Dynamic PET Perfusion Imaging (DPPI) to Characterize Thoracic Tumors: A Phase I Assessment of Ultra-fast Digital PET as an Imaging Biomarker

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Aims and objectives

Dynamic PET perfusion imaging (DPPI), despite its long history, has become a forgotten technique as clinical perfusion imaging moved to dynamic contrast enhanced MRI and CT. We intend to redevelop DPPI using next-generation digital PET technology and focus in this Phase I study on thoracic applications. Next generation digital PET facilitates the clinical use of dynamic acquisition as short whole-body tables times enable more patients to be imaged per hour than typically injection suites are available. Therefore we envision the comprehensive PET examination of the future to be of 10 min total table time, 5 min for perfusion and 5 min for whole-body PET imaging. Perfusion characteristics are known to give important insights into lesion characteristics as had been established with ^{15}O water studies as well as DCE MRI.As no additional tracer is needed, there are no increased cost even with full clinical PET scanner utilization.

Images for this section:

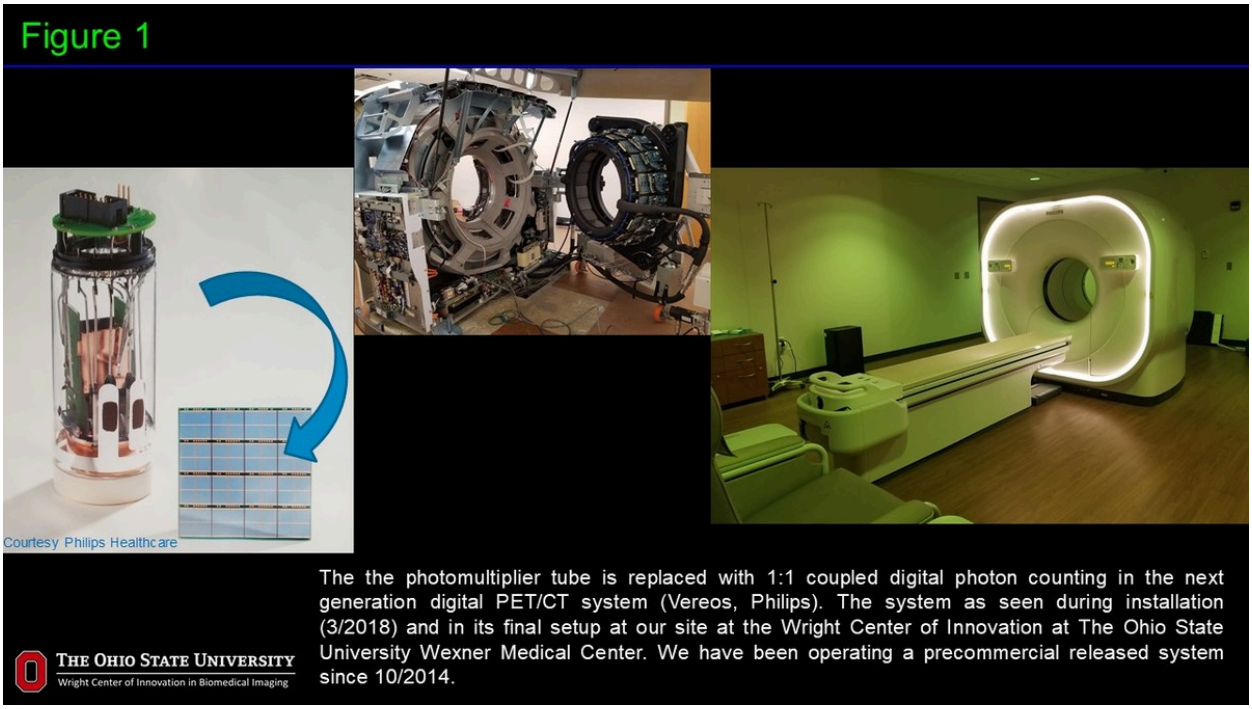

Fig. 1: The photomultiplier tube is replaced with 1:1 coupled digital photon counting in the next generation digital PET/CT system (Vereos, Philips). The system as seen during installation (3/2018) and in its final setup at our site at the Wright Center of Innovation at The Ohio State University Wexner Medical Center. We have been operating a precommercial released system since 10/2014.

Methods and materials

Dynamic FDG PET/CT was performed prior to radiation therapy of advanced thoracic tumors (lung and esophageal) in 24 patients using a next-generation digital photon counting system (Vereos Philips, dPET).

DPPI was performed at the time of bolus injection of ~185 MBq FDG over a volume of interest for 15 min.

PET listmode data were reconstructed using a range of 1 sec/fr to 60 sec/fr.

Blinded review by two experienced PET readers and descriptive statistics were calculated for data analysis.

Results

Dynamic PET Perfusion Imaging can be readily obtain using current and next-gen digital PET systems. The image quality was consistenly diagnostic, however required optimzed reconstruction adjusting for the count sparsity of very short frame times.

Fig.2 presents a coronal view of a DPPI at 1min/frame of patient with an esophageal tumor, Fig.3 using 15 s/ frame both over the first 15 min. Fig. 4 at 9 s/frame over 4 minutes and Fig. 5 at 1 s/frame over 1 min.

Fig. 6 Present the baseline and follow up whole body scans and Fig. 7 presents the dynamic uptake time curves of the four different resolutions at baseline and follow up.

Frame rates of 10 sec/fr led to high quality uptake time curves of the well delineated tumors enabled by a count density adaptive reconstruction approach.

The first 2 min duration of the dynamic series were found to be the most relevant for the perfusion assessment. Uptake time curves were found to be highly analogous to characteristic findings in DCE-MRI.

Images for this section:

Fig. 2: Dynamic PET Perfusion of an Esophageal Cancer at 1 min temporal resolution after injection of ~ 185 MBq FDG.

Fig. 3: Dynamic PET Perfusion of an Esophageal Cancer at 15 s /frame temporal resolution over 15 min p.i.

Fig. 4: Dynamic PET Perfusion of an Esophageal Cancer at 9 s /frame temporal resolution over 4 min p.i.

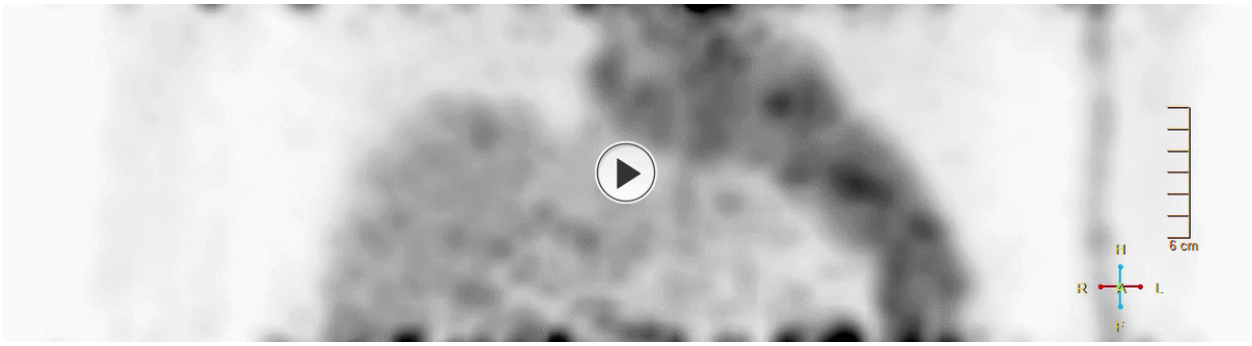

Fig. 5: Dynamic PET Perfusion of an Esophageal Cancer at 1 s /frame temporal resolution over 1 min p.i.

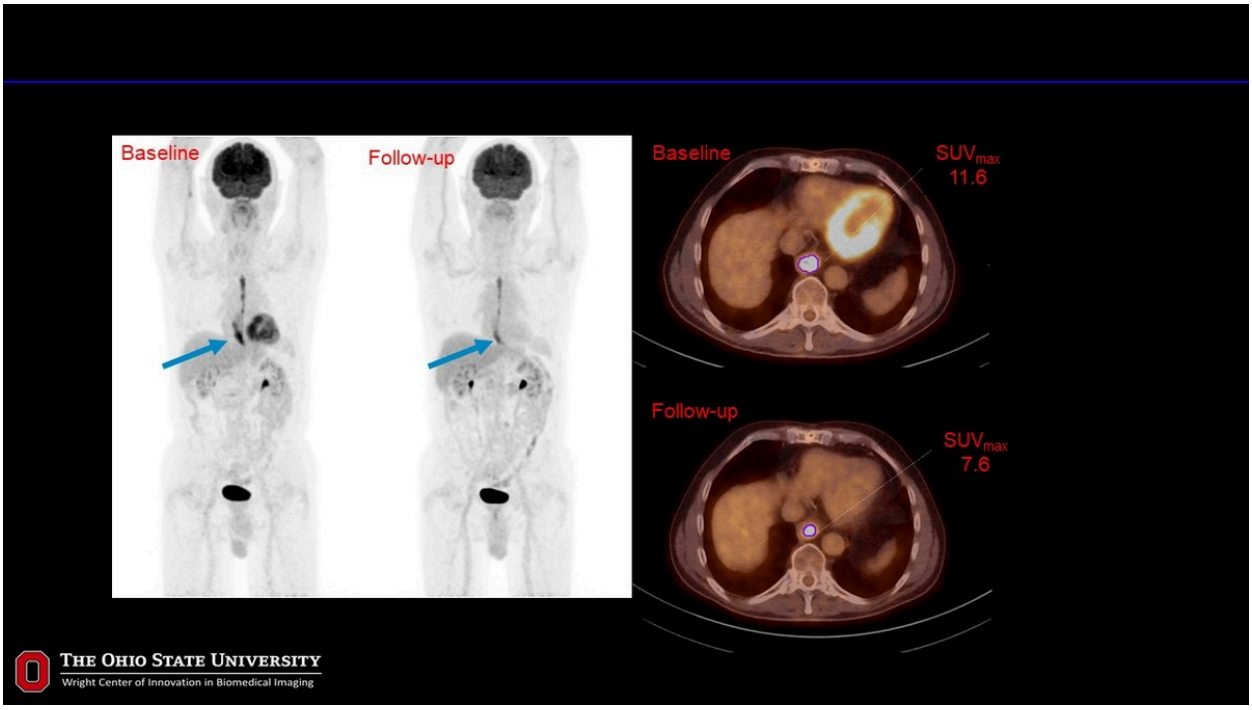

Fig. 6: Whole body PET and axial fusion images at the level of the esophageal tumor at baseline and post radiation therapy.

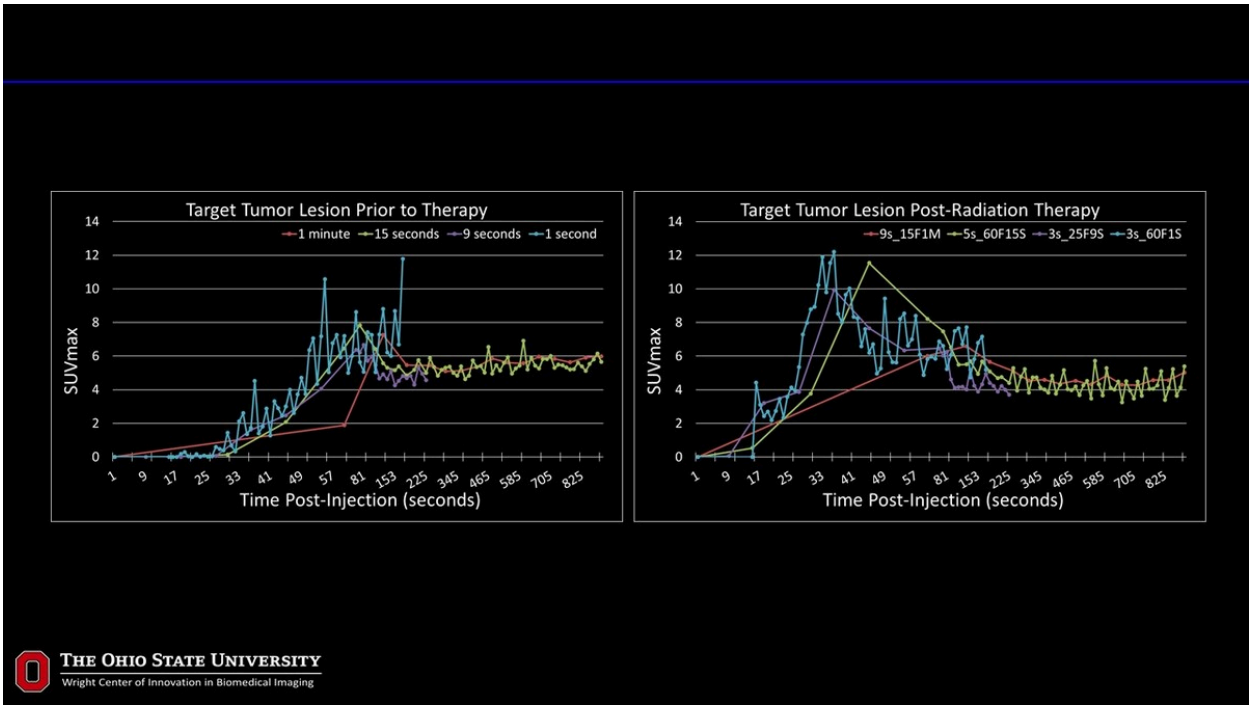

Fig. 7: Uptake time curves from the esophageal tumor at the four different temporal resolutions 1min, 15s, 9s, 1s at baseline and follow up after radiation therapy.

Conclusion

Dynamic PET Perfusion Imaging (DPPI) was achievable using frame rates of 10 sec with acceptable quality for quantitative and visual assessment even at the low FDG dose of 185 MBq.

A short table time of 5 min appears to be sufficient for DPPI acquisition and thus appears to be a clinically viable perfusion imaging methodology that can now be validated in larger trials.

Personal information

This research and development was performed by a multi-disciplianry team at the Wright Center of Innvation in Biomedical Imaging (WCIBMI) at the Ohio State University Wexner Medical Center and James Comprehensive Cancer Center. Michael V. Knopp is Professor of Radiology, Novartis Chair of Imaging Research and the PI/Director of the WCIBMI. Contact: knopp.16@osu.edu, 395 W 12th Ave., Suite 430, Columbus, Ohio 43210, USA

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