# Voxel-Based Group Analysis of Perfusion Images

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## Introduction

Magnetic Resonance Perfusion Imaging using an exogenous contrast agent is a powerful tool for assessing the physiology and pathophysiology of the human brain. This study suggests a procedure to perform group analysis on the parametric images, like cerebral blood flow, blood volume and mean transit times, obtained from individual perfusion studies. The procedure is based on statistical voxel-by-voxel comparison, and has recently been applied in morphometrical data ([1]-[7]).

The method is empirically tested on a group of former professional deep-sea divers (N=20), selected from a major ongoing study (N=120). In order to perform group analysis in this study, the ten youngest divers with normal perfusion and no pathology were selected as a control group.

The mechanism, by which the brain of deep-sea divers is damaged, is still unknown. Polkinghorne et al [8] showed by fluoresceinangiography that the capillary density in the retina among divers was reduced. They also found dilated arteriolas and microaneurysms in the retinal vessels of divers. Their conclusion was that most of these findings could be explained by vascular obstructions.

## Acquisition and Analysis

MR acquisitions were performed on a Siemens Vision 1.5T whole body clinical scanner. A standard, commercial gradient-echo echo planar imaging sequence with parameters TR/TE=1500 ms/60.7ms, FoV=240x240, Matrix=128x128, was selected in addition to thorough conventional MR imaging. The contrast agent, Gadovist, was automatically injected after 12 seconds. In total, 50 time points were measured. The ICE (Image Control and Evaluation) software from NordicNeuroLab AS was used to compute the parametric images from each study.

The voxel-wise group comparison was repeated for blood flow, blood volume and mean transit time, respectively. First, all images were normalized to the same reference image. Normalizing the pre-contrast echo-planar images to a standard EPI-template, and subsequently using the same transformation matrix for each of the parametric images, achieved this. Thereafter a template was created for each parametric image in an iterative manner by averaging the normalized parametric images and using the averaged images to create a new, more accurate, template, which again was used to normalize the original parametric images. Based on the resulting normalized images, an ANCOVA analysis of variance (implemented in SPM2) was performed between the diver group and defined control group. A voxel threshold of $p < 0.01$ and minimum cluster size of 100 voxels.

## Results

Results from the group comparison show distinct clusters, where values of flow are significantly different between the two groups. Several of these areas correlated with findings in cerebral blood volume comparisons and mean transit time. Most prominent were the differences in mean transit time and blood flow differences in the right frontal lobe (Fig. 1). Also, mean transit time differences were seen bilaterally in the Amygdala and subcortical areas, left and right to the ventricles.

## Discussion and Conclusion

The preliminary results of this new voxel-based method on perfusion images indicate a predilection of flow disturbances in certain areas in the brain of divers. It could be assumed that these localized disturbances in blood flow, blood volume, and mean transit time among divers, reflect areas of more vulnerable vessels to injuries related to diving.

The findings of localized perfusion disturbances must be related to the clinical examination. A further validation of these initial findings will be achieved when all divers (N=120) and normal controls are investigated.

In conclusion, the statistical voxel-based procedure presented in this study was successfully applied to parametric perfusion images. One of the major strengths of this procedure is its ability to also identify areas of significant changes without prior assumption. This is a large advantage to previous methods, where predefined regions of interest have to be used. The suggested procedure is thus a valuable tool when performing group analysis in perfusion studies.

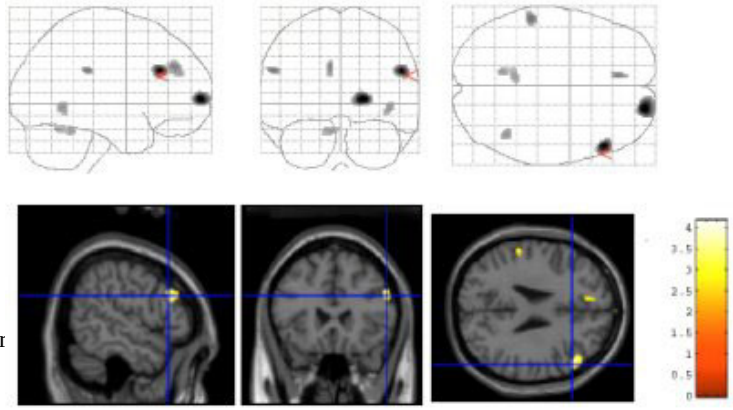

Fig. 1: Significant differences in cerebral blood flow
The color bar to the right indicates t-score values.

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