Altered Regional CO2 Vasoreactivity in Patients with Ischemic Stroke using CASL MRI

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Introduction: Adequate perfusion of regions surrounding the ischemic areas is essential for long-term brain tissue recovery and the clinical outcomes after ischemic stroke. We aimed to investigate the regional differences in CO_2 vasoreactivity (CO_2VR) and their relationships to chronic infarct volume, persistent infarct hyperintensities (PIHs) volume and clinical outcomes.

Materials and methods: 27 subjects with chronic large vessel infarcts in the middle cerebral artery (MCA) territory (age 65.4±8.9 yrs) were compared with 43 controls (68.4±5.8 yrs), matched for age, sex and history of hypertension. Continuous arterial spin labeling (CASL) perfusion MRI, FLAIR, and MP-RAGE image were acquired with a GE 3-Tesla scanner. We measured cerebral blood flow and CO_2VR in regions surrounding the infarct and adjacent vascular territories using CASL during baseline, hypocapnia and hypercapnia, and assessed its relationship to the infarct volume and NIHSS neurological impairment. Image segmentation and registration were used to quantify cerebral blood flow and CO_2VR in major anatomical lobes and vascular territories. Data were analyzed using repeated measures MANOVA adjusted for age, sex and brain volume.

Results:

Between groups: The CO_2VR was lower in the stroke group than control group across several anatomical regions ($p<0.0001$) and vascular territories ($p<0.0001$), bilaterally. The CO_2VR was significantly lower in insular cortex than other regions.

Within stroke group: There were regional differences in CO_2VR between stroke and non-stroke sides ($p=0.0004$). In the stroke group, perfusion during hypercapnia was lower in the MCA territory on the stroke side than on the non-stroke side ($p=0.03$) and compared to the control group ($p=0.01$). The CO_2VR in the MCA was negatively associated with PIHs volume ($p<0.0001$), infarct volume ($p<0.0001$) and the systolic BP increase from hyperventilation to CO_2 breathing ($p<0.0002$). The same relationship was found for CO_2VR in the entire anatomical lobe and peri-infarct regions. Lower CO_2VR was associated with higher NIHSS ($p<0.003$).

Conclusions: Impairment of vasoreactivity to CO_2 stimulus extends beyond infarcted areas into adjacent regions and vascular territories. Neurological status, assessed by NIHSS, correlates with impairment of CO_2VR. Regional differences in CO_2VR may play an important role in long-term recovery from ischemic stroke. These results may be of therapeutic significance to improve the long-term outcome of stroke patients.

Reference:

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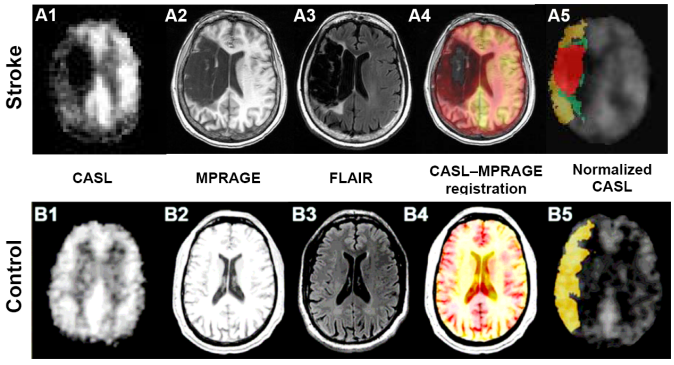

Figure 1: An example of perfusion image registration on anatomical images for a subject with right MCA stroke (A) and a control (B). The perfusion CASL image (1) and anatomical MP-RAGE image (2) are co-registered (4) and normalized to standard template (5). The infarct (red) and PIHs regions (green) on the structural image (2, 3) and MCA territory (yellow) are normalized and overlaid on normalized CASL (5).

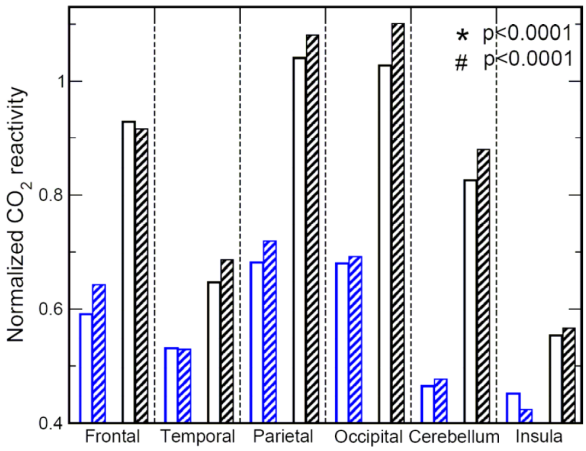

Figure 2: Normalized CO_2 reactivity in anatomical regions and between groups. □ stroke group (stroke side), ▮ stroke group (non-stroke side), □ control group (left side), ▮ control group (right side), * between-group comparisons over all anatomical regions ($p<0.0001$), # between region and side comparisons for both groups ($p<0.0001$).