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PET Centre – Masaryk Memorial Cancer Institute, Brno, Czech Republic

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Introduction

The positron emission tomography (PET) Centre of the Masaryk Memorial Cancer Institute was brought into operation in September 2003, as a second PET Centre in the Czech Republic. The department employs the Siemens E.CAT Accel PET camera with LSO crystals. The 18F-fluoro-2-deoxyglucose (18F-FDG) represents the only PET tracer used so far, delivered twice a day from its producer, the Nuclear Research Institute Rez plc (Prague, Czech Republic).

The Thema Synergy semi-automatic system installed in February 2004 simplified the preparation of the pharmaceutical for each patient, and helped to markedly reduce the technologists' hand absorbed doses.

Administered activity varies depending on the type of study. For a whole-body examination, an average of 370 MBq of 18F-FDG is applied; for a PET scan of the brain or the myocardium, an average of 200 MBq of 18F-FDG is applied per standard patient with body weight of 70 kg.

An average of 17–18 examinations are performed daily from the 18F-FDG supplied — including Saturdays and Sundays — adding to a total of approximately 480 examinations per month. From September 2003 through November 2005 more than 10,000 examinations have been performed. Each PET study is evaluated independently by two physicians specializing in nuclear medicine. The picture documentation of each study (raw data, representative slices, the pseudo-three-dimensional maximum intensity projections (MIP), semi-quantification of the lesions with standardized uptake value (SUV) assessment and eventually PET and computer tomography (CT) or magnetic resonance imaging (MRI) scan fusion) are stored in the picture archiving and communication system (PACS), which makes it accessible for clinical presentation and further processing.

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Analysis with reference to clinical specialties

Due to the orientation of the Masaryk Memorial Cancer Institute, the spectrum of examined patients from various fields of medicine differs from the universally presented patient distribution (Figure 1):

— oncology 94%;
— neurology 4%;
— cardiology 2%.

Position emission tomography scan indications

There are 8 PET scan indications:

— differential diagnostics of foci of unknown character;
— examination of oncological patients in follow-up with history or high risk of tumour relapse;
— examination in patients with elevated tumour marker levels and no clinical signs of tumour and/or inconclusive findings from basic imaging methods;

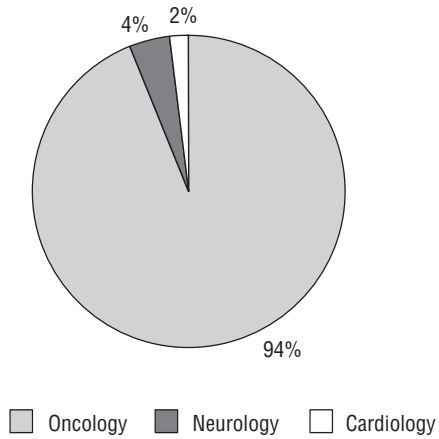

Figure 1. Patient distribution at the MMCI PET Centre.

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— therapeutic effect monitoring especially after chemotherapy in cases where other treatment alternatives are available and/ /or in cases with highly demanding treatment (economy issues, serious side effects, etc.);
— non-oncological indications;
— PET scans for radiotherapy planning;
— detailed examination prior to radical surgery (extended radicality, high morbidity risk, and/or surgery expected to markedly affect the quality of life);
— staging of locoregionally advanced tumours with high dissemination risk following the standard adjuvant treatment

Image fusion

Following the installation of the Syngo software in February 2004, a software fusion of PET images with CT and/or MRI images has been performed at our PET Centre (Figure 2). A digital form of the CT or MRI data in the DICOM 3.0 format is available for image fusion via the PACS archive or a compact disc (in case of external departments not connected via PACS).

The value of the image fusion lies in:
— better specification of foci depicted by the positron emission tomography;
— localization of metabolically active tissue within the detected foci and distinguishing of fibrotic tissue from viable cell regions.

The image fusion is currently performed in approximately a third of all PET examinations, and it became an inherent part of the daily routine allowing for a marked improvement of the PET scan finding evaluation.

Analysis of the FDG-PET findings in correlation with tumour marker levels

In collaboration with the MMCI Department of Laboratory Medicine we have analyzed the correlation of PET scan findings

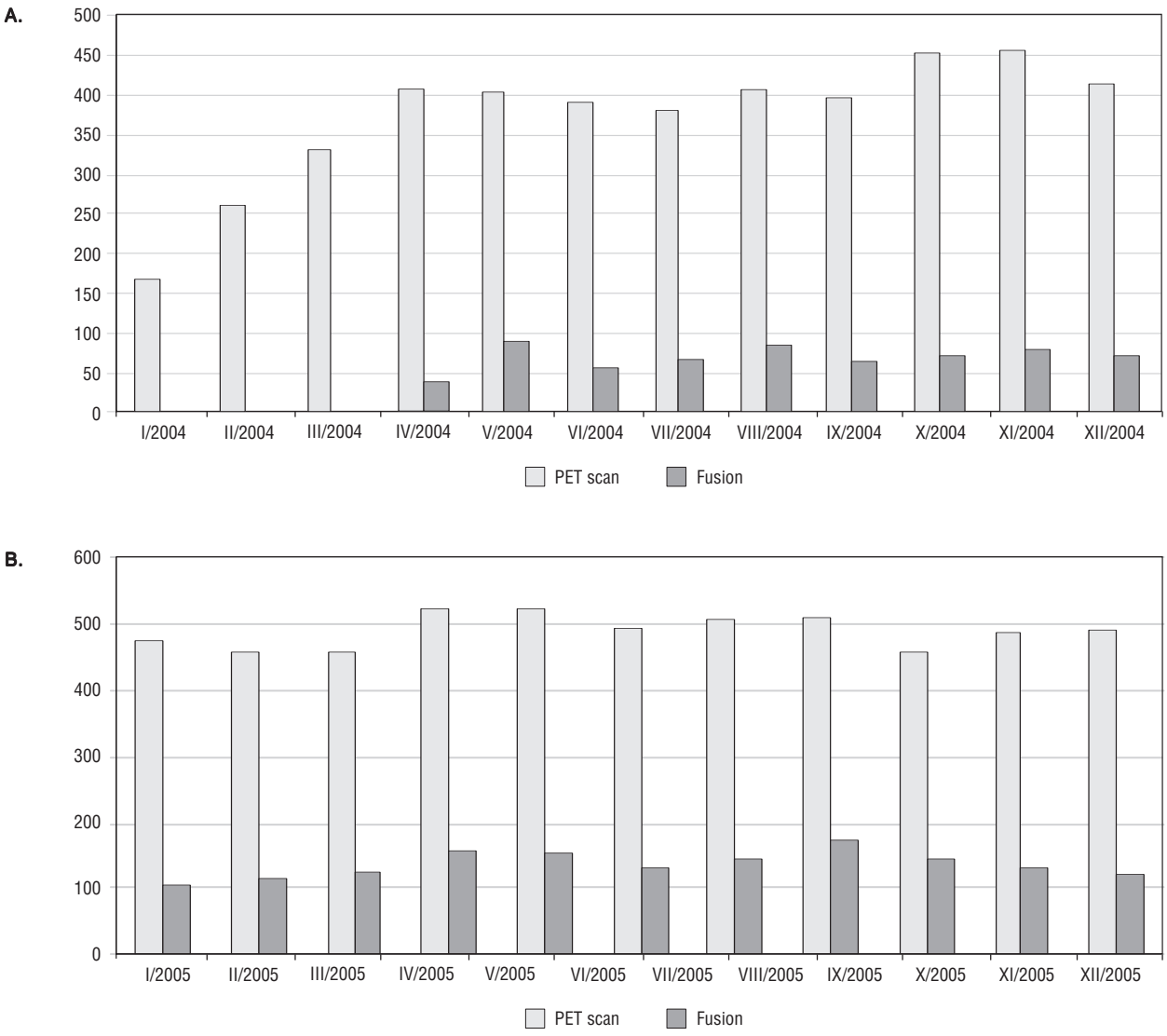

Figure 2. Number of PET examinations and PET/CT or PET/MRI image fusions. **A.** Year 2004: 4563 PET scans, 623 image fusions; **B.** Year 2005 (up to November 30th) : 5350 PET scans, 1479 image fusions.

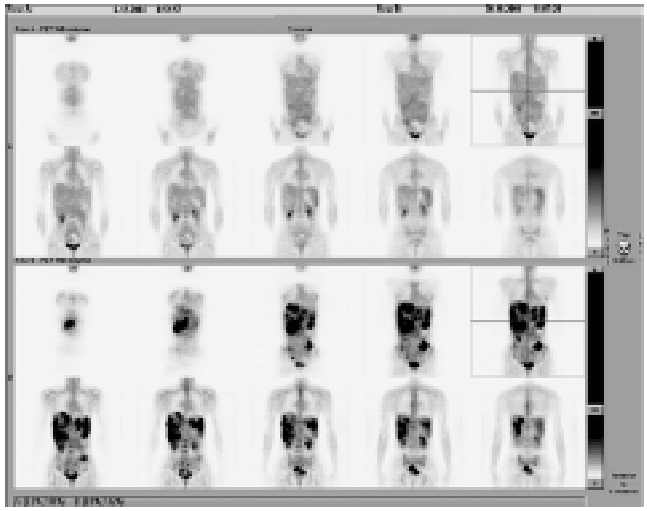

Figure 3. Bottom half of the figure: FDG-PET before therapy detects multiple foci of high tracer uptake in the area of the liver and the abdominal cavity. The finding indicates the presence of viable tumour tissue. Top half of the figure: control FDG-PET after therapy. Perfect clearance of the metabolically active foci indicates a good response to therapy.

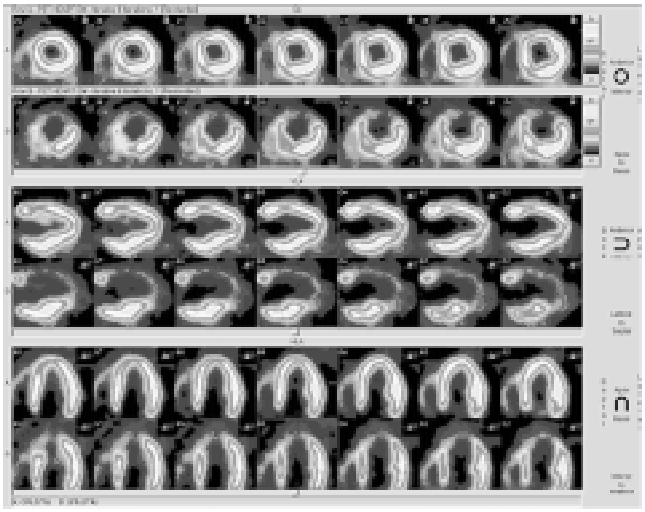

Figure 4. Comparison of left ventricle myocardial activity before and after the stem cell application in a patient overcoming a myocardial infarction. A marked reduction of the extent of the necrosis apically and anteroseptally is apparent following the stem cell application. Bottom row of individual projections: FDG-PET prior to stem cell application. A lack of activity recorded anteroseptally and apically. Top row of individual projections: increased uptake in the affected myocardial regions following the stem cell application.

with the tumour marker levels in patients undergoing repeated FDG-PET examinations. The preliminary data suggests that depending on the diagnosis the FDG-PET findings detect a recurring malignancy sooner than the tumour marker analysis in 1/5 up to 1/3 of the patients. Further analysis and statistical evaluation of the final data in connection with clinical assessment of the patients in this study will specify the incorporation of the PET examination within the algorithm of the diagnostic methods.

Application of FDG-PET in therapy control

The following points are followed closely and compared prior to and after therapy in patients with repeated FDG-PET examinations:

— number and (to a certain extent) size of the glucose hypermetabolism foci;
— metabolic activity of the foci via the SUV (standardized uptake value) assessment.

Decrease in metabolic activity of the foci and/or reduction of their number and size are interpreted as good therapeutic response, and vice versa. A comparative study of FDG-PET findings prior to and following treatment (Glivec) in a patient with GIST (gastrointestinal stromal tumour) is presented as an example of treatment efficacy evaluation in the Figure 3.

Application of FDG-PET in cardiology

We successfully use FDG-PET for viability evaluation of the left ventricle myocardium prior to and following autologous stem cell transplantation in patients overcoming an acute myocardial infarction (Figure 4). A total of 252 examinations have been performed in 111 patients up to the present date. A decrease in activity of more than 50% within the afflicted part of the left ventricle in comparison with the activity of reference myocardium is interpreted as a manifestation of necrosis.

The activity of individual segments of the myocardium is evaluated with the help of the 4D-MSPECT cardiac analysis program and use of the polar maps.

Application of FDG-PET in neurology diagnostics

FDG-PET is performed:

— in patients with epilepsy resistant to pharmacotherapy, qualifying for stereotactic intervention. The examination is performed during the interictal phase. The FDG-PET shows a decreased metabolism area of the cerebral cortex at point of the epileptogenic zone;
— in patients with primary brain tumours or cerebral metastases following radiotherapy or surgery. FDG-PET allows us to distinguish fibrotic scar tissue from an eventual tumour residuum or relapse. Computed tomography and/or MRI findings in a digital form enabling SW fusion of the images are necessary for cerebral foci evaluation.

The Department of Nuclear Medicine and the Positron Emission Tomography Centre of the Masaryk Memorial Cancer Institute currently employ five physicians specializing in nuclear medicine, one physician specializing in both nuclear medicine and radiodiagnostics, nine laboratory assistants and one physicist. The preparation of the radiopharmaceutical is performed by employees of the MMCI Pharmacy.

Acknowledgments

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