Simultaneous Arterial Spin Labelling MRI and H_2O^{15} Position Emission Tomography

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Introduction

A number of studies have compared ASL-MRI and ^{15}O-water PET for the evaluation of ASL reliability and reproducibility. But none of these studies had the possibility to perform both techniques simultaneously to minimize the physiological variations. In this work, a simultaneous ASL-MRI and ^{15}O-water PET approach has been implemented on a hybrid MR-PET for a truly quantitative comparison between the two methods in absolutely the same physiological and functional status.

Materials and Methods

Quantitative measurements of cerebral blood flow (CBF) with PET using ^{15}O-water in comparison to MRI using ASL was performed with an integrated BrainPET-MR scanner developed by Siemens [1]. The BrainPET is operated as an insert within a slightly modified Siemens 3T MAGNETOM Trio MR scanner. The BrainPET is a newly constructed MR-compatible PET detector with an axial field of view of 19.2 cm and an inner diameter of 32 cm. Each detector module has a 12×12 matrix of 2.5×2.5×20 mm^3 individual lutetium oxyorthosilicate (LSO) crystals coupled to a 3 by 3 array of Avalanche photo diodes (APDs). 6 detector modules are aligned within a copper-shielded cassette. 32 of such cassettes form the cylindrical PET detector having an outer diameter of 60 cm fitting the MR bore. Two dedicated head coils for MR, an outer bird cage coil for transmit and an inner 8 channel coil for receive, are optimized with regards to minimal attenuation for PET, can be placed into the PET detector. The BrainPET-MR delivers PET images with an optimal resolution of 3 mm and allows the simultaneous acquisition of PET and MR images without any marked interference between the two modalities.

For ASL-MRI, a pseudo-Continuous Arterial Spin Labelling (pCASL) sequence has been considered for its high SNR [2]. pCASL uses a 1.4s train of RF and gradient pulses to invert the magnetization of blood water flowing through the labelling plane [3]. In our experiments the position of the labelling plane was selected from a quick time-of-flight angiography to ensure optimal orientation of the carotid and vertebral arteries. A delay of 1s was inserted between labelling and readout to guarantee blood perfusion of the majority of the voxels. Pre-saturation pulses are applied to the imaging region before labelling to avoid spin perturbation in imaging planes caused by the labelling train. By using readouts with single-shot 2D EPI, 100 measurements with 50 pairs of label-control volumes were obtained. Explicit sequence parameters were as follows: α/TE/TR=90°/14/4150 ms, dim: 64×64×26, Partial Fourier=6/8, voxel size: 3.4×3.4×5mm^3. The total measurement time for pCASL acquisitions was 6 minutes. After 2 min run of pCASL, ^{15}O water was injected as the PET perfusion tracer. CBF was then quantified by using the ASL toolbox in MATLAB [4].

The PET-based measurement of CBF started with a bolus injection of 555 MBq ^{15}O-labelled water after which the PET data were recorded for 3 min in list mode. The first 60 seconds of PET data after tracer entry into the brain were reconstructed in a summed image so that the autographic method for the calculation of quantitative CBF images could be applied [5]. For this purpose an arterial input function was obtained by continuous blood sampling from the radial artery using an MR-compatible blood radioactivity detector and corrected for delay and dispersion.

Results

An initial qualitative comparison of the bimodal CBF images after measurements of five young male (21~27 years) subjects revealed a basic similarity (Fig 1). Both the PET and ASL fit well within the colour scale ranging from 0 to 120 mL/100g/min. After plotting the whole brain CBF acquired with ASL against that from PET, a quadratic fitting was performed as presented in Fig. 2 with the results of: R = 0.70, y_0 = 21.0±0.2, a = 1.27±4.6e^{-3}, b = -7.7e^{-3}±5.5e^{-5}. Averaged mean CBF from the same five sleep subjects following sleep deprivation shows 55.4±13.3 mL/100g/min in PET and 44.8±8.1 mL/100g/min in ASL. Averaged mean CBF following non-sleep deprivation shows 50.1±4.8 mL/100g/min in PET and 45.9±7.1 mL/100g/min in ASL.

Conclusion

For the first time, this study demonstrates the comparative CBF data acquired simultaneously with ASL and H_2O^{15} By employing a simultaneous acquisition scheme with the hybrid MR-PET scanner and a cyclotron close-by, the physiological and functional variations can be minimized for the comparison of perfusion methods.

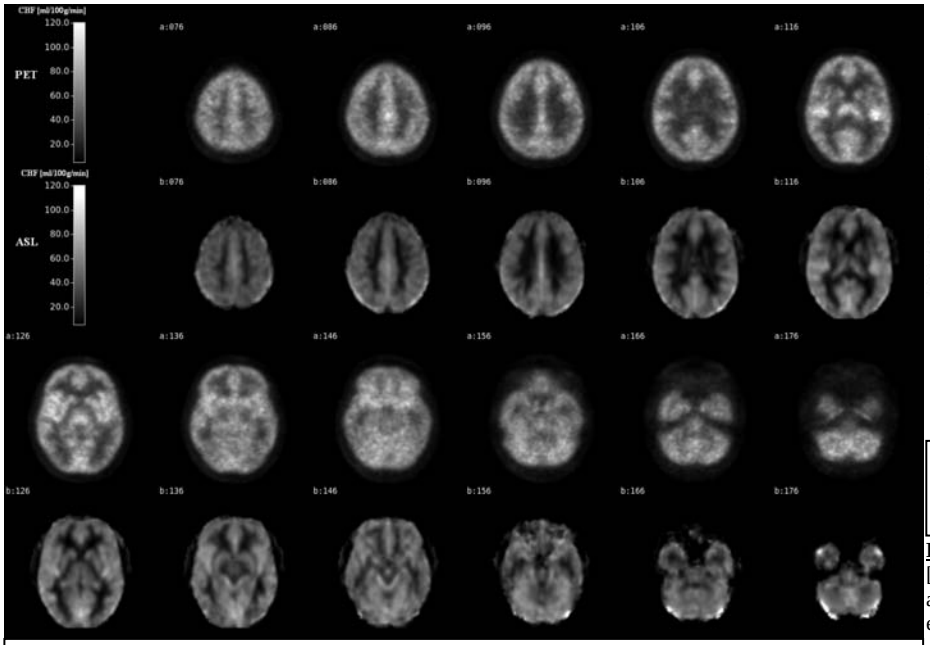

Fig. 1. Averaged CBF of 5 subjects using simultaneous H_2O^{15} PET (1st, 3rdrow) and pCASL MRI (2nd, 4th row). 11 Slices listed at an inter-slice distance of 10mm in the transverse direction.

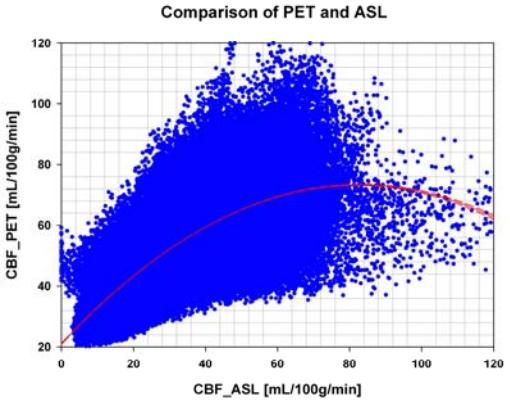

Fig 2. Statistical analysis of the relation between ASL and PET. The paired CBF values in the brain only region were fitted to a quadratic equation.

References :

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