The evolution of positron emission tomography

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This editorial is based on a review of original articles that marked important milestones in the long journey leading positron emission tomography (PET) from a purely scientific method of probing important physiological variables to an imaging tool of recognised value in clinical practice. Like conventional nuclear medicine, the principle of PET is based on the concept of tracer kinetics, which is a measurement of physiological activities resultant from biochemical changes. Unlike nuclear medicine, PET measures biochemical activity at a more basic molecular level because the "probe" is by itself a simple molecule identical to or indistinguishable from the basic biochemical substrates. Its characteristic of positron decay has the advantages of high energy and coincident photon emission, giving PET one more degree of freedom for attenuation correction and true quantification. The common positron emitters (^{18}F, ^{11}C, ^{13}N, ^{15}O) are basic elements of the backbone in organic chemistry, implying that there is an unlimited potential in the investigation of various biochemical pathways.

The potential of these positron emitters in biochemical processes was first discussed early in the 1930s and 1940s[1]. Investigators at Washington University at St. Louis and later at Hammersmith Hospital of London in the 1950s initially proposed that they could be truly applied in biochemical research. In 1964, Washington University was funded by the National Institutes of Health to install the first medical cyclotron in USA, later followed by installations at the Massachusetts General Hospital and Memorial Sloan-Kettering Cancer Center. A positron tomographic system was initiated in Brookhaven National Laboratory for cerebral studies shortly after, and then followed by the eventual birth of the first generation PET scanner dedicated for imaging purposes in the early 1970s at Washington University[2,3].

From the 1970s to 1990s, the development of PET went through more than two decades of tedious research and development. It was a joint force of effort from the scientists of various specialties through improvement in scanner and computer technology, biochemistry and labeling techniques. Among these, technological breakthrough was particularly important in major developments such as multislice detection capability, steady encoding Anger logics, higher crystal efficiency and the use of fluorine-18(F-18)-2-fluoro-2-deoxyglucose (FDG) in the measurement of anaerobic glycolysis.

The key and turning point in putting PET from research to common clinical use came in early 1998 when the USA Food and Drug Administration (FDA) finally approved PET using FDG as a reimbursable imaging technique for evaluation of lung cancer and lung nodules. At that point, financial support started to grow exponentially, naturally paralleled by even greater research opportunities and development of clinical use in many other various disease entities. Nonetheless, final acceptance of PET into clinical oncology and other general aspect of medicine did not occur until the introduction of hybrid PET-computed tomography (CT) scanning technology in 2000-early 2001[4,5]. Clinicians became more convinced of the functional information supplied by PET when the "unclear" background was substituted by a clear CT anatomical roadmap. In recognition of this innovative technological breakthrough by combining molecular information with structural data, PET-CT was named by Time magazine as one of the three greatest inventions of the year 2000[6].

In this issue of the Singapore Medical Journal, original PET research from local data is presented[7,8] as well as another paper from Spain[9]. It is interesting to note that two of the papers are on the application of PET-CT on thyroid disease, which is actually regarded, in general, as one of the relative indications for this imaging. Ong et al has data to support the complementary nature of PET-CT and I-131 scintigraphy in a situation when the latter failed to show metastatic thyroid tumour recurrence in cases of increasing thyroglobulin level[7]. Furthermore, they have added valuable

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data, albeit small, to the literature that thyroid stimulating hormone has no significant impact on their metastatic cancer detection rate. Low et al, on the other hand, has reminded the general physicians that it was not so uncommon for thyroid malignancy to coexist with thyrotoxic nodules[8]. They have demonstrated this finding with a case report backed up by a thorough review of similar cases in the literature. Both papers have contributed useful and meaningful evidence to support that the indications and utility of PET-CT have been well applied in the medical community of Singapore. Considering its young history of only about two years, this is the beginning of a great leap towards a bright future. Perhaps, the next step is to move on to the research and testing of non-FDG radiopharmaceuticals. SMJ

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