Nuclear Medicine Imaging Studies in the Diagnosis of Head and Neck Disease

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KEYWORDS

• PET/CT • Drug-induced osteonecrosis of the jaw (DIONJ) • Nuclear medicine imaging • FDG

KEY POINTS

- Positron emission tomography/computed tomography has proven utility in oncology imaging.
- Fluorodeoxyglucose positron emission tomography/computed tomography may be useful for delineating drug-induced osteonecrosis of the jaw.

INTRODUCTION TO PET/CT IMAGING

The detection and localization of positron decay within the body are the means by which positron emission tomography (PET) images are created. Positron decay is a form of radioactive decay, which is the process by which unstable atoms spontaneously convert to a more stable form with a lower overall energy. The resultant energy emission releases radioactive energy that is used to create medically useful images. Most positron-emitting isotopes are produced in a cyclotron.

Previously, cyclotrons were located only in major research institutions and academic centers, because of the high cost and resources needed to operate and maintain a cyclotron. However, in recent years, cyclotrons have been purchased by commercial companies to produce medically useful isotopes, specifically, positron-emitting isotopes. Also, current cyclotron size has become significantly more convenient than past versions (**Fig. 1**). In particular, the radiotracer fluorodeoxyglucose (FDG) has led the way in PET imaging in routine clinical oncology.[1] PET/computed tomography (CT) scanners combine PET imaging with an in-line CT scanner for accurate localization of PET tracer uptake and comprise most of the current PET scanner sales.

As with all images generated in nuclear medicine, PET attempts to map a biologic process related to the tracer injected. Often the image represents functional metabolic activity, most often for oncologic indications.[1,2] Current radiotracers used for PET/CT imaging are numerous, but only one is used in routine clinical practice at this time, 18F-FDG. This tracer is simply a glucose molecule with one oxygen atom substituted with radioactive fluorine-18 (18F), which is a positron-emitting radioisotope produced in a cyclotron. Metabolic functional imaging with the radiotracer FDG attempts to map the glucose utilization pattern of the bodily tissues. FDG (and nonradioactive glucose) enters cells actively, depending on cell surface transporters (GLUT-1 and -2). Often, these are up-regulated in malignant and inflammatory cells, leading to greater uptake within the cell, and subsequently, leading to abnormalities on PET imaging. Malignant cells also "metabolically trap" FDG, because these cells are unable to metabolize FDG, whereas inflammatory cells are "hypermetabolic" and subsequently use more glucose. Other substrates may be incorporated into radiotracers, for example, fatty acids, amino acids, and charged particles.[3] The development of new radiotracers is an exciting part of nuclear medicine, which will drive future application

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Fig. 1. Typical relative dimensions of a clinical cyclotron. (*Courtesy of* General Electric Company; with permission.)

of PET imaging and image-guided therapy. Advances in radiochemistry have made tracer development an exciting topic, which will become more apparent in the near future.

After intravenous injection, FDG distributes throughout the body, creating a physiologic pattern. Glucose is a substrate for nearly every cell in the human body, especially the brain, heart, liver, and skeletal muscle. These organs provide most of the background activity on PET scans. Normal tissue, including bone marrow, undergoing physiologic metabolism accounts for the remaining background activity on PET scans. FDG has been shown to accumulate avidly in inflammatory cells[4] as well as neoplastic cells. The mechanism of uptake in both inflammatory and neoplastic cells has been well studied.[5] Once activated, inflammatory cells demonstrate markedly increased metabolism, leading to increased glucose utilization and subsequent increased activity on a PET scan. In theory, normal osseous FDG uptake could be used as a biomarker for viable mandible in preparation for surgical resection of diseased bone. However, abnormal osseous uptake on an FDG-PET scan almost always signifies pathologic abnormality, such as metastatic disease, infection, or other inflammation, particularly, drug-induced

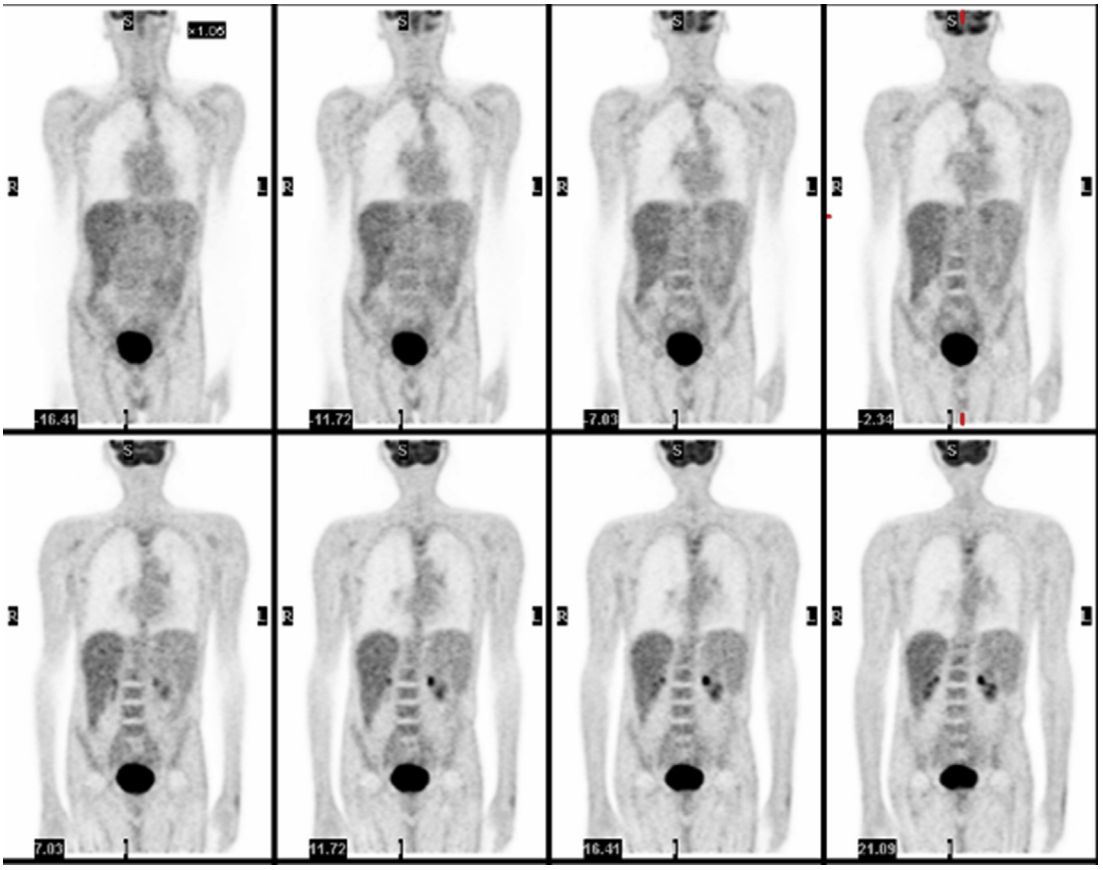

Fig. 2. Normal, physiologic whole-body FDG distribution. Note high background activity in the brain and urinary bladder. (*Courtesy of* General Electric Company; with permission.)