Molecular Imaging and Gastrointestinal Cancers

SNMMI SOCIETY OF NUCLEAR MEDICINE AND MOLECULAR IMAGING

Gastrointestinal (GI) cancers occur in the gastrointestinal tract, a long twisting tube that includes the esophagus, stomach, small and large intestine (which includes the colon), rectum and anus. Along the GI or digestive tract are three organs—the liver, gallbladder and pancreas—that contribute to the digestive process that turns food into energy for the body.

According to estimates from the National Cancer Institute, more than 270,000 new cases of GI cancer were diagnosed in the United States and nearly 134,000 people died from the disease in 2009. Colorectal cancer, which includes malignancies in the large intestine and rectum, is the fourth leading cause of cancer deaths among both men and women.

Molecular imaging has become an essential tool in the diagnosis, evaluation and treatment of patients with gastrointestinal cancers.

What is molecular imaging and how does it help people with GI 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 gastrointestinal cancers?

Positron emission tomography (PET) scans and combination PET and computed tomography (CT) scans may be used to diagnose and monitor the treatment of:

- esophageal cancer
- gastric (stomach) cancer
- small bowel tumors
- pancreatic cancer
- lymphomas in the gastrointestinal tract
- colorectal cancer

Radioimmunotherapy (RIT) is also used to treat some GI cancers.

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.

How is PET used for gastrointestinal cancers?

Esophageal, pancreatic and gastric (stomach) cancers

- PET-CT is able to identify where cancer has spread in the body.

Gastric cancers

- PET-CT studies are used to assess patient response to chemotherapy.

Colorectal cancer

- PET-CT is helpful for nearly all aspects of colorectal cancer diagnosis and treatment, including identifying incidental cancers in the colon
    - PET is more accurate than CT for staging colorectal cancer and is especially valuable for detecting cancer recurrences
    - PET is able to distinguish between cancer recurrences and post-therapy scarring in the colon.
    - PET is able to confirm or rule out the presence of secondary cancers in the liver or lung, providing valuable information that directly affects treatment options

- PET is useful in detecting cancer recurrence in patients who have an increased blood protein called carcinoembryonic antigen (CEA)

GI Lymphoma

- PET-CT plays an important role in the diagnosing and treatment of lymphomas of the GI tract by helping physicians:
    - determine size, metabolic activity and stage of the disease
    - evaluate patient response to treatment for both Hodgkin's and non-Hodgkin lymphoma
    - detect a cancer recurrence

What is radioimmunotherapy (RIT)?

Radioimmunotherapy(RIT) is a personalized cancer treatment that combines radiation therapy with the precise targeting ability of immunotherapy, a treatment that mimics cellular activity in the body's immune system.

In a healthy immune system, certain white cells are able to recognize invading organisms such as bacteria and viruses. The white cell secretes a protein substance called an antibody that identifies a feature of the foreign cell called an antigen. The antibody coats the invading cell, which enables other white cells to destroy it.

In immunotherapy, scientists create monoclonal antibodies in a laboratory that are designed to recognize and bind to the antigen of a specific cancer cell. In RIT, the monoclonal antibody is paired with a radioactive material. When injected into the patient's bloodstream, the antibody travels to and binds to the cancer cells, allowing a high dose of radiation to be delivered directly to the tumor.

Several new radioimmunotherapy agents are under development or in clinical trials.

Is PET covered by insurance?

An initial PET-CT study is covered by Medicare and Medicaid for all patients with gastrointestinal cancers or suspected malignancies; subsequent studies for evaluating treatment options for colorectal and esophageal cancers are also covered. Check with your insurance company for specific information on your plan.

What is the future of molecular imaging and gastrointestinal cancers?

Emerging data from ongoing research indicates that:

- *Esophageal Cancer*
    - PET-CT may be useful in evaluating patient response to treatment.
- *Gastric (stomach) cancer*
    - PET-CT may be able to predict a patient's response to chemotherapy.
- *Small intestinal tumors*
    - PET-CT may help physicians:
        - distinguish benign from malignant tumors

    - distinguish a low- from high-grade sarcoma
    - determine where cancer has spread in the body
    - monitor patient response to treatment

- *Pancreatic cancer*
  - PET-CT may be useful for monitoring patient response to treatment.
- *GI Lymphoma*
  - PET-CT may be able to predict a patient's response to treatment very soon after therapy has begun.

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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