# HIPPOCAMPAL LONGITUDINAL SUB-REGION PERFUSION CAN BE RELIABLY MEASURED USING ASL

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**Introduction:** Numerous animal and human studies show differentiation of anatomy, physiology, and function along the longitudinal axis of the hippocampus (1). Particularly, disease and pathology have also been shown to selectively affect different regions along the longitudinal hippocampus axis (2-3). Therefore, measuring hippocampal longitudinal sub-region perfusion should better facilitate the diagnosis and understanding of healthy and pathological hippocampal physiology. To evaluate the reliability of hippocampal longitudinal sub-region perfusion measurements using arterial spin labeling (ASL), measurement errors due to random spatial noise and temporal physiological noise in FAIR ASL studies of rCBF were evaluated.

**Table 1.** Partial parameters for low and high resolution hippocampus ASL imaging.

| | Low | High |
|---|---|---|
| Number of Imaging Slice | 10 | 20 |
| Slice Thickness/Gap (mm) | 5/1 | 3.5/0.7 |
| Inferior Saturation Number | 48 | 40 |
| Post-bolus Delay $TI_2$ (ms) | 1200 | 1000 |
| Number of Imaging Volumes | 150 | 200 |

**Materials and Methods:** Studies were performed on a 3T Siemens TIM Trio whole-body MR scanner with body coil for RF transmission and a Siemens 12-channel phased array head coil for signal reception. A customized FAIR sequence, OPTIMAL FAIR (4), was optimized for hippocampus perfusion studies and used with 3D PACE for prospective motion correction (5). All 8 healthy subjects were screened and provided written informed consent according to a study protocol approved by the Institutional Review Board. During imaging, subjects were required to have their eyes closed but remain awake.

Both low resolution and high resolution studies were performed, with differing parameters as listed in Table 1 and the following common parameters: in-plane resolution 2 x 2 $mm^2$, TR/TE = 3000/14 ms, FOV = 128 x 128 $mm^2$, matrix size = 64 x 64, left to right phase encoding with 30% oversampling, 6/8 partial Fourier, iPAT GRAPPA factor = 2, A-P slice acquisition order, advanced 3D shimming, selective/spatially-confined inversion slab =148/328 mm, bolus width ($TI_1$) = 600 ms, inferior saturation pulse size/interval = 20 mm/25 ms.

For high resolution imaging, 2 slices were placed anterior to the hippocampus head; for low resolution imaging, the first imaging slice was placed to cover the anterior region of the hippocampus head. EPI proton density images ($M_0$) were acquired with 8 s TR for regional cerebral blood flow (rCBF) quantification using a single blood compartment model (6). Measurement errors due to either random spatial noise, estimated as the mean intensity of noise images obtained without rf, or temporal physiological noise, estimated as the standard deviation of the time series mean rCBF images, were evaluated:

$$\text{rCBF} = \Delta M / (2M_0 \times TI_1 \times \exp(-TI / T_{1b})) \quad [1]$$

$$E_{ransdom} = \sqrt{2 / N_{voxel}} \times \sigma_{random} / (2M_0 \times TI_1 \times \exp(-TI / T_{1b})) \quad [2]$$

$$E_{temporal} = \sigma_{temporal} / \sqrt{N_{PWI}} \quad [3]$$

where $N_{voxel}$ is the total number of averaged voxels, $N_{PWI}$ is the number of averaged perfusion weighted images, and $T_{1b}$ is the $T_1$ of arterial blood, assumed to be 1660 ms (7).

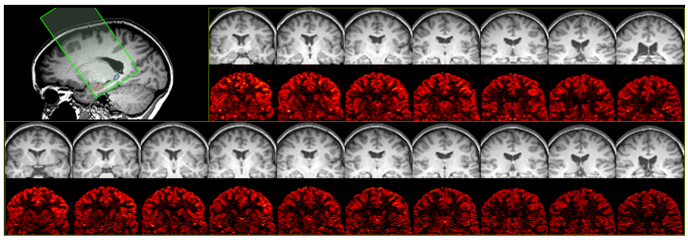

**Fig. 1.** Hippocampus perfusion imaging slab position and the segmentation of hippocampal sub-regions (top left), perfusion-weighted imaging maps using thick (second row) and thin (bottom row) slices and corresponding co-registered anatomic images (rows 1 and 3).

**Results and Discussion:** Images from a typical subject are shown in Figure 1. Measurement errors due to temporal physiological noise are no larger than those due to random spatial noise, which can be, in part, attributed to the application of 3D PACE in ASL imaging (Figure 2). For hippocampus longitudinal sub-region perfusion measurements, errors due to both random spatial noise and temporal physiological noise can be reduced to 8% or less for hippocampus body and tail and 5% or less for hippocampus head and body+tail with more than 90 pairs of label and control images for low resolution and 120 for high resolution. Hippocampus longitudinal sub-region perfusion measurements with eight subjects are represented in Figure 3.

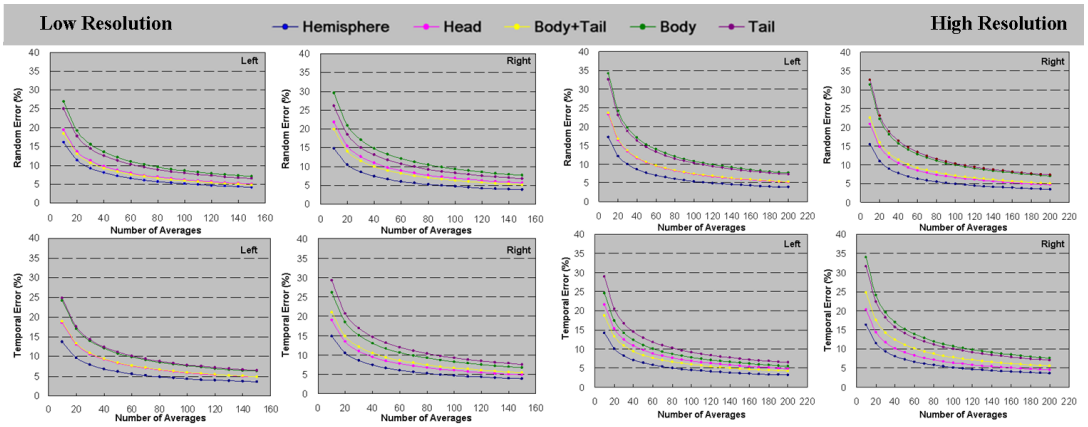


**Fig. 2**. Error analysis results for hippocampus longitudinal sub-region perfusion measurements. Measurement errors are expressed as the percentage of hippocampal perfusion measured in individual longitudinal sub-regions. Random error refers to random spatial noise, and temporal error refers to temporal physiological noise.

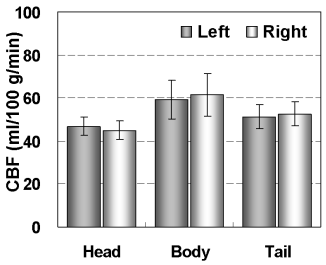


**Fig. 3.** Hippocampus longitudinal sub-region perfusion measurements by using low imaging resolution (2 x 2 x 5 $mm^3$).

**Conclusion:** Hippocampal longitudinal sub-region perfusion can be reliably measured by ASL.

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