Abusive Head Trauma

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disclosures

disclosures

- I have no disclosures related to this talk
  - except
    - I have no particular expertise in this area, and as a neurosurgeon the presentation concentrates on issues directly related to head trauma or peripheral topics that support the diagnosis of head abusive head trauma

outline

Outline

- Nomenclature
- Epidemiology
- Biomechanics / Pathophysiology
- Presentation
- Imaging
- Ophthalmology

Nomenclature

INFANTS AND TODDLERS: ARTICLES

Please! Don't Shake Your Baby

Infants and young children have a relatively large and heavy head, weak neck muscles and a brain that is still developing, making a baby's brain more prone to injury from shaking. With shaking, a baby's head wobbles rapidly back and forth and the brain strikes the inside of the skull. The effect is similar to whiplash. **The brain may bleed or swell, raising pressure, which can further harm brain tissue.** The result may be permanent brain damage. This condition more commonly known as **shaken baby syndrome or shaken impact syndrome** is a grave form of abusive head trauma.

To learn more and to print the complete Please! Don't Shake Your Baby brochure (pdf), click here.

This information was prepared by the Trauma Department and the Child Protection Committee of The Montreal Children's Hospital of the McGill University Health Centre.

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Nomenclature

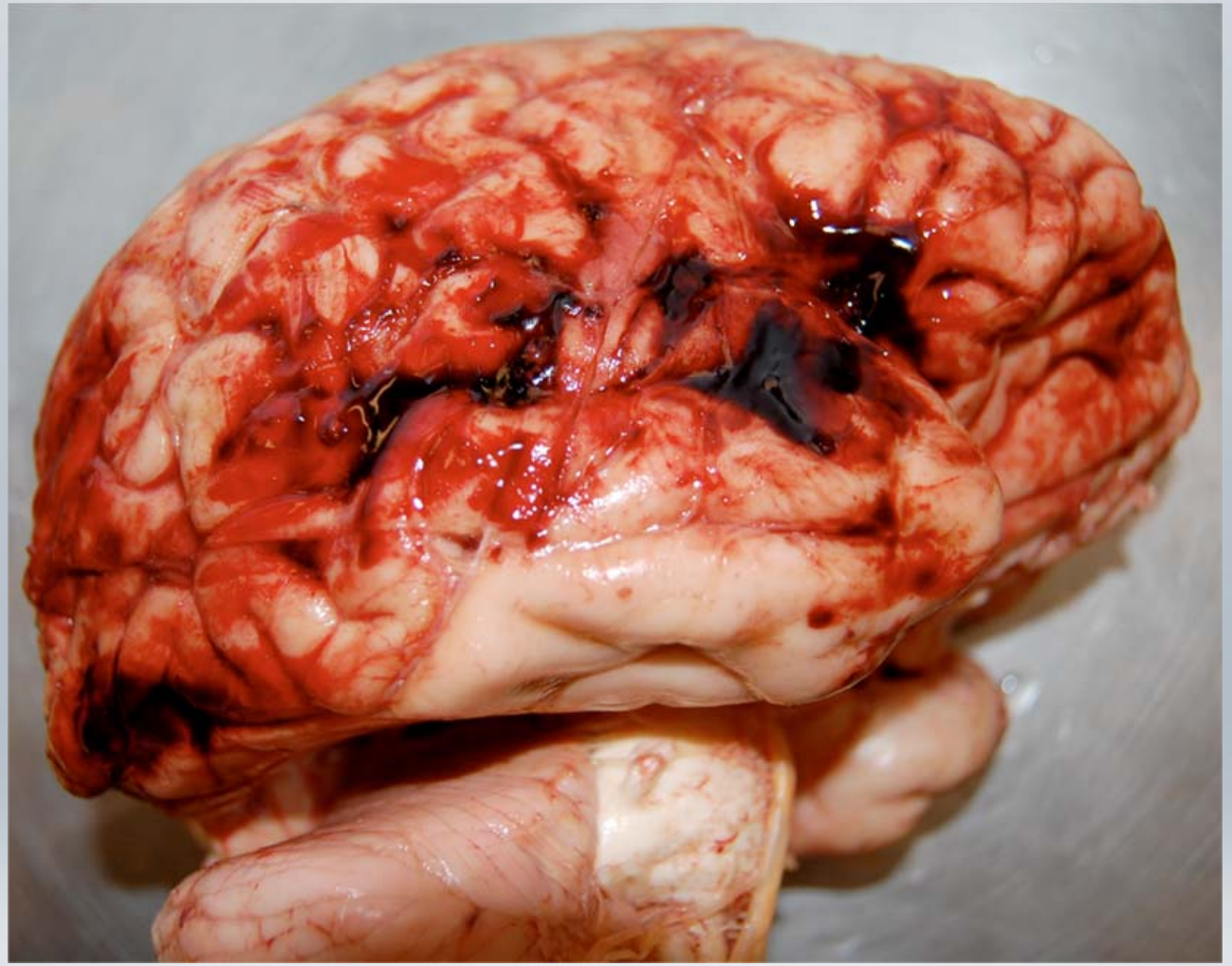
- Shaken baby syndrome
- Shaken impact syndrome
- Trauma X
- Non-accidental head injury
- **Abusive head trauma**

Nomenclature

- Shaken baby syndrome / Whiplash shaken baby syndrome
  - term originates from Ludwig and Warman (1972), Caffey (1974) who published a series of shaking injuries without impact and continues to be supported by some biomechanical evidence
- Shaken impact syndrome
  - popularized by Duhaime (1987) who demonstrated that shaking alone was not sufficient to produce typical injury pattern
- Abusive head injury
  - Term recommended by the American Academy of Pediatrics Committee on Child Abuse and Neglect, 2009
    - removes implication of single or specific injury mechanism from term

Controversy

- Of note there remains controversy in the published literature (particularly in pathology journals) about the existence of this syndrome. Reasons given include
  - very few independent witnessed shaking episodes causing injury
  - no gold standard
    - extremely poor reliability of confessions as evidence
      - therefore circular logic in many publications
  - atypical epidemiological profile (overrepresentation of male patients)
  - poor pathophysiological correlation of biomechanics and injury patterns



biomechanics / pathophysiology

Biomechanics

- Mechanisms of brain injury;
  - direct contusion from skull deformation
  - brain contusion from motion relative to the internal skull surface
  - reduced blood flow caused by pressure or infarction
  - indirect contusion of the brain opposite the side of impact
  - tissue strain produced by relative motion of the brain with respect to the skull or hemisphere
  - rupture or tearing of the blood vessels between the brain and dura mater

biomechanics

- Shaking as a source of injury
  - angular deceleration is associated with cerebral “concussion” and subdural hematoma
  - computer and experimental model support of this as a mechanism
  - perhaps duration of shaking more important than actual force generated in this mechanism

biomechanics

- Shaking vs impact as injury
  - Duhaime created doll model of infant head injury
    - in an infant held by the trunk angular deceleration is 50 X greater when associated with forceful impact vs. shaking alone
      - injury threshold only met when impact occurs resulting in sudden angular deceleration
      - soft surface of impact may not be associated with external trauma
      - autopsy and radiologic evidence of blunt impact is available for most infants with such injuries
    - routine play, swings, falls from low height etc. are insufficient to cause this type of injury

Pathophysiology

- Subdural hemorrhages
  - there is no subdural space
  - hemorrhages occur into a potential space with tear of the dural border layer from the arachnoid
  - blood is usually bilateral widespread thin layer with dependent layering
  - origin cerebral veins, dura, healing subdural membrane or AVM

Pathophysiology

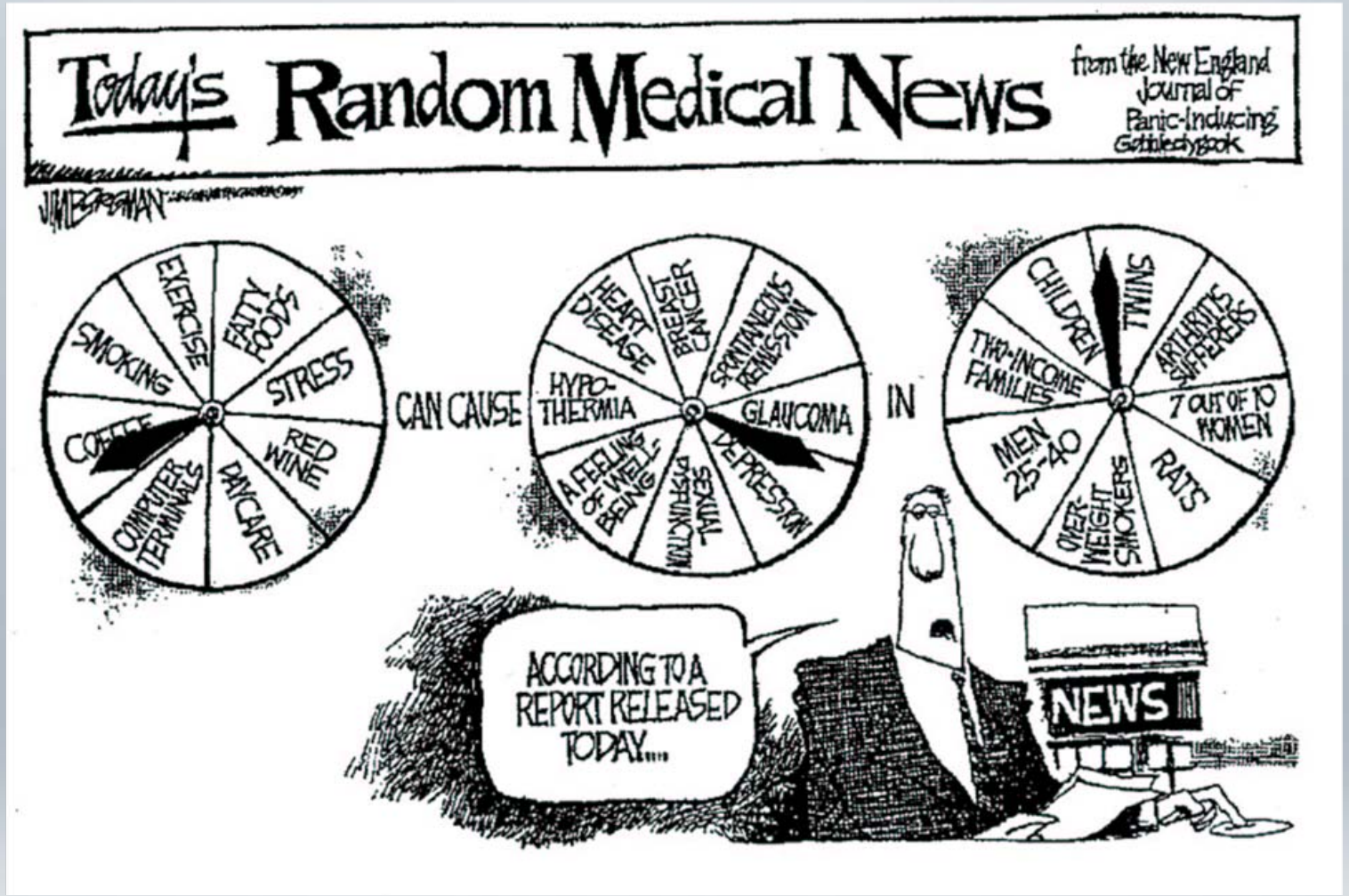
- Rebleeding
  - birth related SDH occurs in 8-46% and usually resolves within 1 month
  - chronic SDH not from acute SDH but from arachnoid tear and subdural hygroma
- Parenchymal bleeding
  - uncommon in the infant brain

Pathophysiology

- Diffuse axonal injury
  - present in severe cerebral injury with hypoxia, ischemia, metabolic disturbance and trauma
  - reported in cervical regions in 2.5-71% of autopsy specimens

Biomechanics

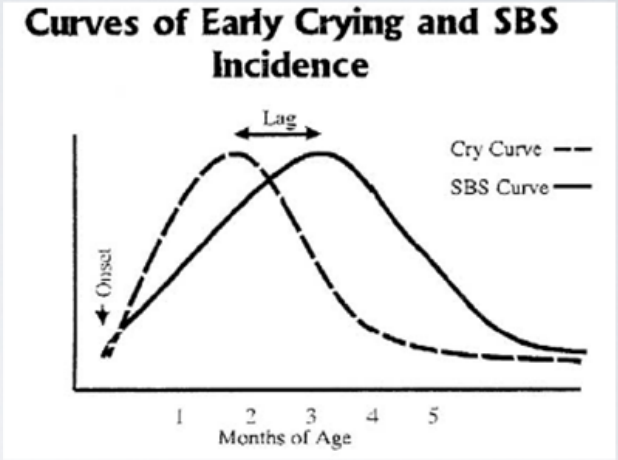
- 106 patients < 3 y.o. with witnessed free fall (2 or more witnesses)
  - 77 (42 fell more than 10 feet) had mild bruises, abrasions, simple fractures
  - 15 with intracranial injury with falls from 5 - 40 ft
  - no life threatening injuries in 3 patients who fell < 10 ft
- 53 patients with unwitnessed falls (or falls witnessed by only 1 caretaker) there were 18 severe injuries including intracranial injuries in patients with falls less than 5 ft



Epidemiology

Epidemiology

- Largely restricted to children < 3 y.o.
  - majority of cases < 1y.o., peak age 2-6 months
    - overlaps with peak ages of normal infant crying



- up to 24% of head injuries under 2 y.o. may be the result of inflicted trauma in some prospective series
  - traumatic deaths more commonly caused by child abuse than any other single cause
- risk factors include; young parents, unstable family situations, low socioeconomic status, disability or prematurity of the child, military service, substance abuse, psychiatric disorders, unreasonable expectations of child behaviour
- perpetrators in descending order of frequency; fathers, boyfriends, female babysitters, mothers

Epidemiology

- True incidence unknown due to under-diagnosis and underreporting
  - estimates of 14-30 / 100 000 infants < 1
    - 152 undiagnosed for each reported case
  - 3% of parents self-report shaking their infants / toddlers
  - more common than all childhood cancers and type I diabetes

presentation

Presentation

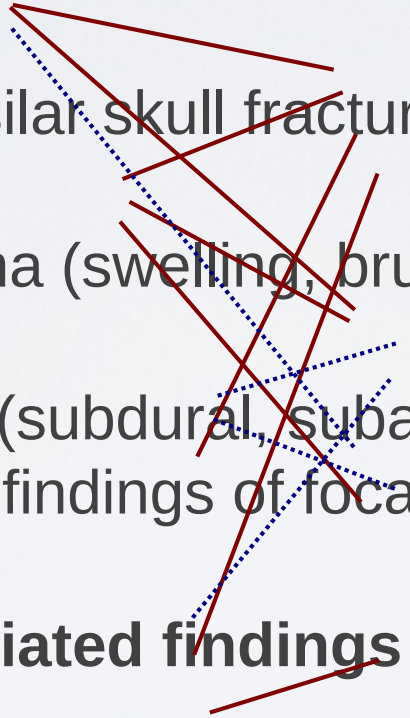
- 2 typical histories
  - short height fall or minor blunt trauma
  - no history
- history inconsistent with developmental level
- changing / evolving history

Presentation

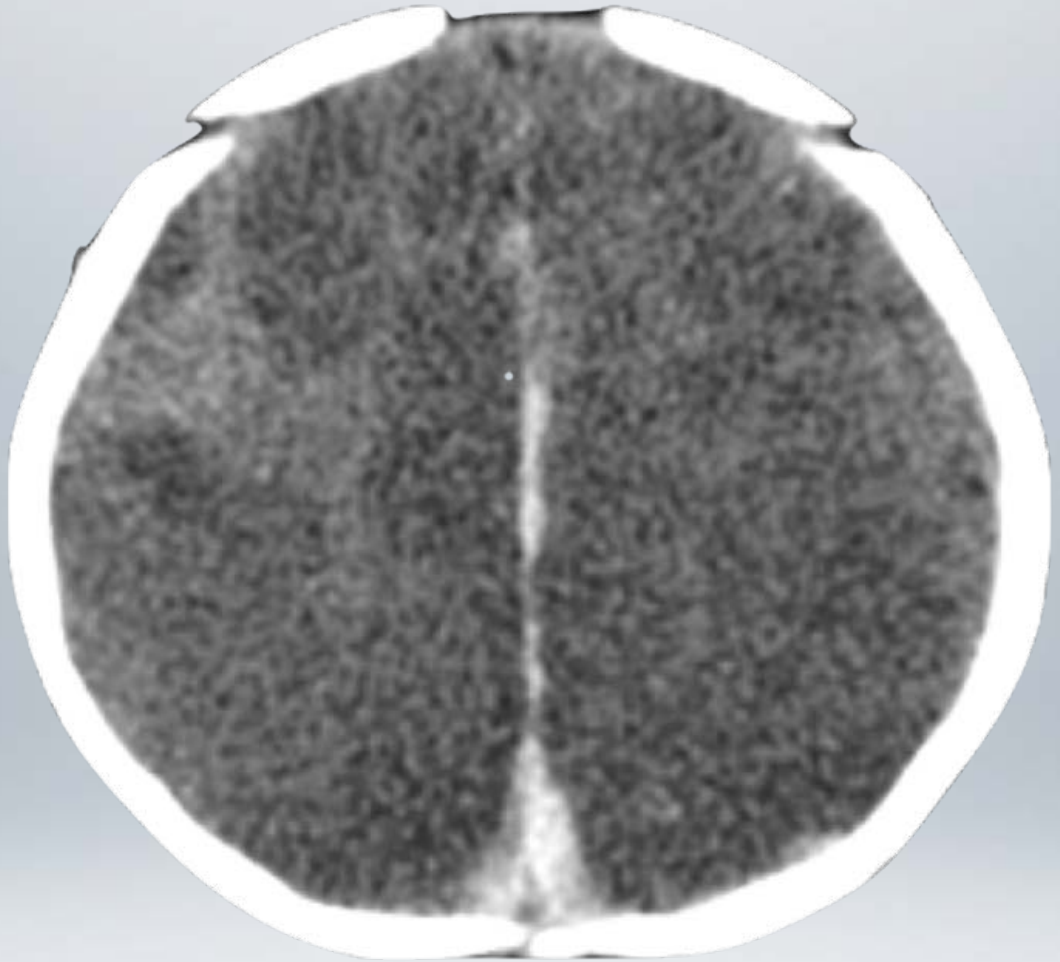
- symptoms
  - poor feeding
  - irritability
  - vomiting, seizures
  - lethargy, breathing difficulties
  - unresponsiveness

Presentation

- **Injury Type**
- skull fracture +/- epidural hematoma
- multiple, stellate or basilar skull fracture
- craniofacial blunt trauma (swelling, bruising)
- intradural hemorrhage (subdural, subarachnoid, intracerebral) with clinical or radiographic findings of focal impact
- **Best history or associated findings**
- unexplained long-bone fractures or old fractures; inflicted soft-tissue injury



Presumptive inflicted injury
Suspicious for inflicted injury



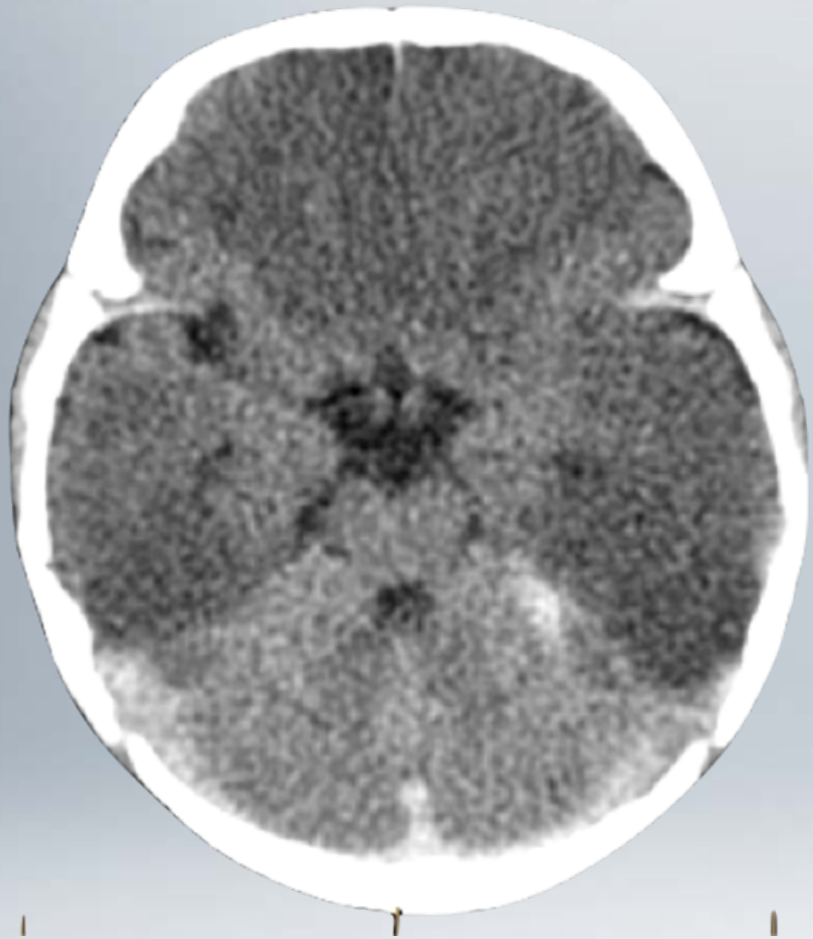
imaging

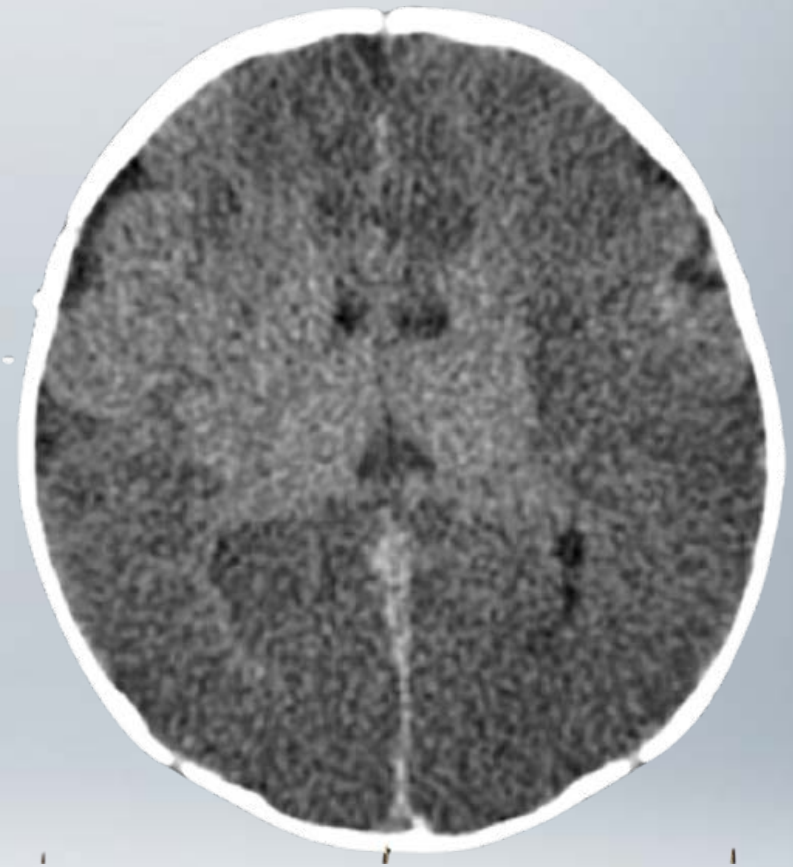
Imaging

- Skull X-ray
  - maybe better than CT to detect skull fractures
  - bilateral, non-parietal fractures suspicious

Imaging

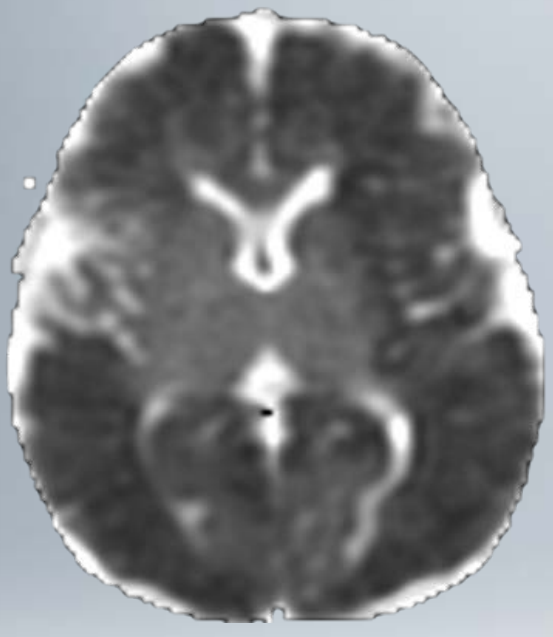
- CT scan
  - rapid easy to acquire without sedation
  - 3D CT reformatting should identify all fractures
  - intracranial hemorrhage, edema, herniation also easily seen
  - SDH often mixed attenuation

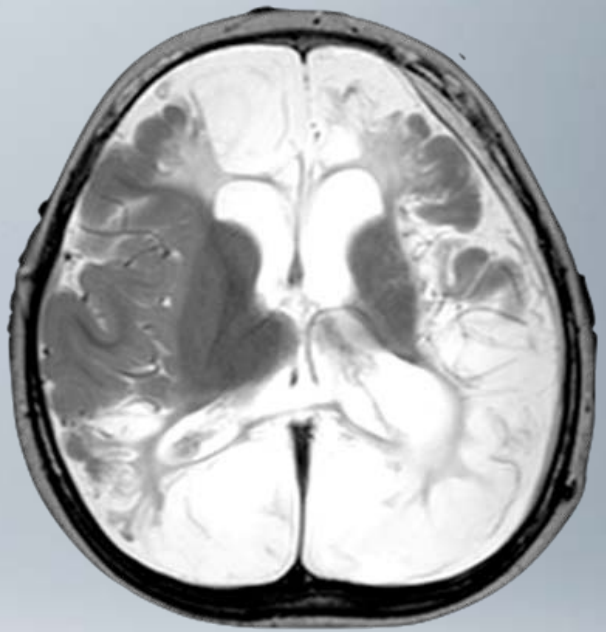




Imaging

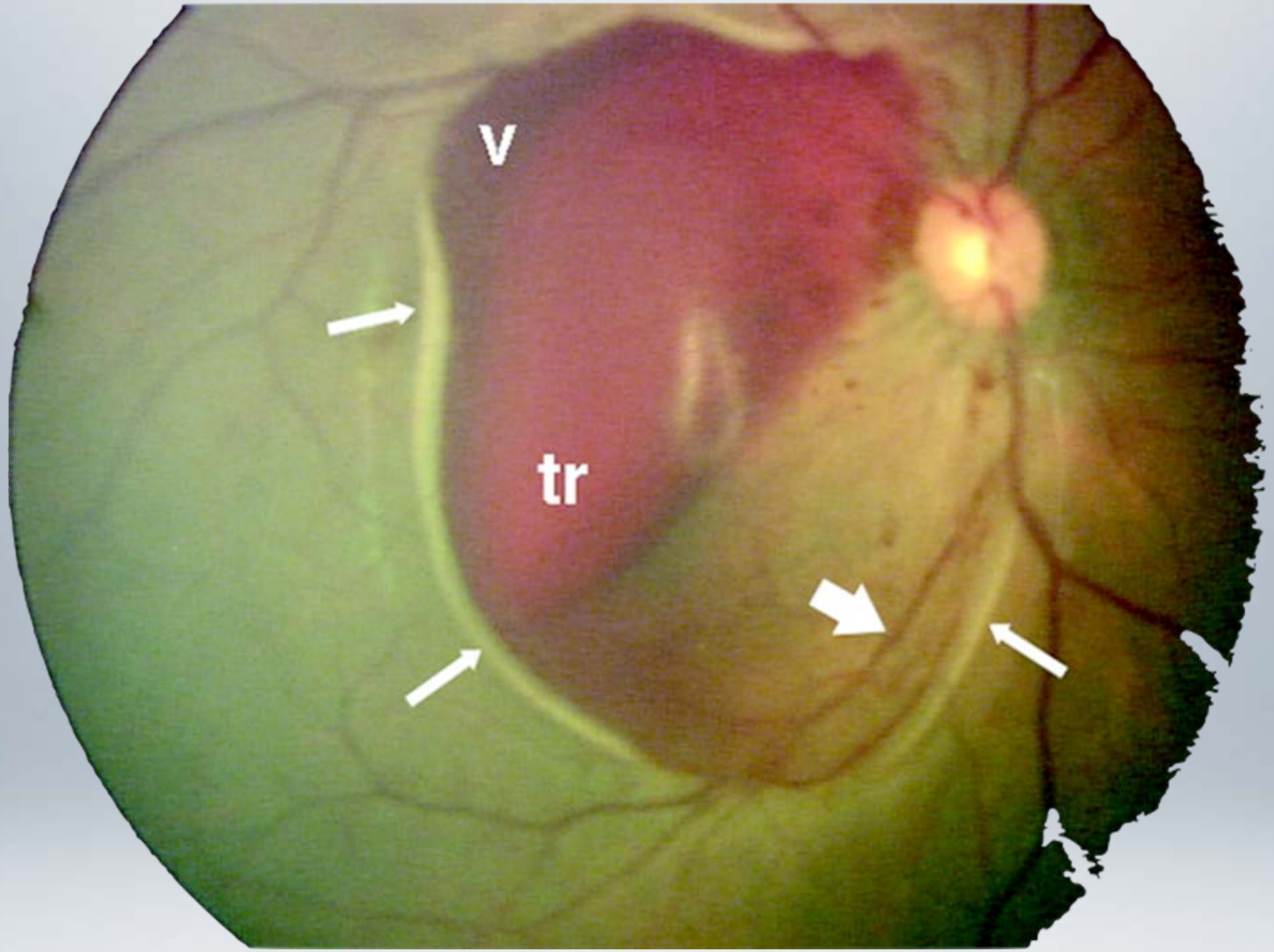
- MRI
  - important role in characterizing the extent of intracranial hemorrhage and determining CNS injury in symptomatic and “asymptomatic” patients
  - better than CT for SDH
  - heterogeneity of hemorrhages can be detected but dating or age determination of blood is problematic
  - diffuse axonal injury can be detected
  - DWI helpful in determining ischemia





Imaging

- **OR of AHT vs accidental injury**
  - SDH - OR = 8.2 (6.1-11)
  - SAH - OR = 0.98 (0.47-2.0)
  - EDH - OR = 0.1 (0.07-0.18)
  - inter-hemispheric hemorrhages - OR = 9.5 (6.1-14.9)
  - multiple extra-axial hemorrhages - OR = 6 (2.5 -14.4)
  - Convexity SDH - OR = 4.9 (1.3-19.4)
  - Post fossa SDH - OR = 2.5 (1-6)



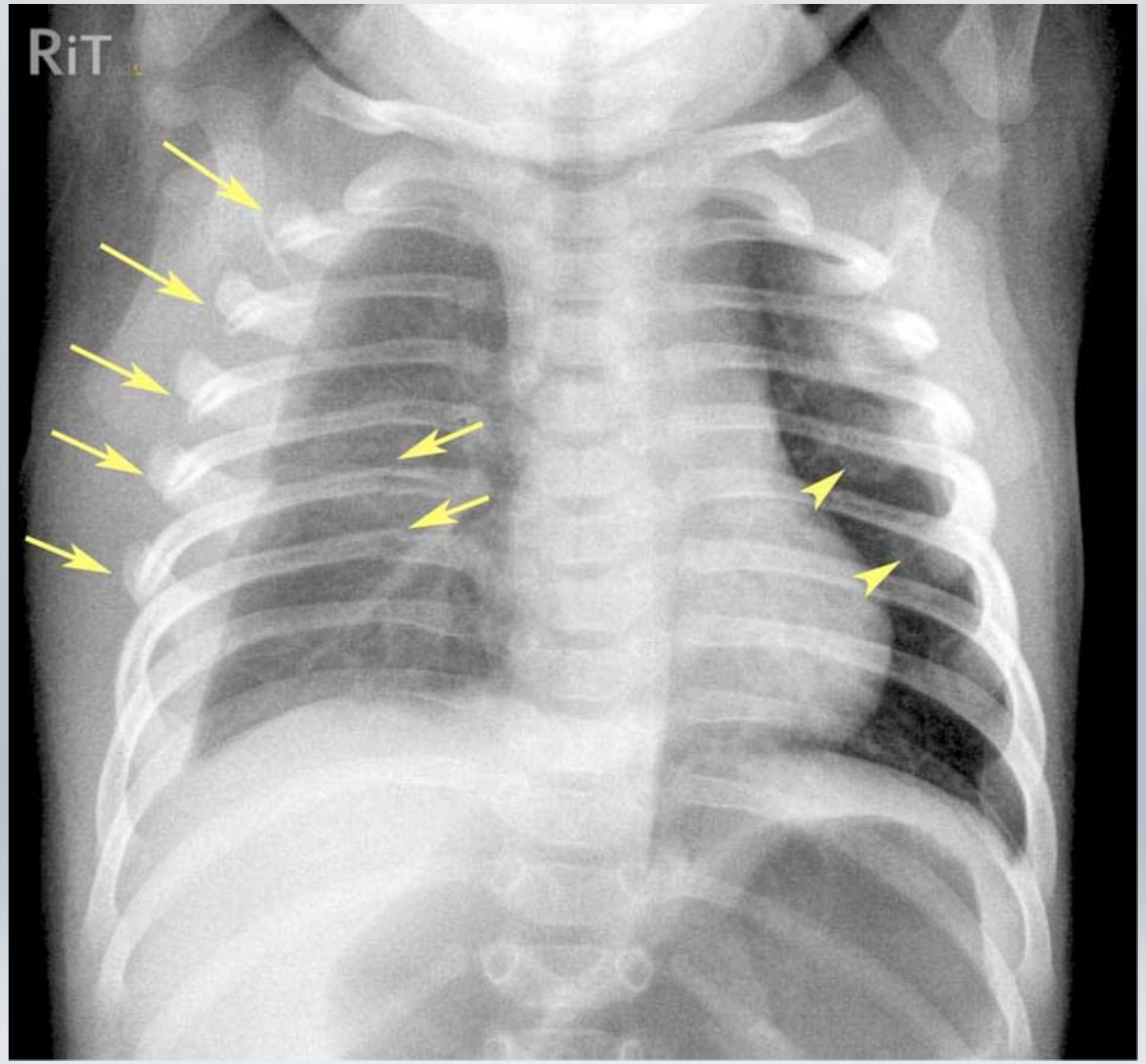
ophthalmology

Ophthalmology

- incidence of retinal hemorrhage in AHT is 85%
  - higher in patients who have died vs survivors
  - cannot be dated with precision
  - elevated intracranial pressure is a rare cause of retinal hemorrhage
    - hemorrhage from optic nerve swelling is not indicative of AHT

Ophthalmology

- exceedingly rare in accidental head injury (except in extreme acceleration - deceleration mechanisms)
- retinoschisis, multiple layered hemorrhages, bilateral hemorrhages and hemorrhages away from posterior pole are more commonly associated with AHT
- differential diagnosis includes many rare disorders however forceful vomiting, persistent coughing, chest compressions have not been shown to reproduce typical RH of AHT
- approximately double rate of diagnosis with trained ophthalmologist vis non-ophthalmologist (mostly related to incomplete exam)



other injuries

Other Injuries

- **Bone injuries**
  - skeletal survey more sensitive and lower radiation than bone scan
    - may need repeated at late stage to identify healing fractures
    - multiple fractures and posterior rib fractures are suspicious
- **Bruising**
  - bruising in non-mobile children,

Differential Diagnosis

Differential Diagnosis

- “No other medical condition fully mimics all the features of shaken impact syndrome”, Duhaime NEJM 1998
- accidental injury
- coagulopathy
- osteogenesis imperfecta
- glutaric aciduria type I

SDH

Table 1 Causes of subdural bleeding.

Causes
Trauma
Non-accidental trauma
Accidental trauma
Traumatic aneurism of middle meningeal artery
"Headbanging" to rock music; "moshing"
Breakdancing
Roller coaster rides
Ute surfing (standing unrestrained on back of utility vehicle travelling at high speed)
Tangential missile wound to head
Boxing
Weight lifting
Medical and surgical interventions
Lumbar puncture
Spinal anaesthesia
Epidural anaesthesia
Lumbar myelography
Ventriculoperitoneal or ventriculoatrial shunt
Craniotomy
Prenatal, perinatal and pregnancy-related conditions
Intrauterine trauma e.g. domestic violence to mother
Idiopathic intrauterine subdural haematoma
Intrauterine isoimmune thrombocytopaenic purpura
Maternal pre-eclampsia
Postnatal cerebral infarction
Birth trauma
Trauma associated with normal vaginal delivery
Forceps delivery
Vacuum extraction (ventouse delivery)
Breech delivery
Other birth trauma
Metabolic diseases
Glutaric aciduria type 1
Canavan disease (unpublished association)
Galactosaemia (unconfirmed case report)
Pyruvate carboxylase deficiency
Cerebral ceroidosis in albinos
Congenital malformations
Intracranial arteriovenous malformations
Cerebral aneurism
Osler–Weber–Rendu syndrome
Arachnoid cyst
Encephalocoele or meningocoele
Spontaneous rupture of a cerebral artery
Schizencephaly or porencephaly
Genetic diseases
Osteogenesis imperfecta
Sickle cell anaemia
Alagille syndrome
Ehlers–Danlos syndrome
Autosomal dominant polycystic kidney disease
Menkes kinky hair syndrome
Prader Willi syndrome
Marfan syndrome
Malignancy
Meningeal carcinomatosis
Leukaemia
Solid tumours of the central nervous system
Primary mucosa-associated lymphoma of the dura
Mass lesions in the subdural space
Autoimmune disorders
Lupus erythematosus
Blood coagulation disorders
Anticoagulant therapies
Haemophilia A and B
von Willebrand disease
Factor V deficiency
Factor XII deficiency
Idiopathic or drug-induced thrombocytopaenic purpura
Haemorrhagic disease of the newborn (vitamin K deficiency)
Disseminated intravascular coagulation (DIC)
Acquired inhibitors of plasma clotting factors
Coagulopathy related to cirrhosis of the liver
Ginko biloba ingestion
Hermansky–Pudlak syndrome
Alpha 1-antitrypsin deficiency
Infectious diseases
Haemophilus influenzae meningitis
Streptococcus pneumoniae meningitis
Other bacterial meningitis
Kawasaki disease
Endocarditis, leading to septic emboli of a cranial artery causing aneurismal rupture of the vessel
Chronic otitis media
Malaria
Herpes simplex encephalitis
Congenital toxoplasmosis
Viral meningoencephalitis (data questionable)
? Pertussis
Poisons/toxins/drug effects
Lead poisoning
Cocaine
Anticoagulant therapy
? Tamoxifen
Other
Haemodialysis of patients with kidney disease
Open heart surgery
Moyamoya disease
Bone marrow transplant
Hyperostosis frontalis interna
Wegener granulomatosis
Benign extra-axial fluid collections of infancy (not generally accepted)
Haemorrhagic shock and encephalopathy
Spontaneous intracranial hypotension
Malignant atrophic papulosis (Degos disease)

assembled for the Third National Conference on Shaken Baby Syndrome at Salt Lake City, September 2000, in part to a paper by Hymel et al. [3] published in 2002, and in part to a chapter by Sirotnak [2] published in a textbook in

Retinal Hemorrhages

Table 2 Causes of retinal haemorrhage.

Causes
Coagulation or haematological disorders
Haemophilia A, haemophilia B
von Willebrand disease
Haemorrhagic disease of the newborn
Thrombocytopaenia
Idiopathic thrombocytopaenic purpura
Hermansky–Pudlak syndrome
Hypofibrinogenaemia
Leukaemia
Aplastic anaemia
Haemolytic anaemia
Pernicious anaemia
Severe anaemia in adults
Protein C deficiency
Glutaric aciduria
Hereditary hemorrhagic telangiectasis (Rendu–Osler–Weber Disease)
Ocular decompression after surgery for glaucoma
Bacterial endocarditis
High altitude
Osteogenesis imperfecta type 1
Retinopathy of prematurity (ROP)
RetCam photography in preterm infant with ROP
Sickle cell retinopathy
Extra-corporeal membrane oxygenation (ECMO)
Galactosaemia
Henoch Schonlein purpura
Oxygen myelography
After anaesthesia
Intraocular surgery
Severe hypertension
Myeloma
Cyanotic congenital heart disease
Carbon monoxide poisoning
Meningococcal meningitis
Meningococcal septicaemia
Meningoencephalitis with rhinovirus or ECHO virus
Raised intracranial pressure and papilloedema
Optic disc drusen
X-linked retinoschisis
Ruptured intracranial aneurysms
Endoscopic spinal surgery
Spinal cord arteriovenous malformation
Tuberous sclerosis
Malaria
Dysproteinaemia
Iron deficiency anaemia
Therapy with desmopressin (DDAVP) nasal spray
In utero exposure to cocaine (in rats)
Pertussis
Hyponatraemic seizures
Hepatitis B vaccination in an adult
Crush injury to chest
Chest compression from safety belt
On exertion, familial
Valsalva retinopathy
Ehlers–Danlos syndrome

Table 2 (continued)

Causes
Bungee jumping
Constipation and hypertension (unconvincing report)
"Normal" in newborn infants
Accidental trauma
Non-accidental trauma

outcome

Outcome

- Studies of outcome of children with TBI and specifically AHT are lacking
- mortality may be 25%
- AHT patients show
  - poorer neurologic ratings (up to half severely disabled)
  - more difficulties with ADL’s
  - more PTSD symptoms with deficits in attention and executive function


Are you tough enough to be gentle?
It only takes a
MOMENT
Shaken Baby
Syndrome
Take a Break - Don't Shake
The Capital Health Authority, Caritas Health Group, Edmonton Police Service, RCMP, and Mé Mówe Child & Family Services would like to thank the following sponsors and contributors:
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For further information on Shaken Baby Syndrome Prevention Project - Edmonton, please contact the Child and Adolescent Protection Centre:
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prevention

Prevention

- Reliable data on prevention on the effectiveness of prevention strategies is somewhat lacking
- Approaches that have been undertaken
  - media coverage of isolated cases
  - non-targeted educational campaigns
  - educational and support initiatives that target specific at risk groups
  - educational programs that target parents still in hospital

Prevention

- Programs exist that disseminate written materials and video materials with a signed acknowledgement of reception to new parents prior to hospital discharge
  - in Western New York annual incidence of AHT declined from 7.0 to 2.5 cases per year with this education program in 1st 2 years of program

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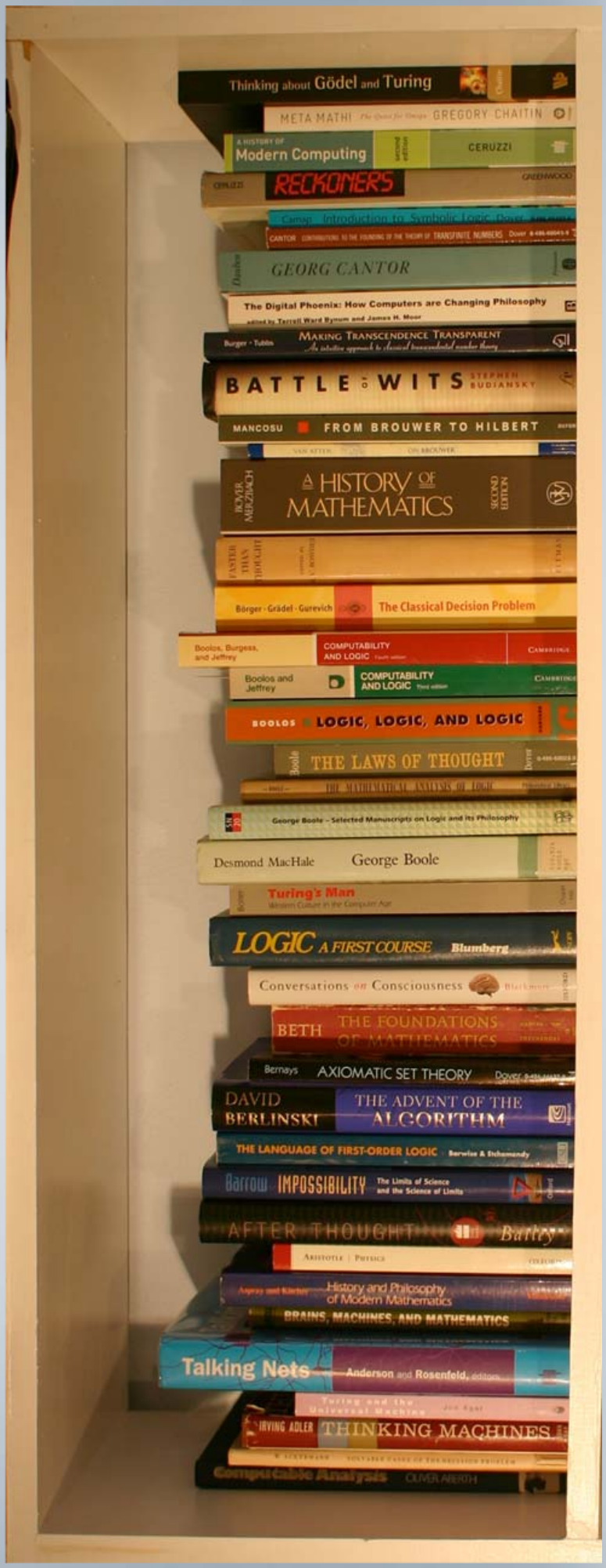
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