Resting State Regional Correlation between FDG-PET and pCASL Perfusion MRI

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INTRODUCTION

Perfusion is normally coupled to metabolism and neural function, and ASL may serve as an alternative and non-radiation method for FDG-PET. However, existing studies comparing ASL and FDG-PET are limited by small sample size (1). Furthermore, correlations between resting glucose metabolism and perfusion for different brain regions have not been investigated. Such information would be useful in interpreting future studies for investigating normal brain function or a diseased state. In this study, we performed a systematic evaluation of resting pseudo-continuous ASL (pCASL) and ^{18}FDG-PET on 19 healthy subjects to determine the correlation between perfusion and FDG-PET CMRglu measurements across different brain regions.

ACQUISITIONS

Nineteen healthy participants (age 23-59 years; 14 Females) underwent PET imaging with a Siemens ECAT EXACT HR+ Scanner, and pCASL and a high resolution structural brain MRI scan using a 3 Tesla Siemens Magnetom Trio scanner. All participants were normotensive and were chosen based on negative screening for neurological and major systemic illnesses. PET and fMRI were performed on different days.

For PET imaging, subjects were scanned in 3D acquisition mode with 6 blocks of 5-min acquisitions, followed by a10-20 minute transmission scan, where 63 slices were obtained with an axial/in-plane resolution of 5mm/4.6mm at FWHM. PET images were corrected for scatter, decay, scanner dead time, and attenuation, and were reconstructed by filtered back projection using an all pass ramp filter of 2mm FWHM. The preprocessed images had a resolution of 128×128 voxels with a zoom of 2.75mm. For pCASL scan, subjects were scanned with their eyes closed with a black screen projected onto video goggles while eye-tracking equipment monitored eye and lid movements. A train of intermittent 360μs RF pulses were applied 9cm beneath the center of imaging slices, with a mean gradient of 0.6mT/m. The pCASL protocol (2) used a 1.5 second labeling pulse train with a 1.2 second delay. Other imaging parameters were: FOV= 220mm, FA=90 degrees, TR=4s, TE=11ms, matrix =64x64, 2D EPI, 24 slices with 5mm thickness and 1mm gap. CBF images were reconstructed using a Matlab program developed in-house.

ANALYSIS

Both pCASL CBF and PET CMRglu images were coregistered with structural MRI, normalized to MNI template, normalized by global mean values, and smoothed with a 8mm FWHM Gaussian kernel. Normalized CBF and PET images were compared within 12 representative ROIs based on the Automated Anatomical Labeling (AAL) toolbox (frontal, parietal, occipital, and temporal lobes, cingulate cortex, thalamus, caudate, putamen, insula, hippocampus, amygdala, and cerebellum) across 19 subjects and across pixels. For the cross subject comparison, we calculated the mean intensities of CBF and CMRglu over each selected ROI in each subject. For the cross pixel comparison, we first calculated the mean normalized maps of pCASL CBF and PET CMRglu over the 19 subjects, and then conducted a pixel-by-pixel correlation within each selected region. In addition, the relative ratio map of mean PET and mean CBF was generated, and a logarithm transformation was performed on the ratio map so that positive and negative values represent PET/ASL ratio greater and less than 1, respectively.

RESULTS

Figure 1 shows a direct comparison of mean normalized ASL CBF and FDG-PET CMRglu images. ASL images show signal loss at lower slices especially around the frontal sinus due to susceptibility effects, but delineate cortical structures more clearly. Figure 2 shows the scatter plots and correlation coefficients of ASL vs. PET across pixels in 12 ROIs which demonstrate a high mean correlation between the 2 modalities (mean r=0.73, p<0.001), with the highest r (=0.94) in parietal lobes and caudate, and the lowest r (=0.25) in the hippocampus. The correlation between mean CBF and CMRglu values across 19 subjects in 12 ROIs was intermediate (mean r=0.31), with the highest r (=0.52) in caudate, and the lowest r (=0.08) in the hippocampus. Figure 3 shows the log(PET/ASL ratio) map which demonstrates relatively higher mean PET CMRglu values in caudate and putamen compared to corresponding ASL perfusion (p<0.001).

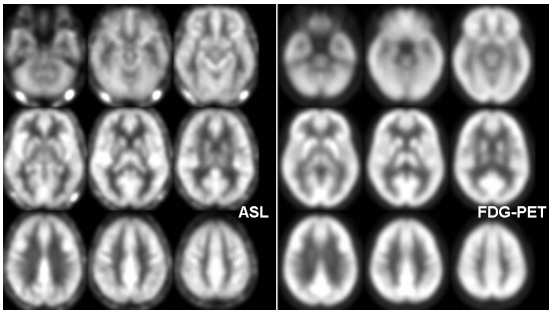

Fig 1. (L) mean CBF(ASL) (R) mean FDG-PET images

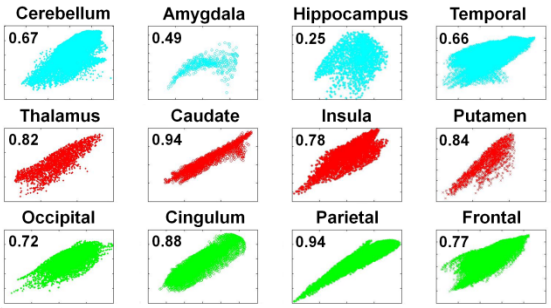

Fig 2. ASL(*x*)-PET(*y*) scatter plot

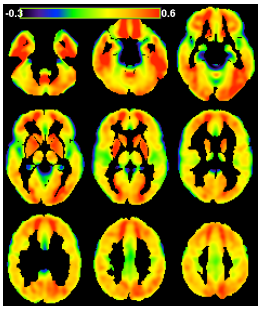

Fig 3. Log of PET/ASL ratio map

DISCUSSION

There is in general a good correlation between ASL CBF and PET CMRglu across pixels in the group mean images. However, the correlation of mean CBF and CMRglu values across 19 subjects is intermediate. There are regional variations in correlations between the 2 modalities. Consistent with an earlier report (1), we found that metabolism of caudate and putamen is significantly higher relative to perfusion rate. While susceptibility effects and ROI size differences may to a certain degree account for the observed regional variations, the biophysical mechanism underlying the coupling and uncoupling of glucose metabolism and perfusion across brain regions warrants further investigation.

REFERENCES [1] Newberg AB et al. NeuroImage 28 (2005) 500 – 506, [2] Wu WC et al. MRM 2007;58:1020-7
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