Total-body PET: Maximizing sensitivity for clinical research and patient care

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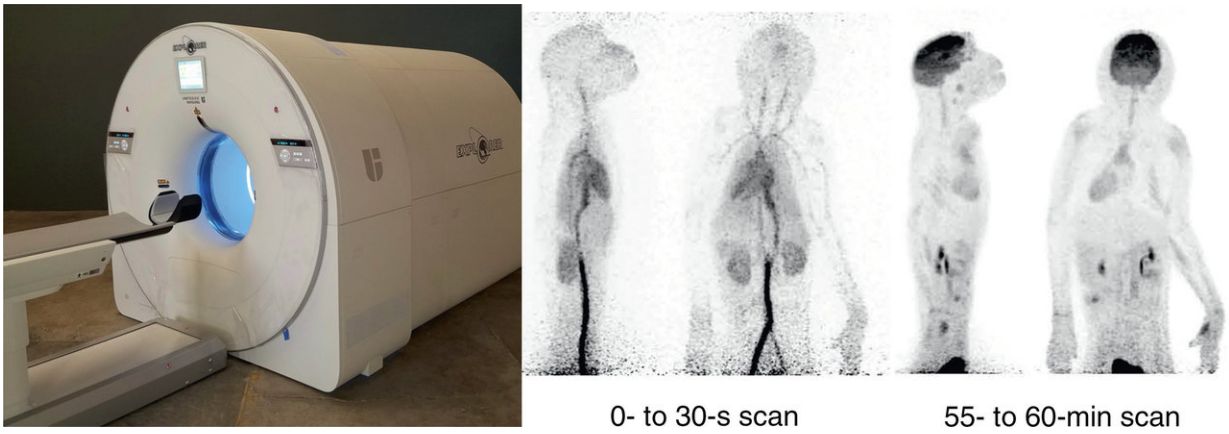

Photograph of the EXPLORER scanner (left) at UC Davis Medical Center and maximum intensity projection images of two frames from a mini-EXPLORER dynamic total-body imaging study following injection of 8.5 MBq 18F-FDG (1/10th standard activity) in a 4.6 kg rhesus macaque. Credit: Simon Cherry et al., University of California, Davis, Calif.

The new total-body PET/CT scanner could revolutionize our understanding and treatment of disease through analysis of better imaging data from the whole body. In The *Journal of Nuclear Medicine* (JNM) featured January article, scientists at the University of California, Davis (UC Davis), outline the development and benefits of this innovative diagnostic tool and explain how maximizing PET sensitivity will advance clinical research and patient care.

Positron emission tomography (PET) is widely considered the most sensitive technique available for non-invasively studying physiology, metabolism and molecular pathways in the living human being. However, there have been drawbacks, including low signal-to-noise ratio (SNR) affecting image quality, long imaging times and concerns regarding radiation dose.

Total-body PET, which encompasses the entire body within the field of view and allows imaging of all the tissues and organs of the body simultaneously, promises to be a game changer.

"It will offer the ability to detect throughout the whole body the location of focal pathologies, including cancer, infection, and inflammation at considerably lower levels of disease activity than is currently possible," explains Terry Jones, DSc, clinical professor of diagnostic radiology at UC Davis.

He points out, "It will also reduce the time taken to scan the whole body by at least a factor of 10, leading to scan times that could be less than one minute. This, for example, will make it far easier to scan infant and pediatric subjects without anesthesia or sedation."

Radiation exposure is reduced as well. Jones notes, "Whole-body PET scans could be performed for a radiation dose roughly equivalent to that received from a round-trip transatlantic flight."

By covering the entire body at once, sensitivity is increased by a factor of ~40 for total-body imaging, or a factor of ~4-5 for imaging a single organ such as the brain or heart. Significant improvements in timing resolution could lead to even further sensitivity gains.

The JNM article states, "Total-body PET offers several opportunities to change the methodological approach to cancer detection and staging, and

this same methodology could also be applied to other systemic conditions, including inflammation (e.g. sarcoidosis), vascular disease, sepsis and infectious disease. The increased sensitivity and dynamic range of total-body PET will allow imaging at high SNR at much later times after tracer injection."

Jones adds, "The ability to study the simultaneous interaction of specific molecular/physiological processes between all the tissues/organs of the body—'systems biology' of the human body in health and disease—is especially relevant for functional brain-body, and body-brain interactions that occur in certain psychological, psychiatric, neurological, and inflammatory conditions."

This new technology is nearing clinical readiness. UC Davis, in collaboration with United Imaging Healthcare, has completed the design of the first prototype total-body PET/CT scanner, called EXPLORER, and components are currently being fabricated and tested. The CT scan is acquired as the patient moves into the PET scanner. A smaller-scale, mini-EXPLORER is for researchers to conduct total-body PET imaging in nonhuman primates.

Total-body PET/CT was initially conceived for clinical research, and it will be a boon for researchers. For example, the ability to determine the pharmacokinetics of new drugs in all the organs and tissues of the body at very low masses and radiation doses has the potential to accelerate the translation of new therapeutic agents to clinical practice.

It has become clear, however, that the new scanner will also impact patient diagnosis and care. "The applications of nuclear medicine will expand considerably across internal medicine at a rate not witnessed to-date, and will become more evenly distributed across the age spectrum," says Jones. "There will be a considerable stimulus/investment to develop new imaging biomarkers especially within immunology and

endocrinology."

He anticipates changes in nuclear medicine departments as well, stating, "One total-body PET scanner could take on the work load of three-to-four conventional PET scanners, and being able to receive imaging biomarkers from more distant distribution centers [due to the scanner's increased sensitivity, which gives biomarkers increased shelf life], will minimize the need for costly in-house biomarker production."

Addressing the cost issue, Jones also points out, "As the impact of high-sensitivity, total-body PET scanning becomes apparent, this will provide a major stimulus to physicists, chemists, and engineers to develop lower-cost detectors for total-body surveillance."

In short, Jones sees the development of total-body PET/CT as "nuclear medicine coming of age."

More information: Simon R. Cherry et al, Total-Body PET: Maximizing Sensitivity to Create New Opportunities for Clinical Research and Patient Care, *Journal of Nuclear Medicine* (2017). DOI: 10.2967/jnumed.116.184028

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