Radiology in Neurosurgery

An Introduction

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Why know imaging?

• **Every** physician must be able to verbally communicate, in basic terms, what is on different radiographic studies.

• Radiology reports can take several hours to formally appear – critical patient decisions must be made **before** that time.
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Descriptions

- **Identify**
  - Patient name
  - Date of study
  - Specific type of study
  - Abnormal findings with location
  - Important normal findings with location
  - Differential diagnosis
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Imaging Studies: Types

- Plain X-Ray
- CT Scan
- Myelogram (Plain & CT)
- MRI
- Angiogram (X-ray & MRA)
- PET Scan
Plain X-Rays

- **Skull Films**
  - Normal: Observe shape, suture lines
  - Abnormal
    - Lytic Lesions -- Multiple myeloma, metastatic disease
    - Fractures - usually following trauma
Normal Skull Films

AP Skull X-ray  
Lateral Skull X-ray

** Skull X-rays are rarely used in neurosurgery, with advent of CT Scan
Multiple Myeloma
• Cervical Spine most difficult & important!
  • Ask: Is this an adequate film? (MUST see C7-T1 junction)
  • Ask: Are the three lines appropriate?
  • Ask: Is there soft tissue swelling (allowed 7 mm @ C3 & 21 mm at C7)
  • Ask: Any fractures otherwise?
  • Ask: Is the clival-C1 line smooth?

• Thoracic & Lumbar fractures
  • Transverse process and compression/burst fractures more often seen
  • Divide spine into 3 columns – 2 or more column injury generally suggests instability
Normal C-Spine Films

AP view

Facets
Spinous Process
Normal C-Spine Films (continued)

Lateral view
Open-Mouth Odontoid View:
To detect stability of C1 fractures & Dens
Flexion-Extension C-Spine X-rays: Is there Instability?
What is wrong with this x-ray?

Answer: Cannot visualize the C7-T1 junction
CT Scan

- Computed Axial Tomography – A collection of superimposed X-rays

- CALCIFIED STRUCTURES (e.g. bone, ACUTE calcium in BLOOD appear WHITE, or hyperdense)

- Ischemic Stroke does NOT show on CT until 12-24 hours after it has occurred – it appears DARK (or hypodense) then

- Slices are taken at plane parallel to anterior skull base floor

- A CT scan is the most frequently ordered study in Neurosurgery - #1 reason: To Rule Out BLEED
CT Scan

Bone Window  Soft Tissue Window
Intracranial Hemorrhage

- Intracranial hemorrhage can be classified according to the space occupied by the blood:
  - Epidural Hemorrhage
  - Subdural Hemorrhage
  - Subarachnoid Hemorrhage
  - Intraparenchymal Hemorrhage
  - Intraventricular Hemorrhage
Intracranial Hemorrhage: Types
Epidural Hemorrhage

- Between skull and dura, limited by periosteal layer so stops at sutures of skull and thus biconvex (lens) shaped

- Due to middle meningeal artery tear, often associated with skull fracture

- Patients can have concussion at injury, then a “lucid interval” when they’re awake from the concussion, and then suddenly worsen due to blood compressing brain

- Treatment is usually emergent surgery (unless extremely small)
Subdural Hemorrhage

- Occur in the 4 A’s: “Alcoholics, Anticoagulant-treated, Aged, and Abuse victims (shaken baby syndrome)”
- Between dura and arachnoid of brain, follows contour of brain so “crescent” shaped
- Due to cortical bridging vein tear - as hemoglobin broken down, blood changes color on CT scan, and can be easily missed (see subacute scan above)
- Usually patients with Subdural hematoma have WORSE brain injury than Epidural hematoma
- Small size bleeds can be spontaneously absorbed by the body, but if midline shift is present, need surgical evacuation
Subarachnoid Hemorrhage

- Subarachnoid hemorrhage is generally feathery in appearance on CT scan, as it’s mixed in with cerebrospinal fluid.
- The MOST COMMON cause of subarachnoid hemorrhage is TRAUMA; the 2nd and 3rd most common causes are aneurysms and arteriovenous malformations.
- No intervention is generally performed for subarachnoid hemorrhage alone.
- However, subarachnoid hemorrhage can cause hydrocephalus (due to obstruction of CSF flow) or vasospasm (due to blood products irritating a vessel) in a delayed fashion.
Intraparenchymal Hemorrhage

- Called “contusions” in trauma - bruising of the brain
- Coup (direct injury of brain from impact) or contre-coup (injury due to brain hitting skull on opposite side as skull decelerates but brain doesn’t) - usually temporal/frontal
- Can develop extreme amount of edema or blossom, so must follow closely with repeat CT scans
- Can be caused by hypertensive hemorrhage in characteristic locations (basal ganglia, thalamus, pons, cerebellum) or arteriovenous malformations
- In older patients (>60) can be caused by cerebral amyloid angiopathy, usually in a lobar location
- Surgical evacuation if excessive mass effect, avoidance of important brain structures to access surgically, and meaningful survival possible
Intraventricular Hemorrhage

- Usually due to extension of intraparenchymal bleed (most commonly from hypertension)

- Treatment depends on whether hydrocephalus develops - then patient may need ventriculostomy placement
Skull Fractures

• Associated with pneumocephaly (air in head) – rarely can develop tension pneumocephalus

• Only significant if open to air, cosmetically disfiguring (greater than full thickness displacement), or associated with air sinus (for risk of infection) or underlying bleed (epidural hematoma)

• Treatment ONLY for cosmesis or prevention of infection (if open to air or to an air sinus)
Hydrocephalus

- Normal CSF flow is from lateral ventricles to third v., via aqueduct to fourth v., then through foramina of Magendie and Luschka to subarachnoid space, then absorption via arachnoid granulations into the superior sagittal sinus.

- Any obstruction of this pathway can cause hydrocephalus.

- Treatment is temporarily by diverting spinal fluid via ventriculostomy catheter; permanently, a shunt (e.g. ventriculoperitoneal, or VP shunt).
Axial CT showing fracture of pedicle and lamina

Sagittal CT reconstructions showing significant body fracture and subluxation
MRI

- Gives BEST picture of brain, in greatest detail
- Only handicaps are that it takes longer to do than CT scan (30 min. for MRI vs. 5 min. for CT), and CANNOT visualize ACUTE blood as well as CT scan
- Good for studying brain tumors, multiple sclerosis, or other lesions in brain which are sometimes difficult to find with CT scan
• Basic images:

  - T1 Weighted Image
    • Better for looking at brain structure in detail
    • CSF is black
    • Can give CONTRAST injection to visualize blood vessels (and hence tumors which ENHANCE with contrast injection)

  - T2 Weighted image
    • Better for looking at fluid (CSF is WHITE) – because of this, edema (e.g. around a brain tumor or contusion) shows up well on T2

• A Bright lesion on MRI is called “hyperintense on MRI”; a Dark lesion is “hypo-intense” NOT hyperdense or hypodense as is described for CT
MRI Brain: The Basic Study Types

T1 w/o contrast  T1 w/ contrast  T2 (contrast never given)
MRI: Views in different planes

http://www.strokecenter.org/pat/diagnosis/mri.htm
Compare the detail:
CT (left) vs. MRI T1 (right)
Compare the detail:
CT (left) vs. MRI T2 (right)
Spine MRI: Sagittal - Herniated Disc with stenosis
Spine MRI: Axial - Hemiated Disc causing canal stenosis

T2 - Normal canal

T2 - Hemiated disc causing canal encroachment & nerve root impingement
Angiography

• Three Types:
  - Conventional X-ray Angiography – enter femoral artery at groin, advance catheter to internal carotid and vertebral arteries, and inject dye to visualize vessels using X-ray
  - MR Angiography – Does not require any injection of contrast, least invasive, can see all but the more detailed structures (>3mm resolution for aneurysms)
  - CT Angiography – Requires intravenous contrast dye injection, used to reconstruct and visualize the vasculature
Basic Study

- Must include all four vessels
  - 2 internal carotid arteries and 2 vertebral arteries

- Done in multiple views with different angles - AP/Lateral/Oblique views

- Options for treatment during angiography include:
  - Embolization (injecting glue into arteriovenous malformations)
  - Mechanically dislodging thrombus
  - Injecting TPA for stroke
  - Performing balloon angioplasty
  - Coiling of aneurysms
Conventional Angiography: Aneurysm

- An abnormal “ballooning” or expansion of the intima and adventitia of the vessel, which is missing the tunica media/smooth muscle layer.

- Aneurysms almost always occur at the bifurcation of vessels.
Conventional Angiography:
Arteriovenous Malformation (AVM)

- An abnormal tangle of vessels, with early filling of the venous circulation (at the time capillaries would normally fill) indicates shunting of the blood from the artery to the vein via the “nidus” or tangle of vessels.
Conventional Angiography: AV Fistula

- A direct shunting of blood from arteries to veins without an elaborate nidus as for an arteriovenous malformation – visualized by early filling of the venous system on dye injection.
PET Scan

• **Principle**
  - Tests metabolism by indicating uptake of radiolabeled glucose.
  - During specific actions, certain parts of the brain show increased activity on PET (see figure).

• **Utility of PET scans**
  - In differentiating radiation-related necrosis (which does not uptake glucose and so appears “cold”) vs. a metabolically active brain tumor (which uptakes high levels of glucose, so is “hot” or dark on PET scans).
Sample cases:

How would you manage...
What do you see & What would you do? – Case 1

- 20 YO WM in MVA
- Intubated and sedated
- GCS 3 in the field
- Head CT as here
What do you see & What would you do? - Case 2

- 56 YO AA M w h/o HTN
- Collapsed at home
- Found to have some confusion and L drift
- Lethargic in ER, then started to have a seizure and was intubated
- Just waking up from paralytic/sedation when you see patient
What do you see & What would you do? - Case 3
References

The End