Functional Brain Imaging with Single Photon Emission Computed Tomography (SPECT)

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Structure of Presentation

I. Overview of brain mapping modalities

II. Description of SPECT

III. Patient presentation
What is functional brain imaging?

• Techniques used to derive images reflecting biochemical, physiologic, or electrical properties of the CNS.

• Main principle: Increased brain activity results in increased blood flow to the active site, or regional cerebral blood flow (Ingvar and Lassen, 1961).
What are the uses of functional imaging?

• *Investigative tool* for understanding neurological processes in normal and abnormal states.

• *Clinical uses* for assisting in diagnosis and prognosis.

• Assist in psychiatric *drug development* and management.
## Modalities Compared

<table>
<thead>
<tr>
<th>Technique</th>
<th>Res.</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECT</td>
<td>7-10 mm</td>
<td>- Low cost</td>
<td>- Radioactivity</td>
</tr>
<tr>
<td>(1976)</td>
<td></td>
<td>- Availability</td>
<td>- Limited resolution</td>
</tr>
<tr>
<td>PET</td>
<td>5 mm</td>
<td>- Good resolution</td>
<td>- Radioactivity</td>
</tr>
<tr>
<td>(1984)</td>
<td></td>
<td>- Metabolic studies (uses $^{15}$O, $^{18}$F, $^{11}$C)</td>
<td>- Expensive</td>
</tr>
<tr>
<td>fMRI</td>
<td>3 mm</td>
<td>- Good resolution</td>
<td>- Expensive</td>
</tr>
<tr>
<td>(1991)</td>
<td></td>
<td>- non-invasive</td>
<td>- Limited to activation studies</td>
</tr>
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SPECT: The basic tools (I)

1) **IV bolus of radio-labeled tracer**

**Perfusion studies:**
- $^{99m}\text{Tc}$ hexamethylpropyleneamine oxime (HMPAO)
- $^{99m}\text{Tc}$ ethylene cysteinate dimer (ECD)

$^{99m}\text{Tc}$ (meta state) → $^{99}\text{Tc} +$ gamma
Radiopharmaceutical (I)

• HMPAO and ECD are *lipophilic*:
  - cross blood-brain barrier
    (within 1-2 minutes)
  - trapped intracellular
    (diffusion rate = 6%/hr)

Radiopharmaceutical (II)

- **Significance for imaging:**
  - Rapid uptake: “Scintigraphic snapshot” of regional perfusion at moment of IV bolus injection.
  - Long half life (6 hr) and slow diffusion rate: “Stable map”, image can be taken several hours after injection.
2) **Gamma camera:**
- Rotates 360° around patient’s head, as close as possible.
- Consists of a collimator, NaI crystals, and photomultiplier tubes.

Adapted from Clare, S. *Functional MRI: Methods and Applications* (1997).
Baseline scan protocol

Place IV  Give bolus  Begin scan  Finish

- 30 min
- 30-40 min
- 20-40 min

Pt at rest

Regional cerebral absorption
Patient Presentation

• Patient is a 63 y.o. male with two years of behavioral and cognitive changes, including decreased activity, loss of interest, and flat emotional state.

• No family hx of AD or dementia.

• Patient has undergone 1.5 yrs of unsuccessful diagnosis/treatment.
## History of Present Illness

<table>
<thead>
<tr>
<th>Date</th>
<th>Physician</th>
<th>Tests</th>
<th>Dx</th>
<th>Rx</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/03</td>
<td>PCP</td>
<td>CT - normal r/o tumor, hematoma</td>
<td>Possible Depression</td>
<td>None</td>
</tr>
<tr>
<td>12/03</td>
<td>Psychiatrist</td>
<td>Depression r/o pseudo-dementia</td>
<td></td>
<td>Zoloft – No improvement</td>
</tr>
<tr>
<td>3/04</td>
<td>Neuropsychologist</td>
<td>IQ, memory tests are low</td>
<td>Possible Alzheimer’s</td>
<td>Aricept – No improvement</td>
</tr>
<tr>
<td>8/04</td>
<td>Neurologist</td>
<td>MRI - normal</td>
<td></td>
<td>Ordered a SPECT scan</td>
</tr>
</tbody>
</table>
SPECT: Cinematic display from sagittal and coronal cx. sections

Beth Israel Deaconess

99mTc - ECD
Cinematic Display of axial cx. section

99mTc - ECD

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Normal SPECT

www.b Brigham.rad.harvard.edu
Axial Cross Sections

Decreased perfusion in frontal lobes

Normal perfusion in temporal-parietal lobes
Characteristic AD SPECT

Decreased perfusion in temporal-parietal lobe

www.brighamrad.harvard.edu
SPECT and Dementia

- SPECT: useful in differentiating types of dementia, though literature is controversial.

- Our patient’s perfusion studies:
  - Significant decrease in frontal lobe
  - Normal temporal-parietal lobe: r/o Alzheimer’s

- Dx: frontal lobe dementia or Pick’s disease.

- Benefits: psychological and more effective Rx.
References


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