III. 16 Installation of a Positron Tomography

Ito M., Yoshioka S., Matsuzawa T., Fukuda H., Yamada K., Endo S. and Ido T.*
Research Institute for Tuberculosis and Cancer, Tohoku University
Cyclotron and Radioisotope Center, Tohoku University

Experience of applications of cyclotron for medicine is growing in the fields of both cancer treatment with high energy particles and in vivo measurement of tissue function or metabolism using short lived isotopes. The positron nuclear medicine seems to be superior to ordinary single photon techniques in sense of accuracy in measurement of tissue concentration of radioisotopes and possibility to use new attractive radiopharmaceuticals labelled with 18-F, 11-C, 13-N, etc., which are essential elements of human body.

Three major components of positron nuclear medicine are cyclotron, radiochemistry and imaging systems. We have run cyclotron for 3 years, and achieved to install labelling systems in a short time and finally been equipped with a positron computed tomography, ECAT II(EG&G Ortecs) in 1981.

System description

The ECAT scanner is composed of;
1. Scanning unit: patient couch and scanning frame (gantry).
2. Data acquisition system: detectors (66 NaI's, hexagonary arranged), coincidence circuit etc.
3. Computer, display, and data storage system. Views of the scanner are shown in Fig. 1 and 2.

Principle of the coincidence detection

A pair of gamma rays emitted by a positron annihilation can be detected using a pair of opposing detectors combined by a coincidence electronic circuits. A hit of a photon on one of detectors opens the coincidence time window for a very short instance and another hit on the opposing detector within the period proves the occurence of annihilation on a line between the detectors. Scatters hardly hit both of opposing detectors so that they may be eliminated as noise (Fig. 3, 4). Therefore collimation with heavy lead is not necessary (electronic collimation).

Another advantage of positron detection is easy correction for tissue photon attenuation. Because a pair of photons always traverse to two opposite direction, path length of the photons through an object, therefore probability for tissue photon attenuation, does not depend on depth of the isotope from body surface. Thus tissue attenuation can be easily corrected using transmission data collected with a ring source equipped to the scanner. Therefore concentration may be compared quantitatively between isotopes exist deep in the body and those near the surface. Performance of the scanner is described elsewhere in the book.

Some ECAT images are shown in Fig. 5 and 6.
Fig. 1. Scanning console of ECAT II.

Fig. 2. Gantry and patient couch of ECAT II.
Fig. 3. Principle of annihilation photon pair detection with the coincidence electronic circuit.
Fig. 4. Detector arrangement and way of scatter subtraction. Each detector of a bank is connected only with the opposite bank by a coincidence circuit. Accidental hits of two detectors by scatter (A & E in the figure) do not pass through coincidence gate and can be eliminated.
Fig. 5. ECAT image of VX2 tumour of a rabbit (viewed from hip). A large necrotic tumour in the left thigh and neighbouring metastasis are clearly visualized. The rabbit are injected C-11 glucose solution. Animal's contour is determined by processing of a transmission image.

Fig. 6. F-18 fluoro-deoxy-mannose image of a rabbit with VX2 tumour (viewed from hip). A tumour in the right thigh is apparent.