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Introducing the PET Centre Prague

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Abstract

The PET Centre Prague (www.homolka.cz/nm) was established in 1999 as the outcome of a joint project of the public Na Homolce Hospital and the Nuclear Research Institute Rež, plc, the Czech radiopharmaceutical producer. Technical and financial assistance was provided by the International Atomic Energy Agency, which perceived the Centre as its model project that could serve as a guide for the development of PET centres in countries sharing a comparable level of development with the Czech Republic. The article maps the history of the project, its design, workplace lay-out and equipment, radiation protection arrangements and spectrum of the first approx. 3,000 investigations.

Key words: positron emission tomography, PET, FDG, Prague, project

History

During the last quarter of a century there has been at first slow, then tentative, and finally amazingly dynamic development of positron emission tomography (PET). The idea of setting up a PET centre on the territory of what is today the Czech Republic had been expressed in the past, but until then the only successful initiative had come from Czech radiopharmaceutical producer Nuclear Research Institute Rež, plc (NRI). In 1996 the project was given support by the Ministry of Health and the State Office for Nuclear Safety. Significant help, both financial and technical, was extended by the International Atomic Energy Agency (IAEA) as part of its technical co-operation programme. IAEA perceived the development of a PET centre in the Czech Republic as a model project [1] that could serve as an example and source of information for developing PET centres in countries that had achieved a comparable stage of development.

The implementation of the model project started in 1997 by seeking the best location for the PET Centre. The first three-quarters of 1998 were devoted to the preparation of project documentation and acquisition of the necessary permits; building work started in the last part of the year. The construction was completed in the middle of the following year and had a certificate of occupancy issued; the separate building (Fig. 1) on the premises of the Na Homolce Hospital (Fig. 2) then started performing some of its planned activities. The first PET scan in the Czech Republic was performed on August 25, 1999, using 2-[^{18}F] fluoro-D-glucose (FDG).

FDG cannot be mentioned without remembering Josef Pacák and his colleagues. They had been the first in the world to create a non-active form of this molecule in 1968 in Prague [2]. Thirty years later, in Toronto, FDG was nominated "nuclear medicine molecule of the century" by Prof. Henry N. Wagner Jr.

Maybe we should explain why the PET Centre started by offering only a part of its planned services. That is connected with FDG too. FDG was of course produced from the time when all the technology was installed in 1999 — not however as a radiopharmaceutical, but as a radiochemical. It is necessary to be aware of the enormous difference between these two seemingly similar concepts. Much additional time was needed to perform the validation of all the production processes and to acquire the permits necessary for the production of pharmaceuticals in the new facility. FDG properties had to be established, clinical trials of the preparation approved, evaluation of the effect on volunteers performed. Finally, the process culminated in the issuing of the registration decree. All this took another two years, which meant that the distribution of FDG for human application started from the middle of October 2001.

Almost 2,700 PET scans could be performed in this interim period, only thanks to the availability of an alternative source of FDG at the Nuclear Physics Institute of the Academy of Sciences of the Czech Republic, which is located at a distance of 40 minutes by car. The production of FDG had started some time earlier at this Institute and had been designated originally for two Prague centres equipped with high energy collimators suitable for SPECT investigation of myocardial viability.

Design and lay-out

The PET Centre Prague was designed to house a satellite positron emission tomography system. The twice-daily production of 60 GBq FDG provides for both the supply of the local centre and for distribution within a reasonable transporting distance (the half-life period of ^{18}F is 110 minutes). The current double-storey building of the PET Centre has been converted from a storage building. The ground floor is the production area and is wholly managed by NRI. The second floor is occupied by the nuclear

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medicine out-patients department of the Na Homolce Hospital. Having separate outside entrances to both floors is a convenient arrangement for the co-existence of two different entities.

The production area complies with the established practice of containing a restricted zone with ventilation-controlled negative pressure. The "clean areas" are inside the controlled zone. The prescribed purity of the environment is controlled by positive pressure ventilation using HEPA filters and by a number of other necessary arrangements. In the clean areas there are also rooms dedicated to the preparation of radiopharmaceuticals for conventional scintigraphy (Fig. 3).

The second floor is divided longitudinally into three independent yet communicating compartments: waiting room, technology, staff-rooms (Fig. 4). The arrangement provides the greatest possible radiation protection, reflects the sequence of individual operations and also observes a certain degree of separation of workers, without however compromising their co-operation. For a number of reasons, the department has been designed to function as a joint PET and conventional scintigraphy work-place.

Along the southern wall there is a common waiting room with entrances leading to the camera rooms and rooms for intravenous administration of radiopharmaceuticals. The long waiting area is designed to present minimal danger of patients irradiating one another. There is a small attached yet separated waiting room for severely ill patients or small children. At the entrance there is an open desk adjacent to the archive and office. The receptionist is shielded by a concrete-filled counter (Fig. 5).

All the four camera rooms are in the interior of the building, protecting instruments from temperature swings. Together with rooms for radiopharmaceutical administration they are located within the controlled zone. This zone is interconnected and linked to the sanitary loop. Radiopharmaceuticals are delivered from the ground floor by a small lift. Moreover a shielded capillary is prepared for transport of ^{15}O oxygen (half-time period 2.1 minutes) straight from the cyclotron into the PET camera room. All camera and administration rooms are connected with the control room, the common work-place of the technologists, where acquisition consoles are located. This layout ensures high radiation protection of the staff, viewing the patients through leaded windows and enables collaboration between the technologists.

In the neighbourhood of this work centre there is a report room in which physicians evaluate images at other consoles. The arrangement allows for contact between the physicians and the technologists while providing the privacy needed for concentration. All these areas are accessible to the staff from the corridor, so staff and patients do not cross one another's paths. The corridor also links offices, coffee room and cloakroom.

Equipment

The heart of the PET Centre is the Belgian IBA Cyclone 18/9 cyclotron (Fig. 6). The produced radionuclide flows from the cyclotron through capillaries into Variotec (a Czech producer) chambers, shielded by 10 cm of lead, which contain the synthetisation computer-controlled modules. The FDG-producing module is a Nuclear Interface product (Germany). The clean area contains boxes with laminary air flow of $<$ 1 microbe per 1 m^3 purity; the boxes and the clean area technology were supplied by a Czech company, Labox. Also on the ground floor there are three large liquid-waste tanks working in alternating regimes — one tank fills while the activity in the second decays to a release level; the third tank is the reserve. The whole required range of laboratory instruments for product quality control is available. The sophisticated ventilation and cooling technology, together with a large number of regulatory, control and security systems, preventing, for example, radioactive leakage into the atmosphere, makes this a very complex installation.

The clinical part is equipped with a CTI/Siemens ECAT EXACT PET scanner (Fig. 7) and a modern double-head Siemens E.CAM scintigraphic camera allowing transmission attenuation correction. Also available is an old Philips camera which, however, is used only exceptionally as an operative reserve. One of the examining rooms has been designed as a reserve for the installation of a second PET camera.

Besides single-purpose evaluation consoles the department has two universal (Nuclear Diagnostics) computers providing fully automated archiving of scanned studies and all-round analyses and viewing of nuclear medicine data. The installed system [3] has the properties of PACS systems. An advantage is the possibility of viewing and of processing basic data by remote access, which opens up telemedical prospects. Moreover, these computers interconnect the camera consoles with the department's information system. Thus the identity of patients needs to be recorded only once when their appointment is made; after that the only thing that needs to be done is to make the selection from the menu — this can be done also at the acquisition consoles. The advanced information system [3] provides flexible support to all the activities of the department and it communicates with the hospital information system. It exceeds the properties of commercially available radiological information systems (RIS).

Radiation protection

Although the radioactivity applied during PET (approx. 500 MBq) is similar to that applied in common scintigraphy, the radiation load on staff is incomparably larger. This is due to the emission of two photons instead of one, to the higher total amount of processed activity due to the shorter half-life period and high penetration. It is not easy to shield high-energy 511 keV radiation. Experience has shown that an approx. 6-cm-thick lead shield is required to shield radiopharmaceuticals used for four PET scans. The tungsten cover of the syringe shields only 2.5 times at 0.8 kg of weight!

There is a number of PET centres that scan 800 to 1,000 patients annually. In these cases the radiation load of the staff is not a severe problem. In the case of the PET Centre in Prague, two-shift operations have been introduced (two FDG supplies daily, up to 10 patients in one day). Besides staff rotation and distance protection, increased attention has been paid to shielding. The walls are covered on both sides by a 2 × 5-cm-thick layer of baryta plaster. A special and powerful shielding has been developed for the storage of active vials and for the subsequent filling of syringes [4]. Another useful aid is the "PETmobile" — a comfortably controlled vehicle for the transport of the fully shielded syringe to the patient.

Figure 1. Building of the PET Centre in Prague (opposite the main hospital building).

Figure 2. Main building of the Na Homolce Hospital (opposite the building of the PET Centre).

Figure 3. Clean area: Preparation of ^{99m}Tc labelled radiopharmaceuticals.

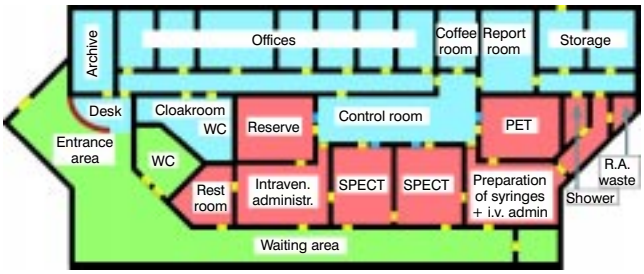

Figure 4. Outpatient room layout. Green: patient area; red: controlled zone; blue: staff area.

Figure 5. Entrance area. The receptionist is shielded by a concrete-filled counter.

Figure 6. Cyclotron IBA, model Cyclone 18/9.

Figure 7. PET scanner CTI, model ECAT EXACT.

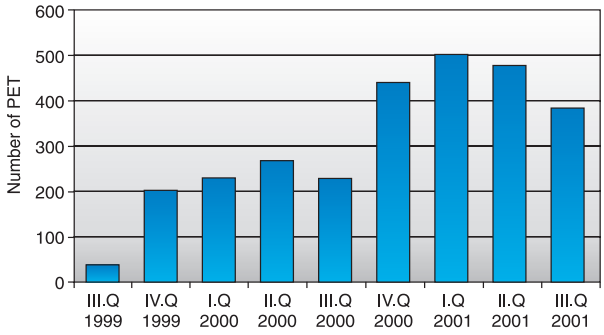

Figure 8. Number of PET scans performed per quarter of years. Operation started on August 25, 1999. Clearly apparent is the positive effect of the second shift (IV.Q/2000) and the negative effect of the holiday period (III.Q).

Operations

The regular delivery of 5 GBq FDG on every working day morning started on August 25, 1999. Until the end of that year the very expensive investigation was neither covered by health insurance nor reimbursed by payments from patients. Intensive negotiations resulted in the approval of the reimbursement from January 1, 2000 of the full cost from mandatory health insurance. Since every citizen of the Czech Republic must be insured, the investigation is available to all citizens free of charge. Since autumn 2000, FDG have been delivered also in the afternoons, which has resulted in an increase in the number of investigations (Fig. 8).

The oncological investigations of the torso are the most frequent type of PET scans (82%). The range of oncological reasons for PET is shown on Figure 9. Brain PET (15%) comprises predominantly investigations for epilepsy and tumours due to the speciali-

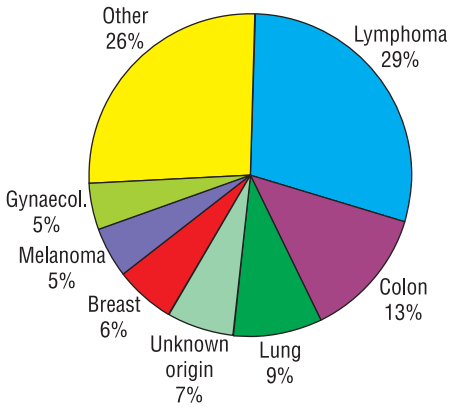

Figure 9. Frequency of reasons for oncological torso PET scan during last 12 months.

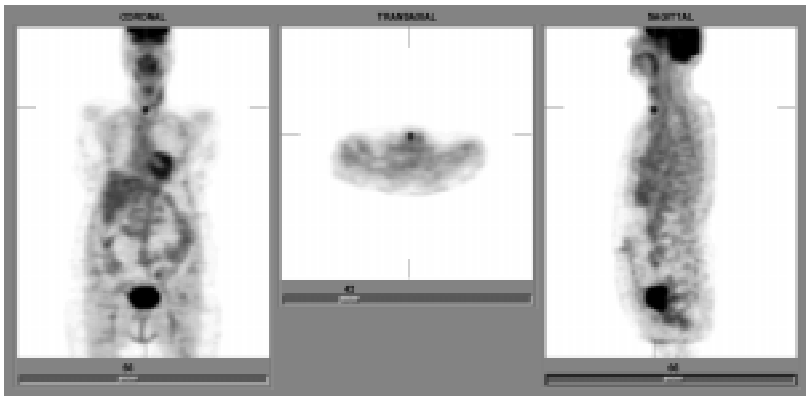

Figure 10. Patient with history of colorectal cancer is presented. Tumour recurrence is considered due to continuously growing CEA blood levels. All conventional investigations of the abdomen were negative. FDG-PET was also negative in the region of abdomen. Thanks to long field of view, PET enabled discovery of latent thyroid cancer duplicity in the time of no clinical signs.

sation of the Na Homolce Hospital. Myocardial viability investigations represent 3% only, since this can be investigated also at other Prague centres using FDG-SPECT. The investigations are performed only in cases indicated by the referring doctor. The suitability of indication is first consulted with PET Centre specialists. The waiting list has so far been kept to one to three weeks. However, increasing awareness among doctors of the method leads to a continuously growing interest and it is clear that the only solution would be the installation of the second scanner.

Conclusion

The PET Centre Prague became a reality as a model project thanks to the co-operation between the Na Homolce Hospital and NRI, and also to the technical and financial assistance from IAEA. The Centre provides a dignified environment for patients and also offers convenient working conditions for the staff. The modern technology applied and the experience of more than 3,000 performed PET investigations is a good basis for high quality diagnostics. The results of the studies performed so far (www.homolka.cz/nm/odb/publikace-e.html) testify to the achievement of diagnostic parameters comparable with literary data. A very important circumstance is the fact that PET investigations are fully covered by medical insurance.

PET today is no longer the cream at the top of nuclear medicine, accessible only to large universities in the technologically most advanced countries. PET has become a clinical tool which ought to be available in all countries where, for instance, chemotherapy is commonly administered to cancer patients. The price of one PET investigation is in fact comparable with the price of a single cycle of chemotherapy, and the rational application of the method leads both to the improvement of the health status of the individual patient (Fig. 10) and, eventually, to savings in national health care.

Acknowledgment

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