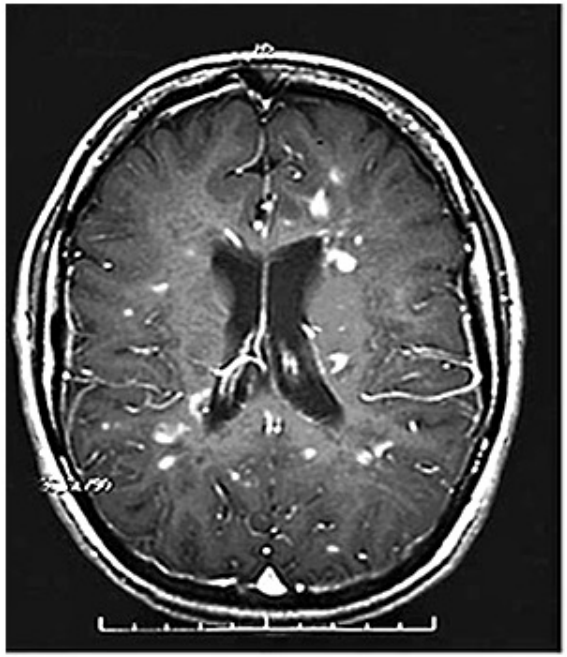
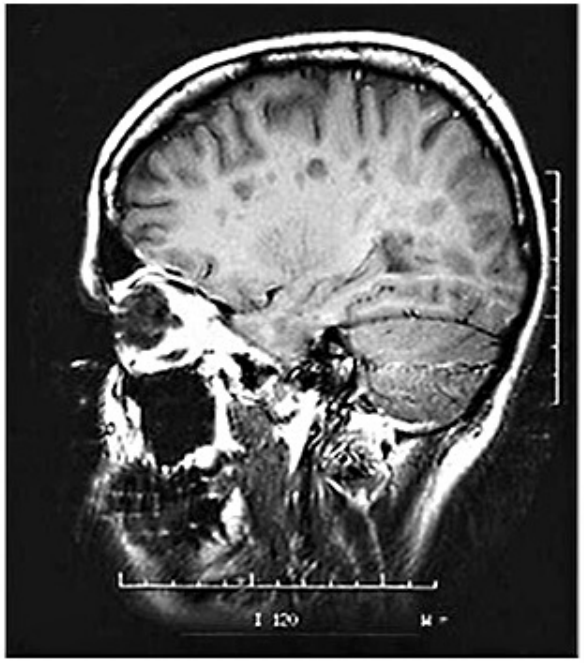
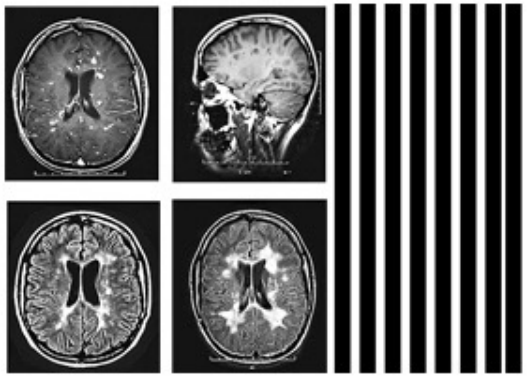




CNS Trauma and Head Injuries

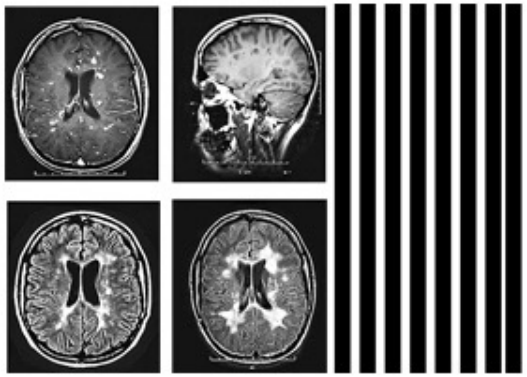
Dr. Gary Mumaugh

SCHOOL OF CHIROPRACTIC
CAMPBELLSVILLE UNIVERSITY



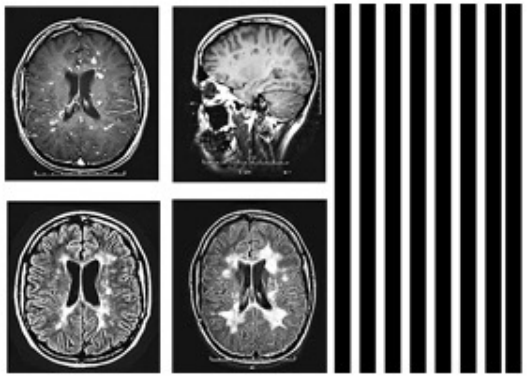
TBI

- Traumatic brain injury (TBI) is the result of an external mechanical force applied to the cranium and the intracranial contents, leading to temporary or permanent impairments, functional disability, or psychosocial maladjustment.



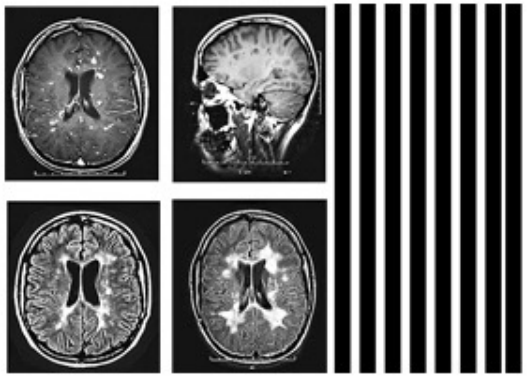
Injuries divided into 2 subcategories

- Primary injury, which occurs at the moment of trauma
- Secondary injury, which occurs immediately after trauma and produces effects that may continue for a long time



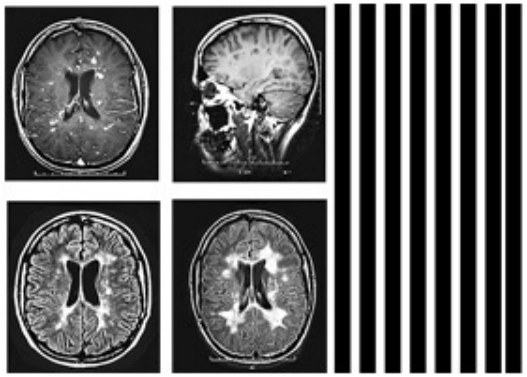
Primary Injury- Physical Mechanisms

- Impact loading - Collision of the head with a solid object at a tangible speed [through a combination of contact forces and inertial forces]
- Impulsive loading - Sudden motion without significant physical contact



Primary Injury- Physical Mechanisms

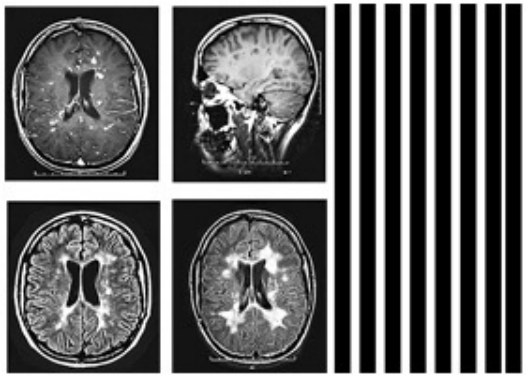
- Static loading - occurs when a slowly moving object traps the head against a fixed rigid structure and gradually squeezes the skull, causing many comminuted fractures and deforms the brain



Tissue Deformation

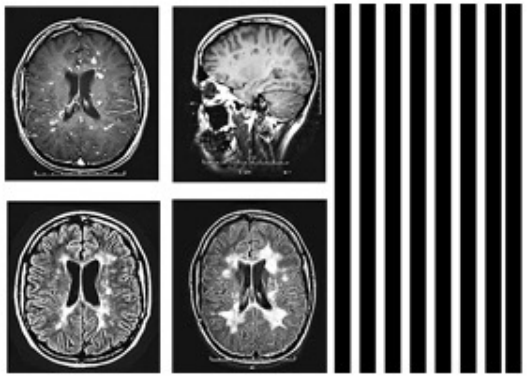
3 basic types of tissue deformation

- Compressive - Tissue compression
- Tensile - Tissue stretching
- Shear - Tissue distortion produced when tissue slides over other tissue



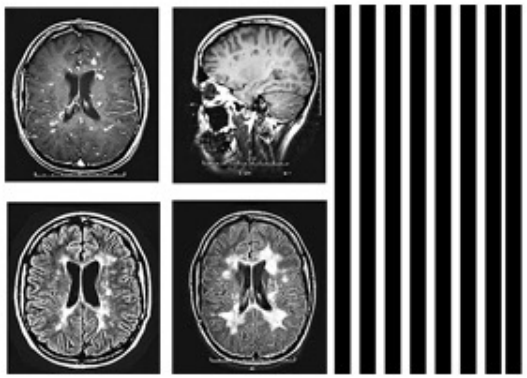
Types of Primary Injuries

- Focal injuries (eg, skull fractures, intracranial hematomas, lacerations, contusions, penetrating wounds)
- Diffuse (as in diffuse axonal injury)



Skull Fractures

- Vault fractures or basilar fractures
- Closed, or open fractures
- Depressed or nondepressed
- Simple fracture and compound fracture
- Vault fractures may extend into the sinuses
- Basal skull fractures may be associated with injuries to the cranial nerves and discharges from the ear, nose, and throat



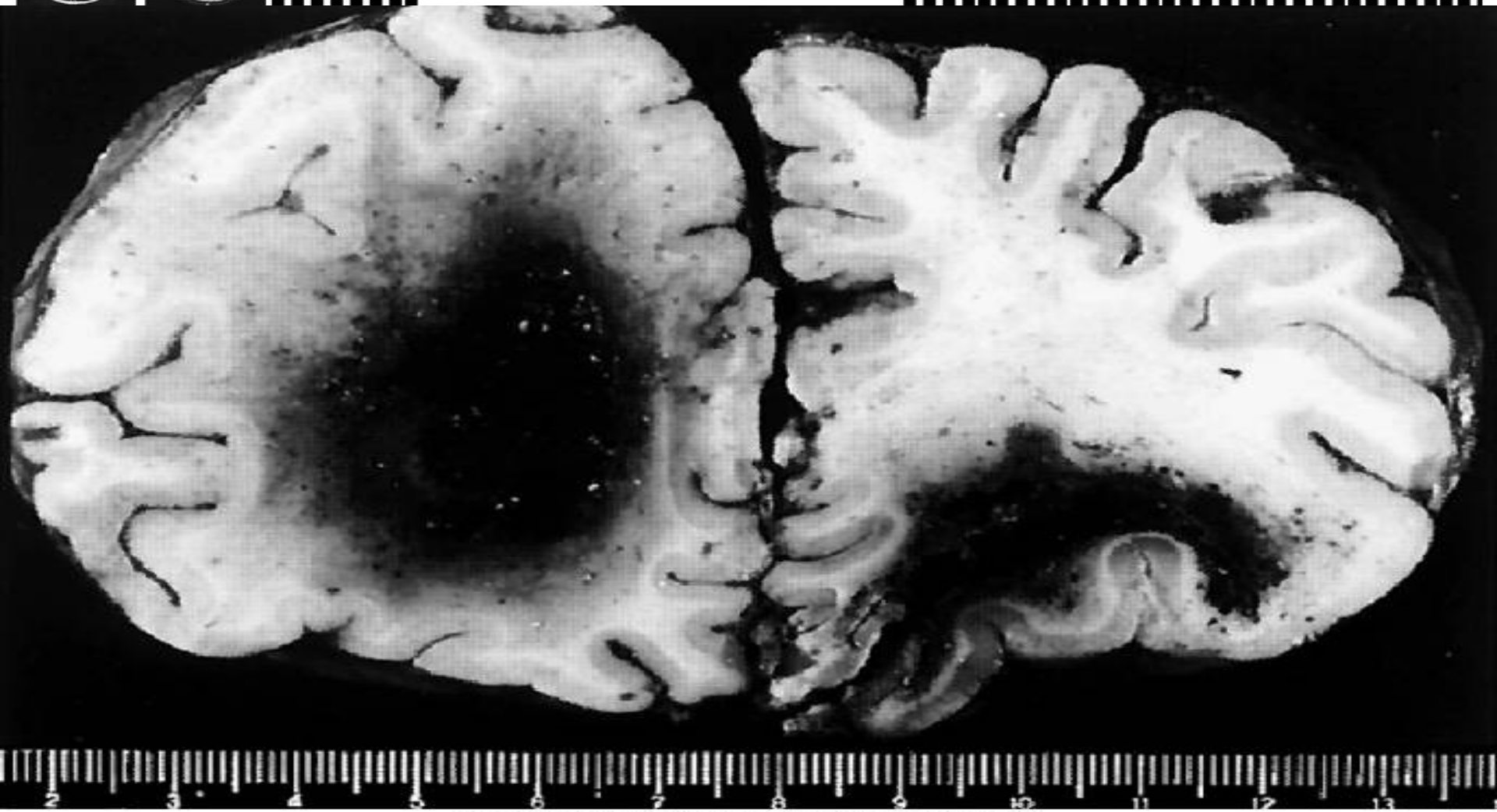
Auditory / Vestibular Dysfunction

- Conductive or sensorineural hearing loss
- Benign paroxysmal positional vertigo

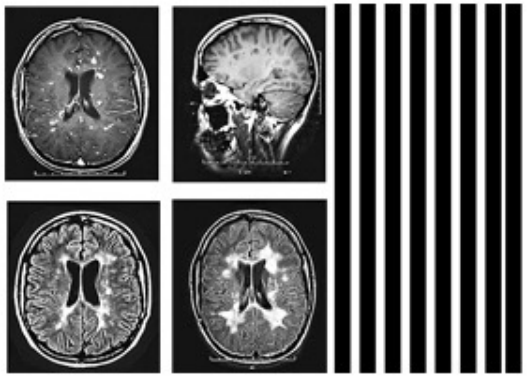
Intracranial Hemorrhages

- Epidural hematoma
- Subdural hematoma
- Intracerebral hemorrhages
- Intraventricular hemorrhage
- Subarachnoid hemorrhage

Hematomas

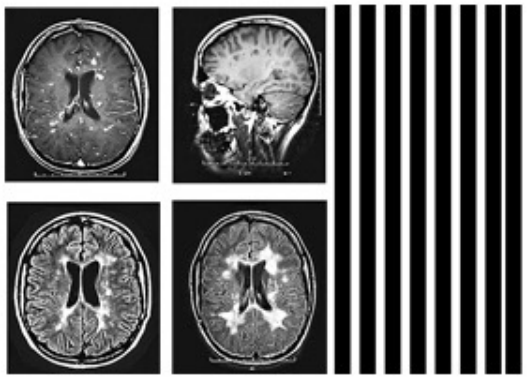


From Kissane JM, editor: *Anderson's pathology*, ed 9, St Louis, 1993, Mosby.



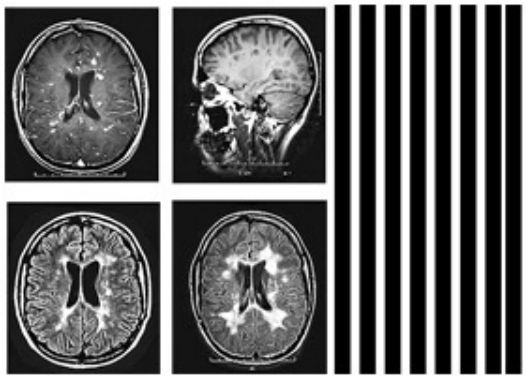
Epidural Hematomas

From Damjanov I, Linder J: *Anderson's pathology*, ed 10, St Louis, 1996, Mosby.



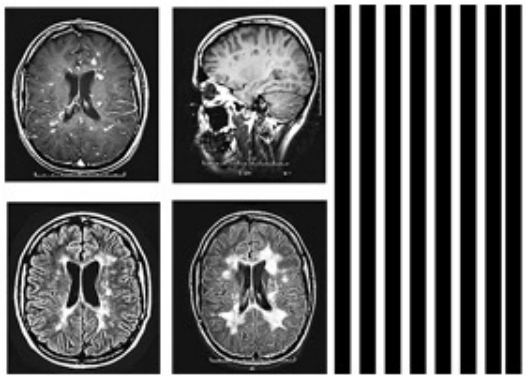
Epidural Hematoma

- Laceration of the dural arteries or veins, or by diploic veins in the skull's marrow
- A tear in the middle meningeal artery
- When hematoma occurs from laceration of an artery, blood collection can cause rapid neurologic



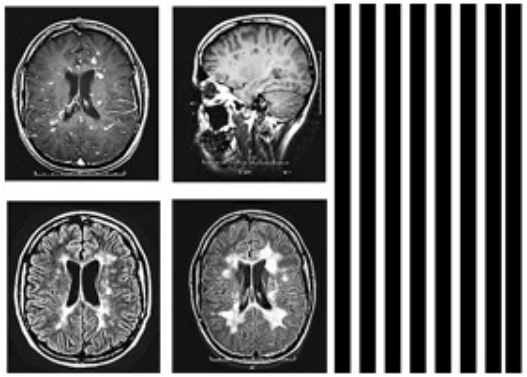
Intracerebral Hemorrhages

- Due to injury to larger, deeper cerebral vessels occurring with extensive cortical contusion.
- Intraventricular hemorrhage tends to occur in the presence of very severe TBI and is, therefore, associated with an unfavorable prognosis.



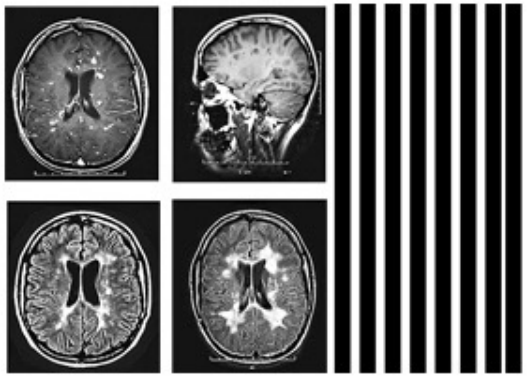
Subarachnoid Hemorrhage

- Lacerations of the superficial microvessels in the subarachnoid space
- If not associated with another brain pathology, this type of hemorrhage could be benign
- May lead to a hydrocephalus if blood products obstruct the arachnoid villi / the third or fourth ventricle



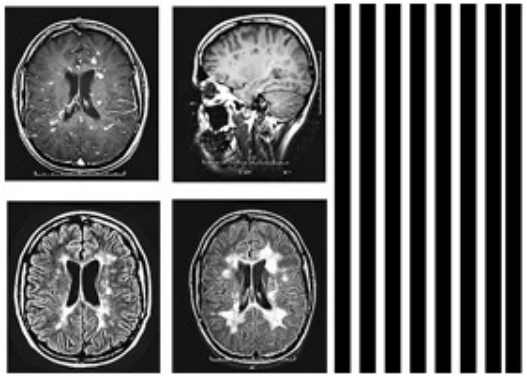
Brain Trauma

- Closed (blunt, nonmissile) trauma
  - Head strikes hard surface or a rapidly moving object strikes the head
  - The dura remains intact and brain tissues are not exposed to the environment
  - Causes focal (local) or diffuse (general) brain injuries



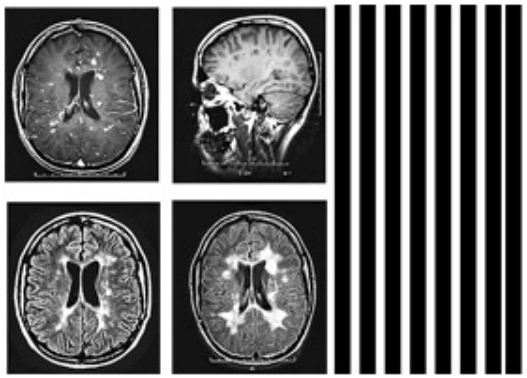
Brain Trauma

- Open (penetrating, missile) trauma
  - Injury breaks the dura and exposes the cranial contents to the environment
  - Causes primarily focal (local) injuries



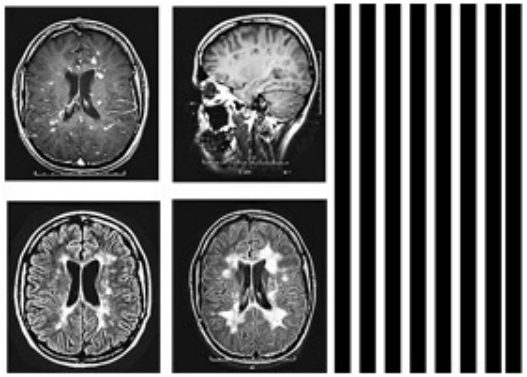
Brain Trauma

- Coup injury
  - Injury directly below the point of impact
- Contrecoup
  - Injury on the pole opposite the site of impact
- Compound fractures
- Basilar skull fracture



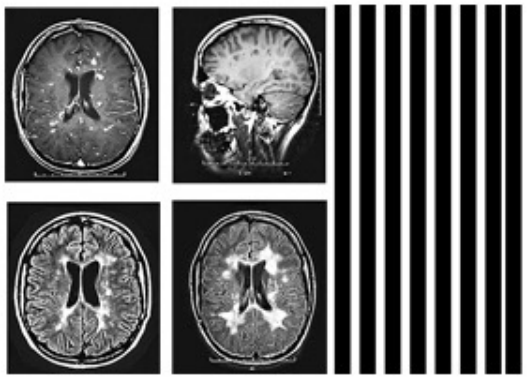
Coup and Contrecoup Contusions

- Coup contusions occur at the area of direct impact to the skull
- and occur because of the creation of negative pressure
- when the skull, distorted at the site of impact, returns to its normal shape.



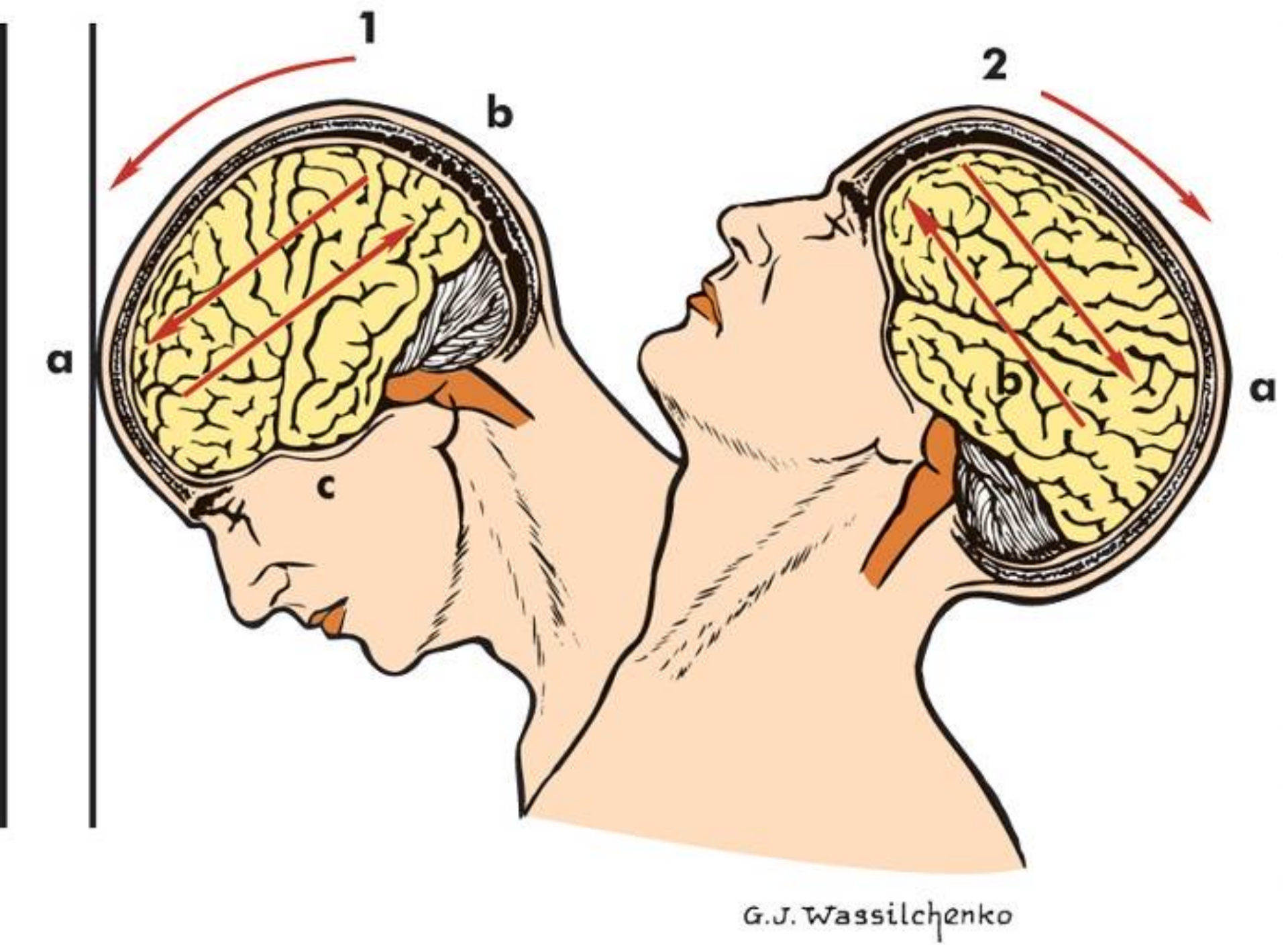
Coup and Contrecoup Contusions

- Contrecoup contusions are are located opposite the site of direct impact
- Cavitation in the brain, from negative pressure due to translational acceleration impacts as the skull and dura matter start to accelerate before the brain on initial impact

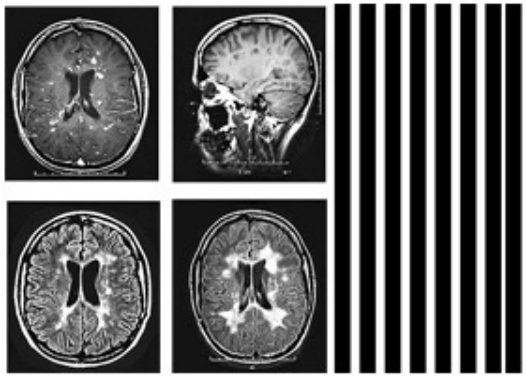


Contusion is Coup or Contrecoup type?

- Impact from a small, hard object tends to dissipate at the impact site, leading to a coup contusion
- In contrast, impact from a larger object causes less injury at the impact site, because energy is dissipated at the beginning or end of the head motion, leading to a contrecoup contusion

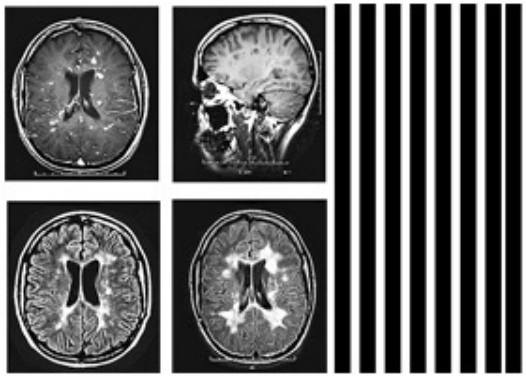


Modified from Rudy EB: Advanced *neurological and neurosurgical nursing*, St Louis, 1984, Mosby



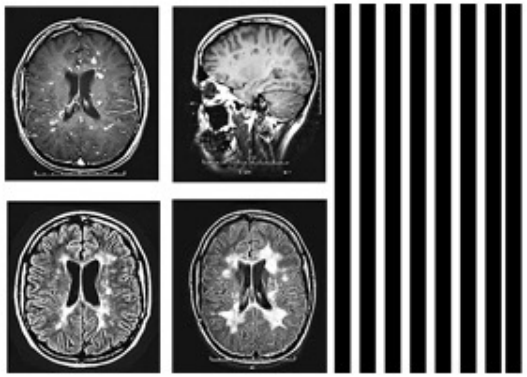
Focal Brain Injury

- A focal brain injury is concentrated in one region of the brain.
- Though having an injury in a specific region in the brain generally makes the trajectory of the injury easier to predict, focal brain injuries are neither more or less serious than diffuse brain injuries.



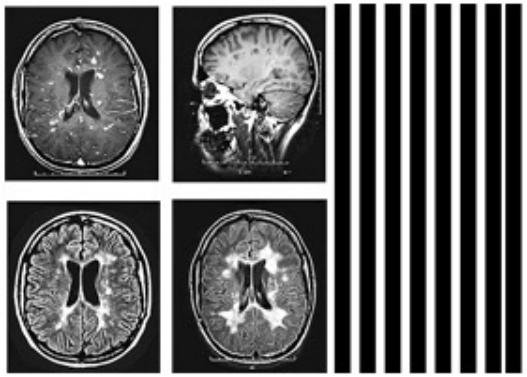
Focal Brain Injury

- A blow to the head, particularly by a sharp object.
- Car accidents, violent assaults, and sudden falls can all lead to this type of injury.
- A blood clot that travels to the brain, blocking oxygen from a specific brain region.
- A brain lesion that cuts off the blood supply to a specific brain region



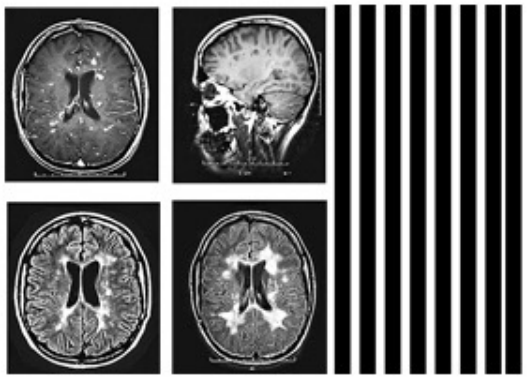
Focal Brain Injury

- Observable brain lesion
- Force of impact typically produces contusions
- Contusions can cause:
  - Extradural (epidural) hemorrhages or hematomas
  - Subdural hematomas
  - Intracerebral hematomas



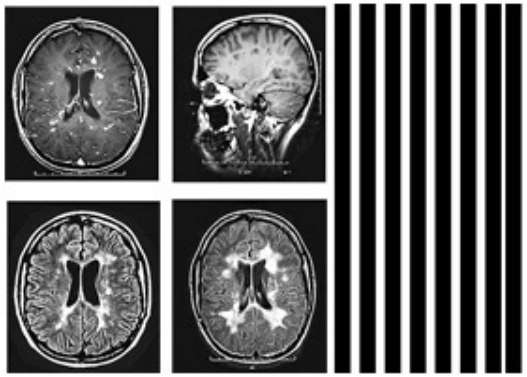
Focal Brain Injury

- Difficulty staying awake.
- Difficulty concentrating.
- Changes in mood or personality.
- Sudden, unexplained fear, paranoia, anxiety, or depression.
- Difficulty speaking or understanding speech.



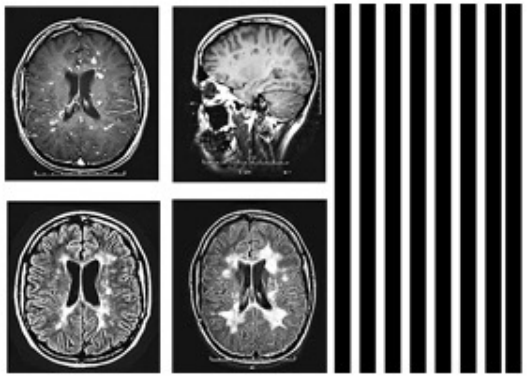
Focal Brain Injury

- Numbness, limpness, or tingling on either side of the body.
- Slurred speech.
- Ringing in your ears.
- Intense headache.
- Changes in vision or consciousness.



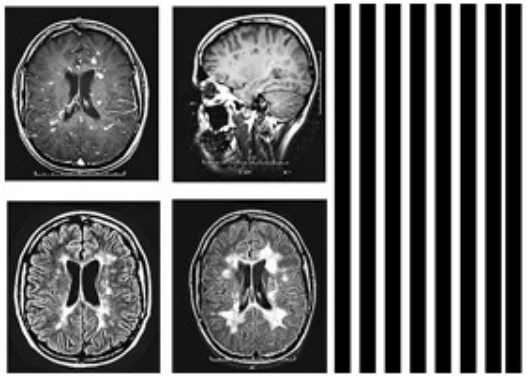
Diffuse Brain Injury

- **Diffuse axonal injury (DAI)**
  - Shaking, inertial effect
  - Acceleration/deceleration
  - Axonal damage
    - Shearing, tearing, or stretching of nerve fibers
  - Severity corresponds to the amount of shearing force applied to the brain and brain stem



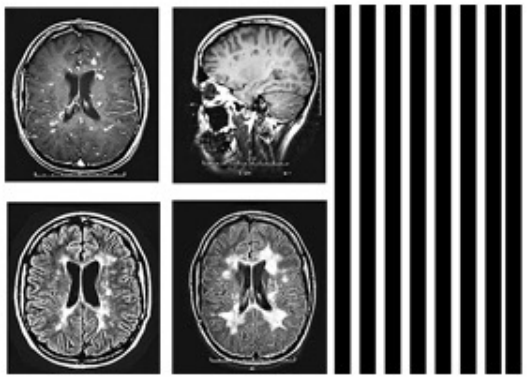
Diffuse Brain Injury

- This complex-sounding term refers to a brain injury that produces brain lesions in bundles of white matter across several brain areas.
- Because several brain regions are affected, a diffuse axonal brain injury is always severe, and can even become life-threatening.



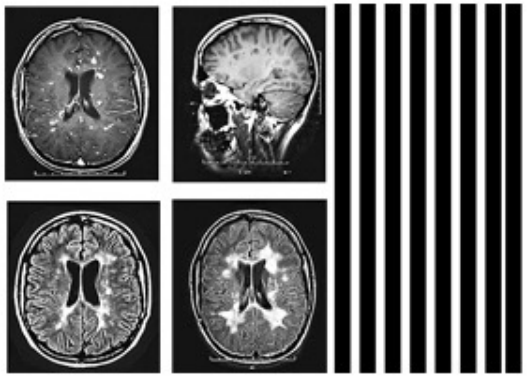
DAI Symptoms

- Changes in perception or cognition.
- Unexplained changes in mood or personality.
- Difficulty recognizing words, places, people, or animals that should otherwise be familiar.
- Trouble reading or speaking.
- Changes in memory.
- Unexplained anxiety or depression.



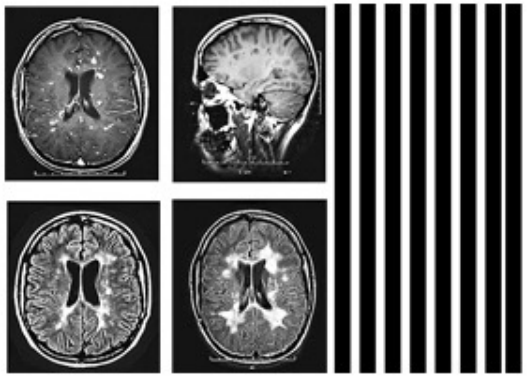
Diffuse Brain Injury

- Categories:
  - Mild concussion
  - Classical concussion
  - Mild, moderate, and severe diffuse axonal injuries (DAI)



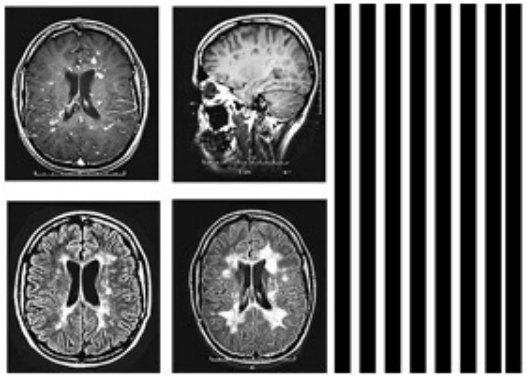
Mild Concussion

- Temporary axonal disturbance causing attention and memory deficits but no loss of consciousness
  - I: confusion, disorientation, and momentary amnesia
  - II: momentary confusion and retrograde amnesia
  - III: confusion with retrograde and anterograde amnesia



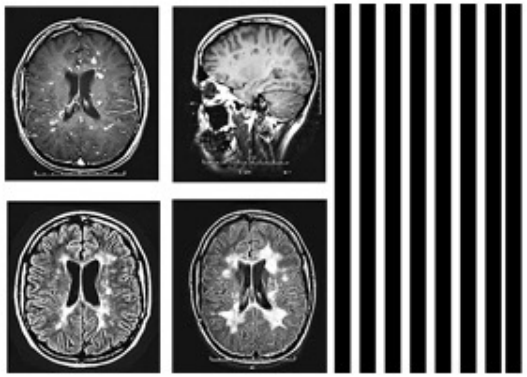
Classic Cerebral Concussion

- Grade IV
  - Disconnection of cerebral systems from the brain stem and reticular activating system
  - Physiologic and neurologic dysfunction without substantial anatomic disruption
  - Loss of consciousness (<6 hours)
  - Anterograde and retrograde amnesia
  - Post-concussive syndrome



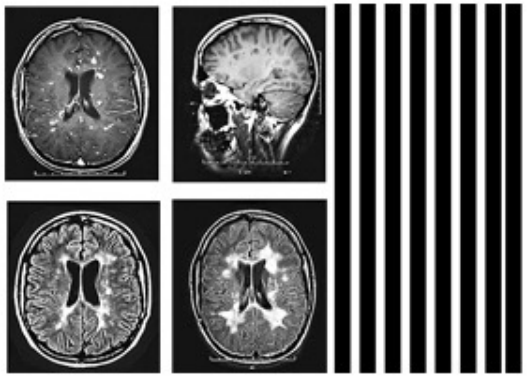
Concussions

- Caused by deformity of the deep structures of the brain
- Leads to widespread neurologic dysfunction
- Can result in impaired consciousness or coma
- Concussion is considered a mild form of diffuse axonal injury



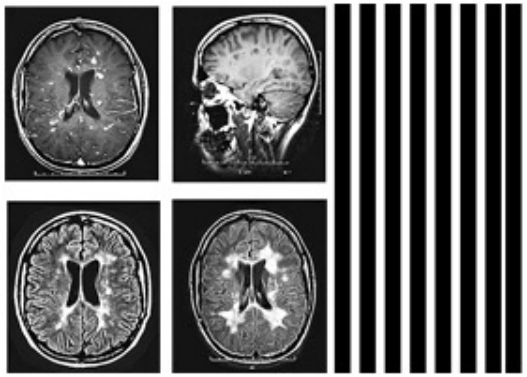
Diffuse Axonal Injury

- Characterized by extensive, generalized damage to the white matter of the brain
- Strains of the tentorium and falx during high-speed acceleration/deceleration produced by lateral motions of the head may cause the injuries
- Could occur as a result of ischemia



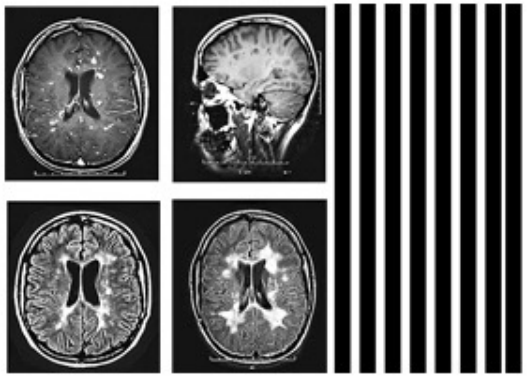
Neuropathologic findings in patients with diffuse axonal injury

- Grade 1 - Axonal injury mainly in parasagittal white matter of the cerebral hemispheres
- Grade 2 - As in Grade 1, plus lesions in the corpus callosum
- Grade 3 - As in Grade 2, plus a focal lesion in the cerebral peduncle



Increased Intracranial Pressure

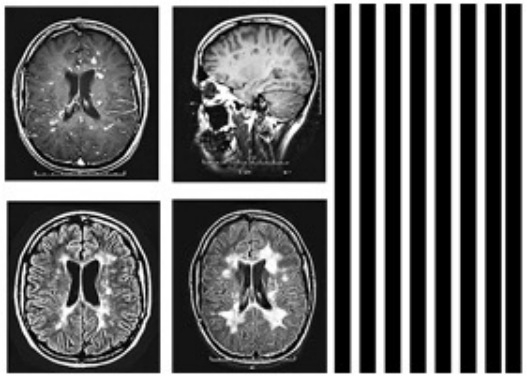
- The severity increase due to heightened ICP [If the pressure exceeds 40 mm Hg]
- Can lead to cerebral hypoxia, cerebral ischemia, cerebral edema, hydrocephalus, and brain herniation



Cerebral edema-contributors

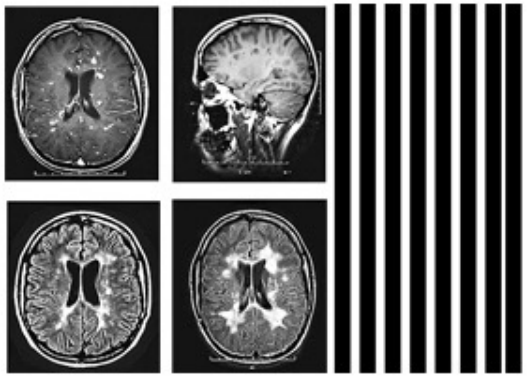
- Neurochemical transmitters increased ICP
- Disruption of the blood-brain barrier
- Impairment of vasomotor autoregulation

leading to dilatation of cerebral blood vessels



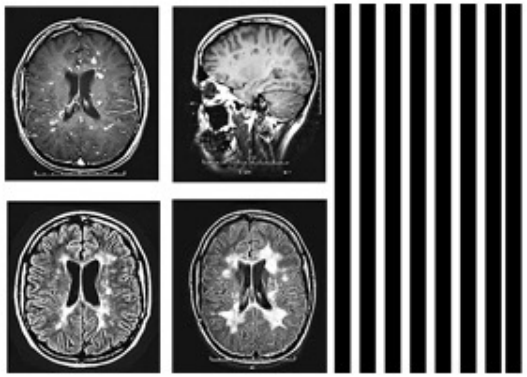
Brain Herniation

- Supratentorial herniation is attributable to direct mechanical compression by an accumulating mass or to increased intracranial pressure



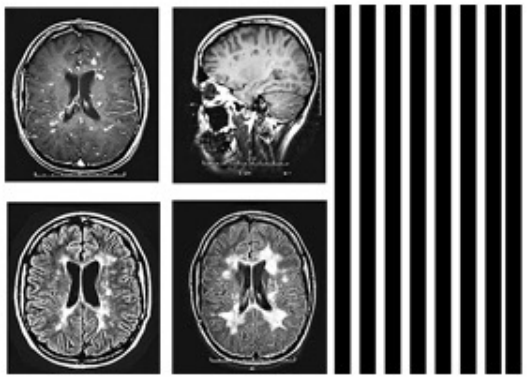
Subfalcine Herniation

- The cingulate gyrus of the frontal lobe is pushed beneath the falx cerebri when an expanding mass lesion causes a medial shift of the ipsilateral hemisphere.
- This is the most common type of herniation.



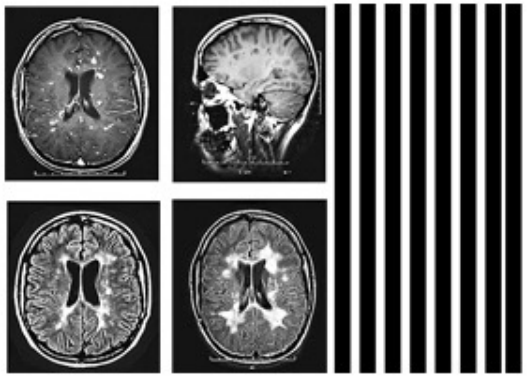
Central transtentorial herniation

- Characterized by the displacement of the basal nuclei and cerebral hemispheres downward while the diencephalon and adjacent midbrain are pushed through the tentorial notch.



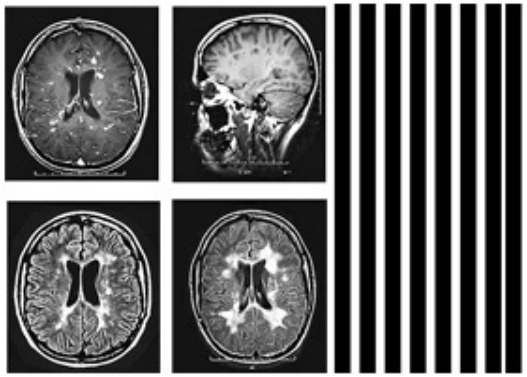
Cerebellar Herniation

- Involves the displacement of the medial edge of the uncus and the hippocampal gyrus medially and over the ipsilateral edge of the tentorium cerebelli foramen
- Causes compression of the midbrain
- The ipsilateral or contralateral third nerve may be stretched or compressed



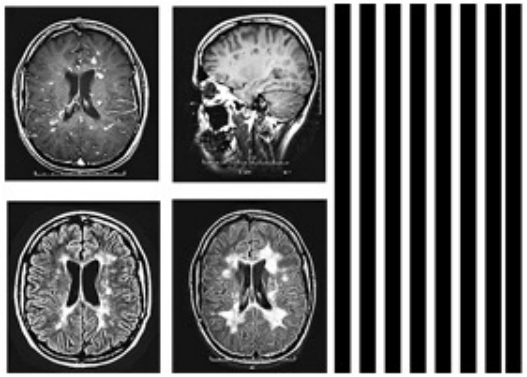
Cerebellar Herniation

- This injury is marked by an infratentorial herniation in which the tonsil of the cerebellum is pushed through the foramen magnum and compresses the medulla, leading to bradycardia and respiratory arrest.



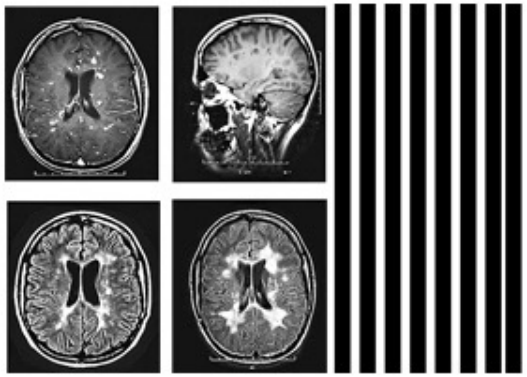
Cerebrovascular Physiology After TBI

- Altered Cerebral Blood Flow & Metabolism
- Can cause flow-metabolism uncoupling, resulting in cerebral ischemia or cerebral hyperemia
- Hyperemia is as bad as ischemia [↑ICP]



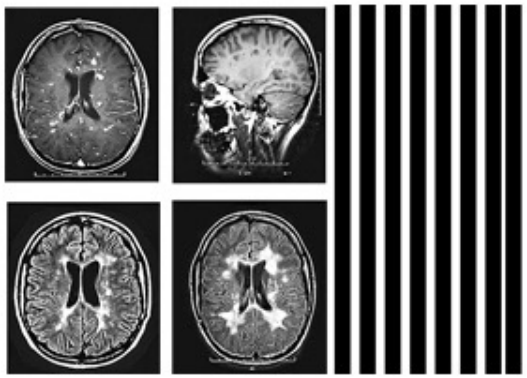
Altered Cerebral Blood Flow and Metabolism

- Focal/global ischemia occurs frequently and is a major reason for poor outcome
- The critical threshold of CBF for the development of irreversible tissue damage is 15 ml 100 g



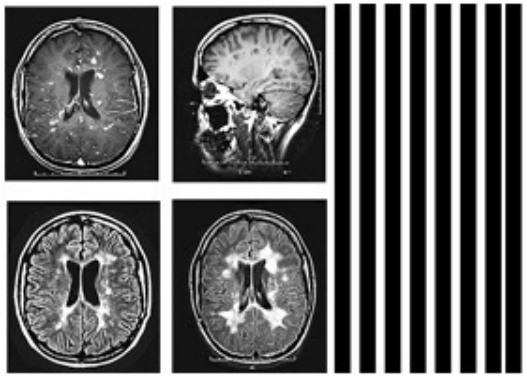
How TBI causes ischemia?

- Morphological injury (e.g. vessel distortion) hypotension in the presence of autoregulatory failure
- Inadequate availability of nitric oxide or cholinergic neurotransmitters
- Potentiation of prostaglandin-induced vasoconstriction



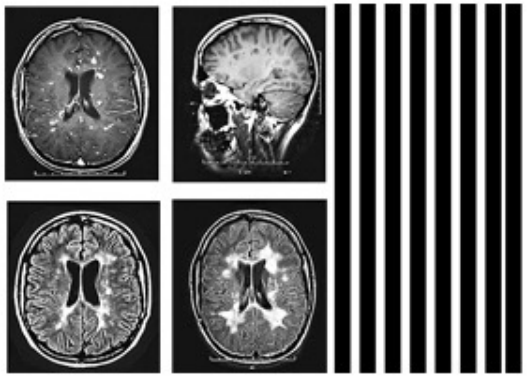
Altered CO2 Vasoreactivity

- During the early period, CO2 vasoreactivity can be transiently impaired, but generally recovers after 4 to 7 days
- May be associated with cerebral hyperemia, cerebral ischemia, or intracranial hypertension



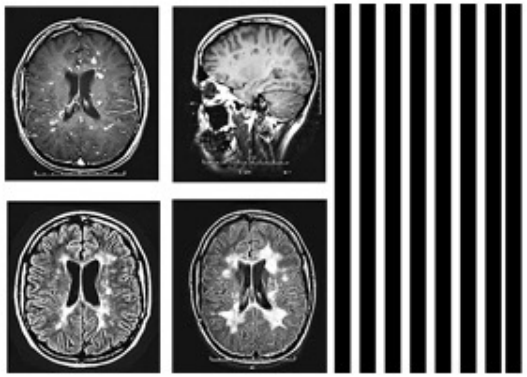
Altered CO2 Vasoreactivity

- Hyperventilation to induce cerebral vasoconstriction and reduce CBF, ICP and cerebral blood volume may unintentionally lead to secondary ischemic damage after TBI
- hyperventilation may not be effective in TBI if CO2 vasoreactivity is decreased.



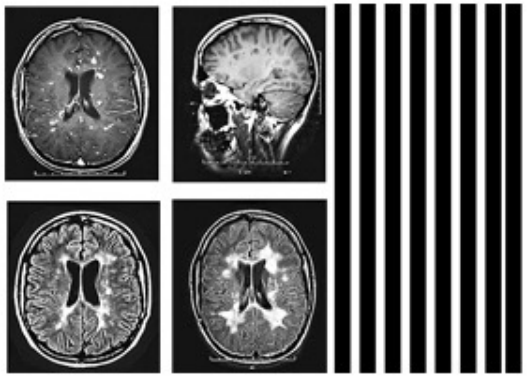
Impaired Cerebral Pressure Autoregulation

- Incidence is 28% after moderate and 67% after severe TBI
- A recent study of severe pediatric TBI reported that cerebral autoregulation often changed and worsened during the first 9 days after injury



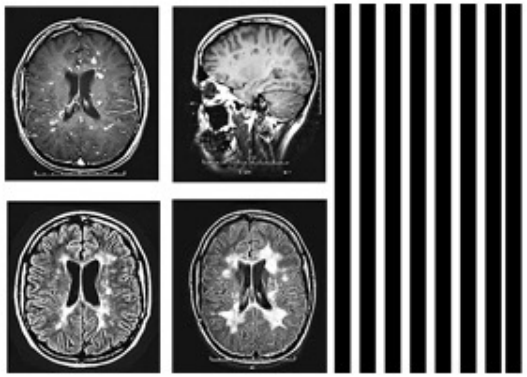
Cerebral Vasospasm

- Occurs in more than one-third of patients with TBI and
- Indicates severe damage to the brain
- Onset varies from post-traumatic day 2 to 15 and hypoperfusion
- Hemodynamically significant vasospasm occurs



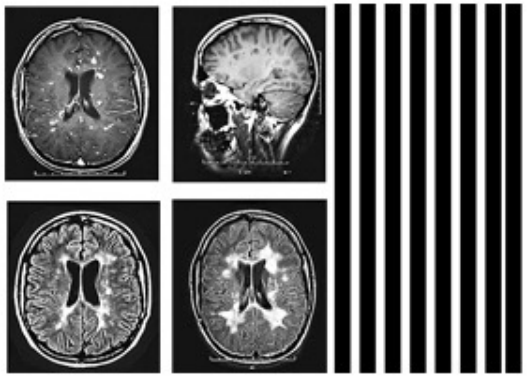
Edema - Vasogenic

- Caused by breakdown of the endothelial cell layer of brain vessels
- Allows for uncontrolled ion and protein transfer from the intravascular to the extracellular (interstitial) brain compartments
- Anatomically, this pathology increases the volume of theextracellular space



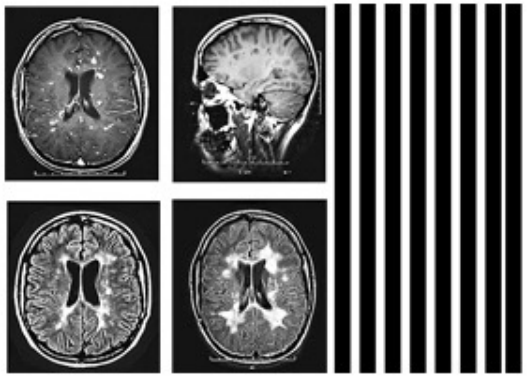
Edema - Cytotoxic

- Caused by intracellular water accumulation due irrespective of the integrity of the vascular endothelial wall.
- More frequent than vasogenic oedema in TBI



Brain Trauma

- Major head trauma
  - A traumatic insult to the brain possibly producing physical, intellectual, emotional, social, and vocational changes
  - Transportation accidents
  - Falls
  - Sports-related event
  - Violence



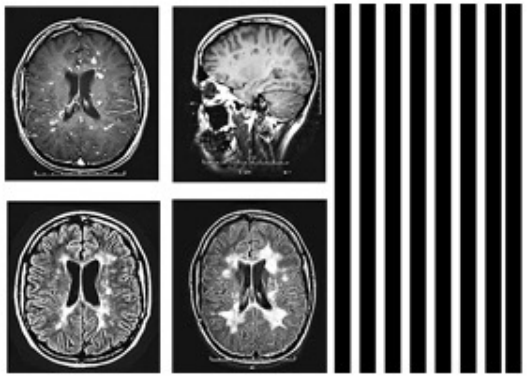
Brain Trauma - Gunther Von Hagen

Go to 34 minutes to 47 minutes

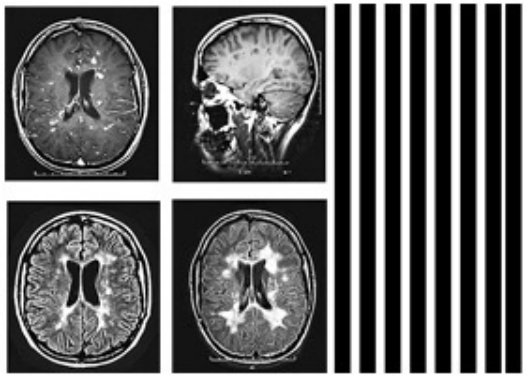
WARNING

Graphic Content:

VIEWER DISCRETION ADVISED

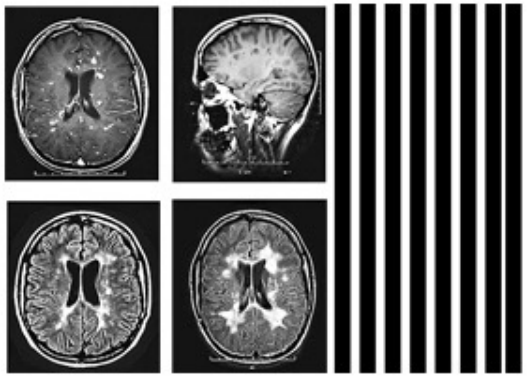


Brain Trauma – Gunther Von Hagen



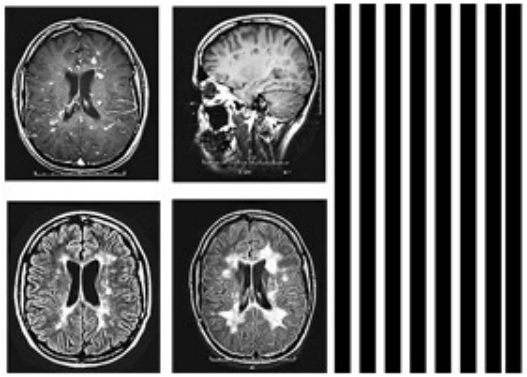
Spinal Cord Trauma

- Most commonly occurs due to vertebral injuries
  - Simple fracture, compressed fracture, and comminuted fracture and dislocation
- Traumatic injury of vertebral and neural tissues as a result of compressing, pulling, or shearing forces

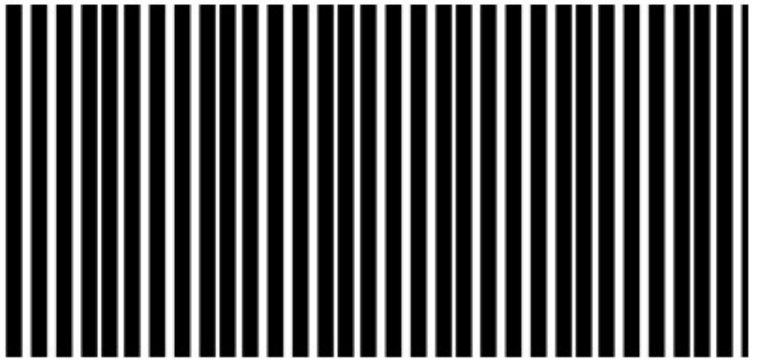


Spinal Cord Trauma

- Most common locations: cervical (1, 2, 4-7), and T1-L2 lumbar vertebrae
  - Locations reflect most mobile portions of vertebral column and the locations where the spinal cord occupies most of the vertebral canal



Spinal Cord Trauma



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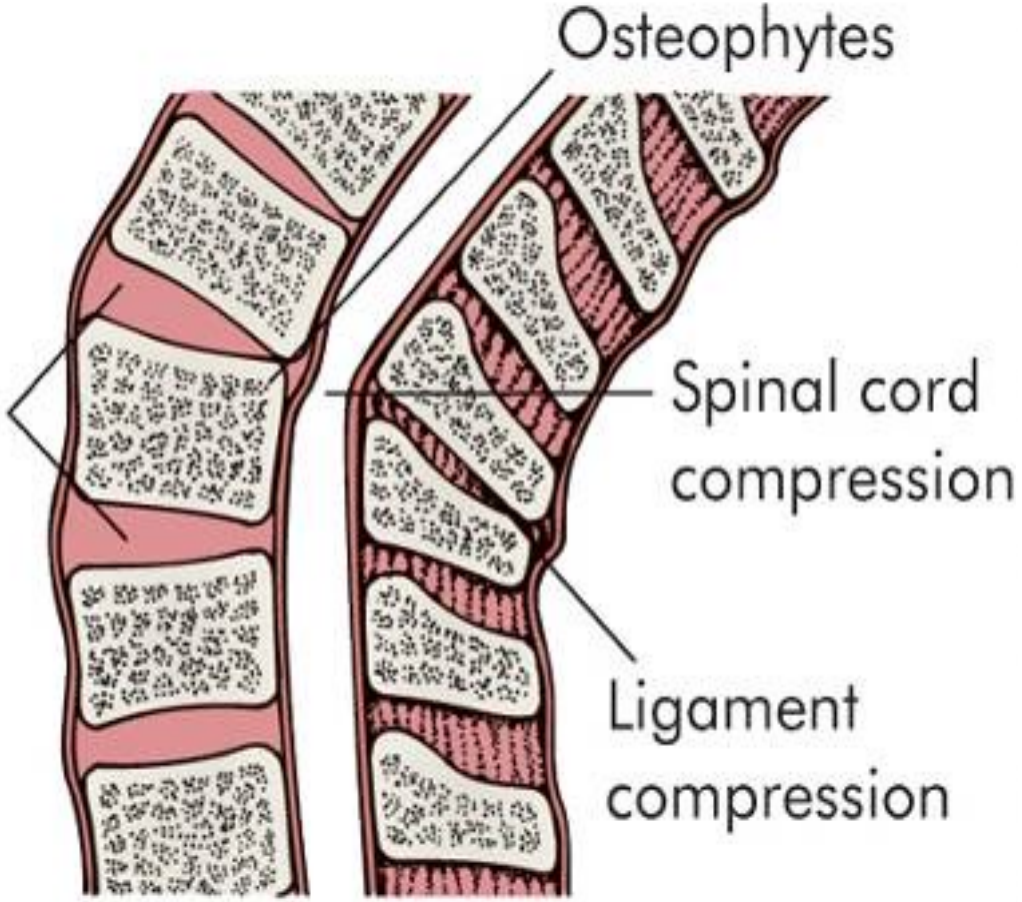
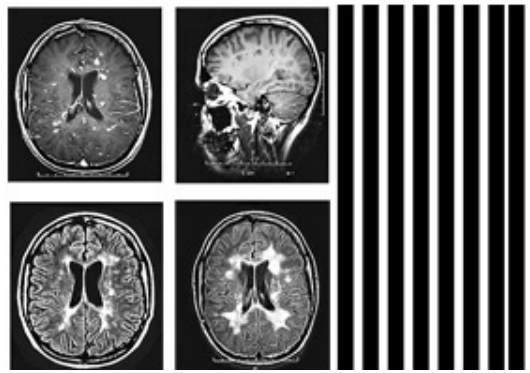
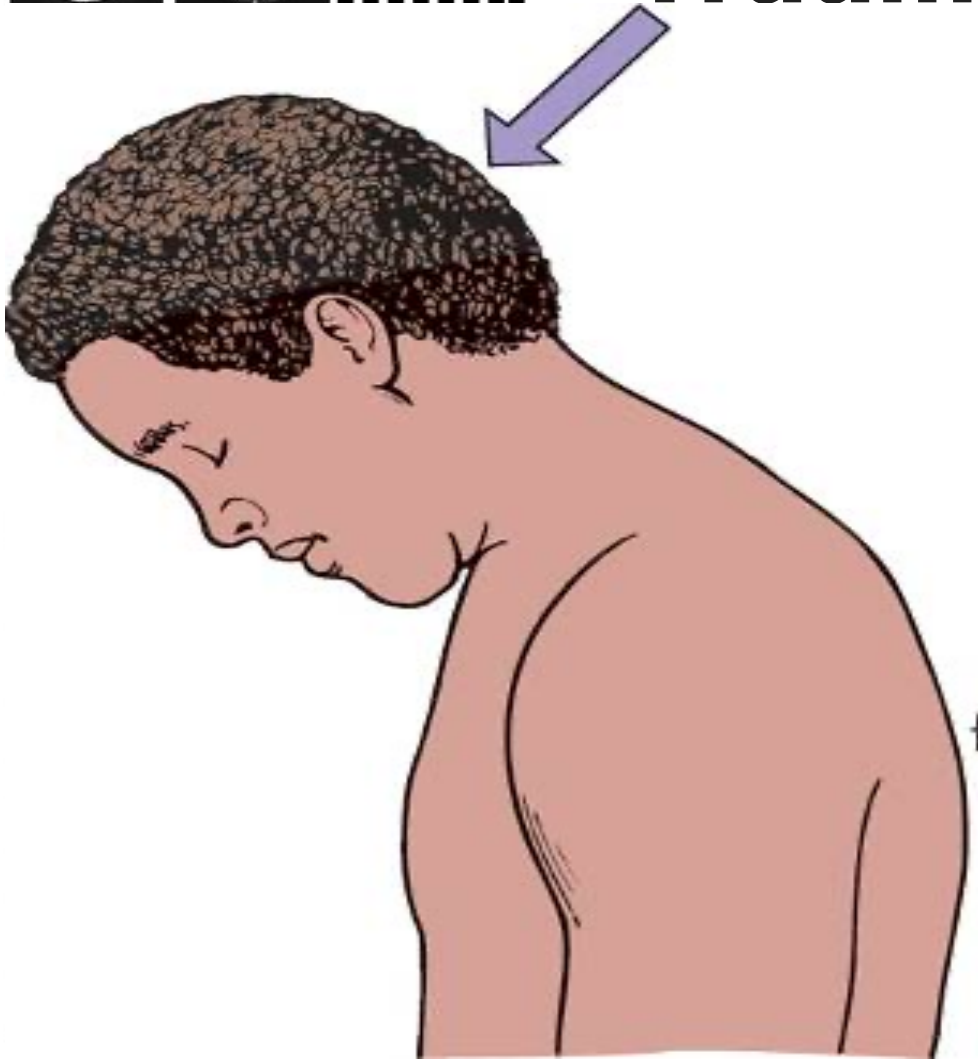
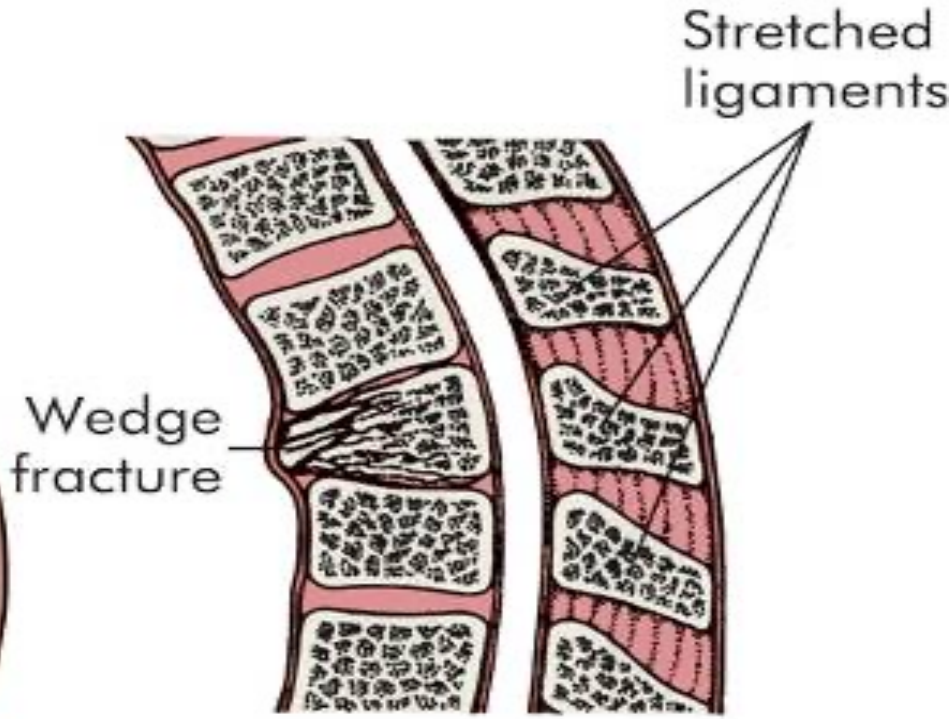
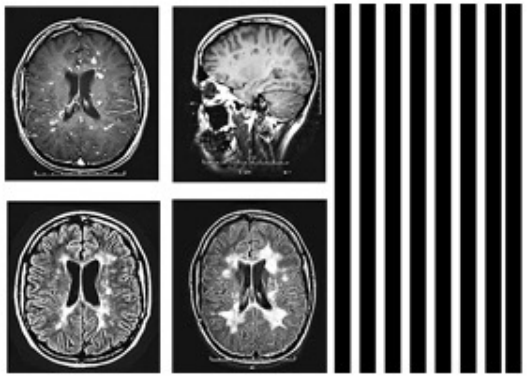


Spinal Cord Trauma









Spinal Cord Trauma

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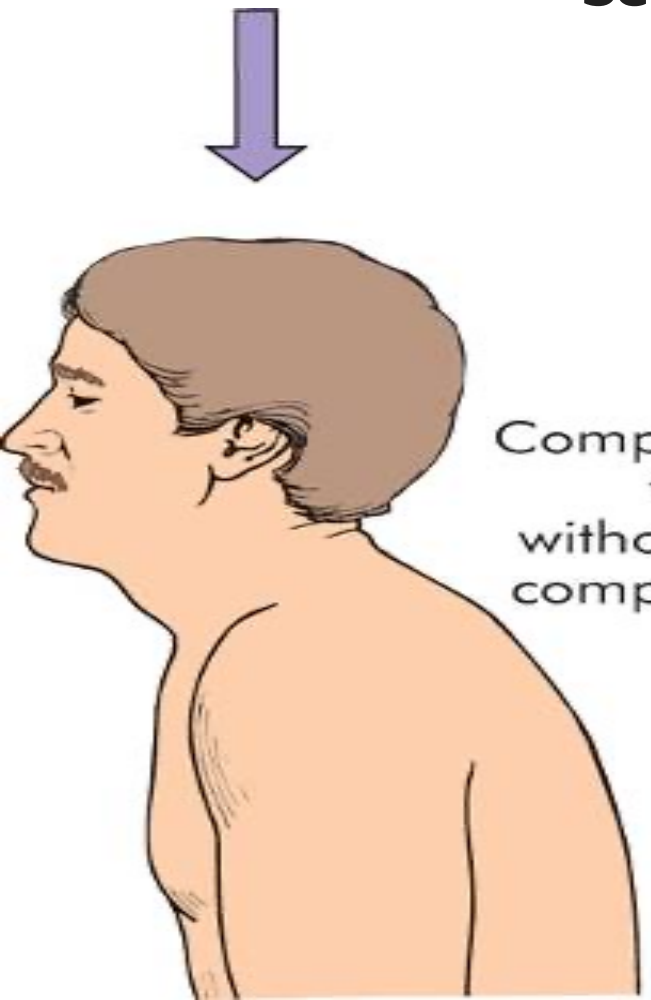
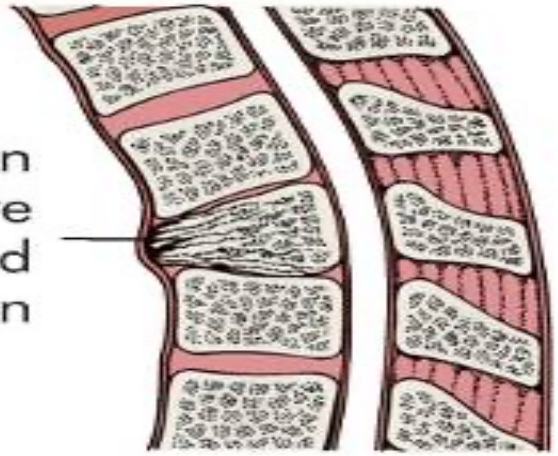
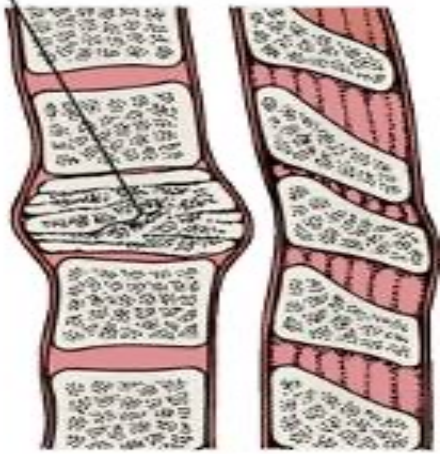
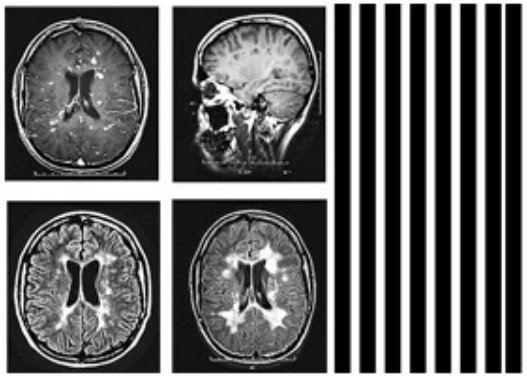


Compression fracture without cord compression

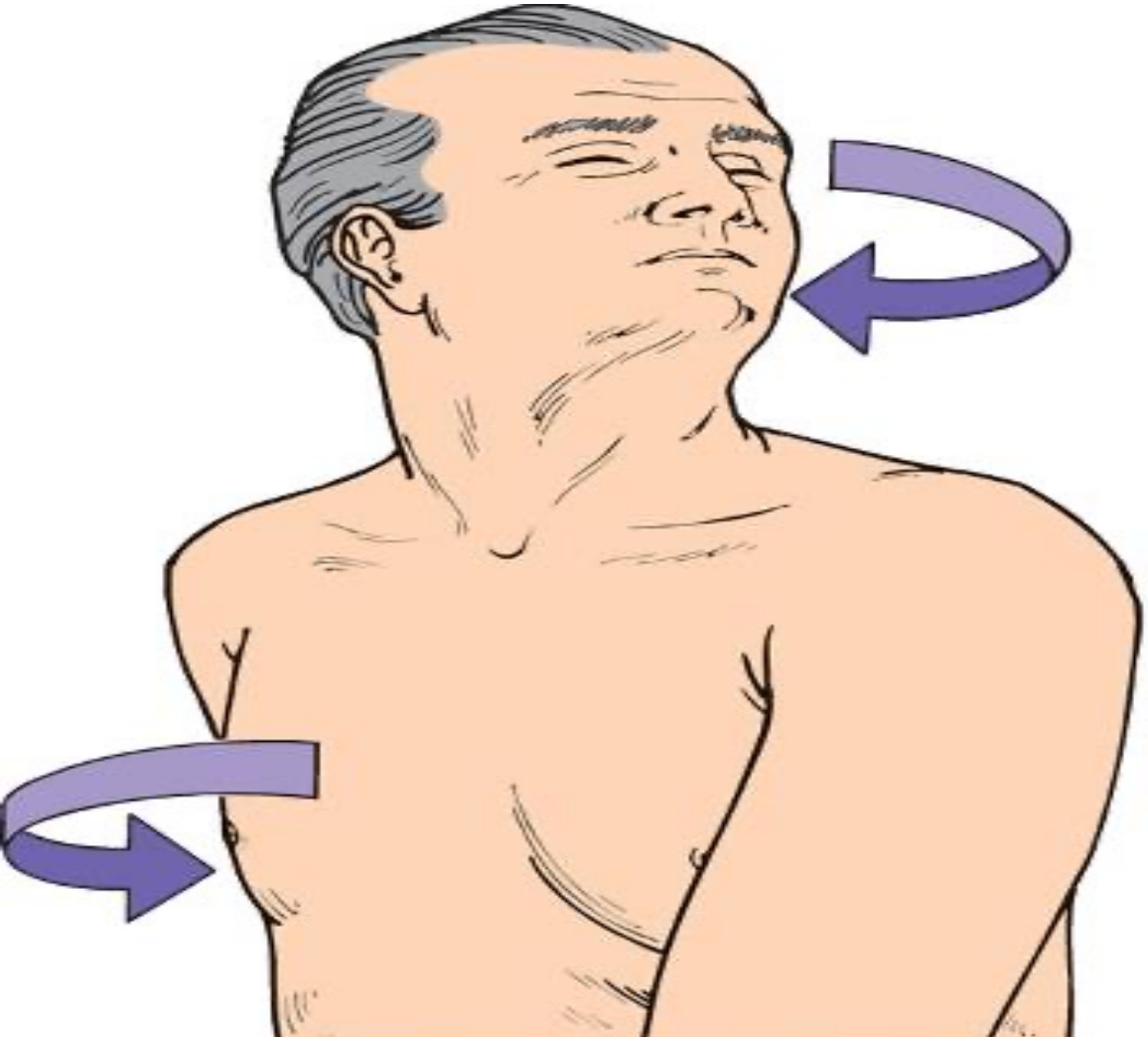


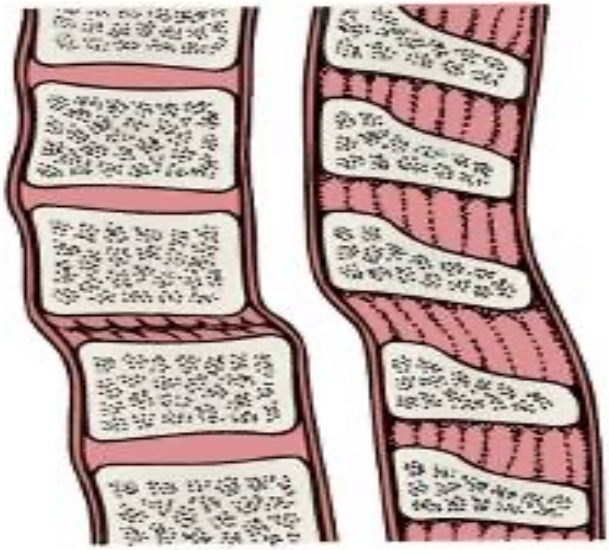
Crushed vertebral body with cord compression

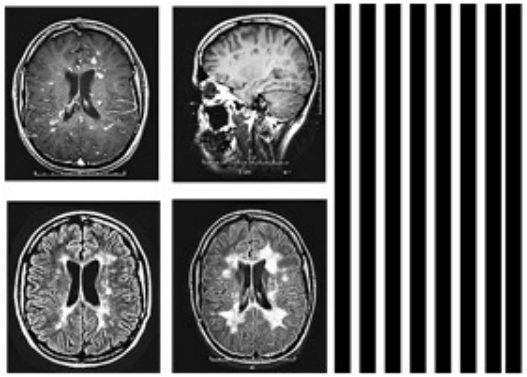




Spinal Cord Trauma







Spinal Cord Trauma

- Spinal shock
  - Normal activity of the spinal cord ceases at and below the level of injury. Sites lack continuous nervous discharges from the brain.
  - Complete loss of reflex function (skeletal, bladder, bowel, sexual function, thermal control, and autonomic control) below level of lesion
- Paraplegia
- Quadriplegia

Concussion – You Shake It, You Break It