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Performance characteristics of a small animal PET camera for molecular imaging

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Background. Molecular imaging using an animal PET camera is a powerful technique for studying the bio-distribution of radiolabelled tracers and ligands, offering a means for in-vivo assessment of new drugs and disease related biochemical processes. The design of such imaging experiments must be guided by knowledge of the performance characteristics of the PET camera. For example, the scientist will need to determine the amount of a compound that must be administered in order for the radiolabelled molecule to produce a PET signal with sufficient strength and resolution to allow detection, visualisation and quantitation. We recently installed a novel type of animal PET camera, the quad-HIDAC, of which only three others are installed world-wide (London, Switzerland, Germany).
The PET Camera. The HIDAC animal PET system, developed by Oxford Positron Systems, is based on high-density avalanche chamber detector modules consisting of argon-flooded multiwire proportional chambers (MWPC) with integrated converter plates made up of laminated layers of lead and insulating sheets, drilled with a dense matrix of small holes, as shown on the left. In each module, the incoming 511 keV photons interact in a converter plate by photoelectric and Compton processes to eject electrons into holes where they are amplified and extracted under a high electric field gradient into the MWPC. The x-y coordinates of the event are recorded by the orthogonal cathode tracks. The holes of the converter planes are 0.4 mm in diameter and 0.5 mm from centre to centre. Four detector banks, each comprising four HIDAC modules, surround the imaging port. The axial field of view is 28 cm long and the transaxial FOV is 17 cm in diameter. Due to the detector design, the HIDAC system inherently yields information on the depth of interaction of the photon in the detector banks. Energy information cannot be obtained with this detector design, but some discrimination of low-energy photons is inherently performed because of the reduced sensitivity of the detectors to low-energy gammas.
Results. The following performance parameters were determined. The values of mean spatial resolution in the three spatial planes were 1.02mm in the horizontal direction, 1.00 mm in the vertical direction, and 0.97mm in the axial direction. Furthermore, measurements across the field of view showed these resolution results to be invariant within a standard deviation of 0.05mm. Therefore, the volumetric resolution is 1.0 cubic mm, or 1

microlitre, which is better than for any other PET system. Absolute sensitivity (scatter-corrected) measured with a point source was found to be 0.75%. Count-rate capability measurements showed a near-linear response at low activities, rising to a 20% loss rate at an activity of 11.5MBq. These results will be essential in designing animal imaging studies for in vivo assessments of new compounds and biochemical processes. A preliminary study using [18-F]-Fluorodeoxyglucose (FDG), shown on the right, clearly demonstrates superb detail of the in vivo tissue biodistribution of glucose metabolism, with muscles, heart, and individual vertebrae musculature being well defined.
Conclusion. This PET camera was found to have better spatial resolution and better uniformity of response over a larger field of view than has previously been reported, and should allow excellent imaging assessment of small regions of radiotracer uptake in the mouse.

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