Am J Transl Res 2026;18(2):1347-1355
www.ajtr.org /ISSN:1943-8141/AJTR0170678

Original Article

DPP-4 inhibitors for preventing post-stroke cognitive impairment in diabetic patients with acute ischemic stroke: a retrospective cohort study

Hongran Fu[1], Jianfang Liu[1], Jie Wu[2], Feihui Zou[3]

[1]Department of Neurology, The Second People's Hospital of Changzhou, The Third Affiliated Hospital of Nanjing Medical University, Changzhou 213000, Jiangsu, China; [2]Department of Neurosurgery, Suzhou Hospital Affiliated to Nanjing University Medical School, Suzhou 215153, Jiangsu, China; [3]Department of Neurosurgery, The Second People's Hospital of Changzhou, The Third Affiliated Hospital of Nanjing Medical University, Changzhou 213000, Jiangsu, China

Received December 11, 2025; Accepted January 27, 2026; Epub February 15, 2026; Published February 28, 2026

Abstract: Objective: To evaluate the preventive effect of dipeptidyl peptidase-4 inhibitors (DPP-4i) on post-stroke cognitive impairment (PSCI) in patients with type 2 diabetes mellitus (T2DM) and concurrent acute ischemic stroke (AIS). Methods: A retrospective cohort study was conducted on 236 patients with T2DM+AIS recruited from April 2021 to October 2024. Patients were grouped based on DPP-4i use: an observation group (107 cases) with DPP-4i therapy and a control group (129 cases) without. Patients' baseline demographics, clinical features, laboratory indices, and follow-up data were extracted from the electronic medical record system. The primary outcome measure was the incidence of PSCI, defined as a Montreal Cognitive Assessment Scale (MoCA) score <26 at six months after AIS. Secondary outcomes included inflammatory cytokines, oxidative stress markers, neuroprotective factors (BDNF), glycemic metabolism indicators, and life quality [Barthel Index (BI), Functional Independence Measure (FIM), and Instrumental Activities of Daily Living (IADL)]. Results: At 6 months after AIS, the incidence of PSCI was significantly lower in the observation group than in the control group ($P<0.05$). Furthermore, inflammatory and oxidative stress marker levels were decreased whereas BDNF level was significantly elevated in the observation group compared to the control group (all $P<0.05$). According to the quality-of-life assessment, patients receiving DPP-4i had higher BI, FIM, and IADL scores ($P<0.05$), along with a lower all-cause readmission rate ($P<0.05$). Subgroup analysis indicated that different DPP-4i types (e.g., sitagliptin, saxagliptin) had consistent cognitive protective effects ($P>0.05$). Conclusion: DPP-4i can lower PSCI risk in T2DM+AIS patients. Its mechanism involves multi-dimensional effects like anti-inflammation, anti-oxidation, insulin sensitivity enhancement, and neuroprotection.

Keywords: DPP-4 inhibitors, type 2 diabetes, acute ischemic stroke, post-stroke cognitive impairment, neuroprotection

Introduction

Post-stroke cognitive impairment (PSCI) is a common and disabling complication of acute ischemic stroke (AIS). Approximately 30% to 50% of patients experience cognitive function decline within 6 months after AIS, manifested by memory impairment and executive dysfunction among others, which significantly compromises independent living ability and long-term quality of life [1, 2]. For AIS patients with type 2 diabetes mellitus (T2DM), hyperglycemia can further increase PSCI risk through mechanisms such as aggravating neuronal oxidative stress, amplifying neuroinflammation, and promoting cerebral amyloid deposition [3]. Currently, PSCI management mainly relies on traditional drugs such as cholinesterase inhibitors. However, effective preventive strategies for the high-risk population with concomitant T2DM and AIS remain limited [4].

In recent years, dipeptidyl peptidase-4 inhibitors (DPP-4i) have attracted increasing interest because of their pleiotropic effects beyond glycemic control [5]. Experimental studies have demonstrated that DPP-4i plays a neuroprotective role by inhibiting inflammatory cytokines

https://doi.org/10.62347/PLKN4994

(ICKs) release, improving endothelial function, and up-regulating brain-derived neurotrophic factor (BDNF) expression [6]. Animal experiments further suggest its ability to attenuate the apoptosis of hippocampal neurons after AIS [7]. Nonetheless, existing studies mostly focused on the short-term effect of DPP-4i on post-AIS glycemic control [8, 9], or on isolated neurological outcomes, such as motor function. Real-world evidence evaluating their effect on PSCI, particularly in patients with concurrent T2DM and AIS, remains limited.

This study comprehensively investigated the preventive effect of DPP-4i on PSCI in T2DM patients with AIS through a retrospective cohort design. By focusing on this high-risk population with concurrent T2DM and AIS, this study aimed to address an important gap in PSCI prevention research. Elucidating the role of DPP-4i in reducing the risk of PSCI may support a dual-benefit therapeutic strategy, hypoglycemic control and neuroprotection, for the comprehensive management of T2DM patients with AIS, facilitating earlier intervention for cognitive decline after AIS and improving long-term prognosis and quality of life.

Materials and methods

Study participants

This single-center, retrospective cohort study enrolled patients with T2DM complicated by AIS who were admitted to The Second People's Hospital of Changzhou between April 2021 and October 2024.

Inclusion criteria: age ≥50 years; first-onset AIS diagnosed by cranial CT; confirmed T2DM [10]; no cognitive impairment upon admission, with a Montreal Cognitive Assessment Scale (MoCA) [11] score ≥26 (adjusted for years of education: illiteracy ≤25, primary school ≤26, middle school or above ≥27); receipt of standardized secondary prevention of AIS (e.g., anti-platelet aggregation, statins, blood pressure/glycemic control) during hospitalization; availability of complete 6 month follow-up data.

Exclusion criteria: pre-AIS diagnosis of dementia; severe hepatorenal insufficiency; history of malignancies and mental illness; death or loss of follow-up during hospitalization; concurrent use of drugs that could interfere with cognition; cumulative DPP-4i treatment period <7 days during hospitalization.

After screening, 236 participants were finally included. Among them, 107 patients who received DPP-4i therapy during hospitalization were assigned to the observation group, while the remaining 129 patients who did not receive DPP-4i treatment constituted the control group. This study was approved by the Ethics Committee of The Second People's Hospital of Changzhou (Approval No. [2025]YLJSA069). Given the retrospective nature and anonymization of the patient data, informed consent was waived.

Treatment methods

After admission, all patients received secondary preventive treatment for AIS, including anti-platelet aggregation (aspirin 100 mg once daily or clopidogrel 75 mg once daily), lipid-lowering therapy with statins (atorvastatin 20-40 mg once nightly), blood pressure control (<140/90 mmHg), and glycemic control (glycated hemoglobin [HbA1c] <7.0%). Patients in the observation group received DPP-4i treatment within 24 hours after AIS onset (i.e., after admission), with specific regimens based on clinical practice (sitagliptin 100 mg once daily, saxagliptin 5 mg once daily, or linagliptin 5 mg once daily). All patients in the observation group continued DPP-4i treatment without interruption throughout the 6-month follow-up period. Those who discontinued DPP-4i treatment due to adverse were excluded prior to analysis.

Data acquisition

Patient data were retrieved from the electronic medical record system, including demographic data (age, sex, years of education), clinical characteristics (TOAST classification, National Institutes of Health Stroke Scale [NIHSS] score, infarction location and volume, time from onset to hospital admission), comorbidities (e.g., hypertension, coronary heart disease), and laboratory indicators(e.g., HbA1c, fasting plasma glucose at admission and discharge). All patients completed 6-month follow-up without dropout.

Primary outcome

The risk of PSCI served as the primary outcome. MoCA scores were evaluated at baseline

and 6 months after treatment. The incidence of PSCI at 6 months after AIS was calculated, defined as a MoCA score <26 points (adjusted for years of education).

Secondary outcomes

Laboratory indicators, including HbA1c, FPG, interleukin-6 (IL-6), tumor necrosis factor-α (TNF-α), high-sensitivity C-reactive protein (hs-CRP), superoxide dismutase (SOD), malondialdehyde (MDA), and BDNF, were measured using enzyme-linked immunosorbent assay (ELISA) at baseline and the 6-month follow-up. The homeostasis model assessment of insulin resistance (HOMA-IR) was calculated according to the formula: HOMA-IR = [fasting blood glucose (mmol/L) × fasting insulin (μIU/mL)]/22.5. Fasting insulin (FINS) levels were detected simultaneously at baseline and 6-month follow-up. At the final follow-up visit, functional outcomes and quality of life were evaluated using the Barthel Index (BI) [12], Functional Independence Measure (FIM) [13], and Instrumental Activities of Daily Living (IADL) scale [14]. In addition, stroke recurrence, mortality, and all-cause readmission rates during the follow-up were also recorded.

Quality control

Relevant data were independently extracted by two investigators, with any discrepancies resolved through discussion with a third investigator. To minimize assessment bias, trained neuropsychologists who were blinded to DPP-4i use were responsible for MoCA assessment (using the standardized version). Similarly, BI, FIM, and IADL assessments were conducted by dedicated rehabilitation therapists who were blinded to DPP-4i use.

Statistical methods

All statistical analyses were performed using SPSS 32.0. Categorical variables were expressed as [n (%)] and compared using chi-square test or Fisher's exact test (count ≤5). Continuous variables were first assessed for normality using the Shapiro-Wilk test. Data with normal distribution were presented as mean ± standard deviation (mean ± SD) and were compared using independent sample t-tests for between-group comparisons and paired t-tests for within-group comparisons. Data with skewed distribution were expressed as median (25th-75th percentile) [M (P25, P75)] and were analyzed using the Mann-Whitney U test for between-group comparisons and the Wilcoxon signed-rank tests for within-group comparisons. Statistical significance was set at $P<0.05$.

Results

Baseline characteristics

There were no significant inter-group differences in demographic variables, clinical features, comorbidities, or baseline laboratory indicators between the two groups ($P>0.05$), indicating good comparability and minimal influences of confounding factors (**Table 1**). All patients completed the prognostic follow-up without missing data.

PSCI incidence

Baseline MoCA scores were comparable between the two groups ($P>0.05$). At 6 months after treatment, MoCA scores decreased in both groups compared to baseline, with a significantly greater reduction in the control group ($P<0.05$). In addition, the incidence of PSCI at post-treatment 6 months in the observation group was 19.63%, significantly lower than 31.78% in the control group ($P<0.05$, **Table 2**).

Subgroup analysis of DPP-4i

Patients in the observation group were further stratified according to the specific DPP-4i agent they received. Subgroup analysis demonstrated no significant difference in cognitive outcomes among different DPP-4i types (e.g., sitagliptin, saxagliptin), suggesting comparable cognitive protective effects across agents ($P>0.05$, **Table 3**).

Dynamic changes in glycemic metabolism and insulin sensitivity

After treatment, the HbA1c and FPG levels decreased significantly in both groups compared to baseline levels ($P<0.05$). Notably, HOMA-IR decreased significantly in the observation group after treatment ($P<0.05$), whereas no obvious change was observed in the

Table 1. Comparison of baseline characteristics between the two groups

	Observation group (n=107)	Control group (n=129)	t or χ^2	*P* value
Age	66.22±4.90	65.81±6.18	0.557	0.578
Sex, n (%)			0.703	0.402
Male	64 (59.81)	84 (65.12)		
Female	43 (40.19)	45 (34.88)		
BMI (kg/m^2)	23.27±3.04	23.32±2.34	0.145	0.885
Duration of T2DM (years)	10.48±2.74	10.31±3.21	0.424	0.672
Time from AIS onset to hospital admission (h)	17.29±7.13	18.44±5.22	1.601	0.111
Years of education, n (%)				
Illiteracy	6 (5.61)	8 (6.20)		
Primary school	68 (63.55)	79 (61.27)		
Secondary school and above	33 (30.84)	42 (32.56)		
Smoking, n (%)			0.936	0.333
Yes	76 (71.03)	84 (65.12)		
No	31 (28.97)	45 (34.88)		
Alcohol consumption, n (%)			0.784	0.375
Yes	26 (24.30)	38 (29.46)		
No	81 (75.70)	91 (70.54)		
Family History of AIS, n (%)			0.014	0.907
Yes	16 (14.95)	20 (15.50)		
No	91 (85.05)	109 (84.50)		

Note: BMI, body mass index; AIS, acute ischemic stroke; T2DM, type 2 diabetes mellitus.

Table 2. Comparison of MoCA scores and PSCI incidence between the two groups

	MoCA scores		PSCI
	Baseline	Post-treatment	
Observation group (n=107)	28.12±1.37	26.68±3.01#	21 (19.63)
Control group (n=129)	28.03±1.40	25.67±3.58#	41 (31.78)
Statistical (t or χ^2)	0.498	2.332	4.463
P	0.619	0.021	0.035

Note: #P<0.05, compared with baseline. PSCI, post-stroke cognitive impairment; MoCA, Montreal Cognitive Assessment Scale.

Table 3. Comparison of MoCA scores stratified by different DPP-4i agents

	MoCA scores		PSCI
	Baseline	Post-treatment	
Sitagliptin (n=54)	28.22±1.48	27.13±2.58#	12 (22.22)
Saxagliptin (n=31)	28.23±1.36	26.37±3.58#	6 (19.35)
Linagliptin (n=22)	28.02±1.35	26.67±2.85#	3 (13.64)
Statistical (F or χ^2)	0.304	0.417	0.733
P	0.739	0.660	0.693

Note: #P<0.05, compared with baseline. DPP-4i, dipeptidyl peptidase-4 inhibitors; PSCI, post-stroke cognitive impairment; MoCA, Montreal Cognitive Assessment Scale.

control group (P>0.05). After treatment, although HbA1c differed insignificantly between groups (P>0.05), the observation group demonstrated significantly lower FPG and HOMA-IR levels than the control group (P<0.05, **Figure 1**).

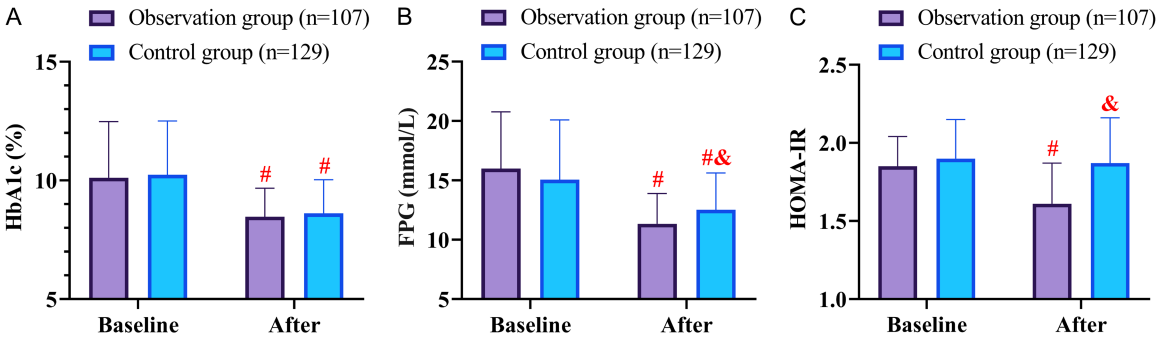

Figure 1. Comparison of glucose metabolism profiles. A. HbA1c; B. FPG; C. HOMA-IR. Notes: #P<0.05, compared to baseline; &P<0.05, compared to observation group. HbA1c, glycated hemoglobin A1c; FPG, fasting plasma glucose; HOMA-IR, homeostasis model assessment of insulin resistance.

Comparison of neuroprotective effects and inflammatory/oxidative stress markers

There were no significant differences in serum indicators between the two groups at baseline (P>0.05). Following treatment, levels of inflammatory cytokines (ICKs) including IL-6, TNF-α, and hs-CRP, were significantly decreased in both groups (P<0.05), indicating alleviated inflammation. Concurrently, MDA levels decreased while SOD increased in both groups (P<0.05), indicating alleviated oxidative stress damage. Additionally, serum BDNF levels were significantly elevated, indicating neurological function improvement.

Inter-group comparison at the 6-month follow-up showed significantly reduced hs-CRP and MDA levels, as well as increased BDNF and SOD levels in the observation group compared to the control group (P<0.05, **Figure 2**). These findings indicate that DPP-4i administration was associated with better neurological function enhancement and inflammation/oxidative stress alleviation.

Comparison of quality of life

Quality of life was assessed using BI, FIM, and IADL scores. At the 6-month follow-up, patients in the observation group demonstrated higher BI, FIM, and IADL scores than those in the control group (P<0.05, **Figure 3**), suggesting superior life quality.

Comparison of prognostic outcomes

There were no significant differences in recurrence or all-cause mortality rates between the two groups (P>0.05). However, the observation group showed an rehospitalization rate of 10.28%, significantly lower than 20.16% in the control groups (P<0.05, **Table 4**).

Discussion

Employing a retrospective cohort design, this study found that DPP-4i use was associated with a lower risk of PSCI in patients with T2DM and AIS. In addition, DPP-4i use was associated with more favorable glucose control and anti-inflammation and anti-oxidation effects, as well as improved quality of life. Specifically, the incidence of PSCI at 6 months after AIS was lower in the observation group, accompanied by greater reductions in ICKs and oxidative stress markers, as well as more evident increases in BDNF and SOD. Functional assessments using BI, FIM, and IADL scales further indicated better functional independence among patients in the observation group. Moreover, a significantly lower all-cause readmission rate was observed in this group. Though not significantly different in recurrence or mortality rates, the observation group demonstrated better rehabilitation quality than the control group. These findings lay a reliable foundation for clinical DPP-4i applications.

Consistent with previous basic research, this study also found that DPP-4i use was associated with a reduced risk of PSCI in patients with T2DM complicated by AIS. In an animal study by Huang et al., DPP-4i reduced glucagon-like peptide-1 (GLP-1) degradation through suppression of DPP-4 enzyme activity, thus activating the PI3K/Akt signaling pathway and reducing hippocampal neuronal apoptosis [15]. The pleiotropic effects of DPP-4i may be exerted through

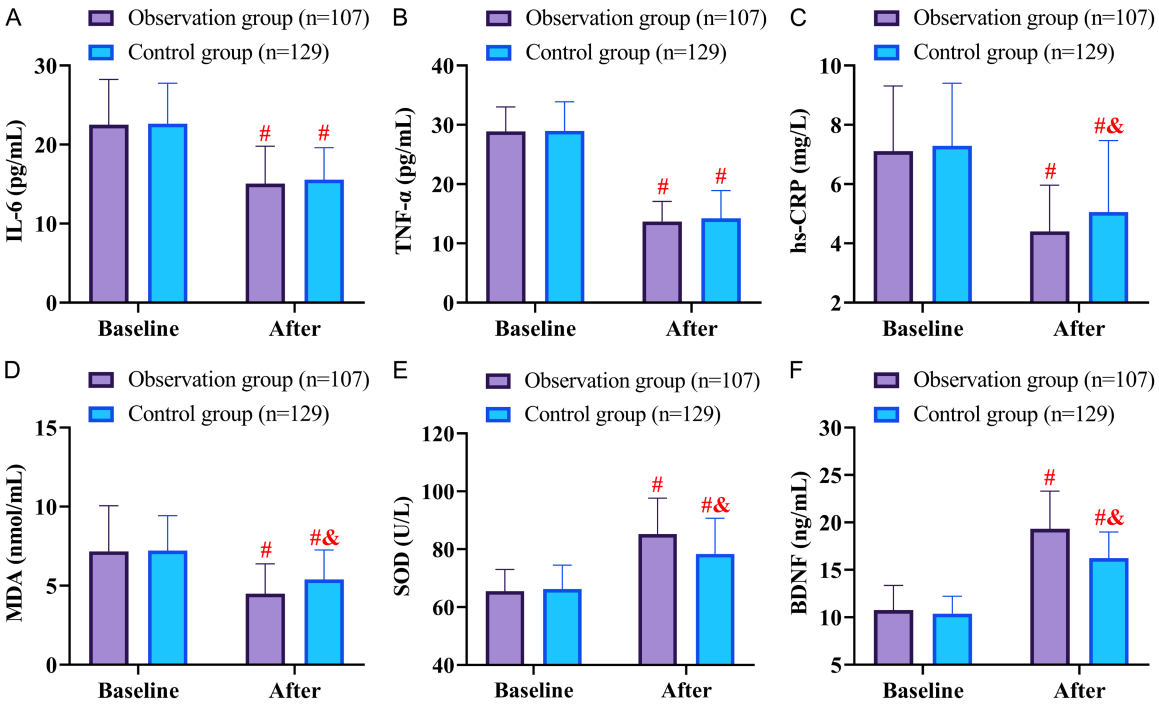

Figure 2. Comparison of neuroprotection effects and inflammatory/oxidative stress markers. A. IL-6; B. TNF-α; C. hs-CRP; D. MDA; E. SOD; F. BDNF. Notes: #P<0.05, compared to baseline; &P<0.05, compared to observation group. IL-6, iInterleukin-6; TNF-α, tumor necrosis factor-α; hs-CRP, high-sensitivity C-reactive protein; SOD, superoxide dismutase; MDA, malondialdehyde; BDNF, brain-derived neurotrophic factor.

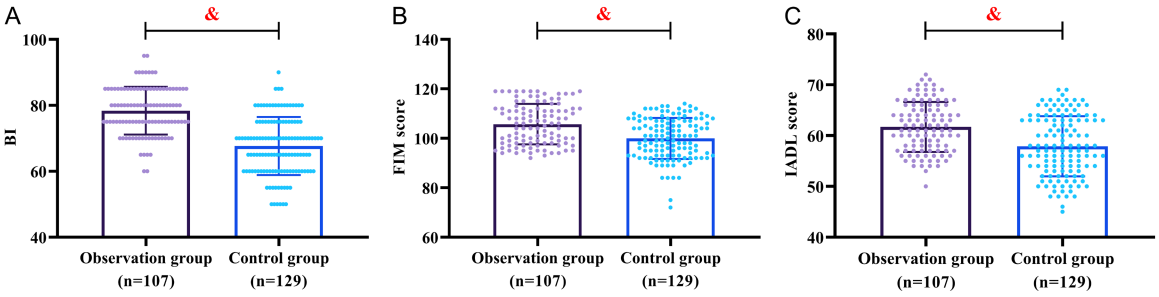

Figure 3. Comparison of quality-of-life scores. A. BI; B. FIM scores; C. IADL scores. Notes: &P<0.05, compared to observation group. BI, Barthel Index; FIM, Functional Independence Measure; IADL, Instrumental Activities of Daily Living.

Table 4. Comparison of clinical outcomes between the two groups

	Recurrence rate	Mortality rate	All-cause rehospitalization rate
Observation group (n=107), n (%)	10 (9.35)	4 (3.74)	11 (10.28)
Control group (n=129), n (%)	12 (9.30)	6 (4.65)	26 (20.16)
χ^2	0.001	0.120	4.314
P	0.991	0.729	0.038

the following pathways: (1) Anti-inflammation: DPP-4i down-regulates systemic inflammatory responses by reducing hs-CRP, IL-6, and other pro-inflammatory cytokines [16], which is consistent with the lower post-treatment hs-CRP levels observed in the observation group; (2) Neuroprotection: Up-regulation of BDNF, promotes synaptic plasticity and neuronal survival

[18]; (3) Attenuation of oxidative stress: DPP-4i was associated with reduced MDA levels and increased SOD activity, indicating an improvement in oxidative stress status. Previous studies had suggested that DPP-4i may suppress oxidative damage by inhibiting NADPH oxidase-mediated free radical generation [19]. Although previous studies had reported that DPP-4i can improve cerebral blood flow [17], this study did not measure cerebral blood flow or vascular function indicators; therefore, this mechanism cannot be directly validated. Notably, subgroup analysis revealed no significant differences in PSCI risk among different DPP-4i agents, suggesting similar cognitive protective effects across DPP-4i types. This discovery also fills the evidence-based gap of cognitive preservation in this subgroup.

Regarding glycemic metabolism, although HbA1c levels decreased in both groups after treatment, no significant inter-group difference was observed, indicating comparable overall glycemic control. However, the observation group showed lower FPG and HOMA-IR, suggesting potential advantages of DPP-4i for improving insulin sensitivity independent of HbA1c. Notably, the lower incidence of PSCI in the observation group despite comparable HbA1c levels highlights the glycemic-independent neuroprotective effect of DPP-4i, which is consistent with its pleiotropic properties. Previous studies have demonstrated that DPP-4i exert glucose-dependent hypoglycemic effects by delaying gastric emptying and inhibiting glucagon secretion, thereby reducing the risk of hypoglycemia [20]. In addition, Bianchi et al. reported that improved insulin resistance, as reflected by lower HOMA-IR, an index closely related to Aβ clearance disorders and tau protein phosphorylation, may reduce neurotoxicity [21]. Therefore, we hypothesize that DPP-4i may also indirectly protect cognitive function by improving insulin resistance.

The significant improvement in BI, FIM, and IADL scores in the observation group also reflects the protective effect of DPP-4i on the overall functional outcomes. This may be related to the following mechanisms: (1) Cognitive preservation improves patients' ability to perform daily activities; (2) Glucose homeostasis reduces the occurrence of metabolic complications, such as infections; (3) Inflammation reduction alleviates non-specific symptoms such as fatigue and depression. Among these, the between-group difference in IADL scores suggests that DPP-4i may be particularly associated with the preservation of higher-order cognitive functions required for complex daily activities, such as financial management and social activities.

Although no significant differences were observed in stroke recurrence or mortality between the two groups, the significantly lower rehospitalization rate in the observation group suggests that DPP-4i may reduce the risk of cardiovascular events by improving metabolic homeostasis and the immune microenvironment. This aligns with previous evidence reported by Sattar et al., showing that GLP-1 receptor agonists (sharing partial overlapping mechanisms with DPP-4i) can reduce the risk of cardiovascular death in patients with T2DM [22].

Based on the results of this study, DPP-4i is recommended as a preferred drug for secondary prevention in patients with T2DM complicated with AIS, especially for those with hyperglycemia, elevated ICKs, or a high risk of cognitive decline. Nevertheless, longer follow-up periods are needed to further verify the long-term effects of DPP-4i on clinical outcomes.

Although extensive efforts were made to adjust for known confounding factors, due to the retrospective design, unmeasured confounders, such as diet and exercise habits may have influenced the final results. In addition, the inclusion of only 236 patients may limit the generalizability of the findings. Objective indicators such as MRI findings (e.g., hippocampal volume, white matter lesions) were not collected, precluding direct correlation between neuroprotective mechanisms and cognitive outcomes. Finally, although subgroup analyses demonstrated consistent effects across different DPP-4i agents, variations in pharmacokinetic and pharmacodynamic properties, such as the longer half-life of sitagliptin, may have affected the universality of these conclusions.

Conclusions

DPP-4i intervention was associated with a reduced risk of PSCI in patients with T2DM and AIS. The mechanism involves the synergistic actions of anti-inflammatory and antioxidant effects, improved insulin sensitivity, and neu-

roprotection. These findings not only provide new evidence for the clinical application of DPP-4i but also provide an important reference for the optimization of comprehensive management strategies for T2DM patients with AIS. Subsequently, prospective multi-center studies need to be conducted to further verify the long-term efficacy and safety of DPP-4i, and to facilitate its clinical transformation in neuroprotection.

Acknowledgements

This work was supported by the Suzhou Science and Technology Development Program (Healthcare Science and Technology Innovation Project, No. SKYD2022089).

Disclosure of conflict of interest

None.

Address correspondence to: Feihui Zou, Department of Neurosurgery, The Second People's Hospital of Changzhou, The Third Affiliated Hospital of Nanjing Medical University, No. 188 Gehu Road, Changzhou 213000, Jiangsu, China. E-mail: zoufeihui888@163.com; Jie Wu, Department of Neurosurgery, Suzhou Hospital Affiliated to Nanjing University Medical School, No. 1 Lijiang Road, Suzhou High-tech Zone, Suzhou 215153, Jiangsu, China. E-mail: wj93334-494@163.com

References

[1] Huang YY, Chen SD, Leng XY, Kuo K, Wang ZT, Cui M, Tan L, Wang K, Dong Q and Yu JT. Post-stroke cognitive impairment: epidemiology, risk factors, and management. J Alzheimers Dis 2022; 86: 983-999.

[2] Filler J, Georgakis MK and Dichgans M. Risk factors for cognitive impairment and dementia after stroke: a systematic review and meta-analysis. Lancet Healthy Longev 2024; 5: e31-e44.

[3] Ma ZY, Wu YY, Cui HY, Yao GY and Bian H. Factors influencing post-stroke cognitive impairment in patients with type 2 diabetes mellitus. Clin Interv Aging 2022; 17: 653-664.

[4] Wu Y, Tan M, Gao Y, Geng N, Zhong W, Sun H, Li Z, Wu C, Li X and Zhang J. Complement proteins in serum astrocyte-derived exosomes are associated with poststroke cognitive impairment in type 2 diabetes mellitus patients. J Alzheimers Dis 2024; 99: 291-305.

[5] He L, Wang J, Ping F, Yang N, Huang J, Li W, Xu L, Zhang H and Li Y. Dipeptidyl peptidase-4 inhibitors and gallbladder or biliary disease in type 2 diabetes: systematic review and pairwise and network meta-analysis of randomised controlled trials. BMJ 2022; 377: e068882.

[6] Demirkilic O, Eski I, Ciftci Ozturk E, Yasun O, Aydin B, Birkan C, Ozsoy A and Sen S. Association between dipeptidyl peptidase-4 inhibitor use and cognitive functions, brain-derived neurotrophic factor, and pentraxin-3 levels in patients with type 2 diabetes. Cureus 2024; 16: e54440.

[7] Zhang Q, Xiao X, Zheng J, Li M, Yu M, Ping F, Wang T and Wang X. Vildagliptin, a dipeptidyl peptidase-4 inhibitor, attenuated endothelial dysfunction through miRNAs in diabetic rats. Arch Med Sci 2019; 17: 1378-1387.

[8] Lee S, Zhou J, Leung KSK, Wai AKC, Jeevaratnam K, King E, Liu T, Wong WT, Chang C, Wong ICK, Cheung BMY, Tse G and Zhang Q. Comparison of sodium-glucose cotransporter-2 inhibitor and dipeptidyl peptidase-4 inhibitor on the risks of new-onset atrial fibrillation, stroke and mortality in diabetic patients: a propensity score-matched study in Hong Kong. Cardiovasc Drugs Ther 2023; 37: 561-569.

[9] Hastrup S, Hedegaard JN, Andersen G, Rungby J and Johnsen SP. Glucagonlike peptide-1 receptor agonists versus dipeptidyl peptidase-4 inhibitors in ischemic strokes with diabetes 2. Eur J Neurol 2024; 31: e16329.

[10] Bellary S, Kyrou I, Brown JE and Bailey CJ. Type 2 diabetes mellitus in older adults: clinical considerations and management. Nat Rev Endocrinol 2021; 17: 534-548.

[11] Carlew AR, Smith EE, Goette W, Lippe B, Lacritz L and Rossetti H. Montreal Cognitive Assessment (MoCA) scores in medically compromised patients: a scoping review. Health Psychol 2021; 40: 717-726.

[12] Uchinaka EI, Hanaki T, Morimoto M, Murakami Y, Tomoyuki M, Yamamoto M, Tokuyasu N, Sakamoto T, Hasegawa T and Fujiwara Y. The Barthel index for predicting postoperative complications in elderly patients undergoing abdominal surgery: a prospective single-center study. In Vivo 2022; 36: 2973-2980.

[13] Pozin M, Najafali D, Naik A, MacInnis B, Subbarao N, Zuckerman SL and Arnold PM. Long-term assessment of the functional independence measure in sports-related spinal cord injury. J Spinal Cord Med 2024; 47: 214-228.

[14] Liu H, Ma Y, Lin L, Sun Z, Li Z and Jiang X. Association between activities of daily living and depressive symptoms among older adults in China: evidence from the CHARLS. Front Public Health 2023; 11: 1249208.

[15] Huang L, Pi J, Gu L, Liao Z and Wang W. Teneligliptin, a DPP4 inhibitor protects dopaminergic

neurons in PD models via inhibiting of oxidative stress and ferroptosis. Eur J Pharmacol 2025; 1002: 177782.
[16] Zhuge F, Zheng L, Pan Y, Ni L, Fu Z, Shi J and Ni Y. DPP-4 inhibition by linagliptin ameliorates age-related mild cognitive impairment by regulating microglia polarization in mice. Exp Neurol 2024; 373: 114689.
[17] Ribeiro-Silva JC, Marques VB and Dos Santos L. Effects of dipeptidyl peptidase 4 inhibition on the endothelial control of the vascular tone. Am J Physiol Cell Physiol 2023; 325: C972-C980.
[18] Abdelhamid AH, Mantawy EM, Said RS and El-Demerdash E. Neuroprotective effects of saxagliptin against radiation-induced cognitive impairment: insights on Akt/CREB/SIRT1/BDNF signaling pathway. Toxicol Appl Pharmacol 2024; 489: 116994.
[19] Fontes MT, Arruda-Junior DF, Dos Santos DS, Ribeiro-Silva JC, Antonio EL, Tucci PFJ, Rossoni LV and Girardi ACC. Dipeptidyl peptidase 4 inhibition rescues PKA-eNOS signaling and suppresses aortic hypercontractility in male rats with heart failure. Life Sci 2023; 323: 121648.
[20] Wang K, Zhang Z, Hang J, Liu J, Guo F, Ding Y, Li M, Nie Q, Lin J, Zhuo Y, Sun L, Luo X, Zhong Q, Ye C, Yun C, Zhang Y, Wang J, Bao R, Pang Y, Wang G, Gonzalez FJ, Lei X, Qiao J and Jiang C. Microbial-host-isozyme analyses reveal microbial DPP4 as a potential antidiabetic target. Science 2023; 381: eadd5787.
[21] Bianchi M and Manco M. Circulating levels of PIN1 and glucose metabolism in young people with obesity. J Endocrinol Invest 2022; 45: 1741-1748.
[22] Sattar N, Lee MMY, Kristensen SL, Branch KRH, Del Prato S, Khurmi NS, Lam CSP, Lopes RD, McMurray JJV, Pratley RE, Rosenstock J and Gerstein HC. Cardiovascular, mortality, and kidney outcomes with GLP-1 receptor agonists in patients with type 2 diabetes: a systematic review and meta-analysis of randomised trials. Lancet Diabetes Endocrinol 2021; 9: 653-662.