Molecular Imaging and Lung Cancer

SOCIETY OF NUCLEAR MEDICINE AND MOLECULAR IMAGING

Lung cancer is the leading cause of cancer death in the United States. According to the National Cancer Institute, more than 200,000 patients were diagnosed with lung cancer and nearly 160,000 died from the disease in 2009.

There are two major categories of lung cancer—small cell lung cancer (SCLC) and non-small cell lung cancer (NSCLC). Molecular imaging is playing an increasingly important role in the detection, diagnosis and treatment of NSCLC, which accounts for the majority of lung cancer cases. Molecular imaging is not typically used for SCLC.

Treatment options for NSCLC include chemotherapy and radiation and if diagnosed early enough, surgery. Accurately identifying if the cancer has spread to other parts of the body is critical for determining treatment options for patients.

What is molecular imaging and how does it help people with lung cancer?

Molecular imaging is a type of medical imaging that provides detailed pictures of what is happening inside the body at the molecular and cellular level. Where other diagnostic imaging procedures—such as x-rays, computed tomography (CT) and ultrasound—predominantly offer anatomical pictures, molecular imaging allows physicians to see how the body is functioning and to measure its chemical and biological processes.

Molecular imaging offers unique insights into the human body that enable physicians to personalize patient care. In terms of diagnosis, molecular imaging is able to:

- provide information that is unattainable with other imaging technologies or that would require more invasive procedures such as biopsy or surgery
- identify disease in its earliest stages and 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:

- determine the extent or severity of the disease, including whether it has spread elsewhere in the body
- select the most effective therapy based on the unique biologic characteristics of the patient and the molecular properties of a tumor or other disease
- determine a patient’s response to specific drugs
- accurately assess the effectiveness of a treatment regimen
- adapt treatment plans quickly in response to changes in cellular activity
- assess disease progression
- identify recurrence of disease and help manage ongoing care

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.

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 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.

What molecular imaging technologies are used for lung cancer?

Positron emission tomography (PET) scans and combination PET and computed tomography (CT) scans are routinely used to diagnose and treat non-small cell lung cancer (NSCLC).

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.

Once the FDG radiotracer accumulates in the body's tissues and organs, its natural decay includes emission of tiny particles called positrons that react with electrons in the body. This reaction, known as annihilation, produces energy in the form of a pair of 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.

Areas where a large amount of FDG accumulates, called 'hot spots' because they appear more intense than surrounding tissue, indicate that a high level of chemical activity or metabolism is occurring there. Areas of low metabolic activity appear less intense and are sometimes referred to as 'cold spots.' Using these images and the information they provide, physicians are able to evaluate how well organs and tissues are working and to detect abnormalities.

PET-CT is a combination of PET and computed tomography (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 types of scans to be viewed in a single set of images. CT imaging uses advanced x-ray equipment and in some cases a contrast-enhancing material to produce three dimensional images.

A combined PET-CT study is able to provide detail on both the anatomy and function of organs and tissues. This is accomplished by superimposing the precise location of abnormal metabolic activity (from PET) against the detailed anatomic image (from CT).

How is PET performed?

The procedure begins with an intravenous (IV) injection of a radiotracer, such as FDG, which usually takes between 30 and 60 minutes to distribute throughout the body. The patient is then placed in the PET scanner where special detectors are used to create a three dimensional image of the FDG distribution.

Scans are reviewed and interpreted by a qualified imaging professional such as a nuclear medicine physician or radiologist who shares the results with the patient's physician.

Depending on the course of treatment, non-small cell cancer patients may require several PET or PET/CT scans, including whole-body scans.

How is PET used for lung cancer?

Physicians use PET and PET-CT studies to:

- **diagnose and stage**: by determining the exact location of a tumor, the extent or stage of the disease and whether the cancer has spread in the body
- **plan treatment:** by selecting the most effective therapy based on the unique molecular properties of the disease and of the patient's genetic makeup
- **evaluate the effectiveness of treatment**: by determining the patient's response to specific drugs and ongoing therapy. Based on changes in cellular activity observed on PET-CT images, treatment plans can be quickly altered
- **manage ongoing care**: by detecting the recurrence of cancer

What are the advantages of PET for people with lung cancer?

- PET and PET-CT are the most accurate tools available for determining whether cancer treatments are destroying cancer cells, if cells are spreading to other parts of the body and whether cancer has recurred after surgery or other treatments.
- Because PET-CT imaging is highly accurate at determining whether non-small cell cancer has spread to the lymph nodes, it can provide a noninvasive alternative to a surgical procedure called mediastinoscopy. In this procedure, tissue is collected from the lymph nodes in the chest cavity and analyzed under a microscope to determine whether cancerous cells are present. If this type of biopsy is necessary, a surgeon may use PET-CT guidance to identify the lymph nodes mostly likely to contain cancer cells.
- Although lung tumors are often initially evaluated through a chest x-ray or CT scan, PET and PET-CT scans are highly accurate at determining whether a lung mass is cancerous and may even eliminate the need for surgical biopsy.
- Recent studies show that molecular imaging technologies change the course of treatment for as many as 64 percent of lung cancer patients.

- Research indicates a correlation between the amount of FDG radiotracer absorbed by the cancer cells during a PET scan and the patient's chances for survival. Patients whose lung cancer absorbs less FDG have a greater survival rate.

Is PET covered by insurance?

PET and PET-CT studies to diagnose, stage, re-stage or identify a recurrence of non-small cell lung cancer are covered by Medicare and Medicaid. Major insurance companies and health maintenance organizations also provide coverage for PET-CT studies for NSCLC. Check with your insurance company for specific information on your plan.

What is the future of molecular imaging and lung cancer?

Researchers are making exciting advances in understanding the molecular and genetic mechanisms that play a role in the development of lung cancer. Promising areas of research include the development of novel reporter-gene imaging systems, which involve engineering genes that are able to adhere to specific cells so they may be tracked with molecular imaging technologies. In addition, scientists are working on ways to image molecular markers and biological pathways that are able to provide insight into the progression of lung disease and its response to treatment

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.

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