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Quantitative Image Derived Input Function from Long Axial Field of View scanners

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Introduction: With the recent introduction of Long Axial Field of View (LAFOV) clinical scanners with simultaneous acquisition of a field of view (FOV) of 1m or more, the sensitivity of PET scanners compared to otherwise state-of-the-art PET scanners with FOVs of 20-25cm, has increased dramatically due to the increased angular acceptance of coincidence events in the scanner. This creates new possibilities for input derived image functions (IDIFs) with high time resolution, low noise, and high spatial resolution.
Here we present the automatization of an IDIF generation on a high sensitivity Siemens Quadra scanner using [15O]-H2O. The derived IDIF is compared to arterial sampling and organ specific delays are estimated based on an automatic segmentation to illustrate the unique possibility of a self-consistent scan including organ specific input functions for whole-body perfusion data in a single session.
Methods: 5 clinically referred patients were included in the study after written consent. 400 +/- 50 MBq [15O]-H2O was injected for each scan session. Each patient underwent either one or two rest and acetazolamide (Diamox) phases, respectively, totaling 16 scan sessions. In one patient arterial blood was sampled by an Allogg automatic blood sampler with a 1 sec. sampling rate matching the shortest PET time framing.
PET data was acquired for a minimum of 3 min. in each session and subsequently reframed in 1x5s, 30x1s, 15x2s, 5x10s, 3x20s frames and were reconstructed using 3D-OP-OSEM with 4 iterations and 5 subsets including time of flight information in a 440x440x645 matrix resulting in 1.65x1.65x1.65 mm3 voxels.
The aorta was segmented by the SegTHOR algorithm on corresponding CT scans. The mask defined by SegTHOR was continuously pixel-wise eroded and optimized with regards to the area under the input function curve (AUC) and keeping the pixel noise in the curve low.
Organ segmentation including liver, lungs, kidneys, spleen, and bone were segmented using a deep learning network on the CT scan as implemented in the MIWBAS research prototype. The extracted masks where hereafter used to extract the mean tissue time activity curves.
Delays from both arterial input sampling and IDIFs were delay fitted using tpcclib (Turku PET centre, version 0.7.6) to the respective regions defined by the masks from MIWBAS. Before fitting, the masks were eroded by two voxels to minimize any edge artifacts on the statistical parameters of the volume. Dispersion was not considered for the IDIFs.
Results: The upper descending part of aorta was selected as a reference segment as the best comprise between diameter of the segment hence minimizing partial volume effects, low spill-in and the relatively small degree of motion in this segment.
An erosion corresponding to a final volume of approximately 4 mL was found to give both the best AUC agreement between arterial sampling and IDIF for both rest and Diamox phase. A good general agreement of peak height was found for the selected degree of erosion between delay and dispersion corrected AIF and IDIF. Additionally, the AUC and peak height were seen to converge towards a stable value indicating minor influence of partial volume effects after this point. The fitted mean delays for right kidney, left kidney, brain, liver (v. portae) and spleen were 3.5s, 2.7s, 2.3s, 18.4s and 1.4s, respectively, agreeing well with literature values.
Conclusion: An automatically derived aorta IDIF from convolutional neural network-based segmentations has been evaluated and compared to an arterial input function. We demonstrate the feasibility of an automatic input function segmentation pipeline on a LAFOV scanner allowing an individual organ input function hence minimizing kinetic model parameter estimation. This enables simultaneous whole-body perfusion in a single scan session with reliable IDIF as verified by comparison to arterial sampling.

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