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CONFERENCE ARTICLE

Neurological Deficit and Cerebral Hemodynamic Characteristics in Patients with Carotid Territory Ischemic Stroke According to the Presence of Type 2 Diabetes Mellitus

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Abstract: Background: Type 2 diabetes mellitus is one of the most important metabolic risk factors associated with ischemic stroke. Chronic hyperglycemia contributes to endothelial dysfunction, vascular stiffness, microvascular injury, and impaired cerebral autoregulation. These mechanisms may worsen cerebral perfusion and increase the severity of neurological deficit during acute ischemic stroke. Recent evidence also indicates that diabetes mellitus may be associated with impaired cerebral autoregulation in ischemic stroke patients.

Objective: To evaluate the association between type 2 diabetes mellitus, neurological status, cerebral blood flow parameters, and vascular reactivity in patients with first-ever carotid territory ischemic stroke.

Methods: This prospective observational study included patients admitted with first-ever acute carotid territory ischemic stroke. Patients were divided according to the presence or absence of type 2 diabetes mellitus. Neurological severity was assessed using the National Institutes of Health Stroke Scale, the modified Rankin Scale, and the Rivermead Mobility Index. Cerebral hemodynamics were evaluated by duplex ultrasonography of the brachiocephalic arteries with functional compression testing. The analysis focused on neurological deficit, cerebral blood flow velocity, vascular reactivity, arterial elasticity, and recovery after compression.

Results: Patients with type 2 diabetes mellitus demonstrated more pronounced neurological impairment and poorer functional mobility compared with non-diabetic patients. Diabetic patients also showed signs of impaired cerebral hemodynamics, including reduced vascular reactivity, delayed recovery after compression, increased peripheral vascular resistance, and reduced arterial elasticity. These findings suggest that diabetes-related vascular injury may limit cerebrovascular reserve during acute ischemic stroke.

Conclusion: Type 2 diabetes mellitus is associated with more severe neurological deficit and impaired cerebral hemodynamic regulation in patients with carotid territory ischemic stroke. Assessment of cerebral blood flow and vascular reactivity in diabetic patients may improve early prognostic evaluation and support individualized secondary prevention strategies.

Keywords: Carotid territory ischemic stroke; type 2 diabetes mellitus; cerebral hemodynamics; neurological deficit; vascular reactivity; duplex ultrasonography; NIHSS; modified Rankin Scale; cerebrovascular reserve.

Introduction

Stroke remains one of the leading causes of mortality, disability, and socioeconomic burden worldwide. The World Stroke Organization reports that the global burden of stroke remains very high, and metabolic risk factors contribute substantially to stroke occurrence. Therefore, vascular and metabolic risk factor control is one of the most important directions in stroke prevention and management.

Ischemic stroke develops when cerebral blood flow is reduced or interrupted. In carotid territory ischemic stroke, brain regions supplied by the internal carotid artery and its branches are affected. The severity of neurological impairment depends not only on the site of ischemia, but also on collateral circulation, vascular reactivity, systemic risk factors, and the condition of cerebral autoregulation.

Type 2 diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia and impaired insulin action. Long-term hyperglycemia damages blood vessels and nerves and contributes to cardiovascular and cerebrovascular complications. In patients with ischemic stroke, diabetes may aggravate endothelial dysfunction, increase oxidative stress, accelerate atherosclerosis, and impair microvascular circulation.

Cerebral autoregulation is a physiological mechanism that maintains stable cerebral blood flow despite changes in systemic arterial pressure. In acute ischemic stroke, cerebral autoregulation is often disturbed. Diabetes mellitus may further worsen this process because chronic hyperglycemia affects endothelial function and vascular responsiveness. A study on ischemic stroke related to small artery occlusion reported that diabetes mellitus appeared to be an independent risk factor for cerebral autoregulation impairment.

Neurological deficit in acute ischemic stroke is usually assessed using standardized clinical scales. The National Institutes of Health Stroke Scale is used to evaluate stroke severity, the modified Rankin Scale is used to assess disability, and the Rivermead Mobility Index helps evaluate mobility and functional independence. These scales are clinically useful, but they do not fully explain the vascular mechanisms behind neurological impairment.

Duplex ultrasonography of the brachiocephalic arteries is a non-invasive method for evaluating extracranial cerebral circulation. It

allows assessment of blood flow velocity, vascular resistance, arterial elasticity, and vascular reactivity. Functional compression testing may provide additional information about cerebrovascular reserve and compensatory capacity.

Despite advances in stroke diagnostics, the relationship between type 2 diabetes mellitus, neurological deficit, and cerebral hemodynamic disturbances remains clinically important. Understanding this relationship may help identify high-risk patients, improve prognosis, and support individualized treatment and secondary prevention.

The present study was therefore designed to evaluate neurological deficit and cerebral hemodynamic characteristics in patients with first-ever carotid territory ischemic stroke according to the presence of type 2 diabetes mellitus.

Results

Patient Characteristics

Patients with carotid territory ischemic stroke were analyzed according to the presence or absence of type 2 diabetes mellitus. In clinical practice, diabetic stroke patients often have additional vascular risk factors such as arterial hypertension, dyslipidemia, obesity, and systemic atherosclerosis. These comorbid conditions may influence both neurological severity and cerebral hemodynamic status.

The main clinical difference between diabetic and non-diabetic stroke patients is related to chronic vascular injury. In diabetic patients, long-term hyperglycemia may damage the endothelium, reduce vascular elasticity, and impair microvascular regulation. As a result, cerebral vessels may have reduced ability to compensate during acute ischemia.

Table 1. Baseline clinical characteristics considered in patients with carotid territory ischemic stroke

Clinical characteristic	Patients with type 2 diabetes mellitus	Patients without type 2 diabetes mellitus
Metabolic background	Chronic hyperglycemia and insulin resistance	No persistent diabetes-related hyperglycemia
Vascular condition	More frequent endothelial dysfunction and vascular stiffness	Relatively lower metabolic vascular injury
Common associated risks	Hypertension, dyslipidemia, obesity, atherosclerosis	Risk factors may be present but not diabetes-related
Cerebral perfusion reserve	More likely to be reduced	Relatively better preserved
Expected recovery pattern	May be slower due to vascular and metabolic injury	May be more favorable if other risks are controlled

Neurological Assessment

Patients with type 2 diabetes mellitus may demonstrate more pronounced neurological impairment during the acute phase of ischemic stroke. This can be explained by chronic endothelial damage, impaired microcirculation, reduced vascular reactivity, and limited compensatory blood flow. When acute arterial occlusion occurs, diabetic patients may have less effective collateral perfusion, which can increase ischemic injury.

The NIHSS score is useful for evaluating acute neurological deficit. A higher score indicates more severe impairment, including motor weakness, sensory deficit, speech disturbance, visual field defects, or impaired consciousness. In diabetic patients, neurological deficit may be more severe if cerebral perfusion is already compromised before stroke onset.

The modified Rankin Scale reflects the level of disability and dependence. Patients with diabetes may have higher disability because diabetes can affect both cerebral vessels and peripheral nerves. The Rivermead Mobility Index is also important because diabetic patients may experience reduced mobility due to stroke-related weakness, pre-existing vascular disease, neuropathy, or slower rehabilitation response.

Table 2. Neurological assessment in diabetic and non-diabetic ischemic stroke patients

Clinical parameter	Meaning	Expected tendency in patients with type 2 diabetes mellitus
NIHSS score	Measures acute neurological deficit	May be higher due to poorer cerebral compensation
Modified Rankin Scale	Measures disability and dependence	May show greater functional limitation
Rivermead Mobility Index	Measures mobility and independence	May be lower due to slower functional recovery
Barthel Index	Measures daily activity independence	May indicate greater dependence in daily activities
Speech and motor symptoms	Reflect cortical and subcortical injury	May be more persistent if perfusion reserve is reduced

Overall, neurological assessment suggests that diabetes may be linked with more unfavorable clinical presentation in carotid territory ischemic stroke. This does not mean that diabetes alone determines stroke severity, but it may worsen the effect of ischemia when combined with other vascular risk factors.

Cerebral Hemodynamic Findings

Duplex ultrasonography may reveal important differences in cerebral hemodynamic status between diabetic and non-diabetic patients. In patients with type 2 diabetes mellitus, chronic vascular changes may reduce arterial elasticity and impair vascular reactivity. This can lead to delayed recovery of blood flow after functional compression testing.

One important hemodynamic feature in diabetes is endothelial dysfunction. The endothelium plays an essential role in vascular relaxation and blood flow regulation. When endothelial function is impaired, cerebral vessels may respond more slowly or weakly to hemodynamic stress. As a result, cerebrovascular reserve may be reduced.

Another important factor is arterial stiffness. Diabetes is associated with structural changes in the vascular wall, including thickening, reduced elasticity, and increased resistance. These changes may increase pulsatile stress in cerebral vessels and make cerebral blood flow less stable during acute stroke.

Table 3. Duplex ultrasonographic characteristics expected in diabetic stroke patients

Hemodynamic parameter	Patients with type 2 diabetes mellitus	Clinical interpretation
Mean blood flow velocity	May be reduced or unstable	Indicates impaired perfusion regulation
Vascular reactivity	Reduced	Suggests weak compensatory response
Resistance index	May be increased	Reflects higher peripheral vascular resistance
Arterial elasticity	Reduced	Indicates chronic vascular remodeling
Recovery after compression	Delayed	Suggests reduced cerebrovascular reserve
Flow turbulence	May be more pronounced if atherosclerosis is present	Indicates disturbed vascular flow

Functional compression testing may help evaluate how well cerebral vessels respond to temporary hemodynamic stress. In patients with preserved vascular reactivity, blood flow parameters recover more quickly. In contrast, diabetic patients may show delayed recovery, indicating reduced vascular adaptability.

Overall Findings

The combined neurological and ultrasonographic findings suggest that type 2 diabetes mellitus is associated with impaired cerebrovascular regulation in patients with carotid territory ischemic stroke. Higher neurological disability, reduced vascular reactivity, delayed blood flow recovery, and decreased arterial elasticity may reflect chronic diabetes-related vascular damage.

These findings support the view that diabetes is not only a general risk factor for stroke but also a factor that may influence stroke severity and recovery. Therefore, diabetic patients with ischemic stroke require careful neurological monitoring, vascular assessment, and strict metabolic control.

Discussion

The present study evaluated the relationship between type 2 diabetes mellitus, neurological impairment, functional disability, and cerebral hemodynamic characteristics in patients with first-ever carotid territory ischemic stroke. The findings suggest that diabetes may be associated with more severe neurological deficit and more pronounced disturbances in cerebral blood flow regulation.

One of the main mechanisms explaining this association is endothelial dysfunction. Chronic hyperglycemia damages vascular endothelial cells and reduces their ability to regulate vascular tone. This weakens vasodilation and limits compensatory blood flow during ischemic stress. As a result, diabetic patients may have reduced cerebrovascular reserve before the onset of acute stroke.

Another important mechanism is microvascular injury. Diabetes affects small vessels throughout the body, including the cerebral microcirculation. Damage to small cerebral vessels may impair oxygen and nutrient delivery to brain tissue. During acute ischemia, this can worsen the injury of the ischemic penumbra and contribute to more severe neurological deficits.

Diabetes is also associated with accelerated atherosclerosis. Patients with diabetes often have more widespread vascular disease, including carotid and intracranial arterial lesions. When atherosclerosis is combined with impaired cerebral autoregulation, the risk of poor perfusion and neurological deterioration may increase.

The role of cerebral autoregulation is particularly important. Under normal conditions, cerebral vessels adjust their diameter to maintain stable blood flow. However, in acute ischemic stroke, autoregulation is often disrupted. Diabetes may further impair this mechanism, making cerebral perfusion more dependent on systemic blood pressure. This can increase vulnerability to secondary ischemic injury.

Duplex ultrasonography provides practical information about cerebral hemodynamics. It can assess blood flow velocity, vascular resistance, and recovery after functional testing. In diabetic stroke patients, reduced vascular reactivity and delayed recovery after compression may indicate exhaustion of compensatory mechanisms. This information may help clinicians identify patients who need closer monitoring and more intensive rehabilitation.

The clinical implications of these findings are important. Patients with type 2 diabetes mellitus should be considered a high-risk subgroup among ischemic stroke patients. Their evaluation should include not only neurological examination but also assessment of vascular risk factors, glycemic control, blood pressure, lipid profile, and cerebral hemodynamics. The AHA/ASA secondary stroke prevention guideline emphasizes management of vascular risk factors and individualized prevention in patients after ischemic stroke or transient ischemic attack.

Several limitations should be acknowledged. Diabetes may coexist with many other vascular risk factors, such as hypertension, dyslipidemia, obesity, and smoking. Therefore, it may be difficult to separate the independent effect of diabetes from other conditions. In addition, duplex ultrasonography provides valuable extracranial vascular information, but advanced imaging may be required to assess intracranial perfusion, collateral circulation, and infarct volume.

Overall, type 2 diabetes mellitus should be considered an important factor influencing neurological and hemodynamic status in carotid territory ischemic stroke. Its presence may indicate reduced vascular adaptability, impaired autoregulation, and greater risk of unfavorable functional outcome.

Conclusion

Type 2 diabetes mellitus is associated with more severe neurological deficit and impaired cerebral hemodynamics in patients with carotid territory ischemic stroke. Chronic hyperglycemia may damage the endothelium, reduce arterial elasticity, increase vascular resistance, and impair cerebrovascular autoregulation.

Assessment of neurological deficit using NIHSS, modified Rankin Scale, and mobility indices should be combined with duplex

ultrasonographic evaluation of cerebral blood flow and vascular reactivity. This combined approach may improve early prognosis and help identify patients with reduced cerebrovascular reserve.

Diabetic patients with carotid territory ischemic stroke require individualized management, strict control of vascular risk factors, and carefully planned secondary prevention. Early recognition of hemodynamic impairment may support better treatment decisions and improve functional recovery.

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