Metabolic Neuroimaging

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PET, SPECT - image *function* predominantly (*anatomy* to lesser degree) - most useful in:

a) disease without easily identifiable anatomic correlates (e.g. Parkinson's disease).
b) diffuse brain disease (e.g. degenerative dementias - Alzheimer's disease, Pick disease).
c) defining epileptic focus noninvasively.
d) differentiation recurrent tumor from radiation necrosis.

Earliest possible diagnosis (altered metabolic activity precedes neuronal loss and even electrical cortical changes)

N.B. in these disorders CT / MRI are often normal, even with advanced cases! (or only nonspecific atrophy)

Positron Emission Tomography (PET)

- tomographic imaging of **injected radioisotopes** (that cross BBB).

- physical-mathematical principles similar to CT, but source of radiation is internal to imaged organ.
- isotopes emit ***positrons**** (vs. SPECT – photons) → PET scanner identifies gamma-rays → CT-like image is developed.

  *when isotope decays, positron is emitted, which combines with electron, both particles then being annihilated to release two gamma-rays that radiate in 180° opposite directions.
- isotopes are short-lived - require production in adjacent cyclotron - *expense and technical complexity*!

  Less favorable cost/benefit ratio than SPECT!
- images can be displayed in axial, coronal, or sagittal projections.
- spatial resolution is inferior to CT and MRI.

PET is superior to any other technique in ability to image *specific receptors*, as well as *related functions*:

a) GLYCOLYSIS evaluation: 2-[^{18}F]-fluoro-2-deoxy-D glucose (FDG) - glucose analog that only enters living cells → once phosphorylated to FDG-6-phosphate, cannot proceed further in glycolytic pathway, and remains metabolically trapped intracellularly.
   – *gray matter* accumulates more FDG than does *white matter*.
   – motor, language, visual, or other sensory task → ↑glucose metabolism in involved cortical region.
   – decreased glucose metabolism in PET correlates with decreased rCBF in SPECT!
b) PROTEIN SYNTHESIS evaluation: ^{11}C-methionine.
c) DNA SYNTHESIS evaluation: ^{11}C-thymidine.
d) RECEPTORS (e.g. on tumors): radiolabeled chemotherapeutic drugs, monoclonal antibodies, and receptor ligands.

– fluorodopa – activity of nigrostriatal dopaminergic system in clinically unclear Parkinson's disease cases (correlation between fluorodopa uptake and striatal dopamine content).

Biochemical flexibility and sensitivity of PET are unparalleled!
- *TRULY METABOLIC IMAGES OF BRAIN*

States with hypometabolism: anoxia, degenerative disease, trauma, aging.
States with hypermetabolism: tumor, infection, seizure foci.

Magnetic Resonance Spectroscopy (MRS)

- noninvasive in vivo method of analyzing detailed chemical spectrograms.

- ***protons*** are currently being imaged clinically.
- proton MRI spectrum is characterized by at least three PEAKS* representing:
  1) creatine (CR) - cellular energy metabolism; present in much higher concentrations in glia than in neurons.
  2) choline (CHO) - cell membranes; present in much higher concentrations in glia than in neurons.
     CHO↑ - abnormal membrane metabolism: myelin breakdown, inflammation, neoplasia.
  3) *N*-acetyl aspartate (NAA) is neuronal marker - found primarily within neurons and precursor cells; NAA is marker of neuronal integrity.
     NAA↓ - neuron loss.

*height of peak reflects concentration of metabolite

- additional peaks (not detectable in MRS of normal brain):
  4) lactate – products of anaerobic glycolysis: inflammation, infarction.
  5) lipids – products of brain destruction
  6) inositol
  7) GABA, glutamate, glutamine.

MRS indications:
1) localization of seizure focus.
2) diagnose and classify dementias (such as Alzheimer's disease).
3) differentiating tumor recurrence from radiation necrosis. see p. Onc1 >>

BIBLIOGRAPHY for ch. "Diagnostics" → follow this LINK >>