Neuro-diagnostics

Neurology Lecture Series

Objectives

- Discuss the most common neurodiagnostic tools used by neurologists: CT, MR, ultrasound, EMG, EEG, genetics.
- Discuss some of the main differences and advantages of each imaging/diagnostic modality, as well as particular uses and indications in acute, subacute and chronic neurological disorders.
- Provide an neuroimaging anatomical review of the brain.
- Provide a pictorial overview of the most common lesions identified on CT, MR and ultrasound.
- Discuss how neurologists can be certified in neurosonology and CT/MR by the American Society of Neuroimaging.

CT

- Uses x-rays to assess the density of the tissues (hence, do not talk about “intensity”).
- Can be done quickly (<60 seconds)
- Used commonly in emergencies
- Good for acute head trauma, identify hemorrhage, identify edema, assess bony structures
- No so good for posterior fossa or spinal cord
What is white on the CT scan?

Mostly:
- Bone (and calcified stuff)
- Bullets (and metal objects)
- Blood (acute clot)
- Contrast (x-ray)

So, what is dark on CT?
- Water (CSF, edema)
- Fat
- Air

MRI
- Uses a magnetic field to align protons, then emits a radiofrequency (RF) pulse to de-align the protons, which in turn release RF back upon re-alignment with the magnetic axis.
- This returned RF is reconstructed to create a "topography map" of protons (water) in tissue.
- So, talk about "intensity" (not density)
- Two basic sequences: T1 and T2
- Good for acute and old stroke, brain tumors, infections, dementia, multiple sclerosis, spinal cord

T1? T2? U2? Me2?
- **T1**
  - Bright: fat, methemoglobin, gadolinium contrast
  - Dark: bone, CSF, edema, air
- **T2**
  - Bright: CSF, edema, methemoglobin (EC)
  - Dark: bone, air, fat, hemosiderin, methemoglobin

Other Common MRI Sequences
- FLAIR: fluid attenuated inverse recovery; it is T2 minus the CSF, makes it easier to appreciate the parenchymal T2 signals
- DWI: diffusion weighted imaging; looks at the diffusion pattern of water, which is restricted when the cells are dead; bright means dead tissue
- ADC: apparent diffusion coefficient; to rule out "T2-shine through" – or artifacts on DWI; dead tissue is dark
- GRE: gradient recovery echo; used to image blood products - blood is black

What are the advantages of CT and MR?
CT versus MR

• CT:
  – Is faster, less claustrophobia, better for acute blood, detect metallic foreign objects, images “hard” tissue better

• MR:
  – Better soft tissue imaging details, detects smaller lesions, non-ionizing technique, images the spinal cord better

How to tell CT from MR?

CT

MR T2

- Look at the bony structures
- Look at the CSF
- Look at the structures details
- Look at the vascular flow voids

Non-contrasted head CT scan (showing right basal ganglia acute hemorrhage)

Identify:
- Lateral ventricles
- Head of caudate
- Septum pellucidum
- Thalamus
- Third ventricle
- Corpus callosum
- Pineal and choroid calcifications
- Insula

Non-contrasted head MR scan T1

Identify:
- Frontal and occipital lobes
- Corpus callosum
- Cingulate
- Third and 4th ventricles
- Mamillary body
- Pituitary gland and stalk
- Pineal
- Aqueduct
- Straight sinus (flow void)
- Cerebellum, and tonsils
- Foramen of Magendie
- Medulla
- Skin and subcutaneous fat
- Bone, bone marrow

Head MR scan T2

Identify:
- Frontal and occipital lobes
- Cingulate
- Corpus callosum
- Lateral and third ventricles
- Head of caudate
- Thalami
- Internal capsule
- Basal ganglia
- Insula
- Septum pellucidum
- Gray and white matter

Head MR scan T2

Identify:
- Extraocular muscles
- Temporal lobes
- Carotid and basilar arteries flow voids
- Pons
- Fourth ventricle
- Cerebellum and vermis
- 8th cranial nerve
- Semicircular canals
- Petrous bones
- Gray and white matter
- Bone
- Skin and subcutaneous fat
Multiple acute ischemic strokes

**DWI**

**ADC**

Hyppocampal Sclerosis

Ultrasound

- Uses sound waves to image tissues (echoranging)
- Typical frequencies are between 2-14 MHz
  - For TCD: 2 MHz
  - For carotids: 5-7 MHz
- TCD is used for intracranial arterial stenosis (as good as MRA), emboli detection, right-to-left shunts, (for therapy: sonothrombolysis)
- CUS: uses triplex to determine the structure of the carotid arteries (plaques?), and measures the blood flow velocities (stenosis?)
- Can be done at bedside, no side effects, affordable
- Requires training and expertise

LCCA normal

RICA >70% stenosis

Noticed the increased systolic velocities (cm/s), right vertical axis

American Society of Neuroimaging (ASN) - asnweb.org

The American Society of Neuroimaging (ASN)

Applications and Eligibility

- Annual Meeting
  - Board of Directors
  - Faculty, Staff
- Education
- Information
- Publications
- Resources
- Contact

Vanderbilt University Medical Center
Department of Neurology
LP
• Done between L3-4 or L4-5
• Spinal needle with stylet, angled up, bevel vertical (not horizontal)
• Normal ICP, lateral decubitus is <18 mmH2O
• Total amount of CSF is 150 cc, cycled 3 times a day
• Uses: neuroinfections, MS, SAH, cancers, medications injections
• Contraindications: intracranial mass-effect, increased ICP, bleeding tendency
• Spinal headache improves in the supine position, and is aggravated by sitting/standing (gravitational pull)

Send CSF for...
• Glucose, total proteins, cell count and differential
• Consider: cytology, VDRL, oligoclonal bands, xanthochromia, microbiological stains and cultures, TB PCR, HSV PCR, CMV
• Many other possibilities

CSF Interpretation
• Hypoglucorrhachia
  – CNS infections, SAH, meningeal carcinomatosis, post-neurosurgery
• Hyperproteinorrachia:
  – CNS infections, SAH, post-neurosurgery, GBS, Behcet’s, sarcoid
• Increased cells
  – CNS infections, meningeal carcinomatosis, SAH, post-neurosurgery, Behcet’s, sarcoid

EEG
• Reads the electrical signal originating in the brain
• There are sets of electrode montages
• Subject to artifacts
• Mature, reliable technique
• Waves (DTAB):
  – Delta: 0-3 Hz
  – Theta: 4-7
  – Alpha: 8-12 Hz
  – Beta: >12 Hz
• Useful in: seizures, seizure foci, sleep studies, unexplained altered consciousness

Normal EEG
Myoclonic-Atonic Seizure
**EMG**
- Evaluates the electrical function of muscles, at rest and during contraction
- Uses needle electrodes
- Assesses motor units, and muscles cells
- Useful in: myopathies, neuropathies (denervation and re-innervation)

**What are fibrillations?**
- Spontaneous action potentials of a single muscle fiber; it is not visible in the physical exam; seen in denervated muscle fibers

**Nerve Conduction Studies**
- Used to evaluate the function of nerves (sensory and motor) and the autonomic system
- Generally, electrical stimulations are provided to the nerve, and the speed and amplitude of the conducted nerve impulse is assessed
- Repetitive nerve stimulation is used in neuromuscular junction disorders
- Used in neuropathies, neuronopathies, myasthenia gravis

**Evoked Responses (ER)**
- Asses the electrophysiological response of the nervous tissues to a variety of stimuli
  - Visual ER: for pre-chiasmaic lesions: optic neuritis
  - Brainstem auditory ER: can help assess hearing loss, used for prognostication in coma
  - Sensory ER: determine CNS conduction abnormalities, intra-op monitoring,
  - Motor ER: intra-op monitoring

**Genetic Testing**
- Available now for many diseases
- There are a series of ethical, medical and financial limitations to their use
- Some diseases or conditions amenable to genetic testing include: Friedreich ataxia, SCA, MELAS, MERRF, Duchene muscular dystrophy, myotonic dystrophy, Wilson’s disease, NF 1 and 2, Fabry disease, metachromatic leukodystrophy, Refsum disease, Charcot-Marie-Tooth neuropathy, Fragile X, CADASIL, Lesch-Nyhan, and many more

**Name 3 neurological diseases or conditions that are amenable to genetic testing?**
Some Others Diagnostic Tests

- Biopsy (i.e. muscle, nerve, brain, meninges)
- Neuropsychological testing
- Autonomic testing, tilt table
- PET
- SPECT
- Polysomnography