Molecular Imaging and Parkinson's Disease

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Parkinson's disease (PD) is a brain disorder that leads to motor symptoms, such as shaking (tremors) and difficulty with walking, movement, and coordination. Patients with PD may also experience non-motor symptoms, such as changes in mood or cognition. PD is a progressive neurodegenerative disorder.

Approximately 60,000 Americans are diagnosed with Parkinson's disease each year, and more than one million people suffer from the disease in the United States. PD is the second most common neurodegenerative disorder after Alzheimer's disease.

A major finding in individuals with PD is the loss of dopamine-producing neurons that normally send signals that coordinate muscle movement, balance, and gait. As a result, the common motor symptoms of the disorder are tremor, or trembling in hands, arms, legs, or chin; rigidity, or stiffness; slowness of movement and impaired balance and coordination. The disease most often develops after age 50 and symptoms vary from patient to patient. The clinical diagnosis of PD sometimes can be difficult. Molecular imaging can aid in distinguishing PD from other types of neurodegenerative disease, side-effects of drugs, toxins, or strokes. In turn, this can improve how physicians treat patients. For example, PD can sometimes cause psychotic symptoms and correct diagnostic imaging can curtail the use of antipsychotics which can be harmful to those with PD.

PD is the most common among a group of movement disorders called Parkinsonian syndromes, all of which result from loss of dopamine-producing neurons. Studies of brain tissues of persons with PD have shown typical microscopic findings of so-called Lewy bodies. This is called typical or idiopathic PD.

With no known cure for the disease, the goal of treatment through medication is to control symptoms. Patients may be prescribed L-DOPA, a drug that can be converted in the brain to dopamine. In some cases, surgery may be appropriate for patients whose disease no longer responds well to drugs. A therapy called deep brain stimulation (DBS) has now been approved by the U.S. Food and Drug Administration. In DBS, electrodes are implanted in the brain and connected to a small electrical device.

What is molecular imaging?

Molecular imaging is a type of medical imaging that provides unique, detailed pictures of what is happening inside the brain at the molecular and cellular level. Other diagnostic imaging procedures—such as x-rays, computed tomography (CT) and ultrasound—primarily offer anatomical pictures.

Molecular imaging offers insights into brain function that are unattainable with other imaging technologies or that would require more invasive procedures, such as biopsy or surgery. Molecular imaging is able to:

- identify disease in its earliest stages or determine the exact location of a tumor, often before symptoms occur or abnormalities can be detected with other diagnostic tests

As a tool for evaluating and managing the care of patients, molecular imaging studies help physicians:

- assess whether the function of brain tissue that uses dopamine have become abnormal in PD, brain injury, other neurological and/or psychiatric disorders

- determine the extent or severity of the disease

- select the most effective therapy based on the unique biologic characteristics of the patient and the molecular properties of a tumor or other disease

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- identify which drugs might be most helpful and which should be avoided
- accurately assess the effectiveness of a treatment regimen
- adapt treatment plans quickly in response to changes in cellular activity
- assess disease progression

Molecular imaging procedures are ***noninvasive, safe and painless***.

How does molecular imaging work?

When disease occurs, the biochemical activity of cells begins to change. For example, cancer cells multiply at a much faster rate and are more active than normal cells. Brain cells affected by dementia consume less energy than normal brain cells. Heart cells deprived of adequate blood flow begin to die.

As disease progresses, this abnormal cellular activity begins to affect body tissue and structures, causing anatomical changes that may be seen on CT or MRI scans. For example, cancer cells may form a mass or tumor. With the loss of brain cells, overall brain volume may decrease or affected parts of the brain may appear different in density than the normal areas. Similarly, the heart muscle cells that are affected stop contracting and the overall heart function deteriorates.

Molecular imaging excels at detecting the cellular changes that ***occur early in the course of disease***, often well before structural changes can be seen on CT and MR images. Molecular imaging can detect abnormalities in the brain months or years before structural changes might occur.

Most molecular imaging procedures involve an imaging device and an imaging agent, or probe. A variety of imaging agents are used to visualize cellular activity, such as the chemical processes involved in metabolism, oxygen use or blood flow. In nuclear medicine, which is a branch of molecular imaging, the imaging agent is a radiotracer, a compound that includes a radioactive atom, or isotope. Other molecular imaging modalities, such as optical imaging and molecular ultrasound, use a variety of different agents. Magnetic resonance (MR) spectroscopy is able to measure certain chemical levels in the body, without the use of an imaging agent.

Once the imaging agent is introduced into the body, it accumulates in a target organ or attaches to specific cells. The imaging device detects the imaging agent and creates pictures that show how it is distributed in the body. This distribution pattern helps physicians discern how well organs and tissues are functioning. Two common clinically used molecular imaging technologies are positron emission tomography (PET) and single-photon emission computed tomography (SPECT).

What is SPECT?

Single photon emission computed tomography (SPECT) involves the use of an imaging device (SPECT scanner) and a radiotracer that is injected into the patient's bloodstream. In perfusion SPECT imaging, the tracer accumulates in cells based on how much blood flow they are receiving. Since blood flow is a correlate of activity in the brain, SPECT show areas of increased and decreased brain activity. In dopamine SPECT, the amount of active dopamine-using brain cells is quantified and aids in diagnosis of Parkinson's Disease.

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What is PET?

PET involves the use of an imaging device (PET scanner) and a radiotracer that is injected into the patient's bloodstream. A frequently used PET radiotracer is 18F-fluorodeoxyglucose (FDG), a compound derived from a simple sugar and a small amount of radioactive fluorine. More active brain cells accumulate more FDG tracer.

Once the radiotracer accumulates in the body's tissues and organs, its natural decay eventually produces photons. The PET scanner, which is able to detect these photons, creates three-dimensional images that show how the radiotracer is distributed in the area of the body being studied.

PET and SPECT scanners are most often combined with CT that produces highly detailed views of the body. The combination of two imaging techniques—called co-registration, fusion imaging, or hybrid imaging—allows information from two different kinds of scans to be viewed in a single set of images. CT imaging uses advances x-ray equipment and in some cases a contrast-enhancing material to produce three-dimensional images.

Are PET and SPECT safe?

Many medical procedures have side effects and risks; the same is true of nuclear medicine diagnostic tests such as PET and SPECT. Each procedure takes a certain amount of radiation to perform appropriately. Used in the right way for the right patient at the right time, nuclear medicine is very safe—the benefits of the procedure outweigh the potential risks.

What molecular imaging technologies are used for Parkinson's Disease?

Because multiple neurological disorders mimic Parkinson's disease, the disease can be difficult to diagnose. Scanning with the FDA-approved radiotracer I-123-ioflupane injection (also called DaTscan) and a SPECT scanner may allow for earlier and more accurate diagnosis of Parkinson's disease (Djang et al., 2012). A scan using DaTscan is able to detect dopamine transporters (DaTs). The distribution of DaTs is abnormal in patients with Parkinsonian syndromes but normal in patients with other conditions, such as essential tremor.

What are the advantages of SPECT and PET for the Brain?

 Dopamine SPECT allow direct assessment of the activity of dopamine-producing neurons in the brain and will assist the clinician in differentiating between Parkinson's disease (where there is a decrease in brain dopamine-producing nerve cells) and essential tremor (where these scans are normal)

 PET allows metabolic activity to be directly visualized, not inferred

 SPECT or PET studies allow abnormal brain function to be detected before structural changes can be seen on CT or MRI

 SPECT or PET studies can aid in the differential diagnosis in PD and the evaluation of non-motor complications, such as Parkinson's psychosis.

 FDG PET and perfusion SPECT are highly useful in detecting specific types of dementia, such as Alzheimer's disease and frontotemporal dementia.

Is molecular neuroimaging covered by insurance?

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Check with your insurance company for specific information on your plan. Not all procedures described herein are covered by every insurance plan.

REFERENCES
Djang DSW. et al., J Nucl Med, 2012, 53:154163.

About SNMMI
The Society of Nuclear Medicine (SNMMI) is an international scientific and medical organization dedicated to raising public awareness about nuclear and molecular imaging and therapy and how they can help provide patients with the best health care possible. With more than 18,000 members, SNMMI has been a leader in unifying, advancing and optimizing nuclear medicine and molecular imaging since 1954.

The material presented in this pamphlet is for informational purposes only and is not intended as a substitute for discussions between you and your physician. Be sure to consult with your physician or the nuclear medicine department where the treatment will be performed if you want more information about this or other nuclear medicine procedures.

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