Microstructural changes in the penumbras of cerebral small vessel disease lesions are associated with cognition and sleep.

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Purpose

To investigate microstructural changes of the penumbra layers surrounding different cerebrovascular disease lesion sub-types and associations with cognition and sleep quality.

Methods

Participants: 146 individuals with CVD from the Ontario Neurodegenerative Disease Research Initiative (ONDRI).

Periventricular and deep white matter hyperintensities (p/dWMH), lacunes, and MRI-visible perivascular spaces (PVS) were segmented. From diffusion MRI, fractional anisotropy (FA) and mean diffusivity (MD) were estimated from the penumbra layers surrounding each lesion sub-type. Linear regression models were used to examine diffusion metrics within each lesion type (central), outermost penumbra layer (distal), across the penumbra gradients (slope), and for all NAWM (global).

Associations with Processing Speed, Executive Function, Memory, Visuospatial Reasoning and sleep quality (PSQI) were examined, controlling for demographics, vascular risk factors, sleep medications and sleep apnea.

Methods

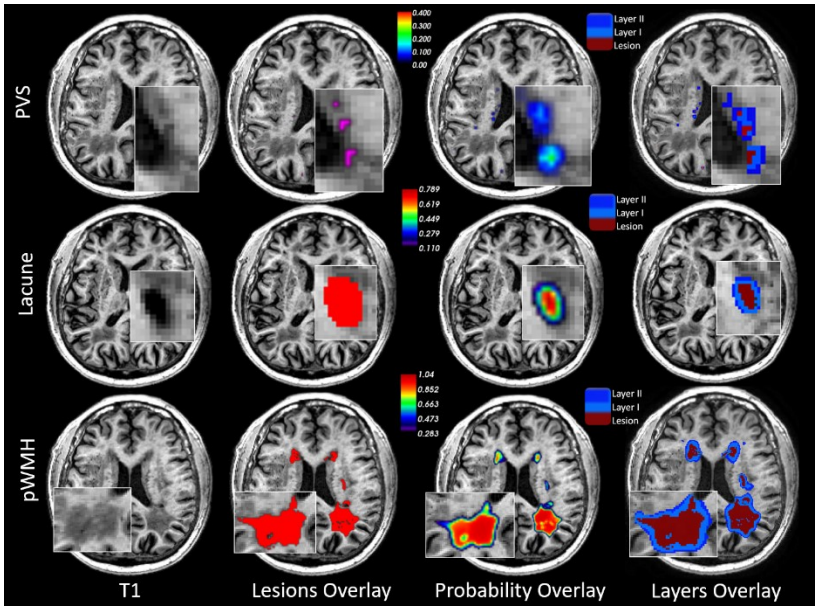

Figure 1. Overview of different lesion sub-types with probability and penumbra layer overlays. Abbreviations: PVS=perivascular spaces, pWMH=periventricular white matter hyperintensities.

Conclusion

These findings suggest that white matter alterations that extend beyond the vascular lesions demarcated on standard structural MRI may be associated with poor sleep quality and cognitive dysfunction.

Results

FA and MD were significantly different between penumbra layers of all lesion sub-types (all $p<0.0001$).

Central: Linear regressions revealed FA within pWMH was associated with memory ($\beta=-0.19$, $p=0.04$); MD within dWMH with processing speed ($\beta=-0.23$, $p=0.03$), and memory ($\beta=-0.2$, $p=0.05$). Sleep analysis revealed MD within dWMH was associated with PSQI ($\beta=-1.22$, $p<0.001$).

Distal: FA in the outermost NAWM layer of BG-PVS was associated with visuospatial ($\beta=0.31$, $p=0.04$), processing speed ($\beta=0.4$, $p=0.004$), and executive function ($\beta=0.29$, $p=0.02$); and FA in the outermost NAWM layer of lacunes was associated with executive function ($\beta=0.52$, $p=0.005$).

Slope: FA slope of pWMH penumbra was associated with memory ($\beta=0.22$, $p=0.02$) and executive function ($\beta=0.19$, $p=0.02$); and, MD slope of dWMH was associated with processing speed ($\beta=0.26$, $p=0.01$), and executive function ($\beta=0.18$, $p=0.04$). Sleep analysis revealed the MD slope of dWMH was associated with PSQI ($\beta=1.13$, $p<0.001$).