

Intracranial Mass Lesions and Elevated Intracranial Pressure

Lissa C. Baird, MD
Assistant Professor
Directory, Pediatric Surgical Neuro-Oncology Department of
Neurological Surgery
Oregon Health & Science University

Conflict of Interest Disclosure

Disclosure

I do not have any financial relationships to disclose.

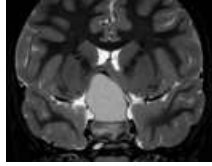
Intracranial Mass Lesions *Overview*

- I. General Principles of Intracranial Mass Lesions
- II. Differential Diagnosis
- III. Signs and Symptoms
- IV. Clinical Management of Mass Lesions and Elevated Intracranial Pressure

I. General Principles of Intracranial Mass Lesions

What is an Intracranial Mass Lesion?

- Space-occupying lesion
- Recognizable volume
- Abnormal



- May cause **mass effect**
Mass Effect = compression of surrounding structures causes **shift** (displacement)
- May cause **elevation of intracranial pressure**

Description of Intracranial Mass Lesions

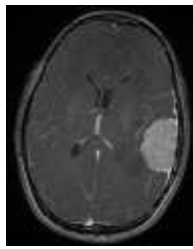
- Intra-axial
- Extra-axial
- +/- mass effect
- Discrete Lesion
- Expansion of Intrinsic anatomy

Intra-axial vs Extra-axial

- Intrinsic to the brain
- Extrinsic to the brain

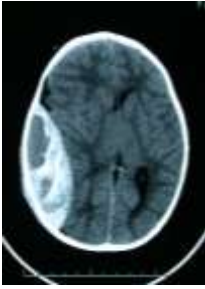


Metastatic tumor



meningioma

Is there Mass Effect on surrounding brain structures?

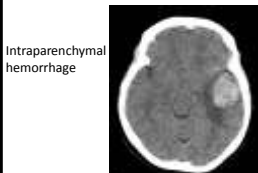


Epidural hematoma



Pineal cyst

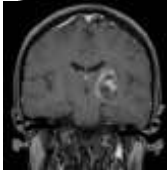
Discrete Lesion or Expansion of Intrinsic Anatomy?



Intraparenchymal hemorrhage



Trapped Temporal horn



tumor



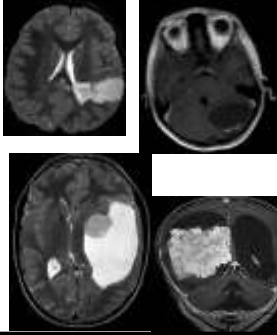
Diffuse intrinsic pontine glioma

II. Differential Diagnosis

- Neoplasm
- Trauma
- Infection
- Stroke
- Cyst
- Vascular
- Hydrocephalus
- Congenital Anomaly

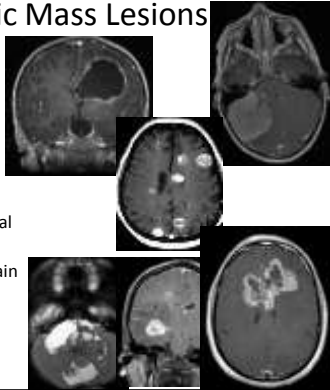
Neoplastic Mass Lesions

- Intra-axial
 - Benign
 - Slow rate of growth
 - Unlikely to metastasize
 - Less surrounding edema
 - Can still cause significant symptoms depending on location



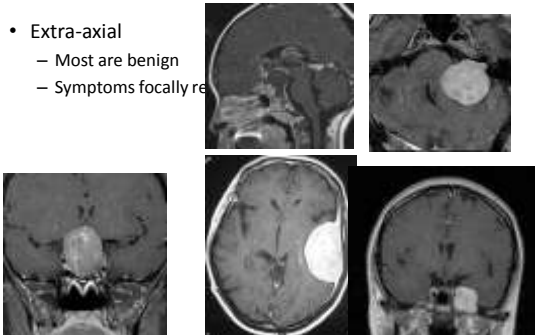
Neoplastic Mass Lesions

- Intra-axial
 - Malignant
 - Metastatic
 - May be multifocal
 - Spread within central nervous system
 - Infiltrate normal brain
 - Severe Edema



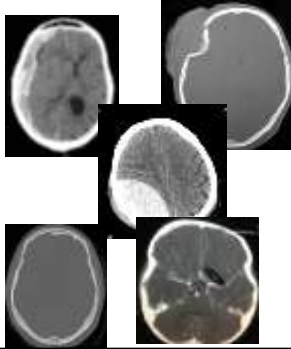
Neoplastic Mass Lesions

- Extra-axial
 - Most are benign
 - Symptoms focally re

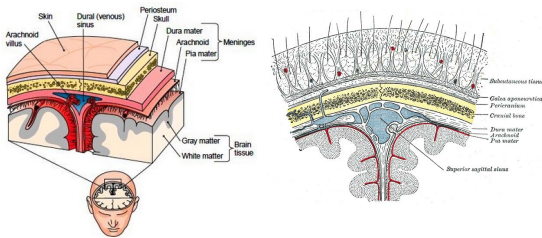


Traumatic Mass Lesions

- Hematoma
- Depressed Skull Fractures
- Foreign Body
 - Penetrating injuries

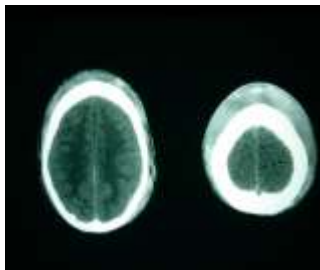


Layers of the Cranial Vault



Subgaleal hematoma

- Between galea aponeurotica and periosteum.
- Blunt trauma
- boggy
- No surgery
- Neonate--volume



Cephalohematoma

- Between the periosteum and the skull
- Do not cross suture lines
- No intervention



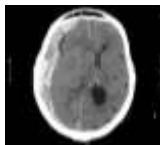
Epidural Hematoma

- Between cranium and dura
- **Convex** shape
- Arterial bleeding
 - Expand rapidly
- **Emergent** Surgical Evacuation



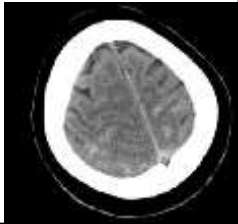
Subdural hematoma

- Hemorrhage in the dura-arachnoid space
 - Bridging veins
 - Shear injury, rotational acceleration
- Concave shape
- Higher mortality
- High association with other underlying brain lesions
- Surgery:
 - Acute presentation = emergent surgery
 - Subacute/Chronic presentation = urgent to semi-elective surgery



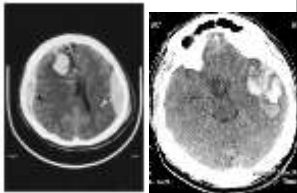
Subarachnoid Hemorrhage

- Between arachnoid and pia
- **Most common** traumatic bleed
- Rupture of small vessels on the surface of brain
- Usually trivial mass effect
- Not Surgical



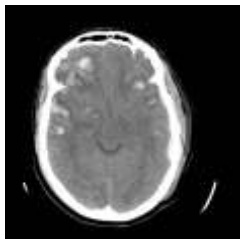
Intraparenchymal Hematoma

- **Often delayed** up to 72 hours.
- High association with hematomas in other intracranial locations.
- Surgery is usually urgent (not emergent) if necessary



Cerebral Contusions

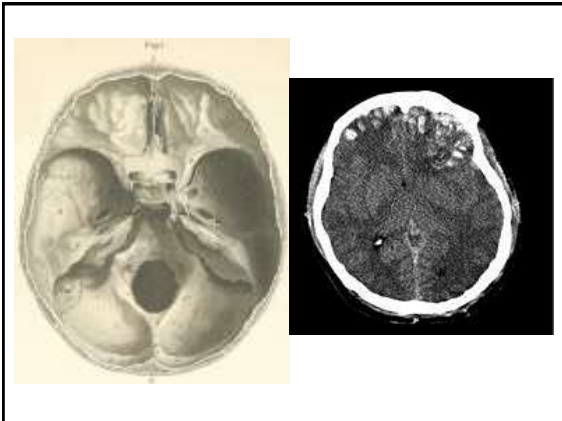
- Bruising of neural parenchyma
- Classically described as **Coup** and **Contrecoup**
- Loss of Consciousness



Coup Contracoup Injury

- Coup:
 - Injury occurs under site of impact/blunt trauma
- Contra-coup
 - Injury occurs opposite site of impact/blunt trauma





Mass Lesions from Infection

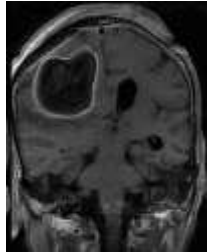
- Cerebral Abscess
- Subdural Empyema
- Epidural Abscess

- Neurological presentation and type of infection determines surgical urgency

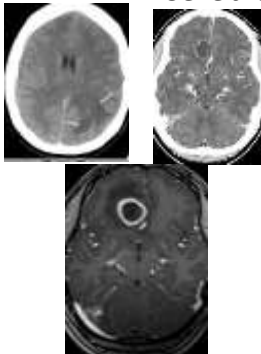
Cerebral Abscess

Predisposing Conditions:

- Otitis Media/mastoiditis
- Sinusitis
- Dental Infection
- Penetrating Trauma
- Pulmonary Infection
- Endocarditis
- Immunocompromise



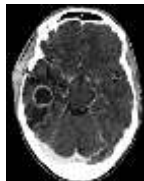
Cerebral Abscess



- Days 1-4: early cerebritis
- Days 4-9: late cerebritis
- Days 10-13: Early capsule formation
- Day 14 and later: Late capsule formation
- Meningitis
- Ventriculitis

Cerebral Abscess

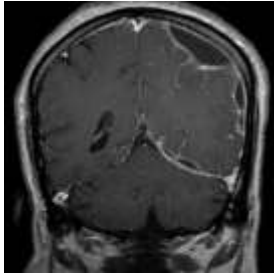
- Symptoms:
- Headache
- Fever
- Focal neurologic deficits
- Altered mental status
- Seizures
- Nausea and Vomiting
- Nuchal rigidity
- Papilledema
- Surgical resection or aspiration (~2.5 cm)
- Antibiotics
- Mortality: 8-25%
- Neurological Sequelae: 20-70%



Subdural Emphyema

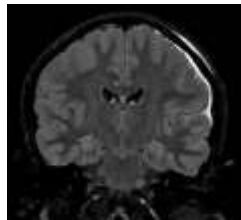
Predisposing Conditions:

- Sinusitis
- Otitis media/mastoiditis
- Skull trauma
- Neurosurgical procedures
- Pulmonary Infections
- Meningitis



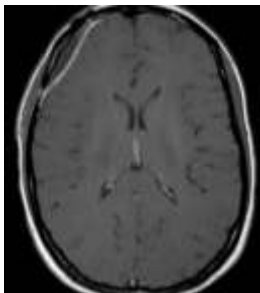
Subdural Emphyema

- Rapidly progressive Symptoms:
- Fever
- Headache
- Vomiting
- Seizures
- Altered Mental Status
- Neurological Deficits
- Coma
- Surgical Emergency
- Antibiotics



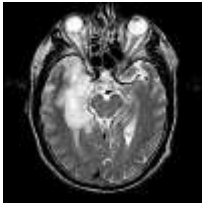
Epidural Abscess

- May be associated with subdural emphyema
- Similar pathogenesis
- Post-neurosurgical: Bone at risk
- Less morbid than subdural



Mass Lesions from Infection

- Encephalitis
- Parasite



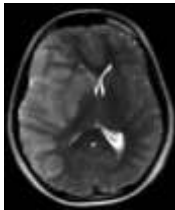
HSV encephalitis

neurocysticercosis



Stroke

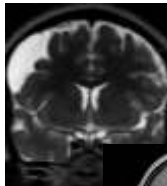
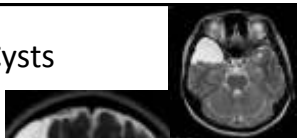
- Ischemic
- Hemorrhagic



Cysts

- Chronic presentation
- Incidental
- Congenital

- Arachnoid cysts



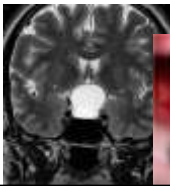
Cysts

- May be asymptomatic
- Headaches
- Endocrinopathies
- Papilledema
- Focal deficits rare

Colloid Cyst



Rathke's Cleft Cyst

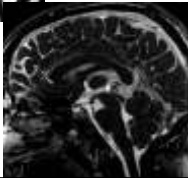


Cysts

- Incidental
- Asymptomatic
- Usually observation only

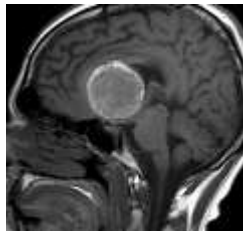


Pineal Cyst



Vascular Mass Lesions

- Aneurysm
- Arteriovenous malformations
- Cavernous malformation



Vascular Mass Lesions

- Headache
- Cranial neuropathies
- Seizure
- Vascular steal deficits
- Asymptomatic

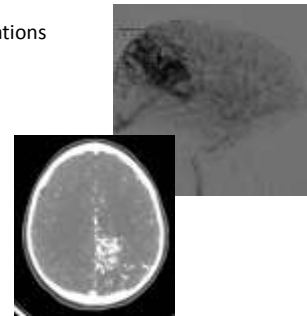
- Hemorrhage
- Vasospasm/Stroke
- Hydrocephalus



Vascular Mass Lesions

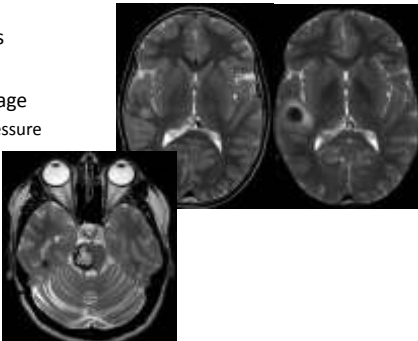
- Arteriovenous Malformations
- Seizures
 - Vascular steal
 - Venous hypertension

 - Hemorrhage



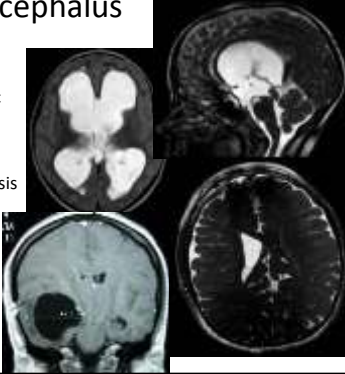
Vascular Mass Lesions

- Cavernomas
- Seizure
 - Hemorrhage
 - Low pressure



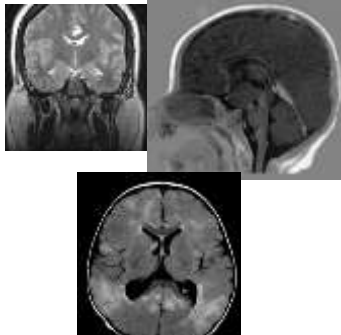
Hydrocephalus

- Communicating
 - Post-hemorrhagic
 - Post-infectious
- Obstructive
 - Aqueductal stenosis
- Trapped ventricle



Congenital Anomalies

- Lipoma
- Hamartoma
 - seizures
- Tubers
 - Tuberous sclerosis
- Seizure focus
- Incidental



III. Signs and Symptoms

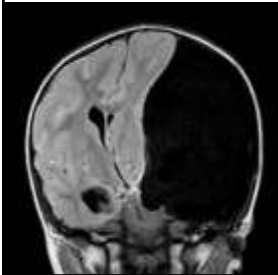
- Focal
- Global
- Herniation Syndromes

Mass Lesions: Does BIG = BAD?

- Not necessarily
- Growth rate of a mass is the most critical variable
 - Chronic vs acute development of mass effect
 - Benign = growth rate is 0
 - Life-threatening = can be massive lesion in seconds
- *However:* Location also important
 - A 1 cm mass lesion may cause devastating symptoms in the brain stem and no symptoms in the frontal lobe

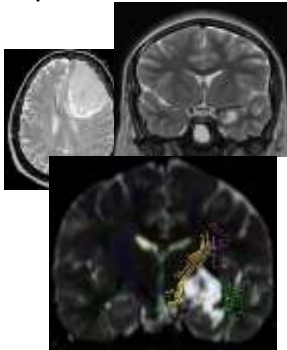
- Headache
- **Not an emergency**

- Confused
- Vomiting
- Anisocoria
- **Emergency**



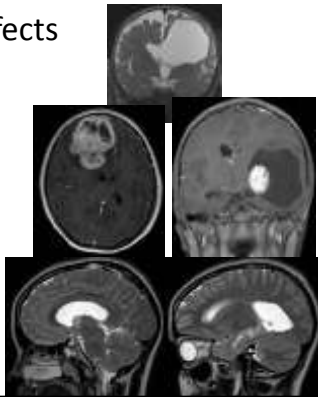
Focal Symptoms

- Cortical
 - Ablative = negative signs
 - Loss of cortical function
 - Irritative = positive signs
 - Seizures
- Subcortical
 - Interruption of tracts
 - Interruption of fasciculi



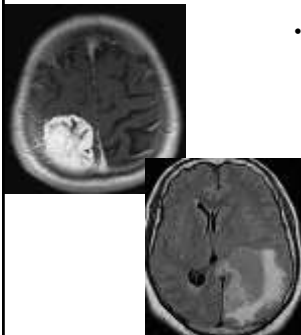
Focal Effects

- Frontal Lobe
 - Personality changes
 - Memory difficulties
 - Cognitive difficulties
 - Bladder incontinence
 - Motor
- Temporal Lobe
 - Dysphasias
 - Memory difficulties
 - Seizures



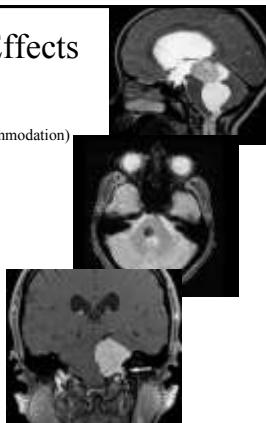
Focal Effects

- Parietal Lobe
 - Neglect syndroms
 - Agnosia, astereognosia, dyslexia, dysgraphia, dyscalculia
 - Sensory disturbance
- Occipital Lobe
 - Cortical blindness
 - Visual field deficit
 - Anton's syndrome



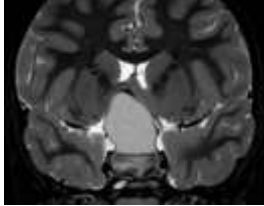
Focal Effects

- Midbrain
 - Parinaud Syndrome:
 - Light near dissociation (- light, +accommodation)
 - Upward gaze palsy
 - Retraction nystagmus
- Pontine
 - Periodic breathing
 - Pinpoint pupils
 - Absent oculovestibular reflexes
 - Quadriparesis
- Medulla
 - Downbeat nystagmus
 - Apnea
- Brainstem or Cranial Nerve:
 - Cranial neuropathies



Focal Effects

- **Sellar/Suprasellar**
 - Endocrinopathies
 - Hypothalamic dysfunction
 - Visual field cut
- **Cerebellum**
 - Ataxia
 - Fine motor dysfunction
 - Dysmetria
 - Nystagmus



Mass Lesions: Global/Distal Effects

- **Elevated Intracranial Pressure**
 - Acute
 - Subacute
 - Chronic
- **Herniation Syndromes**
 - Uncal
 - Subfalcine
 - Trans-tentorial
 - Tonsillar

Mass Lesions: Global Effects

- **Acute** Elevation of Intracranial Pressure
 - Headache
 - Vomiting
 - Seizure
 - Focal neurologic deficits
 - Altered mental status
 - Depressed level of consciousness
 - Bradycardia
 - Hypertension
 - Death



Mass Lesions: Global Effects

- **Sub-Acute** Elevation of Intracranial Pressure

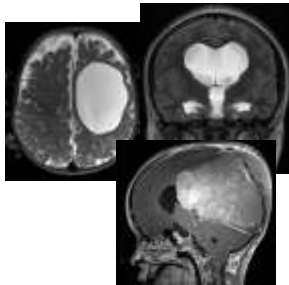
- Headache
- Vomiting
- Lethargy
- Focal neurologic deficits
- Cranial neuropathies (CN III, CN VI)
- Seizure
- Behavioral Changes
- Papilledema
- Blurry vision
- Gait disturbance
-
- Altered mental status
- Depressed level of consciousness
- Death



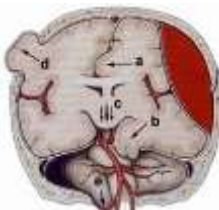
Mass Lesions: Global Effects

- **Chronic** Elevation of Intracranial Pressure

- Asymptomatic
- Headache
- Vomiting
- Papilledema
- Blurry vision
- Behavioral Changes
- Gait disturbance
- Seizure
- Lethargy



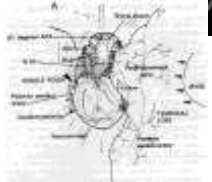
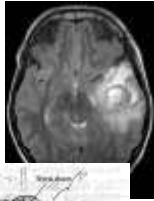
Herniation Syndromes: Uncal Herniation



- Middle fossa lesions
- Uncus of mesial temporal lobe herniates over tentorial incisura

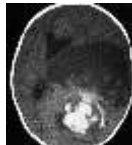
Herniation Syndromes: Uncal Herniation

- Pupillary
 - Fixed, dilated pupil
 - Ptosis
 - CN III palsy ('Down and out')
- Corticospinal
 - Contralateral motor signs in 80%
- Posterior Cerebral Artery infarct



Herniation Syndromes: Trans-Tentorial Herniation

- Central tentorial herniation
 - Diffuse or bilateral hemispheric lesions
 - Displacement of brainstem shears perforating arteries



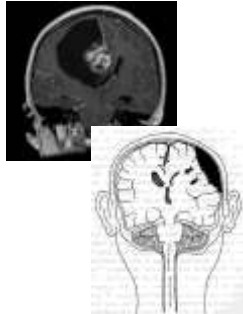
Herniation Syndromes: Trans-Tentorial Herniation

- Central tentorial herniation: progressive dysfunction
 - Pupillary
 - Dilated, pinpoint, irregular fixed
 - Motor
 - Command, localize, withdraw, decorticate, decerebrate, flaccid
 - Ventilatory
 - Cheyne-Stokes, ataxic, apnea
 - Brain Death



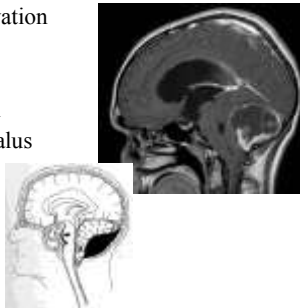
Herniation Syndromes: Sub-Falcine Herniation

- Sub-falcine herniation
 - Unilateral hemispheric lesion
 - Cingulate gyrus herniation under falx cerebri
 - Midline shift
 - Anterior cerebral artery infarct



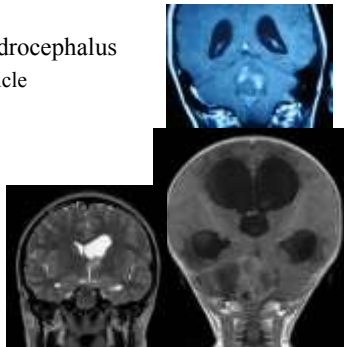
Herniation Syndromes: Tonsillar Herniation

- Severe diffuse ICP elevation
- Posterior Fossa Mass
- Brainstem compression
- Obstructive hydrocephalus
- Sudden apnea/death



Mass Lesions: Distal Effects

- Obstructive hydrocephalus
 - Trapped ventricle



IV. Management of Intracranial Mass Lesions

- Intracranial Pressure (ICP) Management
- Imaging
- Critical Care
- Medical Management
- Surgical Management

Elevated Intracranial Pressure *General Concepts*

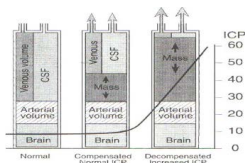
The Cranial Vault

- Brain
- Blood
- CSF



Monro-Kellie Doctrine

- The sum volume of blood, brain, and CSF is constant
- An increase in one needs to be compensated by a decrease in the others
- Failure to compensate will lead to an increase in intracranial pressure (ICP)
- Rapid or extreme elevations of ICP will compromise cerebral perfusion (CPP)
- $CPP = MAP - ICP$. Does not account for cerebral autoregulation



- **Cerebrospinal Fluid**
- Brain
- Blood

Cerebrospinal Fluid (CSF)

- **Ventriculostomy drain**
 - May also serve as an ICP monitor
- LP contraindicated in acute setting
- Carbonic anhydrase inhibitors not effective in traumatic setting



- Cerebrospinal Fluid
- **Brain**
- Blood

Brain

- Osmotics
 - Mannitol
 - BBB
 - Rebound edema
 - Hypertonic saline
 - Loop diuretics
- Lobectomies

Brain

- Osmolar therapy
 - Mannitol
 - BBB
 - Rebound edema
 - Hypertonic saline
 - Loop diuretics
- Lobectomies
 - Rarely needed



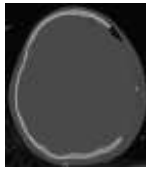
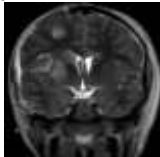
- Cerebrospinal Fluid
- Brain
- **Blood**

Blood

- Evacuate hematomas
- Hyperventilation
- Head of bed elevated
 - Optimize venous outlet
- No cervical restriction
 - 2 fingers under c-collar
 - No jugular lines
 - Trach collars
- Minimize cerebral metabolic activity
 - Sedation
 - Muscle relaxants
 - Burst suppression

Bypass Monroe Kellie physiology

- Decompressive craniectomy
 - Controversial literature
 - Poorly done studies
 - Clinical judgment
 - It works



Management of Intracranial Mass Lesions

- **Acute Presentation**
 - Rapidly increasing ICP
 - Rapidly expanding mass lesion
 - Emergency
- Trauma
- Ventricular shunt malfunction
- Obstructive hydrocephalus



Emergent Management

1. ABCs

- Acute elevation of ICP can lead to:
 - Loss of airway protection
 - Suppression of respiratory drive
 - Bradycardia
 - Hemodynamic instability

2. Neurologic Assessment

- Level of Sensorium
 - Glasgow Coma Score

Emergent Management

2. If signs of herniation are present:

- Mannitol, hypertonic saline bolus
- Hyperventilation (pCO₂ 30-35)
- Elevate HOB 15-30 degrees



3. Imaging:

- Identify a surgical condition
- Head CT is standard

4. Operating Room for surgical management

- Evacuate hematoma, CSF diversion, decompressive craniectomy

Emergent Management

5. Ongoing Medical Management:

- Goal ICP < 20 mm Hg
- Osmotic treatment
 - Na goals: 150-160
 - Hypertonic saline is preferred over repeat mannitol dosing
 - Serum osmolality < 320 mOsm/kg
- pCO₂ 32-35
- Euvolemic with isotonic saline
- Normotensive, maintain cerebral perfusion
- HOB elevated >30 degrees
- Sedation and analgesia
- Control fever
- Seizure prophylaxis
- Euglycemia
- Avoid anemia

Non-Emergent Management of Intracranial Mass Lesions

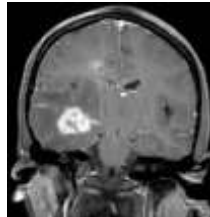
Subacute or Chronic Presentation

- Observe
 - Risk of progression
- Steroids
 - Vasogenic edema
- Surgery
 - Remove mass
 - Alleviate focal pressure from mass



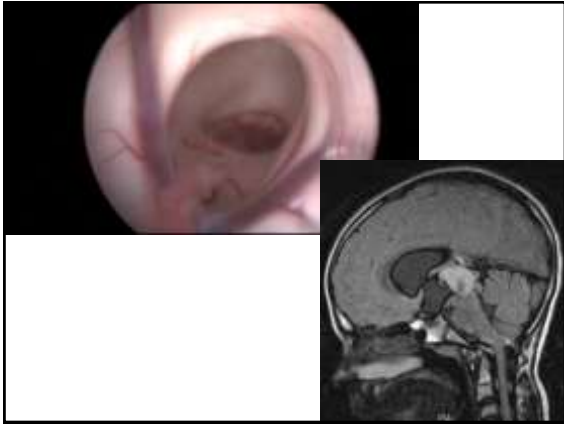
Non-Emergent Management

- Steroids
 - Appropriate in the treatment of vasogenic edema (tumor and infection)
 - Contraindicated in the treatment of cytotoxic edema (cranial injury and stroke)
 - Mechanisms are obscure:
 - membrane stabilization
 - free radical quenching
 - edema resolution
 - slightly reduced CSF formation
 - anti-inflammatory effects



Surgical Treatment of Mass Lesion

- Option for non-surgical treatment?
- Mass effect?
- Potential for Progression?
- Location
 - Risk of morbidity?
 - Resources available?
 - Technology: Stealth, MRI, endoscopy
 - PICU
 - Neuro-anesthesia





Case 1

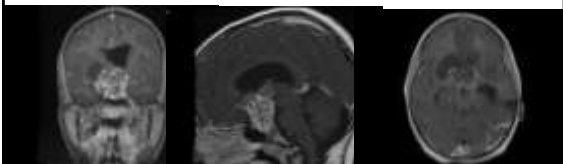
A 28 year-old male presents to his PCP with 2 months of visual deterioration, occasional headaches that are well managed with ibuprofen, and dizzy episodes several time each day.

He has no allergies and takes no other medications

His past medical history is significant for appendicitis and asthma.

- Examination reveals bilateral temporal visual field deficits and papilledema. Otherwise neurological exam is normal.

1. Describe the lesion(s) causing mass effect.
2. Which of the lesions is most urgent?
3. What is the likely time course of presentation for the:
a) Sellar mass b) trapped ventricle



Case 2

A 22 year-old male is found down after an apparent assault.

He is noted at the scene to have a Glasgow Coma Score of 12.

On arrival to the trauma bay his GCS is noted to be 5.

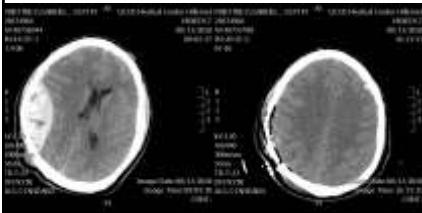
Examination

Right pupil 6 mm, no reaction

Left pupil 3 mm, reactive

Case 2

1. What is the level of urgency?
2. Go through the appropriate initial management steps for this patient's care.
3. A CT is obtained. Describe the findings.



Case 3

A 50 year-old man presents to his PCP. His wife expresses concern regarding frequent episodes of confusion and forgetfulness. He has a long history of migraines which seem to have worsened over the past one year. He had a fall down the stairs 4 weeks prior.

Exam

Alert, oriented, conversant, speech fluent, repeats answers

PERRL, CN II-XII intact

Motor strength 5/5

Right pronator drift present

Case 3

What is the differential diagnosis?

An MRI is obtained. What initial steps should be undertaken in his management?

What is the likely time course for this mass lesion?



Case 4

A 69 year-old female present with "dizzy spells", worsening balance, and multiple recent falls

PMH: DM I; HTN; breast cancer

Exam:

Alert, oriented, appropriate

PERRL, CN II-XII intact

Motor 5/5

LUE dysmetria on finger to nose testing

Gait is ataxic

1. Do her symptoms suggest a likely localization for a lesion?
2. An MRI is obtained. What are the likely distal and global effects progression of this mass could lead to?