Title: Quantitative Hybrid PET/CT for Cancer Imaging: Diagnosis and Monitoring Treatment Response

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Structured Abstract:

Hybrid PET and CT imaging is an imaging modality that allows contemporaneous PET metabolic/molecular imaging using tracers that target specific aberrant metabolic or molecular processes in the tumour, and CT anatomical imaging with or without contrast during a single diagnostic session on a single device. Current clinical applications of hybrid PET/CT cancer imaging has relied heavily on measuring the tracer accumulation in the tumour as a surrogate of the pathologic activity targeted by the tracer or tumour size measurement, both of which lack sensitivity and specificity in detecting cancer and assessing treatment response.

Therefore, it is critical to developing quantitative techniques for assessing the physiologic and/or molecular characteristics of tumours with clinical PET/CT scanners to inform clinical decisions making. We hypothesized that quantitative hybrid PET/CT imaging could sensitively diagnose cancer and monitor its treatment response. Based on patient cohorts available from existing clinical trials, my PhD research focused on prostate cancer for cancer diagnosis and lung cancer for monitoring treatment response. Patients with histology-confirmed cancer were evaluated using dynamic PET imaging with appropriate tracers and CT Perfusion (CTP) with an iodinated contrast agent to evaluate the metabolic and pathologic molecular activity and perfusion in tumours.

In the lung cancer study (MISSILE-NSCLC), patients with early-stage non-small cell lung cancer were evaluated with dynamic [18F]FDG and CTP before and after stereotactic ablative radiotherapy (SABR) to assess imaging response and the results correlated with pathological complete response. A set of BV pre-SABR (baseline blood volume) and relative change in SUV-max was shown to be the most sensitive model to predict complete pathological response with sensitivity, specificity and AUC of 85%, 92% and 92%, respectively.

In the prostate cancer study (IGPC-2), patients were evaluated with dynamic 18F-FCH/CTP or 18F-DCFPyL/CTP, respectively, and correlated with biopsy and digital histopathological images. The most sensitive parameter set to localize and detect prostate cancer is the plasma net uptake rate (Ki) and the dissociation rate constant (k4) of 18F-DCFPyL with sensitivity, specificity and AUC of greater than 90%, in reference to both the biopsy and histology.

In conclusion, our studies show that quantitative functional parameters from dynamic PET and CTP can detect cancer and predict treatment response with acceptable performance metrics.