Early white matter microstructural alterations in cerebral small vessel disease: A tract-specific diffusion tensor imaging and cardio-cerebrovascular risk perspective

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Abstract

Background: Silent cerebral small vessel disease (CSVD), marked by white matter hyperintensities (WMHs), are commonly detected incidentally on neuroimaging. Emerging evidence links early brain microstructural changes to modifiable cardio-cerebrovascular risks, even without neurological symptoms. This study aimed to explore the relationship between cardio-cerebrovascular risk, white matter tract integrity, and cognitive performance in asymptomatic adults, using QRISK3 profiling, diffusion tensor imaging (DTI), and neurocognitive evaluation. Methods: Sixty neurologically asymptomatic adults (mean age: 39.8 ± 11.5 years) with low to moderate QRISK3 scores underwent standardized neurocognitive assessment 3T brain MRI, including DTI sequences. Lesion-guided

region-of-interest (ROI) tractography was used to assess six bilateral white matter tracts commonly affected in CSVD: the anterior and superior corona radiata and the superior longitudinal fasciculus (SLF). Results: WMHs were identified in 20 individuals (33.3 %). Their presence was significantly associated with aging, systolic blood pressure, hypertension, and QRISK3 score ($p < 0.05$). While no significant cognitive impairment was observed, processing speed was negatively correlated with age and QRISK3. Although DTI metrics such as fractional anisotropy (FA) and mean diffusivity (MD) did not significantly differ across groups, tract-specific analysis revealed that higher QRISK3 scores were significantly associated with reduced white matter integrity in the left SLF. Conclusion: These findings highlight the presence of early, subclinical white matter alterations in individuals at cardio-cerebrovascular risk, even in the absence of neurological symptoms. The integration of tract-specific DTI analysis with vascular risk profiling may provide a sensitive approach for detecting preclinical CSVD and guiding early intervention strategies in at-risk populations. © 2025 The Authors

Author keywords

Cerebral small vessel disease; Diffusion tensor imaging; Microstructure; QRISK3; White matter integrity

Indexed keywords

EMTREE medical terms

adult; aging; Article; asymptomatic disease; atrial fibrillation; axial diffusivity; body mass; brain scintiscanning; cardiovascular risk; cardiovascular risk factor; cerebrovascular disease; Chinese; corona radiata (brain); diffusion tensor imaging; diffusion weighted imaging; disease risk assessment; educational status; family history; female; fluid-attenuated inversion recovery imaging; fractional anisotropy; human; hyperlipidemia; hypertension; magnetic resonance tractography; major clinical study; Malay (people); male; mean diffusivity; mental performance; neuroimaging; non insulin dependent diabetes mellitus; nuclear magnetic resonance imaging; processing speed; qrisk3 score; radial diffusivity; scoring system; smoking; superior longitudinal fasciculus; systolic blood pressure; T1 weighted imaging; T2 weighted imaging; Wechsler adult intelligence scale; white matter; white matter lesion

Device trade names

Commercial names given to devices, used for branding and differentiation in the market, commonly referenced in scientific and clinical research.

Tradename	Country	Manufacturer

Tradename	Country	Manufacturer
Achieva	Netherlands	Philips

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