PET Imaging Provides Insight into the Behavior of Alzheimer’s Disease

Alzheimer’s disease (AD) is the most common form of dementia, a group of disorders that impair mental functioning. At the moment, AD is progressive and irreversible. Abnormal changes in the brain worsen over time, eventually interfering with many aspects of brain function. Memory loss is one of the earliest symptoms, gradually progressing to a decline in other intellectual abilities and changes in personality and behavior.

Alzheimer’s disease leads to nerve cell death and tissue loss in the brain. As AD progresses, the brain shrinks dramatically, affecting nearly all its functions. Along with cell atrophy, other brain changes associated with AD are the appearance of the characteristic plaques and tangles around and inside nerve cells.

Brain Anatomy and Behavior

The cerebral cortex accounts for about two-thirds of the brain mass and lies over and around most of the remaining structures of the brain. It is the most highly developed part of the human brain and is responsible for thinking, perceiving, and producing and understanding language. The cerebral cortex can be divided into four lobes, each having a specific function. Abnormalities caused by AD to any of the brain regions results in problems with the associated mental functions.

PET's ability to measure metabolism has important implications in diagnosing AD, because it can illustrate where brain activity differs from the norm. PET also is useful in differentiating Alzheimer’s disease from other forms of dementia disorders, such as frontotemporal dementia or FTD, vascular dementia, Parkinson’s disease, Huntington’s disease, etc.

When comparing a normal brain versus an AD-affected brain on a PET scan, a distinctive pattern of affected areas appear. These are regions of the brain where cell atrophy has begun and metabolic activity has decreased. In fact, the pattern often can be recognized several years before a physician is able to confirm the diagnosis and is also used to differentiate Alzheimer’s from other types of dementia or depression.

Cracking the PET Color Code

PET scans provide three-dimensional information of the brain’s metabolic function. Each dot represents the intensity of the glucose metabolism activity. At CACIR, we analyze the images by color coding the metabolic activity recorded by the PET scanner and projecting the brain activity onto two-dimensional perspectives of the brain. The analysis and projections are produced using the 3D stereotactic surface projection.

Two types of images are produced by the SSP program: the glucose metabolic activity image or map is color coded so that the most active regions show up as red or white, and the least metabolically active regions are designated by the dark colors violet and blue. These images are used for identifying the regions of activity or atrophy caused by AD in the brain.

In order to visualize the changes from the normal, healthy population, the Z-score image is used. This is a statistical map of an individual’s brain activity compared to the averaged normal elderly population. It shows explicitly the reduction of glucose activity or degeneration caused by AD in the individual brain.

SSP Maps of the Brain

The results of SSP processing of PET images are displayed from 6 different perspectives:
- right and left lateral, right and left medial, superior and inferior.
- The cortical lobes are delineated in color on the surface SSP maps for reference.

Normal Elderly Population

In the early stages of the disease, limited areas of the brain are dysfunctional. Decreased activity usually begins in the posterior cingulate gyrus and also affects the parietal and temporal association cortex.

Mild AD

As the disease progresses, more brain cells atrophy, and involvement of the parietal and temporal cortical areas increase. PET scans show decreased activity of the brain in those regions.

Moderate AD

In the late stages of AD, the affected areas are more pervasive. Metabolic declines in the parietal and temporal lobes increase, and the frontal cortex becomes progressively more affected. The structures that are spared and remain functioning (dark blue regions) are the portions of the cortex that control the motor systems such as the legs, arms and hands, the internal structures (center structures that are dark blue) and the visual cortex in the occipital lobe.

Severe AD

In the advanced stages of AD, the remaining unaltered areas (red region) are limited to the leg and arm motor cortex and the visual cortex.