

Table S1. The detailed MRI scan parameters in the present study

Contrast	Orientation	Voxel /mm³	Parameters	Scan time
T1w MPRAGE	3D sagittal	1.00×1.00×1.00	TE=3.0ms, TR=6.7ms, TI=880ms, shot interval=2000ms, Flip angle=8°	4:30
T2w	2D axial	0.51×0.51×6.50	TE=105ms, TR=2500ms, SPIR fat suppression	1:05
SWI	3D axial	0.63×0.63×0.80	first TE=7.2ms, echo spacing = 6.2ms, 5 echoes, Flip angle=17°, TR =37ms	2:20
FLAIR	2D axial	0.53×0.53×6.50	TE=110ms, TR=7000ms, TI=2300ms, SPIR fat suppression	2:27
DWI	2D axial	1.20×1.20×6.50	TE=98ms, TR=2500ms, b=1000s/mm ² , ADC and eADC calculated online	0:30
DTI	2D transverse	1.88×1.88×2.50	TE=90ms, TR=3500ms, b=0 and b=1000s/mm ² with 32 diffusion encoding directions, SPIR fat suppression	4:05

T1w MPRAGE, T1-weighted magnetization prepared rapid acquisition gradient-echo; T2w, T2-weighted; SWI, susceptibility-weighted imaging; FLAIR, fluid-attenuated inversion recovery; DWI, diffusion weighted imaging; DTI, diffusion tensor imaging; ADC, apparent diffusion coefficient.

Table S2. Clinical characteristics between participants included or excluded in present analysis

Characteristic	Included(n=2219)	Excluded(n=848)	P value
Sociodemographics			
Age(years), mean±SD	61.3±6.6	60.8±6.9	0.045
Sex(male), n(%)	1019(45.9)	408(48.1)	0.28
Vascular risk factors			
BMI(kg/m ²) , mean±SD	24.0±3.0	23.3±3.1	<0.001
SBP(mmHg), median (IQR)	129.0(118.0-140.0)	127.25(116.00-137.50)	0.004
DBP(mmHg), median (IQR)	75.0(69.5-81.0)	74.0(68.0-81.0)	0.02
Hypertension, n(%)	976(44.0)	345(40.7)	0.10
Diabetes Mellitus, n(%)	505(22.8)	158(18.6)	0.01
Hypercholesterolemia, n(%)	494(22.3)	122(14.4)	<0.001
Stroke/TIA, n(%)	67(3.0)	31(3.7)	0.37

Coronary artery disease, n(%)	10(0.5)	3(0.4)	0.95
Atrial fibrillation, n(%)	17(0.8)	9(1.1)	0.43
Current drinking, n(%)	397(17.9)	177(20.9)	0.058
Current Smoking, n(%)	436(19.7)	193(22.8)	0.056
Laboratory data, median (IQR)			
Total cholesterol (mmol/L)	5.4±1.0	5.1±1.0	<0.001
Triglycerides (mmol/L)	1.8±1.3	1.7±1.2	<0.001
HDL-C (mmol/L)	1.4±0.3	1.3±0.3	<0.001
LDL -C(mmol/L)	2.8±0.8	2.7±0.7	<0.001
FBG (mmol/L)	6.0±1.6	5.8±1.6	<0.001
HbA1c(%)	6.0±1.0	5.9±0.9	<0.001
HCY (mmol/L)	11.9±6.1	12.0±6.6	0.53
Medication, n (%)			

Antihypertensive	594(26.8)	229(27.0)	0.90
Lipid-lowering	101(4.6)	19(2.2)	0.003
Antiplatelet	68(3.1)	12(1.4)	0.01
Anticoagulant	3(0.1)	1(0.1)	1.00
Antidiabetic	220(9.9)	54(6.4)	0.002
MoCA adjusted by education, median (IQR)	22.0(19.0-25.0)	21.00(18.0-24.0)	<0.001

IQR, interquartile range; SD, standard deviation; CSVD, cerebral small vessel disease; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; TIA, transient ischaemic attack; HDL-C, high-density lipoprotein; LDL-C, low-density lipoprotein; FBG, fasting blood glucose; HbA1C, glycosylated hemoglobin; HCY, homocysteine; MoCA, Montreal Cognitive Assessment.

Table S3. Clinical characteristics among all participants with or without present CSVD

Characteristic	The CSVD score (Wardlaw)*			Modified CSVD score (Rothwell)†		
	Absent(n=1540)	Present(n=679)	P value	Absent(n=1293)	Present(n=926)	P value
Sociodemographics						
Age(years), mean±SD	59.9±6.0	64.6±6.7	<0.001	59.7±6.0	63.7±6.7	<0.001
Sex(male), n(%)	671(43.6)	348(51.3)	<0.001	580(44.9)	439(47.4)	0.23
Vascular risk factors						
BMI(kg/m ²), mean±SD	23.9±3.0	24.1±3.1	0.15	23.9±3.0	24.1±3.1	0.11
SBP(mmHg), median (IQR)	127.0(116.5-137.5)	133.5(123.0-144.0)	<0.001	126.5(116.0-137.0)	132.0(122.0-143.0)	<0.001
DBP(mmHg), median (IQR)	74.5(69.0-80.5)	76.0(70.5-82.5)	<0.001	74.5(69.0-80.5)	76.0(70.5-82.0)	<0.001
Hypertension, n(%)	574(37.3)	402(59.2)	<0.001	459(35.5)	517(55.8)	<0.001
Diabetes Mellitus, n(%)	311(20.2)	194(28.6)	<0.001	251(19.4)	254(27.4)	<0.001

Hypercholesterolemia, n(%)	334(21.7)	160(23.6)	0.33	292(22.6)	202(21.8)	0.67
Stroke/TIA, n(%)	26(1.7)	41(6.0)	<0.001	22(1.7)	45(4.9)	<0.001
Coronary artery disease, n(%)	8(0.5)	2(0.3)	0.70	9(0.7)	1(0.1)	0.09
Atrial fibrillation, n(%)	9(0.6)	8(1.2)	0.14	8(0.6)	9(1.0)	0.35
Current drinking, n(%)	262(17.0)	135(19.9)	0.10	220(17.0)	177(19.1)	0.20
Current Smoking, n(%)	307(19.9)	129(19.0)	0.61	267(20.7)	169(18.3)	0.16
Medication, n (%)						
Antihypertensive	328(21.3)	266(39.2)	<0.001	257(19.9)	337(36.4)	<0.001
Lipid-lowering	57(3.7)	44(6.5)	0.004	46(3.6)	55(5.9)	0.008
Antiplatelet	35(2.3)	33(4.9)	0.001	25(1.9)	43(4.6)	<0.001
Anticoagulant	0(0.0)	3(0.4)	0.03	0(0.0)	3(0.3)	0.14
Antidiabetic	129(8.4)	91(13.4)	<0.001	103(8.0)	117(12.6)	<0.001
MoCA adjusted by education,	23.0(19.0-25.0)	22.0(18.0-25.0)	0.001	23.0(19.0-26.0)	22.0(18.0-25.0)	<0.001

median (IQR)

IQR, interquartile range; SD, standard deviation; CSVD, cerebral small vessel disease; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; TIA, transient ischaemic attack; HDL-C, high-density lipoprotein; LDL-C, low-density lipoprotein; FBG, fasting blood glucose; HbA1C, glycosylated hemoglobin; HCY, homocysteine; MoCA, Montreal Cognitive Assessment; WMH, white matter hyperintensities; BG-EPVS, enlarged perivascular space in basal ganglia; CMBs, cerebral microbleeds.

*The CSVD score (Wardlaw's scale; from 0 to 4 scores): 1 point allocated for WMH burden (periventricular WMH Fazekas 3 or deep WMH Fazekas 2–3), moderate-to-severe (>10) BG-EPVS and presence of lacunes and CMBs.

†Modified CSVD score (Rothwell's scale; from 0 to 6 scores): 1 point allocated for presence of lacunes, 1–4 CMBs, frequent-to-severe (>20) BG-EPVS, modified WMH burden Grade 1(total periventricular + subcortical WMH Fazekas 3–4), 2 points allocated for ≥ 5 CMBs and modified WMH burden Grade 2 (total periventricular + subcortical WMH Fazekas 5–6).

STable 4. Logistic regression analyses for the associations between the DTI-ALPS index and presence and severity of CSVD

Variables	Model 1		Model 2		Model 3	
	OR/cOR(95% CI)	P value	OR/cOR(95% CI)	P value	OR/cOR(95% CI)	P value
Presence of CSVD(Wardlaw*)						
Continuous (per 1-SD decrement)	1.31(1.18-1.45)	<0.001	1.27(1.14-1.41)	<0.001	1.27(1.14-1.41)	<0.001
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	1.11(0.83-1.48)	0.49	1.12(0.84-1.50)	0.44	1.10(0.82-1.47)	0.54
Q2 (1.57-1.65)	1.22(0.91-1.63)	0.18	1.22(0.91-1.64)	0.19	1.20(0.89-1.61)	0.23
Q1 (<1.57)	1.87(1.41-2.47)	<0.001	1.79(1.34-2.38)	<0.001	1.77(1.33-2.35)	<0.001
Modified presence of CSVD (Rothwell†)						
Continuous (per 1-SD decrement)	1.32(1.20-1.45)	<0.001	1.28(1.16-1.41)	<0.001	1.27(1.16-1.41)	<0.001
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	0.95(0.74-1.23)	0.70	0.96(0.74-1.24)	0.75	0.94(0.72-1.22)	0.64

Q2 (1.57-1.65)	1.08(0.84-1.40)	0.55	1.08(0.83-1.40)	0.59	1.06(0.81-1.38)	0.67
Q1 (<1.57)	1.92(1.48-2.48)	<0.001	1.82(1.40-2.36)	<0.001	1.80(1.38-2.34)	<0.001
Total burden of CSVD (Wardlaw*)						
Continuous (per 1-SD decrement)	1.39(1.26-1.54)	<0.001	1.35(1.22-1.49)	<0.001	1.34(1.21-1.49)	<0.001
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	1.08(0.81-1.44)	0.59	1.10(0.83-1.47)	0.50	1.08(0.81-1.44)	0.60
Q2 (1.57-1.65)	1.20(0.90-1.59)	0.22	1.21(0.90-1.61)	0.20	1.18(0.88-1.58)	0.26
Q1 (<1.57)	2.01(1.53-2.65)	<0.001	1.91(1.45-2.53)	<0.001	1.89(1.43-2.49)	<0.001
Modified total burden of CSVD (Rothwell†)						
Continuous (per 1-SD decrement)	1.40(1.28-1.53)	<0.001	1.36(1.24-1.49)	<0.001	1.35(1.23-1.48)	<0.001
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	0.96(0.75-1.23)	0.75	0.97(0.76-1.26)	0.84	0.96(0.74-1.23)	0.73
Q2 (1.57-1.65)	1.09(0.85-1.40)	0.51	1.09(0.85-1.41)	0.50	1.07(0.83-1.39)	0.59

Q1 (<1.57)	2.09(1.63-2.67)	<0.001	1.98(1.54-2.55)	<0.001	1.95(1.51-2.50)	<0.001
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OR, odds ratio; cOR, common OR CI, confidence interval; DTI-ALPS, diffusion tensor imaging analysis along the perivascular spaces; CSVD, cerebral small vessel disease; BMI, body mass index; TIA, transient ischaemic attack; WMH, white matter hyperintensities; BG-EPVS, enlarged perivascular space in basal ganglia; CMBs, cerebral microbleeds.

Model 1: adjusted for age and sex;

Model 2: adjusted for age, sex, BMI, stroke/TIA, hypertension, diabetes mellitus, hypercholesterolemia, coronary artery disease, atrial fibrillation, current drinker, and current smoker;

Model 3: adjusted for age, sex, BMI, stroke/TIA, hypertension, diabetes mellitus, hypercholesterolemia, coronary artery disease, atrial fibrillation, current drinker, current smoker, antihypertensive medication, lipid-lowering medication, antiplatelet medication, anticoagulant medication, and antidiabetic medication.

*The CSVD score (Wardlaw's scale; from 0 to 4 scores): 1 point allocated for WMH burden (periventricular WMH Fazekas 3 or deep WMH Fazekas 2–3), moderate-to-severe (>10) BG-EPVS and presence of lacunes and CMBs.

†Modified CSVD score (Rothwell's scale; from 0 to 6 scores): 1 point allocated for presence of lacunes, 1–4 CMBs, frequent-to-severe (>20)

BG-EPVS, modified WMH burden Grade 1(total periventricular + subcortical WMH Fazekas 3–4), 2 points allocated for ≥ 5 CMBs and modified WMH burden Grade 2 (total periventricular + subcortical WMH Fazekas 5–6).

As total CSVD burden and modified total CSVD burden were ordinal categorical variables, ordinal logistic regression model was used and cORs were presented, whereas logistic regression analysis was used and ORs were presented for presence and modified presence of CSVD.

Table S5. Logistic regression analyses for the associations between the DTI-ALPS index and individual neuroimaging markers of CSVD

Variables	Model 1		Model 2		Model 3	
	OR/cOR(95% CI)	P value	OR/cOR(95% CI)	P value	OR/cOR(95% CI)	P value
WMH burden						
Continuous (per 1-SD decrement)	1.45(1.28-1.65)	<0.001	1.40(1.23-1.59)	<0.001	1.41(1.24-1.61)	<0.001
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	1.09(0.75-1.60)	0.65	1.14(0.77-1.68)	0.52	1.13(0.77-1.67)	0.53
Q2 (1.57-1.65)	1.43(0.99-2.07)	0.059	1.47(1.01-2.15)	0.04	1.45(1.00-2.12)	0.053
Q1 (<1.57)	2.25(1.58-3.19)	<0.001	2.15(1.50-3.08)	<0.001	2.16(1.51-3.10)	<0.001
Modified WMH burden						
Continuous (per 1-SD decrement)	1.43(1.30-1.58)	<0.001	1.39(1.26-1.54)	<0.001	1.39(1.26-1.54)	<0.001
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	1.06(0.80-1.39)	0.70	1.08(0.82-1.43)	0.57	1.22(0.92-1.61)	0.17

Q2 (1.57-1.65)	1.23(0.93-1.61)	0.14	1.24(0.94-1.64)	0.13	1.22(0.92-1.61)	0.17
Q1 (<1.57)	2.27(1.74-2.96)	<0.001	2.16(1.65-2.83)	<0.001	2.14(1.63-2.80)	<0.001
Presence of lacunes						
Continuous (per 1-SD decrement)	2.03(1.62-2.54)	<0.001	1.86(1.48-2.33)	<0.001	1.91(1.52-2.41)	<0.001
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	0.77(0.35-1.72)	0.53	0.82(0.37-1.84)	0.63	0.80(0.35-1.79)	0.58
Q2 (1.57-1.65)	1.74(0.88-3.44)	0.11	1.72(0.86-3.44)	0.13	1.68(0.84-3.38)	0.14
Q1 (<1.57)	3.27(1.74-6.14)	<0.001	2.95(1.55-5.61)	<0.001	2.90(1.52-5.55)	0.001
BG-EPVS(moderate-to-severe)						
Continuous (per 1-SD decrement)	1.49(1.26-1.77)	<0.001	1.42(1.20-1.69)	<0.001	1.45(1.21-1.73)	<0.001
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	1.63(0.91-2.90)	0.10	1.70(0.95-3.05)	0.07	1.62(0.90-2.91)	0.11
Q2 (1.57-1.65)	1.95(1.11-3.41)	0.02	1.99(1.13-3.50)	0.02	1.87(1.06-3.31)	0.03

Q1 (<1.57)	2.61(1.53-4.46)	<0.001	2.44(1.42-4.19)	0.001	2.42(1.41-4.17)	0.001
CSO-EPVS(moderate-to-severe)						
Continuous (per 1-SD decrement)	0.99(0.91-1.08)	0.85	0.97(0.89-1.07)	0.55	0.97(0.89-1.06)	0.53
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	0.95(0.74-1.22)	0.70	0.96(0.75-1.23)	0.76	0.96(0.75-1.23)	0.74
Q2 (1.57-1.65)	1.07(0.83-1.37)	0.62	1.07(0.83-1.38)	0.59	1.06(0.82-1.37)	0.63
Q1 (<1.57)	0.87(0.67-1.12)	0.27	0.83(0.64-1.07)	0.15	0.83(0.64-1.07)	0.15
Presence of CMBs						
Continuous (per 1-SD decrement)	1.11(0.96-1.28)	0.14	1.08(0.93-1.24)	0.31	1.05(0.91-1.22)	0.49
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	0.83(0.56-1.23)	0.35	0.82(0.55-1.21)	0.31	0.79(0.53-1.18)	0.26
Q2 (1.57-1.65)	0.66(0.44-1.00)	0.050	0.63(0.42-0.97)	0.03	0.62(0.40-0.94)	0.02
Q1 (<1.57)	1.11(0.77-1.61)	0.58	1.05(0.72-1.54)	0.80	1.00(0.68-1.47)	1.00

CMBs burden

Continuous (per 1-SD decrement)	1.12(0.98-1.29)	0.11	1.09(0.95-1.26)	0.23	1.06(0.92-1.23)	0.40
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	0.84(0.57-1.24)	0.39	0.83(0.56-1.23)	0.34	0.81(0.54-1.20)	0.29
Q2 (1.57-1.65)	0.66(0.44-1.00)	0.053	0.64(0.42-0.97)	0.03	0.62(0.40-0.94)	0.03
Q1 (< 1.57)	1.14(0.78-1.65)	0.50	1.08(0.74-1.57)	0.70	1.03(0.70-1.50)	0.89

Brain atrophy(GCA scale 2-3)

Continuous (per 1-SD decrement)	1.33(1.13-1.57)	<0.001	1.28(1.08-1.52)	0.004	1.29(1.09-1.53)	0.003
Q4 (≥ 1.76)	Ref.		Ref.		Ref.	
Q3 (1.66-1.75)	1.19(0.70-2.03)	0.51	1.21(0.71-2.07)	0.48	1.28(0.74-2.19)	0.38
Q2 (1.57-1.65)	1.42(0.85-2.37)	0.18	1.41(0.84-2.35)	0.19	1.46(0.87-2.46)	0.15
Q1 (< 1.57)	1.73(1.06-2.81)	0.03	1.64(1.00-2.68)	0.049	1.67(1.01-2.74)	0.04

OR, odds ratio; cOR, common OR CI, confidence interval; DTI-ALPS, diffusion tensor imaging analysis along the perivascular spaces; CSVD,

cerebral small vessel disease; BMI, body mass index; TIA, transient ischaemic attack; WMH, white matter hyperintensities; EPVS, enlarged perivascular space; BG-EPVS, basal ganglia-EPVS; CSO-EPVS, centrum semiovale-EPVS; CMBs, cerebral microbleeds; GCA, global cortical atrophy scale.

Model 1: adjusted for age and sex;

Model 2: adjusted for age, sex, BMI, stroke/TIA, hypertension, diabetes mellitus, hypercholesterolemia, coronary artery disease, atrial fibrillation, current drinker, and current smoker;

Model 3: adjusted for age, sex, BMI, stroke/TIA, hypertension, diabetes mellitus, hypercholesterolemia, coronary artery disease, atrial fibrillation, current drinker, current smoker, antihypertensive medication, lipid-lowering medication, antiplatelet medication, anticoagulant medication, and antidiabetic medication.

As Modified WMH Burden and CMBs Burden were ordinal categorical variables, ordinal logistic regression model was used and cORs were presented, whereas logistic regression analysis was used and ORs were presented for others.

Table S6. Linear regression analyses for the association between the DTI-ALPS index and cognitive function in individuals with CSVD

	Presence of CSVD (Wardlaw*, n=679)		Presence of CSVD (Rothwell†, n=926)	
	β (95%CI)	P value	β (95%CI)	P value
Model 1	5.20(2.95, 7.44)	<0.001	4.09(2.18, 6.00)	<0.001
Model 2	4.89(2.61, 7.16)	<0.001	3.82(1.90, 5.74)	<0.001
Model 3	4.95(2.67, 7.23)	<0.001	3.83(1.90, 5.76)	<0.001
Model 4	4.78(2.46, 7.09)	<0.001	3.68(1.72, 5.64)	<0.001

Model 1: adjusted for age, sex, and education;

Model 2: adjusted for age, sex, BMI, stroke/TIA, hypertension, diabetes mellitus, hypercholesterolemia, coronary artery disease, atrial fibrillation, current drinker, current smoker, and education;

Model 3: adjusted for age, sex, BMI, stroke/TIA, hypertension, diabetes mellitus, hypercholesterolemia, coronary artery disease, atrial fibrillation, current drinker, current smoker, antihypertensive medication, lipid-lowering medication, antiplatelet medication, anticoagulant medication, antidiabetic medication, and education.

Model 4: adjusted for age, sex, BMI, stroke/TIA, hypertension, diabetes mellitus, hypercholesterolemia, coronary artery disease, atrial fibrillation, current drinker, current smoker, antihypertensive medication, lipid-lowering medication, antiplatelet medication, anticoagulant medication, antidiabetic medication, education, total burden of CSVD (Wardlaw and Rothwell as appropriate).

*The CSVD score (Wardlaw's scale; from 0 to 4 scores): 1 point allocated for WMH burden (periventricular WMH Fazekas 3 or deep WMH Fazekas 2–3), moderate-to-severe (>10) BG-EPVS and presence of lacunes and CMBs.

†Modified CSVD score (Rothwell's scale; from 0 to 6 scores): 1 point allocated for presence of lacunes, 1–4 CMBs, frequent-to-severe (>20) BG-EPVS, modified WMH burden Grade 1(total periventricular + subcortical WMH Fazekas 3–4), 2 points allocated for ≥ 5 CMBs and modified WMH burden Grade 2 (total periventricular + subcortical WMH Fazekas 5–6).

Figure S1. The distribution of CSVD burden by quartiles of the DTI-ALPS index

The percentage of total CSVD burden according to quartiles of DTI-ALPS index.

DTI-ALPS, diffusion tensor imaging-analysis along the perivascular spaces; CSVD, cerebral small vessel disease; WMH, white matter hyperintensities; BG-EPVS, enlarged perivascular space in basal ganglia; CMBs, cerebral microbleeds.

*The CSVD score (Wardlaw's scale; from 0 to 4 scores): 1 point allocated for WMH burden (periventricular WMH Fazekas 3 or deep WMH Fazekas 2–3), moderate-to-severe (>10) BG-EPVS and presence of lacunes and CMBs. Grade 0, total CSVD burden score 0; Grade 1, score 1; and Grade 2, score 2–4.

†Modified CSVD score (Rothwell's scale; from 0 to 6 scores): 1 point allocated for presence of lacunes, 1–4 CMBs, frequent-to-severe (>20) BG-EPVS, modified WMH burden Grade 1(total periventricular + subcortical WMH Fazekas 3–4), 2 points allocated for ≥ 5 CMBs and modified WMH burden Grade 2 (total periventricular + subcortical WMH Fazekas 5–6). Grade 0, modified total CSVD burden score 0; Grade 1, score 1; Grade 2, 2–6.

