Gamma camera positron emission tomography: implications for clinical and research studies

Positron emission tomography (PET) was first developed in the 1970s in research establishments as a useful functional imaging tool. The geographical spread and distribution of this technology has been restricted because of the requirement for a cyclotron either on site or in close proximity. Along with a range of research applications, the role of PET scanning in clinical practice has received renewed interest recently.

The most commonly used radiopharmaceutical employed in PET imaging is ^{18}FDG (fluorodeoxyglucose labelled with fluorine-18). The half-life of this radiopharmaceutical is 110 minutes. Along with an increased clinical role for ^{18}FDG PET imaging in various clinical settings, double-headed gamma cameras evolved and the ability to perform ^{18}FDG tomographic imaging was refined. The longer half-life of ^{18}FDG (compared to other PET tracers) meant that it was no longer necessary for cyclotrons to be located on site. The establishment of regional collaboration for ^{18}FDG imaging means that cyclotrons, radiochemistry laboratories and the imaging scanners could be located within a 1-hour radius of each other. This article discusses the clinical experience and possible implications for research.

WHAT DOES LABELLED FDG SHOW?

FDG behaves as ordinary glucose in the body and when labelled with ^{18}F can be used to demonstrate areas with high glucose utilization in the body. This is used to good effect in an oncological setting as malignant cells have increased glucose metabolism thus differentiating them from normal tissue. The interpretation of structural imaging such as computed tomography (CT) or magnetic resonance imaging (MRI) is difficult in patients who have had either surgery or radiotherapy on the area in question. ^{18}FDG imaging helps distinguish tumour recurrence from either post-surgical scar or fibrosis, or radiation necrosis. While CT or MRI abnormality is usually defined by size (e.g. an enlarged lymph node in a patient with carcinoma is considered suspicious for metastatic lymph node involvement), interpretation of metabolic imaging is independent of size.

CLINICAL ROLE OF PET SCANNING

The clinical use of PET scanning can be considered under various clinical questions. If there is a high suspicion of presence of a carcinoma (e.g. rising tumour markers), the high sensitivity of ^{18}FDG to detect sites of abnormal glucose metabolism could be used to identify any abnormality. A solitary pulmonary nodule on structural imaging would be classified as malignant if it shows increased ^{18}FDG uptake. In disorders involving multiple sites such as Hodgkin's disease or melanoma, ^{18}FDG can be used to identify the extent of disease. In brain tumours ^{18}FDG is useful for guiding biopsy and assessing treatment response.

Collimated gamma camera PET has been introduced in a clinical environment in the light of growing pressure from referring clinicians to provide a PET imaging service to enhance their diagnostic and prognostic abilities for specific malignant conditions. The expected reduction in spatial resolution (down to 3.5 full width half maximum (FWHM) mm from 4.5 for dedicated PET scanners) and reduction in sensitivity (down to ~15 kilo counts per second (kcps) from ~150 kcps for dedicated PET scanners) is offset by the availability of ^{18}FDG for clinical use. Gamma camera PET is considered inferior to dedicated full ring PET for the detection of malignant lesions smaller than 1.5 cm in diameter. The selection of patients for scanning based on clinical and structural imaging criteria has to be done in the context of lesions at least 1.5 cm or more in diameter on structural imaging.

Clinical interests are usually in very specific areas with good clinical and structural imaging support. These areas may include brain tumours, pancreatic carcinomas and lung carcinomas.

Referrals for scanning of brain tumours are usually from regional neurological and neurosurgical centres. Patients with oligodendrogliomas identified on CT or MRI scanning are assessed with thallium-201 brain single photon emission tomography (SPET) and ^{18}FDG brain SPET to assess the grade of malignancy and to plan further therapy. A high-grade hypermetabolic tumour is considered suitable for chemotherapy, while a low-grade low metabolic tumour is considered more amenable to surgery. A serial scan may show response of the tumour to therapy.

An important clinical question in patients with suspected pancreatic carcinoma is the possibility of the mass being caused by chronic pancreatitis. Patients with equivocal CT scans may be referred from regional pancreatic surgery units. Patients with normal ^{18}FDG scans are selected for conservative management as the findings are more likely to be caused by pancreatitis, and those with significant tracer uptake in the pancreatic bed are scheduled for pancreatectomy as the findings are more likely to be caused by pancreatic carcinoma.

Patients with suspected recurrence in the site of previous surgery for lung carcinoma may be referred from regional lung cancer units. Areas with positive ^{18}FDG uptake are considered sites of recurrence of tumour.

METHODS USED

All patients are starved for 6 hours before the intravenous administration of ^{18}FDG. For brain imaging 250 megabecquerels (MBq) is injected in a quiet and dark environment. Patients are rested for 20 minutes before the injection and maintain this for a further 30 minutes. For pancreas and lung imaging 400 MBq is injected intravenously and 50 minutes later tomographic imaging is acquired. To exclude the possibility of hyperglycaemia causing false negatives, a finger-prick glucose measurement is taken. Tomographic images are acquired using the high energy collimators, and 30 seconds per angle over 32 angles (for each head). After appropriate reconstruction and processing, images are displayed in a three-dimensional format to include transverse, coronal and sagittal views.

INITIAL RESULTS

Preliminary analysis of the clinical follow-up action on the basis of the ^{18}FDG scans in the author's department has shown a high degree of reliability of the scans, with appropriate clinical action following on as a consequence of the tests.

While the requirement for lesions to be at least 1.5 cm or more on CT or MRI may be considered to be a significant negative factor for including these scans in research, research protocols can be and have been designed after taking these factors into consideration.

KEY POINTS

- The most commonly used radiopharmaceutical in positron emission tomography (PET) imaging is fluorodeoxyglucose labelled with fluorine-18 (^{18}FDG).
- The half life of ^{18}FDG is 110 minutes, thereby cyclotrons, radiochemistry facilities and scanners can be located within a 1-hour radius of each other.
- PET scanning is useful in defining the location and extent of malignant tissue, and in guiding further treatment.
- Gamma camera PET scanning is not reliable for lesions less than 1.5 cm in diameter.
- Gamma camera PET images are clinically useful and can be used to guide further clinical action in centres without access to full-ring PET systems.

CONCLUSION

^{18}FDG SPET is feasible, clinically applicable and provides useful clinical guidance in specific areas. While this technique may rank as a poor substitute for a ring-system PET scanner from the theoretical perspective, on a practical scale, the technique provides good quality images for interpretation and further clinical action. HM

S Vinjamuri

Consultant Physician/Honorary Senior Lecturer in Nuclear Medicine

Royal Liverpool University Hospital

Liverpool L7 8XP

Some aspects of this paper were discussed at the Imaging in Cancer Research Meeting organised by British Institute of Radiology on 2 November 2001; and in Vinjamuri S, Noonan EC (2001) Collimated gamma camera PET in a clinical setting. Rad **27(310):** *26*

Further reading

Anonymous (1991) Clinical PET: its time has come. *J Nucl Med* **32**: 4

Erasmus JJ, McAdams HP, Patz EF Jr et al (1998) Thoracic FDG PET: state of the art. *Radiographics* **18:** 5–20

Hoh CK, Hawkins RA, Glaspy JA et al (1993) Cancer detection with whole body PET using 2-[18F]fluoro-2-deoxy-D-glucose. *J Comput Assist Tomogr* **17:** 582–9

Hoh CK, Schiepers C, Seltzer MA et al (1997) PET in oncology: will it replace other modalities? *Semin Nucl Med* **27**: 94–106

Jarritt PH, Acton PD (1996) PET imaging using gamma-camera systems-a review. *Nucl Med Commun* **17:** 758–68