The Status of the EXPLORER Total Body PET Scanner Program

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The status of the construction of the World's first Total Body PET Scanner within the EXPLORER program is reported, and the vision outlined of its applications in healthcare and clinical research.

Positron emission tomography, is the most sensitive and specific means for quantitatively imaging molecular interactions and pathways in humans.[1] Its use in clinical research, has led to numbers of exciting discoveries in regional tissue function in health and disease. However there have been have been experienced 4 main physical restrictions to PET not realising its full investigative potential in healthcare and research namely: i) Image quality is poor compared to other imaging modalities due to there being recorded a limited number of photons-"photon deficient" ii) When time series PET data is recorded for tissues, along with the arterial input function, the image data can be processed, through kinetic models, to derive quantitative values of the rate constants of the tracer's exchange in the tissue being imaged. However, sampling of arterial blood is invasive and in practise is undertaken infrequently iii) It has only been possible to record one area of the body at a time despite the labelled tracer's being distributed throughout the whole body, iv) There is a defined limit as to how much radiation absorbed dose can be administered which restricts image quality.

The reason for these restrictions is that the axial field of view of a PET scanner is typically limited to around 24 cms. This results in less than 1% of the photons emitted from the body being detected from a subject to which a radiotracer has been administered. The 2metre axial field of view EXPLORER will serve to overcome these 4 restrictions. This instrument is destined to emerge from the EXPLORER consortium on the USA, which realised NIH funding to enabling the first Total Body PET Scanner to be constructed by the Chinese company: United Imaging Healthcare-see figure[2]. Consisting of a total of 560,000 individual detector elements of 2.76mm in size, data will be recorded in either time frame mode or the total singles streamed for off-line analysis. The coincidence resolving time is 409 +/- 39 pico seconds. An X-Ray CT scanner is mounted at the front of the scanner whose detector elements are sufficiently noise free to result in CT scans undertaken with radiation absorbed doses comparable to those experienced with planer digital radiology. The first scanner is due to be completed during the first quarter of 2018, and after physical testing, and used to file for FDA approval, will be shipped to the University of California, Davis for further physical testing and the first clinical applications.

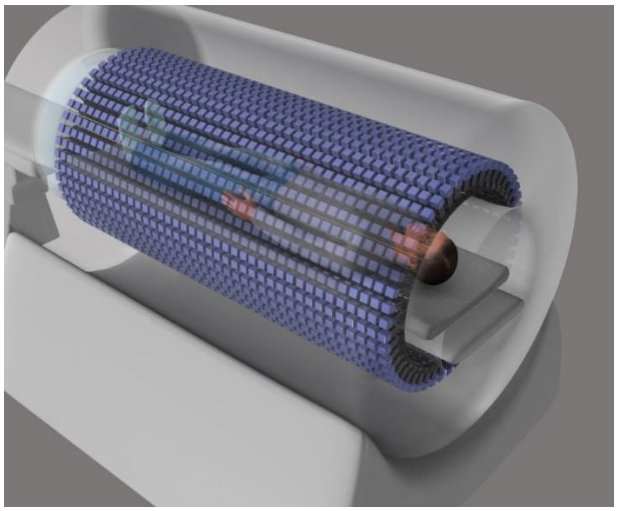

Figure: EXPLORER: The World's first Total Body PET Scanner. Construction to be completed in the first quarter of 2018.

With the estimated commercial purchase price of this scanner being about $10M, there are those who believe the scanner will be too expensive, and its use limited to a niche area. However, a recently published review of the history of PET scanner development, pointed out that the cost of improvements in PET scanner technology over the years, has been absorbed by the improvement in applications[3]. This implies that the cost: benefit trend will extend to there being affordable Total Body PET scanners. To substantiate this belief, the following summarises some of the projected applications in healthcare and clinical science:

In current Nuclear Medicine health care applications, the emphasis is on whole body PET scanning in cancer using ^{18}FDG and other imaging bio-markers; extending to support for theranostics programs.

The quality impact that Total Body PET Scanning will bring includes: i) higher quality images, ii) the ability to provide image derived arterial input functions to routinely compute quantitative data on the rates of exchange of tracer without the need for invasive arterial blood sampling, iii) widen the range of applications of PET, as research, using total body PET Scanning, translates into healthcare procedures, iv) access to a wider range of imaging biomarkers from more distant commercial manufactures up to a further 5 half-lives away.

The practical and economic impact that Total Body PET Scanning will bring includes: i) faster patient throughput, ii) one scanner doing the workload of 3-4 conventional PET scanners and hence saving on space and personal, iii) the ability to easily prescribe image data of sufficient quality to meet the clinical question, iv) prescribing conventional PET scanner quality at 1/40 of the radiation dose to the patient, and hence less doses to staff handling patients, and those involved in the production of the tracer, v) avoiding having to establish costly Good Manufacturing Processing (GMP) for each new tracer, by virtue of being supplied with commercially produced tracers at some 5 further half-lives away from the scanning centre, vi) Extend the working day and even consider 24/7 working if supplied by distant sources of commercial manufactured imaging bio-markers, vii) provides the opportunity for undertaking both substantial routine healthcare and clinical research programs.

The experimental medicine applications of Total Body PET Scanning; transformative research:

- **Detecting occult low density multi-system disease** including: Ultra-staging of micro-metastases, atherosclerotic plagues, inflammation, and infection
- **Providing total body kinetics of:** Drug delivery / extended time courses / physiologically based pharmaco-kinetic models, pipe line for radio-labelled imaging biomarkers, Toxicology
- **Studying physiological interactions between the body's organs: "**Systems Biology"
- **Enabling low radiation dose studies**: Repeat studies, multi-parameter studies, normal subjects, young patients, maternal-fetal
- **Interactive brain: body studies:** Anxiety, depression, Alzheimer's disease, metabolic syndrome / obesity, central-peripheral neuronal synapse
- **Expanding the commercial future**: Translating experimental studies to clinical applications.

References:

T. Jones, "The role of positron emission tomography within the spectrum of medical imaging," Euro. J. Nucl. Med. Mol. Imaging 23(7), 807–813 (1996).

2. S. Cherry, R Badawi, J Karp, W Moses, P Price and T Jones "Total-body imaging: transforming the role of positron emission tomography (PET) in translational medicine," Sci. Trans. Med. 9, eaaf6169 (2017) 15 March 2017

3. T Jones and D Townsend "History and future technical innovation in positron emission tomography Journal of Medical Imaging Jan–Mar 2017 • Vol. 4(1) 011013-2-to 011013-17