Title: Quantitative Hybrid PET/CT for Prostate Cancer Imaging: Application to 18F-DCFPyL and Comparison with 18F-FCH

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Structured Abstract:

Introduction: Prostate cancer (PCa) usually is characterized by the presence of multiple intraprostatic nodules consists of a dominant nodule and one or more smaller nodules. Recent studies with 18F-DCFPyL show that it is better to localize and detect PCa nodules with higher contrast to background than 18F-fluorocholine (FCH). Therefore, here we investigated whether the difference between the 18F-DCFPyL and 18F-FCH can be explained by their kinetic behaviour in PCa.

Methods: Patients with PCa were evaluated with either dynamic 18F-DCFPyL or 18F-FCH PET. The dynamic PET imaging protocol with each tracer consisted of 10 images at 10 s each, 5 at 20 s, 4 at 40 s, 4 at 60 s and 4 at 180 s for a total acquisition time of 22 min. Based on prostate sextant biopsy and a standardized uptake value (SUV) map constructed from the sum of the last 4 dynamic frames (12-22 min post injection), tumour and benign tissue regions of interest (ROI) are segmented. In addition to SUV, the ROI time-activity curves are fitted using the Johnson-Wilson-Lee (JWL) model to evaluate the following model parameters. Logistic regression with backward elimination will be used to determine the best parameters to distinguish tumour from benign tissue. Additionally, computer simulation was used to investigate how the estimated JWL model parameters vary with the signal-to-noise (SNR) ratio of the time-activity curve. The mean and standard deviation for each parameter were calculated based on multiple noise runs using known parameter values found in tumour and benign tissue.

Results: To date, 12 patients were evaluated with dynamic 18F-DCFPyL PET, and another 12 patients with similar characteristics (mean PSA, Gleason score, proportion of prostate involved with tumour) underwent dynamic 18F-FCH PET. Amongst SUV and the model parameters, dissociation rate constant (k4) and net uptake rate from plasma (Ki) were the best combination of parameters to discriminate tumour from benign tissue for 18F-DCFPyL while SUV and influx rate (k1) were the best combination for 18F-FCH. The bias and coefficient of variation (COV) of the 18F-DCFPyL parameter estimates were 1.22% and 10.39% for k4 and -0.16% and 1.75% for Ki and increased as the SNR decreased.

Discussions: The difference in PET images obtained with 18F-DCFPyL and 18F-FCH could be explained by the model parameters. Superior 18F-DCFPyL tumour contrast is due to the higher differential normalized washout from the bound pool, as estimated by the inverse of binding potential (k4/k3) in benign tissue than tumour. The higher binding rate constant (k3) of 18F-FCH than 18F-DCFPyL explains why 18F-FCH SUV can be used to differentiate tumour from benign tissue within minutes of injection. Computer simulation studies show that at the clinical doses used, 18F-FCH and 18F-DCFPyL model parameters can be determined with acceptable bias and COV (< 15%).