13 - Single Photon Emission Computed Tomography SP

Single Photon Emission Computed Tomography - SPECT

 This is called Blood Oxygen Level Dependent (BOLD) technique. This process is the basis for functional MRI. fMRI is a proxy measure of tissue activity that depends on relative changes in perfusion; it does not measure the actual neuronal metabolism. No radioactive isotopes are administered in fMRI; this is a significant advantage over PET and SPECT. A subject can perform a variety of tasks, both experimental and control, in the same imaging session. In resting fMRI, the brain regions that have high levels of activity during rest are studied. These regions include the precuneus, lateral parietal regions and medial prefrontal cortex. A network of these regions showing higher baseline activity at rest is called default mode network or DMN. Single Photon Emission Computed Tomography - SPECT SPECT uses radioactive compounds to study regional differences in cerebral blood flow within the brain. This records the pattern of photon emission from the bloodstream which varies according to the level of perfusion in different regions of the brain. Similar to fMRI it does not measure neuronal metabolism directly. SPECT uses compounds labeled with single photon-emitting isotopes: iodine-123, technetium-99m, and xenon-133. Xenon-133 quickly enters the blood and is distributed to areas of the brain as a function of regional blood flow. Xenon-SPECT is thus referred to as the regional cerebral blood flow (rCBF) technique. Xenon-SPECT can measure blood flow only on the surface of the brain, which is an important limitation. Assessment of blood flow to the whole brain with SPECT requires the injectable tracers such as technetium-99m-d,l-hexamethyl propylene amine oxime (HMPAO). This is attached to highly lipophilic molecules that rapidly cross the blood-brain barrier to enter brain cells. Once inside the cell, the ligands are enzymatically converted to charged ions, which remain trapped in the cell. Thus, over time, the tracers are concentrated in areas of relatively higher blood flow. This is the ligand most commonly used in detecting perfusion changes in dementia. In addition to studying perfusion, Iodine-123 (123I)-labeled ligands for the muscarinic, dopaminergic, and serotonergic receptors can be used to study the occupancy and distribution of

these receptors. Iodobenzamide is used for D1/D2 receptors; iomazenil is used for GABA-A receptors; nor-β- CIT for dopamine and serotonin transporters; epidepride for D2/D3 receptors.

© SPMM Course Positron Emission Tomography – PET PET can be used to study blood flow, receptor distribution and metabolic activity of brain tissue. A key difference between SPECT and PET is that in SPECT a single particle is emitted, whereas in PET two particles are emitted; the latter reaction gives a more precise location for the event and better resolution of the image. The isotopes used in PET decay by emitting positrons, with the resolution closer to its theoretical minimum of 3 mm. Relatively few PET scanners are available because they require an on-site cyclotron to make the isotopes. The most commonly used isotopes in PET are fluorine-18, nitrogen-13, and oxygen-15. These isotopes are usually linked to another molecule, except in the case of oxygen-15 (15O). The most commonly employed ligand is [18F]fluorodeoxyglucose (FDG). FDG gives direct information about neuronal metabolism. Other molecules are listed in the table below. Diffusion tensor imaging – DTI DTI combines the principles of nuclear magnetic resonance and molecular diffusion. Diffusion refers to the random translational motion of molecules, also called Brownian motion, that result from the energy carried by these molecules. During their random, diffusion-driven displacements, molecules probe tissue structure at a microscopic scale well beyond the usual image resolution: the predominant direction of the molecular movement can help determine the integrity and trace white matter tracts. In traditional diffusion weighted images only 3 gradient directions are applied; DTI – diffusion tensor allows multiple (e.g. 16) gradients . From DTI, mathematical measures such as the Fractional Anisotropy (FA) can be calculated. This is an index of the integrity of white matter. The principal direction of the diffusion tensor can be used in tractography to infer the whitematter connectivity of the brain.

Purpose PET ligand Blood flow C15/H215O Glucose metabolism F18 deoxyglucose Dopamine D2 receptors 11C raclopride Dopamine neuron density 18F dopa; 18F metatyrosine GABA-A receptors 11C flumazenil 5HT2 receptors 18F altanserin; setoperone Striatal D2, cortical 5HT2 11C methylspiperone Serotonin synthesis rate 11C methyltryptophan Muscarinic receptors 11C scopolamine

© SPMM Course Neuroimaging findings in psychiatry: Neuroimaging findings in depression Periventricular and deep WM hyperintensities Subcortical – thalamic and striatal hyperintensities Decreased frontal and basal ganglia volumes Decreased metabolism in prefrontal cortex, Anterior cingulate & amygdale Higher prefrontal metabolism (esp. anterior cingulate) predict better treatment response Higher 5HT2A receptor density – higher dysfunctional negative thoughts Increased MAO-A activity (especially women) Elevated D2 binding in untreated depression – psychomotor retardation Therapeutic dose of SSRIs- 80% 5HT transporters occupied Neuroimaging findings in schizophrenia Ventricular enlargement Loss of grey matter – especially insular cortex, anterior cingulate (medial prefrontal cortex) and medial temporal lobe Progressive loss of brain volume in first few years of diagnosis fMRI reveals poor DLPFC activation in executive tasks Decreased NAA (N-Acetyl aspartate) in PFC (neuronal loss) in MRS Widespread reduction in DTI (diffusion tensor) – fractional anisotropy: frontal and corpus callosum – more in chronic treated patients Neuroimaging findings in Alzheimer’s

Ventricular enlargement Loss of temporal lobe volume – especially hippocampus Decreased parieto-temporal fMRI activation and SPECT blood flow Neuroimaging findings in OCD

Both reduced and increased volumes of caudate nuclei reported. Higher caudate blood flow due to increased metabolism. This reduces after effective treatment of the OCD. (Adapted from Murray, R, et al. (ed) Essential Psychiatry, Cambridge Press) Neuroimaging findings in Childhood-Onset Schizophrenia: Summary of key grey matter structural changes reported from Childhood-Onset Schizophrenia samples (Rapoport & Gogtay, 2011). In addition to what is shown, a ventricular enlargement at baseline and slower growth rates of (especially right hemispheric) white matter are also noted. From Hollis & Palaniyappan, Rutter's Child and Adolescent Psychiatry, Ed: Thapar et al...6e. Wiley & Sons.

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