A

Inpatients treated in Department of Dyskinesia from January 2021 to December2022 (Training set, n=2109)

Patients were excluded:
Essential tremor (n=98)
Multiple system atrophy (n=152)
Alzheimer's disease (n=223)
Parkinson's syndrome (n=814)
Progressive supranuclear palsy (n=70)

Patients diagnosed with Parkinson's disease (n=752)

Patients were excluded :
Poor quality of substantia nigra image (n=113)
Without TCS results (n=75)
Incomplete clinical information (n=59)

Satisfied TCS image (n=505)

Patients were excluded:
DBS implantation (n=64)
Duplicate patients (n=56)

PD with cognitive impairment (n=204)

PD without cognitive impairment (n=181)

B

Inpatients treated in Department of Dyskinesia from January 2023 to December2023 (Test set, n=836)

Patients were excluded:
Essential tremor (n=43)
Multiple system atrophy (n=85)
Alzheimer's disease (n=63)
Parkinson's syndrome (n=301)
Progressive supranuclear palsy (n=41)

Patients diagnosed with Parkinson's disease (n=303)

Patients were excluded :
Poor quality of substantia nigra image (n=59)
Without TCS results (n=25)
Incomplete clinical information (n=31)

Satisfied TCS image (n=188)

Patients were excluded:
DBS implantation (n=11)
Duplicate patients (n=12)

PD with cognitive impairment (n=115)
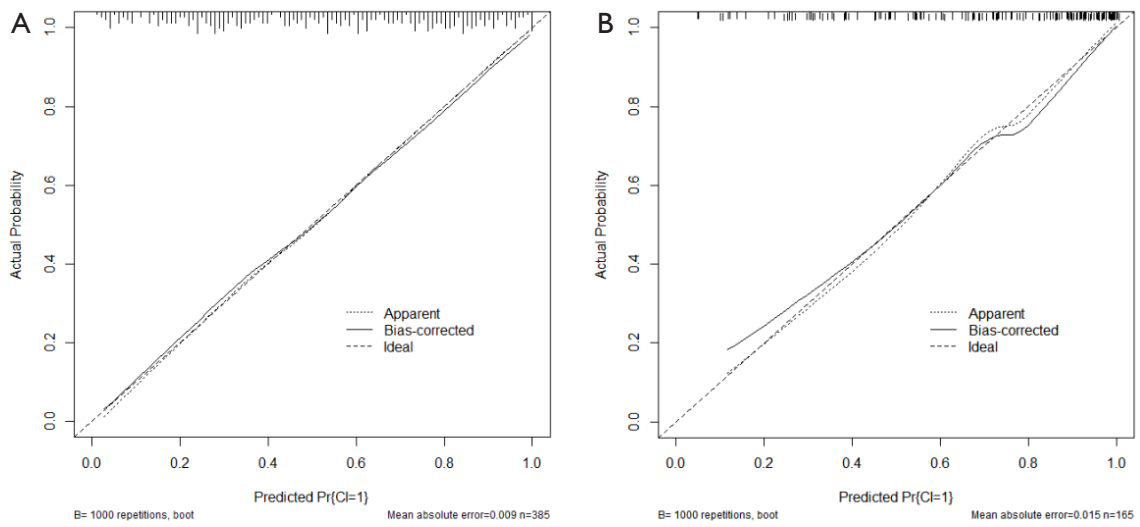
PD without cognitive impairment (n=50)

Figure S1 The flowchart of patient selection in the (A) training set and the (B) test set. TCS, transcranial sonography; PD, Parkinson's disease; DBS, deep brain stimulation.

Figure S2 Calibration curves for the nomogram indicating good agreement between the predictors and observations. (A) Training set. (B) Test set. Pr, probability; Cl, Class.

Table S1 Comparison of baseline demographic and clinical data of the training group and test group

Parameter	PD		P value
	Training group (n=385)	Test group (n=165)	
Male gender (%)	246 (63.9)	99 (60.0)	0.387[a]
Age (years)	63.33±9.69	64.68±8.83	0.09[b]
BMI (kg/m^2)	24.19±3.57	24.26±3.57	0.856[b]
Duration of disease (years)	6.00±4.83	6.77±3.93	0.182[b]
Education level (years)	12 (0,21)	12 (0,22)	0.766[c]
Smoking, n (%)	86 (22.3)	31 (18.8)	0.351[a]
Drinking, n (%)	79 (20.5)	30 (18.2)	0.529[a]
Hypertension, n (%)	123 (31.9)	66 (40.0)	0.068[a]
Diabetes mellitus, n (%)	58 (15.1)	25 (15.2)	0.979[a]
Hyperlipidemia, n (%)	57 (14.8)	36 (21.8)	0.044[a]
H-Y stage	2.7±0.95[d]	2.82±0.87[d]	0.058[b]
MoCA score	23±5.85	21.47±5.38	0.029[b]
PDD, n (%)	97 (25.2)	57 (34.5)	0.025[a]
UPDRS-III	37.8±16.92	40.08±16.36[e]	0.152[b]
Hcy (µmol/L)	15.70±8.33	16.08±8.45	0.627[b]
Folate (ng/mL)	7.88±85.17	8.32±5.92[f]	0.377[b]
Vitamin B12 (pg/mL)	490.11±402.44	489.79±362.49[g]	0.993[b]
Ferritin (ng/mL)	121.09±113.37	128.68±95.44[h]	0.482[b]
NSE (ng/mL)	15.24±3.25	15.30±3.63	0.849[b]
SNH, n (%)	230 (59.7)	110 (66.7)	0.125[a]
Area of SNH (cm^2)	0.21 (0,1.11)	0.25 (0,0.85)	0.94[c]

[a], χ^2 test; [b], unpaired independent *t*-test; [c], nonparametric Mann-Whitney test; [d], missing value: H-Y stage, training group 1 and test group 1; [e], missing value: UPDRS-III, test group 1; [f], missing value: folate, test group 1; [g], missing value: vitamin B12, test group 1; [h], missing value: ferritin, test group 1. Education level and area of SNH are presented as median (interquartile range); gender, smoking, drinking, hypertension, diabetes mellitus, hyperlipidemia, PDD, and SNH are presented as number (frequency); and the other parameters are presented as the mean ± standard deviation. PD-CI, Parkinson's disease with cognitive impairment; PD-NCI, Parkinson's disease without cognitive impairment; BMI, body mass index; H-Y, Hoehn and Yahr; MoCA, Montreal Cognitive Assessment; PDD, Parkinson's disease with dementia; UPDRS-III, Unified Parkinson's Disease Rating Scale Part III; Hcy, homocysteine; NSE, neuron-specific enolase; SNH, substantial nigra hyperechogenicity.

Table S2 Spearman correlation analysis of age, disease duration, and other variables in the training set

Parameter	Education level	H-Y stage	UPDRS-III	MoCA	Hcy	Folate	Vitamin B12	Ferritin	NSE	Area of SNH
Age	−0.152	0.153	0.051	−0.214	0.029	0.057	−0.063	0.011	0.053	0.065
	P=0.003	P=0.003	P=0.320	P<0.001	P=0.573	P=0.265	P=0.216	P=0.829	P=0.297	P=0.205
Disease duration	−0.023	0.384	0.304	−0.188	0.177	0.126	−0.119	−0.049	0.10	0.030
	P=0.654	P<0.001	P<0.001	P=0.002	P<0.001	P=0.013	P=0.02	P=0.334	P=0.050	P=0.561

H-Y, Hoehn and Yahr; UPDRS-III, Unified Parkinson's Disease Rating Scale Part III; MoCA, Montreal Cognitive Assessment; Hcy, homocysteine; NSE, neuron-specific enolase; SNH, substantial nigra hyperechogenicity.

Table S3 Comparisons of gender difference in various parameters in the training set

Parameter	Male (n=246)	Female (n=139)	P value
Age (years)	63.27±9.91	63.43±9.33	0.874[a]
BMI (kg/m²)	24.29±3.73	24.03±3.27	0.490[a]
Duration of disease (years)	6.21±5.21	5.65±4.07	0.276[a]
Education level	12 (0, 21)	10 (0, 21)	0.018[c]
Smoking, n (%)	82 (33.3)	4 (2.9)	<0.001[b]
drinking, n (%)	76 (30.9)	3 (2.2)	<0.001[b]
Hypertension, n (%)	83 (33.7)	40 (28.8)	0.316[b]
Diabetes mellitus, n (%)	37 (15.0)	21 (15.1)	0.986[b]
Hyperlipidemia, n (%)	43 (17.5)	14 (10.1)	0.049[b]
H-Y stage	2.66±0.93	2.65±0.99[d]	0.860[a]
MoCA score	22.46±5.71	22.94±6.12	0.483[a]
UPDRS-III	37.91±16.89	37.74±17.03	0.924[a]
Hcy (μmol/L)	16.68±8.99	13.98±6.71	0.002[a]
Folate (ng/mL)	7.33±5.18	8.84±5.04	0.006[a]
Vitamin B12 (pg/mL)	467.91±429.34	529.41±347.82	0.15[a]
Ferritin (ng/mL)	138.91±138.40	89.55±82.31	<0.001[a]
NSE (ng/mL)	15.25±2.83	15.23±3.90	0.938[a]
SNH, n (%)	165 (67.1)	65 (46.8)	<0.001[b]
Area of SNH (cm²)	0.33 (3, 1.11)	0 (0, 0.93)	<0.001[c]
CI, n (%)	140 (56.9)	64 (46.0)	0.04[b]

[a], unpaired independent *t*-test; [b], χ² test; [c], nonparametric Mann-Whitney test; [d], missing value: H-Y stage, female 1. Education level and area of SNH are presented as median (interquartile range); smoking, drinking, hypertension, diabetes mellitus, hyperlipidemia, SNH, and CI are presented as number (frequency); and the other parameters are presented as the mean ± standard deviation. BMI, body mass index; H-Y, Hoehn and Yahr; MoCA, Montreal Cognitive Assessment; UPDRS-III, Unified Parkinson's Disease Rating Scale Part III; Hcy, homocysteine; NSE, neuron-specific enolase; SNH, substantial nigra hyperechogenicity; CI, cognitive impairment.

Table S4 Logistic regression analysis of possible risk factors and cognitive impairment in the training set

Parameter	Cognitive impairment (univariate analysis)		Cognitive impairment (multivariate analysis)	
	OR (95% CI)	P value	OR (95% CI)	P value
Gender (male)	0.646 (0.425,0.982)	0.041	0.561 (0.330, 0.954)	0.033
Age	1.036 (1.014, 1.059)	0.001	1.039 (1.011, 1.066)	0.005
BMI	0.988 (0.934, 1.045)	0.671		
Duration of disease	1.032 (0.988, 1.079)	0.159		
Education year	0.889 (0.847, 0.934)	<0.001	0.892 (0.842, 0.954)	<0.001
Drinking history	0.717 (0.434, 1.185)	0.195		
Smoking history	0.676 (0.415, 1.102)	0.116		
Hypertension	0.793 (0.515, 1.220)	0.291		
Diabetes mellitus	0.764 (0.434, 1.346)	0.352		
Hyperlipidemia	0.467 (0.257, 0.850)	0.013	0.528 (0.259,1.074)	0.078
H-Y stage	1.480 (1.184, 1.850)	0.001	0.991 (0.733, 1.340)	0.953
PDD	0	0.996		
UPDRS-III	1.031 (1.018, 1.045)	<0.001	1.026 (1.009,1.043)	0.003
Hcy	1.031 (1.003, 1.059)	0.032	1.020 (0.989, 1.052)	0.216
Folate	0.984 (0.946, 1.022)	0.403		
Ferritin	1.001 (0.999, 1.002)	0.535		
Vitamin B12	1.00 (0.999,1.000)	0.314		
NSE	1.590 (1.409, 1.794)	<0.001	1.562 (1.374, 1.776)	<0.001
SNH	0.473 (0.312, 0.716)	<0.001	0.545 (0.330, 0.902)	0.018
Area of SNH	3.020 (1.397, 6.528)	0.005	1.115 (0.562, 2.213)	0.755

OR, odds ratio; CI, confidence interval; BMI, body mass index; H-Y, Hoehn and Yahr; PDD, Parkinson's disease with dementia; UPDRS-III, Unified Parkinson's Disease Rating Scale Part III; Hcy, homocysteine; NSE, neuron-specific enolase; SNH, substantial nigra hyperechogenicity.