CSF contamination contributes to apparent microstructural alterations in amnestic Mild Cognitive Impairment

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Target audience

Diffusion MRI specialists, researchers with interest in neurodegeneration and/or healthy ageing

Purpose

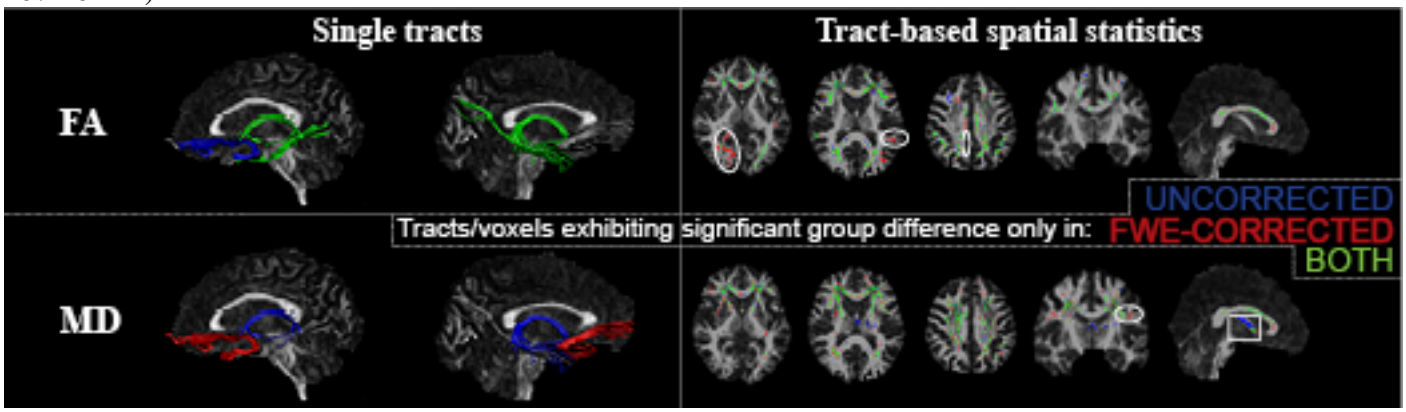
Neurodegeneration is associated with atrophy, which leads to artefacts through partial volume effects due to cerebrospinal-fluid contamination (CSFC). Little is known about the importance of such effects but they are often assumed to be small, or adequately dealt with by approaches such as skeletonisation in tract-based spatial statistics (TBSS). We explored the influence of CSFC on apparent microstructural alterations in amnestic mild cognitive impairment (MCI), the prodromal stage of Alzheimer's disease.

Methods

25 patients with MCI and 20 healthy elderly controls underwent diffusion-weighted MRI (3T GE HDx system, twice refocused spin-echo echo planar imaging sequence, 2.4 mm isotropic voxels, TE = 87 ms, b = 1,200 s/mm^2, 30 isotropically distributed directions, 3 non-diffusion-weighted scans, acquisition time approx. 13 min). The effect of CSFC was modelled on intravoxel diffusion data using a post-acquisition approach of Free Water Elimination (FWE), which adopts a two compartmental model and fits two tensors to diffusion data, one anisotropic and one isotropic with diffusion characteristics of free water. [1] Uncorrected values of fractional anisotropy (FA) and mean diffusivity (MD) and values, corrected for CSFC were computed in each voxel. Results of group comparison in uncorrected and FWE-corrected data were compared at several spatial levels: individually reconstructed single tracts (fornix, uncinate fasciculus, parahippocampal cingulum reconstructed by region of interest based deterministic tractography), at the level of a tract skeleton (TBSS), and mean metric values derived from whole white matter by the use of histograms.

Results

Group differences were found at all spatial levels of analysis in both uncorrected and FWE-corrected data. CSFC led to a different outcome in a number of assessed tracts (Fig, left). Widespread areas of increased FA and reduced MD were observed in MCI with some notable differences, e.g. exaggerated group differences in fornix microstructure in uncorrected data (Fig, right). Both approaches yielded significantly decreased mean histogram FA and increased mean MD in MCI. However, a proportion of observed relative difference between groups was due to CSFC (33% for MD, 16% for FA).



Discussion

Tracts varied in their susceptibility to CSFC. Both spurious group differences, driven by CSFC, and masking of true differences were observed. TBSS were found to be robust for much of the skeleton but with some localised CSFC effects. Group differences in white matter histogram measures were also partly driven by CSFC.

Conclusion

CSFC has an impact on quantitative differences between MCI and controls. It also affects the apparent spatial pattern of white matter involvement. Techniques such as FWE provide a means to disentangle intrinsic and volumetric alterations in individuals prone to atrophy. FWE can be applied *post-hoc* to diffusion data acquired by standard single *b*-value protocols and can therefore be used for many sequences in current use.

References

1. Pasternak O, Sochen N, Gur Y, Intrator N, Assaf Y. Free water elimination and mapping from diffusion MRI. Magn Reson Med. 2009;62(3):717-730.