Total-body PET/CT - first clinical experiences and future perspectives

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Introduction

Total-body PET and long axial field of view (> 77 cm) scanners have been in development since the 90's and now available commercially world-wide. The first total-body PET/CT in the US, uEXPLORER, was installed at UC Davis in 2019 as part of the EXPLORER Consortium.

We describe potentials of this scanner, impact on diagnosis and quantification, early clinical challenges at our institution, and future perspectives.

Figure 1: uEXPLORER total-body PET/CT at UC Davis

Scanner characteristics

The uEXPLORER total-body PET/CT is composed of 8 PET units along the axial direction, forming a total axial length of 194.0 cm (conventional=15-35 cm) and provides signal collection efficiency gain (15–68-fold compared to conventional length PET) and high spatial resolution. Using a 57° acceptance angle makes it possible to simultaneously image most organs of interest in adults in a single bed position with uniform quality. This allows for higher sensitivity and improved lesion detection, enhancing clinical applications not readily available on current conventional scanners.

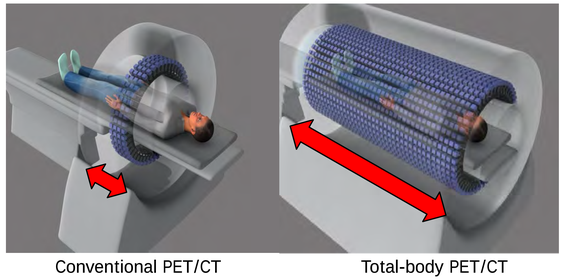

Figure 2: Comparison of conventional vs total body PET/CT

Enhanced clinical applications of Total-body PET/CT

Improved Image Quality

Improved spatial resolution and sensitivity is best demonstrated by the substantial improvement in image quality compared to conventional scanners which allows for better appreciation of small structures such as small metastasis which can have downstream prognostic consequences.

Decreased Acquisition Time

Advancements in sensitivity and spatial resolution in total-body scanners can be used to decrease the overall acquisition time (20->2.5 min) while maintaining diagnostic quality images. This may be beneficial for pediatric/anesthesia patients, high volume hospitals, motion mitigation (pain/unable to tolerate long), and radiotracers with transient uptake (impacts biodistribution).

Dose reduction

High signal collection efficiency allows a significant decrease in the injected activity (8->0.5 mCi) with minimal impact on image noise, reducing effective radiation dose to the patient, improve staff safety and may help with logistical concerns for shorter lived radiotracers.

Delayed scanning

Ability to acquire diagnostic quality images with small amounts of activity provides flexibility in the timing of image acquisition allowing for acquisition at delayed time points (standard ^{18}F-FDG doses from 20 min-> 12 hrs). This can increase detection of small and previously occult lesions by improved clearance of significant background activity and coexisting inflammatory processes.

Simultaneous Total-Body Dynamic Imaging

Total-body PET enables simultaneous imaging of the entire body allowing for measurement of full spatiotemporal distribution of radiotracers, kinetic modeling, creation of multiparametric images, and providing simultaneous whole body physiologic and biologically relevant data.

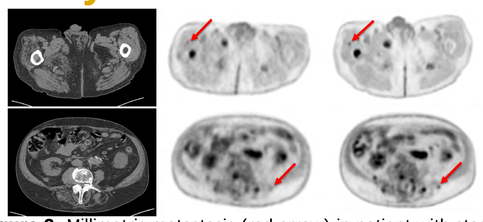

Figure 3: Millimetric metastasis (red arrow) in patient with stage 4 lung cancer on uExplorer (right) and conventional (Siemens Biograph, middle)

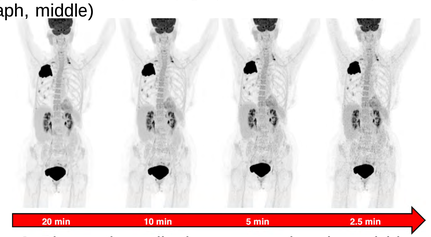

Figure 4: Diagnostic quality images at reduced acquisition times (as low as 2.5 min) in a patient with right upper lobe lung cancer.

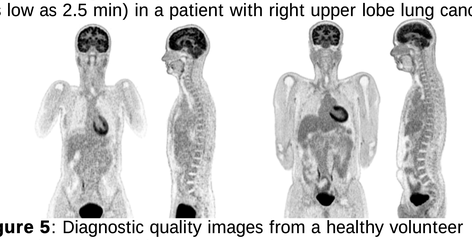

Figure 5: Diagnostic quality images from a healthy volunteer scanned on the total-body scanner with 2 mCi (right) and 0.5 mCi (left) ^{18}F-FDG

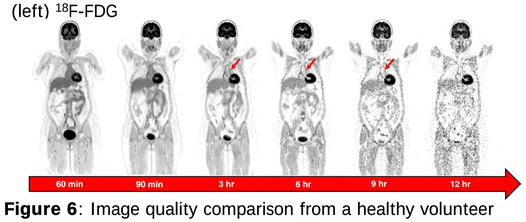

Figure 6: Image quality comparison from a healthy volunteer scanned on a total-body scanner at different uptake-times with noted clearance in blood pool over time.

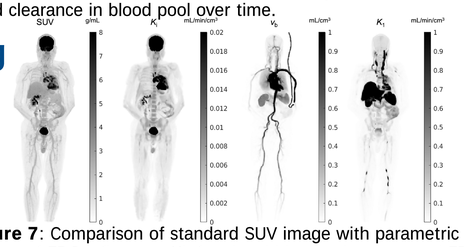

Figure 7: Comparison of standard SUV image with parametric images of FDG influx rate Ki, fractional blood volume v_b, and FDG delivery rate K_1 of a cancer patient

Limitations and challenges

Higher sensitivity of total-body scanners bring along new limitations and challenges as this potentially increases false positive findings due to the increased prominence of small findings and variable (shortened/delayed) scanning can cause new logistical workflow issues.

Data storage capacity, longer processing/reconstruction time due to the large data sets acquired are other limitations but may be overcome by future advancements in reconstruction algorithms and computing hardware.

Questions remain in knowledge regarding to what extent image quality improvement adds to clinical value beyond what is currently available, and such questions are being addressed/explored in our future research.

Conclusions

Total-body PET imaging at our institution has demonstrated many advantages over conventional PET. However, comes with considerations and challenges for adaptation of existing logistical workflows and clinical radiologic interpretation. With better understanding of the potential of total-body PET, smooth implementation and optimization of this technology can be achieved.

Acknowledgements

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Reference

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