

modality for the diagnosis and management of cancer. PET yields high-quality images that characterize substrate metabolism, cellular proliferation, receptor density, and other parameters used to identify cancer and evaluate its response to treatment (23). Radiolabeled tracers injected in non-pharmacologic doses are used to construct three-dimensional images by computer to demonstrate the location and concentration of the tracer of interest (24). PET allows the physician to secure an image that is essentially a low-resolution autoradiograph showing the regional concentration of a positron-emitting nuclide inside the body (25). It is a method for quantitative imaging of regional function and chemical reactions within various organs of the human body. Imaging applications of PET have shown great use, for instance, in mapping regional blood flow, oxygen metabolism, regional blood volume, rates of use of metabolic substrates, receptor-specific tracer binding, bone remodeling, tumor receptor density, and reporter gene expression (24).

The tracers used in PET imaging are natural biochemicals labeled with radionuclides of carbon, nitrogen, oxygen, and fluorine. This allows analysis in terms of physiology and biochemistry at a level of sophistication beyond that encountered in traditional nuclear medicine. No other technology can image body chemistry with such sensitivity, so that the moment-to-moment change in concentration of a tracer in the blood or tissue can be determined in absolute units. Other imaging modalities, such as CT and MRI, provide predominantly anatomic information, and this is thought to be the future of imaging. CT is based on portrayal of the distribution of attenuation of x-rays passing through the body. MRI exploits the variation in regional concentrations of hydrogen and nuclear relaxation parameters to generate image contrast and to provide information about free water content, relative blood flow, and the concentration of contrast agents. Clinical PET is being used with CT to combine anatomic information (CT) with functional molecular information (PET) to advance cancer management (24).

Chemical changes occur prior to anatomic changes in most disease states, and PET can detect functional abnormalities before anatomic changes have occurred. PET evolved with its main focus on studies of the brain and heart. However, it has emerged as a valued diagnostic tool for diagnosis and therapy monitoring of patients with lymphoma, as a means to assess estrogen receptors in primary and metastatic breast cancers and to identify resectable colorectal tumor recurrence. In epilepsy, PET and surface electroencephalography are used in concert with clinical assessment of symptoms and signs to try to localize areas of the brain that are the foci of epileptic seizures when surgical intervention is the only remaining method to prevent the seizures.

Tumors have more intermediary metabolism than normal tissue, and PET use is advantageous because it can qualitatively and quantitatively study metabolism. Several processes, including glycolysis, increased membrane glucose transfer capability, and RNA, DNA, and protein synthesis are demonstrated and/or accelerated in tumors. In the 1930s, Warburg demonstrated that glucose was used more in tumorous tissue than in normal tissue, and this remains today as a foundation for PET imaging in oncology (26). The radiopharmaceutical most widely used for evaluating tumors with PET imaging is [¹⁸F]-fluorodeoxyglucose because it has been demonstrated useful for tracing glucose metabolism, for detecting malignant tissue, and for quantifying changes in tumor glycolysis during and after treatment. Thus, it is useful for diagnosis, staging, and monitoring various cancers, including lung, colorectal, melanoma, lymphoma, and head and neck, among others. [¹⁸F]-FDG has a 110-minute half-life, which is much easier to work with than a 2-minute half-life. PET scanning has also been demonstrated to predict accurately a patient's clinical and pathological response and survival in patients who undergo preoperative chemotherapy on the treatment strategy for esophageal carcinoma (27).

When a radionuclide within the body decays by emission of a positron, that particle travels a very short distance (1 to 4 mm)