Introduction to Neuroimaging

BRAIN

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Brain Imaging: “The Big 10”

- Infarction
- Hemorrhage
- Infection
- Tumor
- Trauma

- Dementia
- MS
- Epilepsy
- Cranial neuropathy
- Orbits / Ophtho dx
Acute Ischemic Stroke Imaging

- Confirm diagnosis
- Triage for therapy (risk / prognosis)
  - Rule out hemorrhage
  - Assess damage: location, pattern, extent
  - Is there salvageable brain ("penumbra")?
- Follow outcome
  - Vessel patency, ultimate infarct size, hemorrhagic transformation
CT Signs in Early MCA Ischemia

- Hyperdense MCA
- Insular Ribbon
- Lentiform Nucleus
Pathophysiology of Ischemic Injury: Duration and Degree of ↓ CBF

- Normal neuronal function
- Reversible injury (penumbra)
- Infarction

CBF (ml / 100g / min)

Time (hrs)
MRI in Stroke Intervention

“The 4 P’s”

MRA
Perfusion MR
Diffusion MR

Pipes → Perfusion → Parenchyma

“Penumbra”

Rowley AJNR 22(4); 599-601, 2001
PCA Infarct
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Cerebral Hemorrhage

- Trauma
- Ruptured aneurysm
- Hypertensive
- Hemorrhagic transformation of ischemic infarction (esp. venous)
- Venous infarction
- Tumor
- Vascular malformations
- Angioinvasive infection
- Amyloid angiopathy
Cerebral Hemorrhage

Acute intraparenchymal hematoma
Cerebral Hemorrhage

Hemorrhagic melanoma metastases
Cerebral Hemorrhage

Acute subarachnoid hemorrhage
(and intraventricular)
Subdural vs. Epidural Hematoma
Cerebral Hemorrhage

Acute subdural hematoma
Cerebral Hemorrhage

Acute epidural hematoma
**Subdural:**

- Follows inner layer of dura
- "Rounds the bend" to follow falx or tentorium
- Not affected by sutures of skull
- Tendency for crescentic shapes
- More mass effect than expected for their size
- Typical source of SDH: cortical vein

**Epidural:**

- Follows outer layer of dura (periosteum)
- Crosses falx or tentorium
- Limited by sutures of skull (typically)
- Tendency for lentiform shapes
- Typical source of EDH:
  - skull fracture with arterial or sinus laceration

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Cerebral Hemorrhage

Mixed acute/chronic subdural hematoma
Cerebral Hemorrhage

Hematocrit level!
MRI of Hemorrhage

MR appearance of hematomas depends on image type.

Magnetic properties change over time (Hgb breakdown products), allowing approximate dating.
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Infection

- Meningitis
- Encephalitis
- Cerebritis and parenchymal abscess
- Empyema (subdural/epidural)
Meningitis

**Leptomeningitis:** pia-arachnoid

**Pachymeningitis:** dura

Most common imaging findings in meningitis: **NONE** !!
Herpes Encephalitis
Cerebritis w/ Bacterial Abscess

T1 + Gd

T2

Diffusion
Cerebritis w/ Subdural Empyema

- T1 + Gd
- T2 FLAIR
- Diffusion
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Brain Tumor Imaging

**Diagnosis**
- Location: Intra- / Extra-axial, Supra- / Infra-tentorial, Grey / white matter, etc.
- Single or multiple?
- Tumor or tumor-like alternatives?
- Histology: Type and grade?

**Treatment Planning**
- Surgery, radiation, chemo tx
- Functional MRI for eloquent brain mapping
- 3D scans to guide surgery, radiation

**Follow-up**
- Stable vs. recurrence / progression
- Complications
Intra- or Extra-axial?
Intra- or Extra-axial?
Tumor vs. Other Masses

GBM

Arachnoid Cyst

Abscess

Hematoma

“Tumefactive” MS
Tumor vs. Stroke

Cytotoxic Edema

- Cellular swelling
- Gray-white margin lost

Vasogenic Edema

- Leaky capillaries
- Gray matter is spared
Tumor?
Stroke?
Encephalitis?
3D Imaging for XRT or Surgical Guidance
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Fractures: CT not MRI!
Traumatic Brain Swelling

Know your basal cisterns!

Cerebellomedullary (Cisterna Magna)
Pontine
Cerebellopontine angle
Traumatic Brain Swelling

Know your basal cisterns!

- Suprasellar
- Interpeduncular
- Ambient
- Quadrigeminal
Traumatic Brain Swelling

Effacement of basal cisterns

Traumatic brain swelling with downward herniation
Traumatic brain swelling
Extra-axial Hemorrhage

Subdural

Epidural

Subarachnoid
Intra-axial Hemorrhage

Hemorrhagic contusions
Intra-axial Hemorrhage

Hemorrhagic contusions

Mechanism
- Direct contact with skull
- Shear-strain deformation

Lesion locations
- Commonly located along inferior, lateral, and anterior frontal and temporal lobes
- Often above bony prominences (petrous pyramid, sphenoid wing, orbital roof)

Appearance of cortical contusions
- Overlying cortex, by definition, always involved (vs. DAI)
- “Salt and pepper” appearance due to intermixed hemorrhage and edema
- Non-hemorrhagic contusions often not initially seen on CT scans
- Lesions often more visible days after injury as edema and hemorrhage increase
- Acute lesions much more conspicuous on T2 or T2-FLAIR MRI
Intra-axial Hemorrhage

Diffuse Axonal (Shear) Injury (DAI)
Diffuse Axonal (Shear) Injury (DAI)

T2: Reveals non-hemorrhagic lesions occult on CT
Diffuse Axonal (Shear) Injury (DAI)

T2*: Increased sensitivity to hemorrhage
**Diffuse Axonal (Shear) Injury (DAI)**

- Tissues with differing elastic properties **shear** against each other, **tearing** axons.
- Caused by rapid deceleration/rotation of head.
- **Locations:**
  - Cerebral hemispheres near gray-white junction
  - Basal ganglia
  - Corpus callosum, especially splenium
  - Dorsal brainstem
- High morbidity & mortality – common cause of post-traumatic vegetative state
- Initial CT often normal despite poor GCS
  - Lesions often non-hemorrhagic and seen only on MRI
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Dementia

• Primary role of imaging is to exclude treatable causes, e.g.:
  ▪ Hydrocephalus
  ▪ Subdural hematoma
  ▪ Neoplasm
Dementia

Irreversible dementias (imaging non-specific):

- Alzheimer’s disease
- Multi-infarct dementia
- Dementias associated with Parkinson’s disease and similar disorders
- AIDS dementia complex
Alzheimer’s: Temporal-Parietal Lobe Atrophy (Late)
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Multiple Sclerosis (MS) Imaging

- MRI is the imaging study of choice
- Help establish “dissemination of lesions in time and space”
- Estimate disease burden
- Identify acute (inflammatory) vs. chronic lesions (enhancement = active inflammation)
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Seizure Imaging

• MRI is the imaging study of choice
• Identify and localize offending lesion
  • New onset vs. chronic epilepsy
  • Younger vs. older patients
  • Search may be guided by EEG / clinical sx
• Preoperative planning
  e.g. language lateralization before temporal lobectomy
Congenital anomalies: Polymicrogyria
Congenital anomalies: Schizencephaly
Mesial Temporal Sclerosis

Most common pathology found in medically refractory epilepsy patients

Rare under age 10 or with new seizures

Pathogenesis unknown
- Post ictal / kindling?

Pathology:
Hippocampal atrophy / gliosis
Mesial Temporal Sclerosis

- Atrophy
- Loss gray-white
- $\uparrow T2$ / FLAIR
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Cranial Nerve Imaging

FIESTA

CN-7

CN-8

CN-5
Vestibular Schwannoma
Intracochlear Schwannoma
30 y/o F with 6wk h/o blurred vision

Craniopharyngioma
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