffee table	Kitchen counter, playground, slides, standing height, on chair, top of bunk bed, top of stairs, walkers	Porch, window, balcony, tree
<b>Likelihood of intracranial trauma</b>	Highly unlikely	Unexpected but possible	Reasonable to expected

# Breath Holding Spells

- Rare prior to 6 months of age
- Peak at 2 years of age
- Abate by 5 years of age
- Management is reassurance and support

# Clinical Questions

- Are the child's findings due to trauma or a medical problem (or a combination of the two)?
- If trauma, are the injuries due to:
  - abuse opposed to neglect?
  - an unintentional (accidental) cause?
  - birth trauma?

# What Could We Learn?

## Final Presentation and Admission

- Get complete history
- Get old records
  - 911 call documentation/ transcripts
  - EMT records are very important in abuse cases and provide crucial information
  - PCP contacts and records, birth records

# History of Abusive Head Trauma (AHT)/ SBS

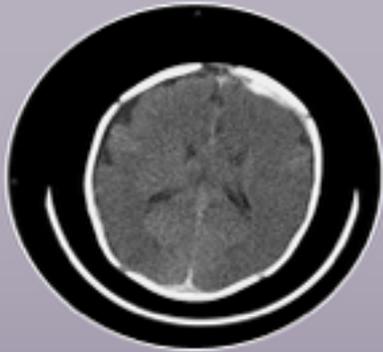
- Tardieu 1860: Array of physical injuries
- Caffey 1946: Subdural hematoma (SDH) with long bone injury and retinal hemorrhage (RH)
- Kempe 1962: "Battered Child Syndrome"
- Guthkelch 1971: SDH and whiplash injuries
- Caffey 1972: Whiplash shaken-infant syndrome
- Ludwig and Warman 1984: "Shaken Baby Syndrome" (SBS)
- Duhaime 1987: SBIS doll model with impact – 20-54%
- Duhaime et. Al 1998: "Controversy" remains if impact is required to cause permanent spectrum of injuries (Shaken Baby Syndrome)
- AAP Statement 2009: Policy Statement - AHT

# Overview of AHT/SBS

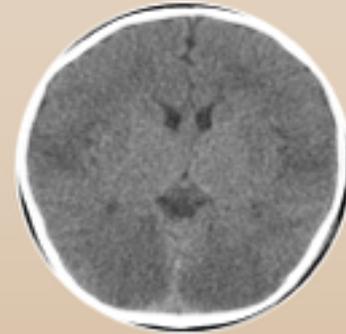
- Shaken Baby Syndrome/Abusive Head Injury is a recognized diagnosis in the medical literature
  - Extensive medical literature over the past 50 years as well as clinical experience - more than 1000 peer-reviewed clinical medical articles written by over 1000 medical authors from more than 25 different countries
  - No legitimate medical debate - legal/media
- The most common cause of traumatic death in infants under one year of is head injury
- Occurrence of approximately 20/100,000 children/year
- Estimated 80% of deaths from head trauma in children < age 2 years old are abuse
- Severe neurological, developmental, and behavioral sequelae in AHT victims, even those infants appearing normal 2 months post-injury

(Christina CW et al, Understanding Abusive Head Trauma in Infants and Children - Answers from America's Pediatricians, American Academy of Pediatrics)

# Abusive Head Trauma Varying Presentations



**Sleepy**  
**Lethargy**  
**Irritability**  
**Poor Feeding**  
**"Not acting right"**



**Signs of  
sepsis/meningitis**  
**Seizure**  
**Unconscious**  
**Apnea**  
**Death**

**← Less Severe to More Severe →**

# Varying Presentations

- Frequently have no or only nonspecific symptoms
- Absence of neurologic symptoms should not exclude the need for imaging
- Decision requires careful consideration of symptoms, signs, history and judicious use of other ancillary tests

(Greenes DS, Schutzman SA, Pediatrics. 1999;104:861-867)  
(Laskey AL, Holski M, Runyon DK, Socolar RR, J Pediatr. 2004;144:719-722)

# Perpetrator

- Triggers
  - Crying
  - Toilet Training
  - Perceived misbehavior
  - Sometimes no apparent trigger
- Adult strength

# Perpetrator

## Analysis of 151 Colorado SBS victims 1982-1994

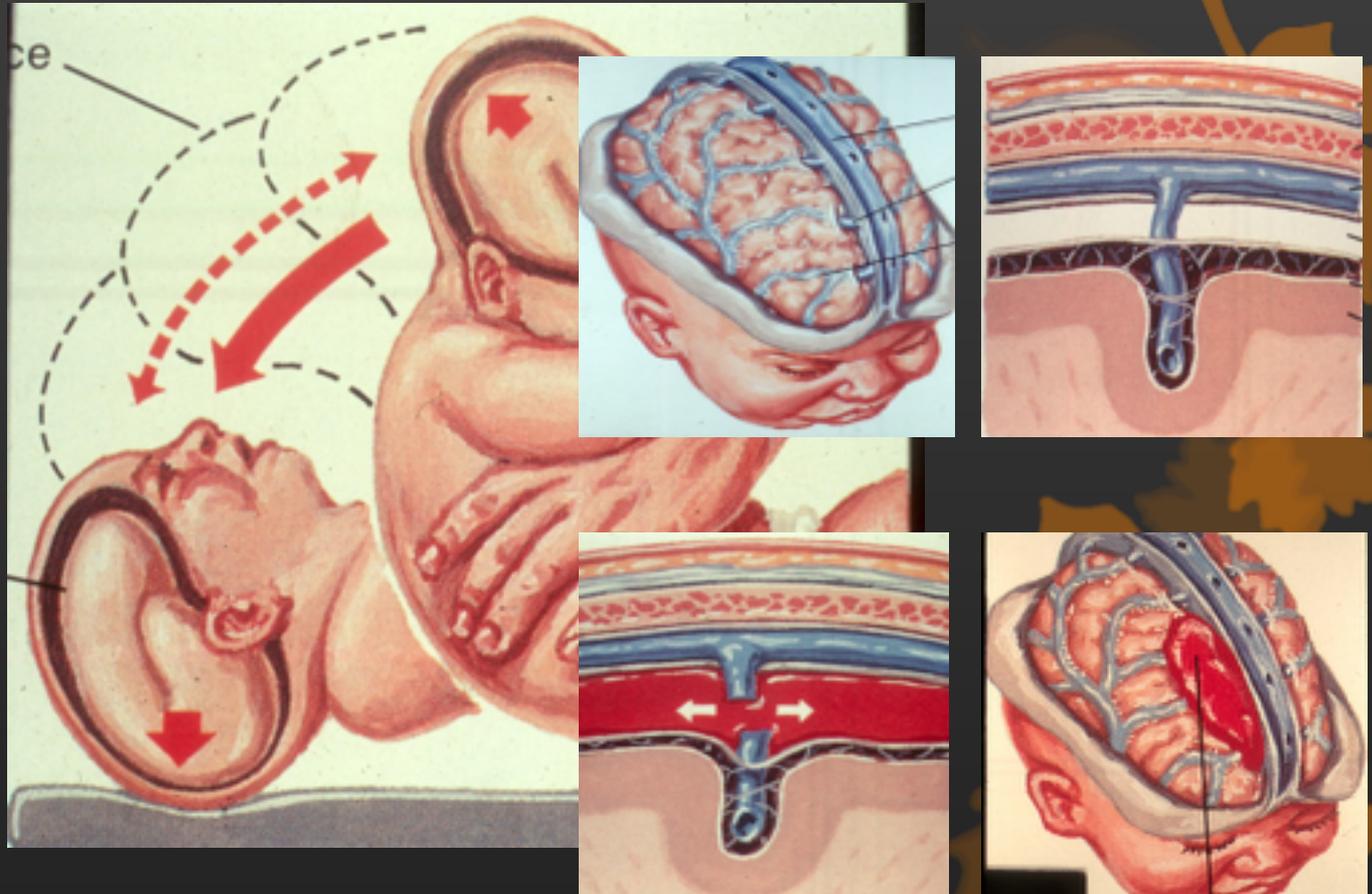
- 23% of the victims died
- 60% male and 40% female victims
- 97% of the alleged perpetrators were with the child at the time of onset of symptoms
- Perpetrators:
  - 37% biological fathers
  - 20.5% boyfriend of the mother
  - 17.3% female babysitters
  - 12.6% biological mother
  - 3.9% male babysitter

(Starling et. al. Pediatrics. 1995;95(2):259-62)

# Abusive Head Trauma/SBS

- Violent, sustained acceleration-deceleration  
+/- Blunt Head Trauma
- Usually under one year of age
- Can be up to 5 years of age
- Characteristic Injuries
  - Brain
  - Eye
  - Bone
- 25-30% mortality
- Long term complications

# Pathogenesis of AHT/SBS



# Complete History

- Past medical history (include birth history)
- Routine health care / immunizations
- Developmental history
- Social history
- Family medical history
- Review of systems



# History of Presenting Illness

- What events preceded the injury?
- Who had access to the child?
- When did the child last feed and behave normally?
- Is there a triggering event?
- What was the caretaker's response to the injury?
- What is the affect of the caregiver?
- If the child is verbal, what do they say happened?
- Are there any adult or child witnesses?



# Injury to a child?



“Do the facts as given in the history, correlate with the following:

- severity of the injury?
- age of the injury?
- location of the injury?
- pattern of the injury?
- developmental age of the child?

# Differential Diagnosis

- Accidental trauma
- Coagulopathies such as hemophilia Vitamin K deficiencies
- Meningitis and encephalitis
- Glutaric Aciduria Type I
- Osteogenesis imperfecta

# Alternative Diagnoses (Not Supported in the Literature)

- Hypoxia
- Venous sinus thrombosis
- Immunizations
- Rebleed theory (Subdural is only marker of injury)
- Birth
- Benign extra-axial fluid of infancy (BAEF)
- Short falls

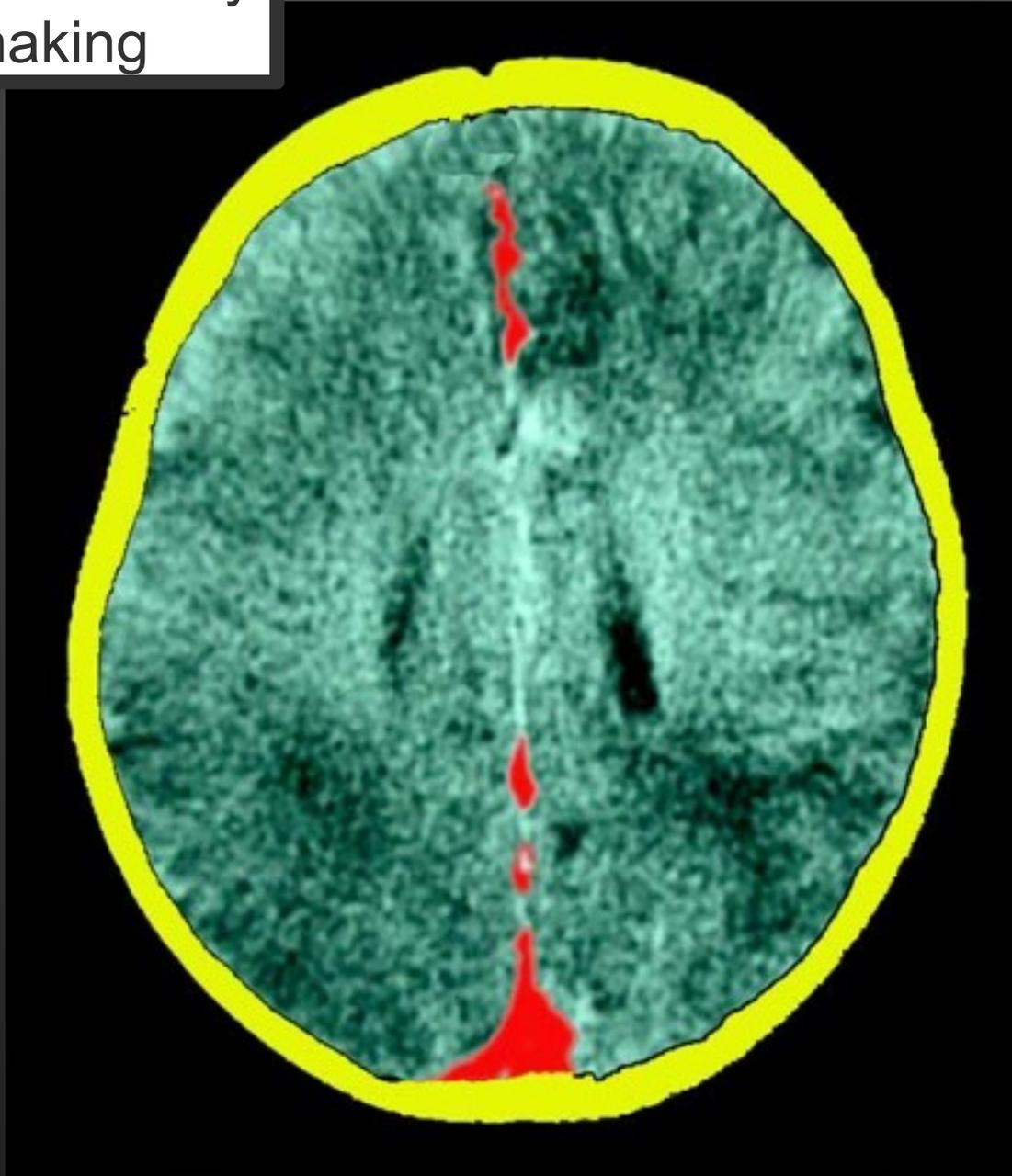
# AHT/SBS Outcomes – Neurologic/ Developmental Outcomes

- 1/3 die
- 1/3 severe disability
- 1/3 short-term “normal” – Of these patients, 1/2 will develop late findings:
  - Microcephaly, hydrocephalus, seizures, hemiparesis, developmental disability, learning delays, psychological and/or behavior difficulties

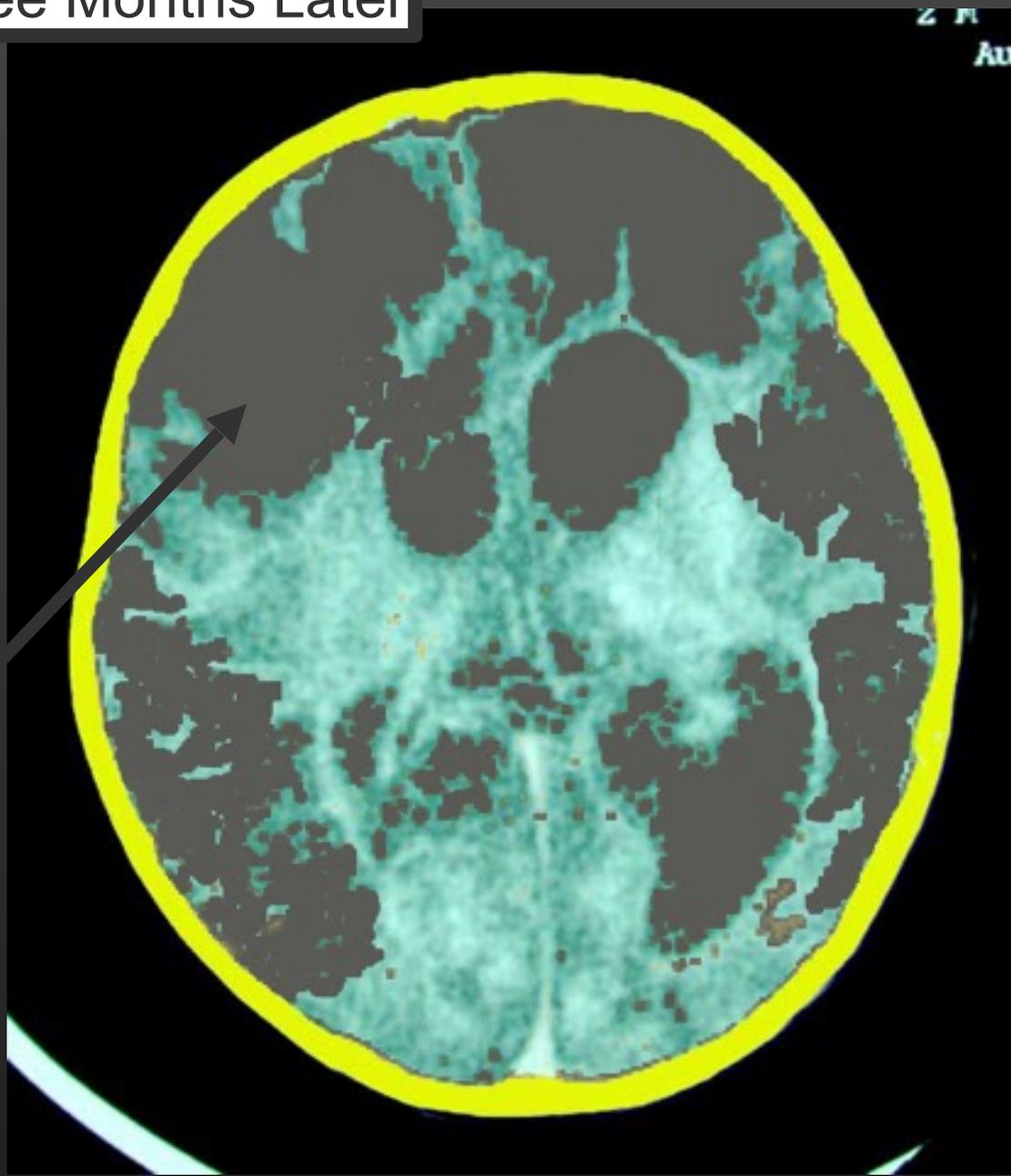
# AHT/SBS Outcomes – Visual Outcomes

- Poor neurologic outcome – poor visual outcome
- 2/3 will have some form of visual impairment
- Of those, 1/4 to 1/3 will be blind

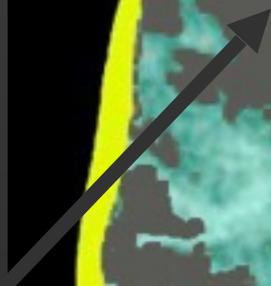
# CT Scan Immediately After Shaking

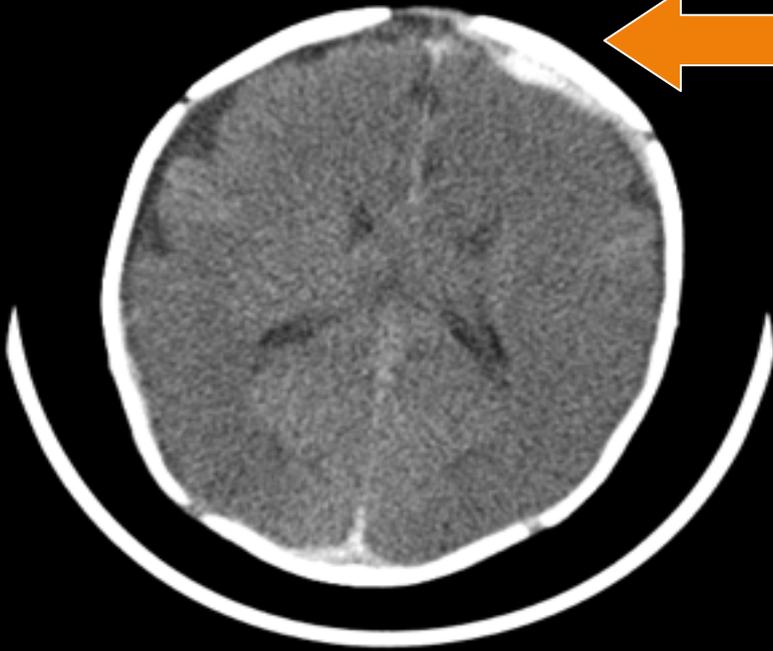


CT Scan Three Months Later



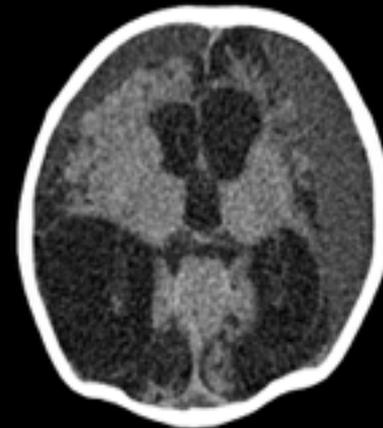
Areas of  
Brain Loss





Acute **subdural** and inter-hemispheric hemorrhage, with global cerebral edema, early parietal and occipital lobe infarction

6 months after injury, Global volume loss, with a devastated neurological exam and a grim developmental prognosis



# Chronic Subdural Hematoma

- Nomenclature is confusing!!!!
- Most common cause in children is trauma
- 3 processes resulting in chronic accumulation of fluid within the subdural space
  - Liquefaction of an acute SDH
  - CSF enters the subdural space through an opening in the anachnoid (subdural hygroma)
  - Purulent response to infectious process (empyema)
- ~1/4 of acute SDH will develop into CSH ... with the exception of birth-related SDH

(Swift et al: Chronic subdural hematoma in children. Neurosurgery Clinics of North America 11(3):439-446, 2000.)

# Rare Medical Conditions

## Coagulopathy and Hemostasis Defects

### Work-Up:

- Vitamin K deficiency
- Hemophilia A (VIII)
- Factor XIII Deficiency
- Von Willebrand Disease
- Trauma-Related Coagulopathy
- Platelet Disorders
- Coags
- Platelets
- Von Willebrand antigen
- Von Willebrand activity (ristocetin)
- Factor VIII assay
- Factor IX assay

# Rare Medical Conditions Metabolic/Genetic

- Intracranial Fluid Collections
- Scurvy
- Glutaric Aciduria, Type 1
- Menkes Disease
- Ehler's Danlos Syndrome

## Work-Up:

- Serum amino acids
- Urine organic acids
- Quantitative serum glutaric acid
- Glutaric acidemia type 1 gene testing
- Serum acyl-carnitine profile