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RADIOPHARMACEUTICALS IN PET, PROGRESS AND PROMISE

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The PET method is designed to probe human biochemistry and physiology in both normal and pathological states. Its strength lies in the ability to allow the determination or delineation of these biochemical or physiological parameters in a quantitative manner. The technology is driven by the short half-life of the major positron emitters, carbon-11, nitrogen-13 and fluorine-18 and oxygen-15 and their associated radiotracers. Radioisotope generators such as the strontium-82/rubidium-82 parent-daughter, germanium-68/gallium-68 and a number of other potentially useful positron emitters such as bromine-75 can also be considered for PET, but will not be covered in this presentation.

The vitality of PET and its integration into clinical practice will continue to be inextricably related to the advances in chemistry and instrumentation made at the major cyclotron-PET centers and to the rapid transfer of the fruits of basic research and the new high technology to the clinical sector. Currently there is a lag between advances in the basic research arena and their translation into routine clinical practice.

Many of the new radiotracers discussed below are not available for routine use because the automated, robot-operated or remote systems required for their production have not been commercialized. For example, the number of syntheses of carbon-11 and fluorine-18 compounds reported in the literature to mid 1988 were 428 and 240 respectively. The first synthesis of a carbon-11 labeled compound was reported in 1941 and the first synthesis of a fluorine-18 compound in 1967. Yet of all of these compounds reported, only a few of these have seen universal or nearly universal application, e.g. 2-deoxy-2-[^{18}F]fluoro-D-glucose, the various fluorine-18 or carbon-11 labeled butyrophenones, and 6-[^{18}F]-fluorodopa. In the near future the fluorine-18 labeled steroids may see wider applications. In addition to these compounds, oxygen-15 labeled oxygen, water, carbon monoxide and carbon dioxide and nitrogen-13 labeled ammonia are fairly widespread in clinical use.

The major focus to date has been the investigation of the normal and pathological states of the heart and brain including brain tumors. Studies are beginning to appear which encompass other tissues and organs such as lung, liver, pancreas, breast and prostate.

Each organ presents special challenges in the development of suitable labeled compounds designed to probe a specific normal or aberrant biochemical function.

The general aspects of PET and its capabilities have been described in depth in several books (1,2). Chapters on Radiopharmaceuticals in PET can be found in these books (3,4). In addition, a short monograph on the synthesis of positron emitter labeled compounds has also been published (5). A more recent general overview of radiopharmaceuticals for PET (and other aspects of

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