



RESEARCH ARTICLE

Association of Poor Long-Term Glycemic Control with Stroke Pattern, National Institutes of Health Stroke Scale Score, and Early Prognosis in Patients with Acute Cerebrovascular Event

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ABSTRACT

Background: Stroke remains one of the leading causes of mortality and long-term disability worldwide. Diabetes mellitus is a major modifiable risk factor for cerebrovascular disease, and chronic hyperglycaemia contributes to endothelial dysfunction, accelerated atherosclerosis, and impaired cerebral circulation. Glycated haemoglobin (HbA1c) reflects long-term glycaemic control over the preceding two to three months and has emerged as an important biomarker for predicting vascular complications. Although several studies have evaluated the association between HbA1c and stroke outcomes, evidence regarding its relationship with stroke pattern, National Institutes of Health Stroke Scale (NIHSS) score, and early prognosis in the Indian population remains limited.

Methodology: A hospital-based cross-sectional observational study was conducted in the Department of Medicine, Pt. JNM Medical College and Dr. B.R.A.M. Hospital, Raipur, Chhattisgarh, over one year. One hundred consecutive adult patients presenting with acute cerebrovascular events confirmed by computed tomography (CT) or magnetic resonance imaging (MRI) were enrolled. Clinical characteristics, vascular risk factors, HbA1c, stroke subtype, NIHSS score at admission, and early clinical outcome were recorded. Patients were categorized into good glycaemic control (HbA1c <7.0%) and poor glycaemic control (HbA1c ≥7.0%). Statistical analysis included Chi-square test, independent Student's t-test, Pearson correlation, and multivariable logistic regression. A p-value <0.05 was considered statistically significant.

Results: Among the 100 enrolled patients, 62% had poor long-term glycaemic control (HbA1c ≥7.0%). Poor glycaemic control was significantly associated with ischemic stroke (77.4% vs. 57.9%; p=0.039), higher NIHSS scores (13.8±5.2 vs. 9.7±4.6; p<0.001), severe stroke (43.5% vs. 18.4%; p=0.012), and poor early clinical outcome (54.8% vs. 26.3%; p=0.006). HbA1c showed a moderate positive correlation with NIHSS score (r=0.49, p<0.001). Multivariable logistic regression identified HbA1c ≥7.0% (OR 3.46, 95% CI 1.38–8.66; p=0.008), hypertension (OR 2.81, 95% CI 1.10–7.19; p=0.031), and age ≥60 years (OR 2.47, 95% CI 1.01–6.04; p=0.047) as independent predictors of poor early prognosis.

Conclusion: Poor long-term glycaemic control is significantly associated with greater stroke severity, higher NIHSS scores, ischemic stroke predominance, and poorer early prognosis in patients with acute cerebrovascular events. HbA1c may serve as a useful prognostic biomarker for early risk stratification in acute stroke.

Recommendation: Routine HbA1c assessment should be incorporated into the initial evaluation of patients presenting with acute stroke. Early identification of poor glycaemic control may facilitate risk stratification, optimize management, and improve neurological outcomes. Larger multicentre prospective studies are recommended to validate these findings.

Keywords: Acute stroke; HbA1c; Glycaemic control; NIHSS; Ischemic stroke; Prognosis; Cerebrovascular disease.

Indian J. Pharm. Biol. Res. (2026): <https://doi.org/10.30750/ijpbr.14.4.35>

INTRODUCTION

Stroke is one of the leading causes of death and long-term disability worldwide and continues to pose a major public health challenge. According to the Global Burden of Disease Study, more than 12 million individuals experience a new stroke each year, with nearly two-thirds of cases occurring in low- and middle-income countries. India contributes substantially to this burden because of the increasing prevalence of vascular risk factors, population ageing, and changing lifestyles. Despite advances in acute stroke

management, stroke remains a major cause of mortality, disability, and healthcare expenditure in the country.[1,2]

Diabetes mellitus is a well-recognized independent risk factor for cerebrovascular disease. Individuals with diabetes have nearly twice the risk of developing stroke compared with the general population, and the coexistence of hypertension, dyslipidaemia, obesity, and smoking further increases this risk. Persistent hyperglycaemia promotes endothelial dysfunction, oxidative stress, accelerated atherosclerosis, chronic inflammation, platelet

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How to cite this article: Gupta P, Chouhan A, Venugopal Margekar, V, Patel RK. Association of Poor Long-Term Glycemic Control with Stroke Pattern, National Institutes of Health Stroke Scale Score, and Early Prognosis in Patients with Acute Cerebrovascular Event. *Indian J. Pharm. Biol. Res.* 2026;14(4):255-262.

Source of support: Nil

Conflict of interest: None.

Received: 20/07/2026 **Revised:** 25/08/2026 **Accepted:** 02/10/2026

activation, and impaired fibrinolysis, thereby increasing susceptibility to cerebral ischemia and vascular injury.[3,4]

Glycated haemoglobin (HbA1c) is considered the gold standard for assessing long-term glycaemic control because it reflects the average blood glucose concentration during the preceding two to three months. Unlike random or fasting blood glucose measurements, HbA1c is relatively unaffected by the acute stress response associated with stroke and therefore provides a more reliable estimate of chronic glycaemic status. Elevated HbA1c has been associated with increased risk of both microvascular and macrovascular complications, including ischemic heart disease, nephropathy, retinopathy, peripheral vascular disease, and cerebrovascular events.[5,6]

Experimental and clinical evidence suggests that chronic hyperglycaemia adversely affects the cerebral vasculature through multiple mechanisms. Long-standing hyperglycaemia impairs endothelial nitric oxide production, increases oxidative stress, promotes inflammatory cytokine release, enhances thrombus formation, and disrupts the blood-brain barrier. These pathological processes may contribute to larger cerebral infarcts, impaired collateral circulation, increased cerebral oedema, and delayed neurological recovery following acute stroke.[7]

The National Institutes of Health Stroke Scale (NIHSS) is the most widely accepted clinical instrument for assessing neurological impairment in patients with acute

stroke. The scale evaluates consciousness, language, motor function, sensory deficits, visual fields, coordination, and neglect, allowing objective quantification of stroke severity. Higher NIHSS scores have consistently been associated with larger infarct size, prolonged hospital stay, greater functional disability, and increased mortality, making the scale an important prognostic tool in routine clinical practice.[8]

Several studies have demonstrated that poor long-term glycaemic control is associated with increased stroke severity, unfavourable functional outcome, recurrent stroke, and increased mortality. Elevated HbA1c levels have been reported to correlate with higher NIHSS scores, larger infarct volume, poorer neurological recovery, and worse functional status at discharge. However, the magnitude of this association varies across different populations because of differences in ethnicity, healthcare systems, treatment protocols, and cardiovascular risk profiles.[9,10]

India has one of the largest populations of individuals with diabetes mellitus worldwide, and the incidence of acute stroke continues to rise steadily. Nevertheless, limited evidence is available regarding the relationship between chronic glycaemic control, stroke subtype, neurological severity, and early clinical outcome among Indian patients presenting with acute cerebrovascular events. Identifying this relationship may facilitate early risk stratification and guide therapeutic decision-making in routine clinical practice.[11]

Therefore, the present study was undertaken to evaluate the association of poor long-term glycaemic control with stroke pattern, National Institutes of Health Stroke Scale score, and early prognosis among patients with acute cerebrovascular events admitted to a tertiary care teaching hospital. Additionally, the study aimed to identify independent predictors of poor early outcome and assess the prognostic utility of HbA1c in acute stroke management.[12]

Materials and Methods

Study Design

A hospital-based cross-sectional observational study was conducted to evaluate the association between long-term glycemic control and stroke pattern, National Institutes of Health Stroke Scale (NIHSS) score, and early prognosis among patients presenting with acute cerebrovascular events.

Study Setting

The study was carried out in the Department of Medicine, Pt. Jawaharlal Nehru Memorial (Pt. JNM) Medical College

and Dr. B.R.A.M. Hospital, Raipur, Chhattisgarh, India.

Study Duration

The study was conducted over one year (January 2025 to December 2025).

Study Population

Adult patients presenting with acute cerebrovascular events (ischemic or hemorrhagic stroke) within seven days of symptom onset were screened for eligibility.

Sample Size

A total of 100 consecutive patients fulfilling the eligibility criteria were enrolled.

Inclusion Criteria

- Age ≥ 18 years.
- Clinical diagnosis of acute stroke confirmed by CT or MRI brain.
- Admission within 7 days of symptom onset.
- Known diabetes mellitus or newly diagnosed diabetes according to ADA criteria.
- Written informed consent from patient or legally authorized representative.

Exclusion Criteria

- Transient ischemic attack (TIA).
- Stroke secondary to trauma.
- Cerebral venous sinus thrombosis.
- Brain tumors.
- CNS infections.
- Severe chronic kidney disease requiring dialysis.
- Terminal malignancy.
- Pregnancy.
- Incomplete laboratory or imaging data.

Study Variables

Primary Exposure

Long-term glycemic control assessed using HbA1c.

Poor long-term glycemic control:

HbA1c $\geq 7.0\%$

Good glycemic control:

HbA1c $< 7.0\%$

Primary Outcomes

- Stroke pattern
- Stroke severity (NIHSS)
- Early functional outcome

Secondary Variables

- Age
- Gender
- BMI

- Smoking
- Alcohol use
- Hypertension
- Dyslipidemia
- Duration of diabetes
- Admission blood glucose
- Hospital stay
- In-hospital mortality

Data Collection

After obtaining informed consent, demographic and clinical information was recorded using a structured case record form.

The following information was collected

- Age
- Sex
- Residence
- Occupation
- Duration of diabetes
- Hypertension
- Smoking
- Alcohol intake
- Previous stroke
- Medication history
- Time from symptom onset
- Blood pressure
- Height
- Weight
- BMI

Clinical Evaluation

Each patient underwent a complete neurological examination.

Stroke severity was evaluated using the National Institutes of Health Stroke Scale (NIHSS) immediately after admission by trained physicians.

NIHSS severity categories were classified as

Neuroimaging

- All patients underwent CT brain.
- MRI brain was performed whenever clinically

NIHSS Score	Severity
0–4	Minor
5–15	Moderate
16–20	Moderate to severe
21–42	Severe

indicated.

Stroke pattern was categorized as

- Ischemic stroke
- Intracerebral hemorrhage

Laboratory Investigations

- Venous blood samples were collected after admission.
- The following investigations were performed:
- Complete blood count
- Random blood sugar
- Fasting blood sugar
- HbA1c
- Serum creatinine
- Liver function tests
- Lipid profile
- Electrolytes
- ECG

HbA1c estimation was performed using High Performance Liquid Chromatography (HPLC).

Assessment of Early Prognosis

Early prognosis was evaluated during hospitalization.

Patients were categorized into

- Improved
- Stable
- Deteriorated
- Death
- Modified Rankin Scale (mRS) at discharge was also documented.

Poor outcome

mRS 3–6

Good outcome

mRS 0–2

Outcome Measures

- Primary Outcome
- Association of poor long-term glycemic control with
- Stroke pattern
- NIHSS score
- Early prognosis

Secondary Outcomes

- Relationship between HbA1c and
- Stroke subtype
- Hospital stay
- Mortality
- Functional outcome

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation (SD), while categorical variables were summarized as frequencies and percentages. Comparisons between categorical variables were performed using the Chi-square test or Fisher's exact test, as appropriate. Continuous variables were compared using the Independent Student's t-test. The correlation between HbA1c and NIHSS score was assessed using the Pearson correlation coefficient. Variables showing statistical significance on univariate analysis were entered into a multivariable logistic regression model to identify independent predictors of poor prognosis. Adjusted odds ratios (ORs) with 95% confidence intervals (95% CIs) were calculated. A two-tailed p-value <0.05 was considered statistically significant.

Ethical Considerations

- The study protocol received approval from the Institutional Ethics Committee of Pt. JNM Medical College and Dr. B.R.A.M. Hospital, Raipur, prior to commencement.
- Written informed consent was obtained from every

Table 1: Baseline Demographic Characteristics of the Study Population (n = 100)

Variable	Frequency (n)	Percentage (%)
<i>Age Group (years)</i>		
<50	18	18.0
50–59	26	26.0
≥ 60	56	56.0
<i>Gender</i>		
Male	62	62.0
Female	38	38.0

Mean age = 61.8 ± 11.9 years

Table 2: Baseline Clinical Characteristics

Variable	n (%) / Mean $\pm$ SD
Hypertension	68 (68.0)
Dyslipidaemia	46 (46.0)
Smoking	29 (29.0)
Alcohol use	24 (24.0)
Duration of diabetes >10 years	42 (42.0)
Mean HbA1c (%)	7.9 ± 1.6
Mean NIHSS score	12.2 ± 5.3

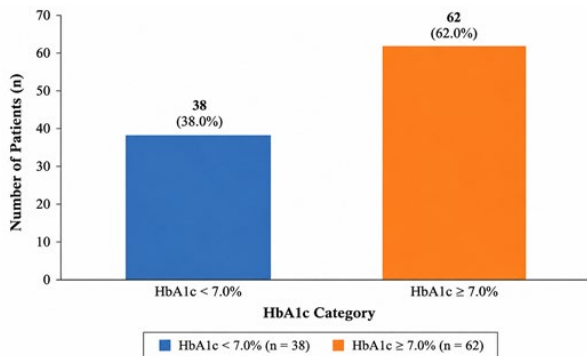


Figure 1: Distribution of HbA1c Categories

participant or legally authorized representative.

- Confidentiality of patient information was maintained throughout the study.
- The study adhered to the ethical principles outlined in the Declaration of Helsinki and Good Clinical Practice guidelines.

RESULTS

A total of 100 patients presenting with acute cerebrovascular events were included in the study. The mean age of the study population was 61.8 ± 11.9 years (range: 34–87 years). Most patients belonged to the ≥ 60 years age group (56%). Males constituted 62 (62.0%) patients, while females accounted for 38 (38.0%). Baseline demographic characteristics are summarized in Table 1.

The baseline clinical characteristics of the study population are shown in Table 2. Hypertension was present in 68%, diabetes duration exceeded 10 years in 42%, and dyslipidaemia was identified in 46% of patients. The mean

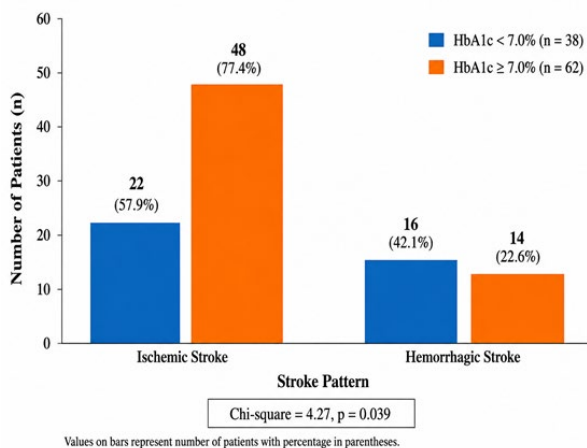


Figure 2: Stroke Pattern According to HbA1c Category

Table 3: Distribution According to HbA1c Category

HbA1c Category	Frequency	Percentage
<7.0%	38	38.0
≥7.0%	62	62.0

Table 4: Association Between HbA1c and Stroke Pattern

Stroke Pattern	HbA1c <7%	HbA1c ≥7%	Total
Ischemic	22	48	70
Hemorrhagic	16	14	30

Table 5: Comparison of NIHSS Scores According to HbA1c

HbA1c Group	Mean NIHSS ± SD	p-value
<7.0%	9.7 ± 4.6	
≥7.0%	13.8 ± 5.2	<0.001

HbA1c level was $7.9 \pm 1.6\%$, while the mean admission NIHSS score was 12.2 ± 5.3 .

Patients were categorized according to long-term glycaemic control. Poor glycaemic control (HbA1c $\geq 7.0\%$) was observed in 62 patients (62.0%), whereas 38 patients (38.0%) had HbA1c $< 7.0\%$. The distribution is presented in Table 3.

The distribution of HbA1c categories is illustrated in Figure 1.

Overall, **70 patients (70.0%)** had ischemic stroke, while **30 (30.0%)** presented with intracerebral haemorrhage. Ischemic stroke was significantly more common among

Table 6: NIHSS Severity According to HbA1c Category

NIHSS Severity	HbA1c <7%	HbA1c ≥7%
Mild	11	9
Moderate	20	26
Severe	7	27

Chi-square = 8.89, p = 0.012

Table 7: Association Between HbA1c and Early Prognosis

Outcome	HbA1c <7%	HbA1c ≥7%
Good outcome	28	28
Poor outcome	10	34

Chi-square = 7.62, p = 0.006

Table 8: Correlation Between HbA1c and NIHSS Score

Variable	Correlation coefficient (r)	p-value
HbA1c vs NIHSS	0.49	<0.001

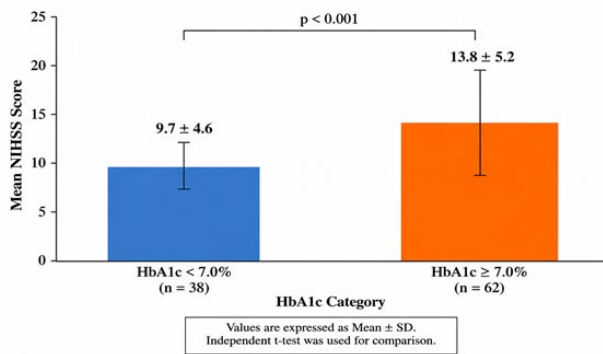


Figure 3: Comparison of NIHSS Score According to HbA1c Category

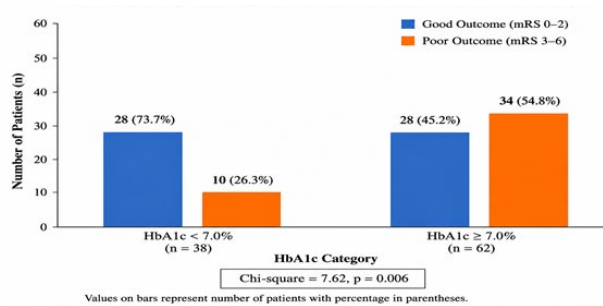


Figure 4: Early Clinical Outcome According to HbA1c Category

patients with poor glycaemic control (77.4%) than among those with HbA1c <7.0% (57.9%) ($\chi^2 = 4.27$, $p = 0.039$) (Table 4).

The distribution of stroke subtype according to HbA1c category is shown in **Figure 2**.

Stroke severity was assessed using the NIHSS score. Patients with poor glycaemic control demonstrated

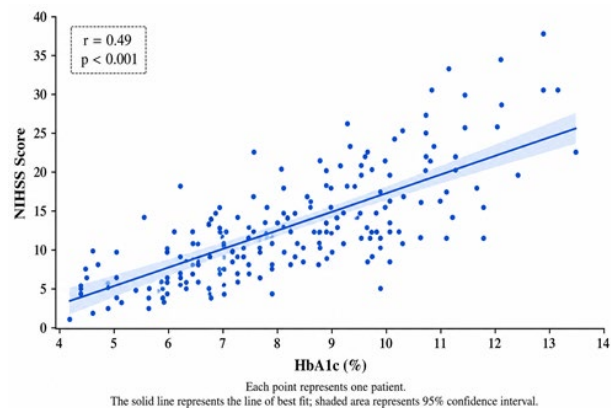


Figure5: The correlation between HbA1c and NIHSS score is illustrated in Figure 5.

Table 9: Multivariable Logistic Regression Analysis for Poor Early Prognosis

Variable	Adjusted OR	95% CI	p-value
HbA1c ≥7.0%	3.46	1.38–8.66	0.008
Hypertension	2.81	1.10–7.19	0.031
Age ≥60 years	2.47	1.01–6.04	0.047

Chi-square = 4.27, $p = 0.039$

significantly higher NIHSS scores (13.8 ± 5.2) compared with those with good glycaemic control (9.7 ± 4.6 , $p < 0.001$) (Table 5).

The comparison of NIHSS scores between HbA1c groups is illustrated in Figure 3.

Patients were further categorized according to NIHSS severity. Severe stroke (NIHSS ≥16) occurred significantly more frequently among patients with HbA1c ≥7.0% (43.5%) than among those with HbA1c <7.0% (18.4%) ($\chi^2 = 8.89$, $p = 0.012$) (Table 6).

Poor early clinical outcome (mRS 3–6) was significantly more common among patients with poor glycaemic control (54.8%) than among patients with HbA1c <7.0% (26.3%) ($\chi^2 = 7.62$, $p = 0.006$) (Table 7).

The distribution of early clinical outcomes according to HbA1c category is presented in Figure 4.

Pearson correlation analysis demonstrated a significant positive correlation between HbA1c level and NIHSS score ($r = 0.49$, $p < 0.001$), indicating that worsening long-term glycaemic control was associated with increasing stroke severity (Table 8).

Variables that were statistically significant on univariate analysis were entered into a multivariable logistic

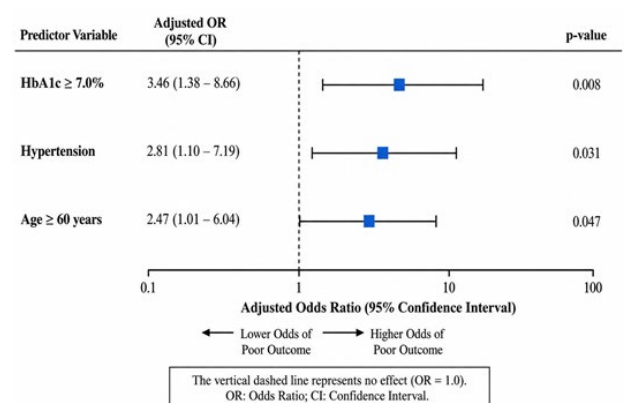


Figure 6: Forest Plot of Independent Predictors

regression model. Poor glycaemic control (HbA1c $\geq 7.0\%$), hypertension, and age ≥ 60 years remained independent predictors of poor early prognosis (Table 9). The independent predictors of poor early prognosis are illustrated in Figure 6 (Forest Plot).

DISCUSSION

The present study evaluated the association between long-term glycaemic control and stroke pattern, neurological severity, and early prognosis among patients with acute cerebrovascular events. The major findings were that 62% of patients had poor glycaemic control (HbA1c $\geq 7.0\%$), and elevated HbA1c was significantly associated with ischemic stroke, higher NIHSS scores, severe stroke, poor early functional outcome, and independently predicted adverse prognosis. These findings suggest that chronic hyperglycaemia plays an important role in determining stroke severity and early clinical outcome.

In the present study, poor glycaemic control was observed in 62% of patients, indicating that chronic hyperglycaemia is common among individuals presenting with acute stroke. Persistent hyperglycaemia promotes endothelial dysfunction, oxidative stress, chronic inflammation, and accelerated atherosclerosis, thereby increasing susceptibility to cerebrovascular disease. A recent systematic review and meta-analysis also demonstrated that elevated HbA1c is associated with increased mortality and poor functional outcomes following both ischemic and hemorrhagic stroke, highlighting its value as a prognostic biomarker. [13]

A significant association was observed between elevated HbA1c and ischemic stroke, with ischemic events occurring more frequently among patients with poor glycaemic control. Chronic exposure to hyperglycaemia promotes atherosclerotic plaque formation, vascular inflammation, and platelet activation, favouring thrombotic cerebrovascular events. Similar findings have been reported by Acampa et al., who demonstrated that poor prestroke glycaemic control was associated with greater ischemic stroke severity and poorer long-term outcomes. [14]

Patients with HbA1c $\geq 7.0\%$ had significantly higher mean NIHSS scores and a greater proportion of severe stroke than those with good glycaemic control. Chronic hyperglycaemia is known to impair cerebral microcirculation, increase oxidative stress, and exacerbate ischemic neuronal injury, resulting in more severe neurological deficits. These findings are consistent with previous studies showing that elevated HbA1c correlates

with increased NIHSS scores and larger infarct burden in patients with acute ischemic stroke. [15]

Poor early clinical outcome was significantly more common among patients with elevated HbA1c in the present study. Furthermore, HbA1c $\geq 7.0\%$ remained an independent predictor of poor prognosis after adjustment for other clinical variables. Similar results were reported in a recent prospective cohort study, which demonstrated that admission HbA1c independently predicted poor functional outcome after acute ischemic stroke with high diagnostic accuracy. These findings support the routine use of HbA1c for early risk stratification in patients presenting with acute stroke. [16]

Another important finding was the significant positive correlation between HbA1c and NIHSS score ($r=0.49$), indicating that worsening long-term glycaemic control is associated with increasing neurological impairment. This relationship supports the concept that HbA1c reflects cumulative vascular injury rather than acute stress hyperglycaemia alone. Therefore, HbA1c may serve as a simple, inexpensive, and reliable biomarker for identifying patients at increased risk of severe stroke and poor early outcome. [17]

Overall, the findings of the present study reinforce existing evidence that poor long-term glycaemic control adversely influences stroke severity and prognosis. Early assessment of HbA1c at hospital admission may help clinicians identify high-risk patients who require closer monitoring, aggressive management of vascular risk factors, and individualized rehabilitation strategies to improve neurological outcomes.

CONCLUSION

The present study demonstrated that poor long-term glycaemic control, as reflected by an HbA1c level $\geq 7.0\%$, was significantly associated with ischemic stroke, higher NIHSS scores, greater stroke severity, and poorer early clinical outcomes among patients with acute cerebrovascular events. Furthermore, elevated HbA1c remained an independent predictor of poor early prognosis after adjustment for age and hypertension. These findings indicate that HbA1c is a valuable marker of chronic glycaemic status and may serve as a simple, inexpensive, and reliable prognostic biomarker for early risk stratification in patients with acute stroke. Routine assessment of HbA1c at hospital admission may facilitate identification of high-risk patients, enable timely optimization of glycaemic and vascular risk factors, and support individualized

management strategies to improve neurological outcomes. Larger multicentre prospective studies with longer follow-up are warranted to further validate these findings.

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