



Glycated Hemoglobin as A Marker for Predicting Outcomes of Patients with Hemorrhagic Stroke

Moid Khan¹, Mazhar Badshah¹, Ahmed Hussain¹, Najeeb Khan¹, Faiz Khan¹, Nabeel Tariq¹

¹Department of Neurology, PIMS Hospital, Islamabad, Pakistan.

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Correspondence to: Moid Khan
Department of Neurology, PIMS Hospital,
Islamabad, Pakistan.

Email: moidkhan734@gmail.com

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ABSTRACT

Background: A severe cerebrovascular event with a high morbidity and fatality rate is hemorrhagic stroke (HS). Finding trustworthy prognostic indicators is essential to enhancing clinical results. Glycated hemoglobin (HbA1c), which has been connected to vascular dysfunction and the risk of stroke, is a measure of long-term glycemic management. Its predictive usefulness for hemorrhagic stroke outcomes is still unknown, though. **Objective:** This study aims to evaluate the role of HbA1c as a predictive biomarker for clinical outcomes in patients with hemorrhagic stroke, focusing on stroke severity, functional recovery, and mortality. **Methods:** At Quetta's Bolan Medical Complex Hospital, 300 patients with hemorrhagic stroke were the subjects of a prospective observational study. Based on their HbA1c readings, patients were divided into three groups: <5.7%, 5.7%–6.4%, and >6.5%. The Glasgow Coma Scale (GCS) and NIH Stroke Scale (NIHSS) were used to measure clinical severity. The modified Rankin Scale (mRS) was used to assess functional outcomes both at discharge and ninety days after the stroke. Independent predictors of unfavorable outcomes were found using logistic regression analysis. **Results:** Significantly negative outcomes were seen by patients with HbA1c >6.5%, including higher mean blood pressure (160/95 mmHg ± 14, p=0.001), higher NIHSS scores (14.7 ± 5.2, p=0.002), and lower GCS scores (8.9 ± 3.2, p=0.001). This group had the lowest functional independence (18.2%, p=0.001) and the highest mortality (36.4%, p=0.002). Along with age >60 years, hypertension, and high NIHSS scores, logistic regression verified that HbA1c >6.5% was an independent predictor of poor functional recovery (OR: 2.9, p=0.001). **Conclusion:** In hemorrhagic stroke patients, elevated HbA1c levels are linked to worse functional recovery, higher mortality, and more severe stroke. A major independent predictor of unfavorable outcomes is a HbA1c >6.5%. These results imply that regular HbA1c testing could help patients with hemorrhagic stroke with risk assessment and clinical decision-making.

INTRODUCTION

Research indicates that diabetes mellitus is presently increasing globally as a medical condition affecting approximately 400 million people worldwide (1). Research shows that diabetes mellitus will affect about 600 million people by 2040 (1, 2). The known link between diabetes as a neurovascular risk factor supports the prediction that numerous stroke patients will demonstrate diabetes mellitus (3,4). Meta-analysis research showed that acute hyperglycemia together with diabetes existed as strong risk factors for negative outcomes after ischemic and hemorrhagic stroke events (5).

Large-scale multi-center research based on 27,000 participants revealed diabetes affected one-fifth of acute stroke patients while only 22 percent of patients who did not suffer from stroke (6). The research demonstrated that diabetes establishes a higher association with ischemic stroke than with hemorrhagic stroke (6). Multiple research investigations reveal that diabetes leads to increased

stroke fatalities and prolonged hospital care together with higher admission occurrences and poorer rehabilitation results (7–10). Results from several different studies demonstrate that diabetes status does not impact stroke recovery outcomes after a stroke event (11, 12). Glycated hemoglobin (HbA1c) has proven itself as an effective biochemical assessment method.

This measure provides information regarding the long-term blood sugar management during a 120-day period. 3 months or 120 days (13, 14). The testing benefits from minimal stress-induced misinterpretation errors and ignores brief blood glucose changes (13, 14).

Determining HbA1c does not require overnight fasting because testing only needs a small blood sample amount (14). These features most likely make HbA1c testing possible for routine diabetic mellitus screening, especially in hospital settings.

Scientists have established that HbA1c functions as an effective measurement of damaged blood vessels in

diabetic patients (15, 16). Multiple research studies have proven that HbA1c shows strong relationships with various diabetes complications (15–17). Research has not sufficiently established how the test predicts neurological conditions occurring quickly such as strokes. Doctors have been investigating how HbA1c levels of hemorrhagic and ischemic stroke patients relate to their medical results. The available current understanding does not provide support for these guidelines.

The use of HbA1c for stroke patient outcome prediction requires gathering high-quality evidence from combining study results. This analysis evaluated the relationship between HbA1c measurements and mortality along with early neurological and functional outcomes for ischemic and hemorrhagic stroke patients by considering all available factors.

Hemorrhagic stroke (HS) is a serious cerebrovascular incident with high risk of morbidity and death. Since bleeding weak blood arteries (i.e., blood arteries of low pressure) in the brain, it causes subarachnoid hemorrhage (SAH) and intracerebral hemorrhage (ICH) (Patel et al., 2021). Improvements in neurocritical care, however, have not been enough to improve the prediction of clinical outcomes in HS. For example, although provided with useful information, traditional prognostic indicators such as hematoma volume, Glasgow Coma Scale (GCS) score, and intraventricular hemorrhage do not encompass the entire spectrum of metabolic influence on stroke recovery. (18)

Glycated hemoglobin (HbA1c) is a long-term indicator of glucose metabolism and is represented by average blood glucose level for past two to three months (19). Elevated HbA1c may also worsen the hemorrhagic stroke outcome because it has been associated with endothelial dysfunction, increased oxidative stress, and systemic inflammation (20). New data suggest HbA1c may be a biomarker for predicting morbidity and death in stroke patients, particularly if glycemia is poorly managed or a case of undiagnosed diabetes (21).

LITERATURE REVIEW

Glycated hemoglobin (HbA1c) is an important biomarker of long-term glycemic management and represents the average blood glucose levels over the previous two to three months. It has received a great deal of scientific interest as a putative predictor of outcome following hemorrhagic stroke. This review of the literature investigates the relationship between clinical outcomes of hemorrhagic stroke patients and their HbA1c levels. HbA1c and ROI have predictive power for hemorrhagic transformation and neurological outcomes for patients with acute anterior stroke. The result is that increased HbA1c is associated with higher negative outcomes and increases chances of hemorrhagic transformation. The reason for this is that hemorrhagic transformation is associated with increases in HbA1c in the patients with stroke — it's likely that chronic hyperglycemia would exacerbate a particular weakness of the errant vasculature in the brain (22). However, another study which was prospective and conducted in many areas of Beijing aimed to analyze the glycemic status of the population before and after having a stroke, with the intention of finding out the duration of

their condition or even the severity of the ICH, This cohort showed that although there was a positive association between high random blood glucose and fasting blood glucose levels on admission with increased ICH volume and severity of NHL, this was not the case with HbA1c levels (23). The above results suggest that HbA1c, which is an index of chronic glycemic control, is not useful in the acute stroke and that elevated admission blood glucose, reflecting acute hyperglycemia, is related to the degree of stroke severity and immediate outcome. Jafar et al (2021) Systematic Review and Meta analysis: The Role of HbA1c as a Prognostic Factor for Stroke Patients Ischemic and Hemorrhagic. Analysis showed that mortality and functional outcomes of hemorrhagic stroke patients with high HbA1c level were associated with higher mortality rate. When literally combined the information showed that patients with HbA1c levels lower than or equal to 6.5 % were at increased threat of prolonged pathological activity and therefore long-term glycemic adjustment was critical in the guidance of stroke clinical practice (24). This finding is supported by a study by Sung et al. (2017) in which HbA1c, fasting glucose, or admission random glucose were studied as predictive factors for neurological outcomes following acute ischemic stroke. Even though patients' acute glucose readings were thought to indicate the severity of the stroke as it occurred, HbA1c levels provided further predictive information about long term functional outcomes and worse recovery trajectories were seen generally with those patients who had higher HbA1c levels, demonstrating the role of chronic hyperglycemia on stroke recovery. (25)

In the Japanese cohort research, HbA1c was found to be associated with hemorrhagic stroke risk and other stroke subtypes in Ohira et al. (2008). While higher HbA1c levels were demonstrated to be associated with an elevated risk of ischemic stroke (26), but not hemorrhagic stroke (26), this suggests that chronic hyperglycemia may have variable effects, such that it is more harmful in affecting ischemic strokes. When put together, these studies provide a sophisticated view of the role of HbA1c in hemorrhagic stroke outcome. Some study say acute glycemic measurements may be more important stroke related symptoms, if poor glycemic control leading to acute hyperglycemic state, however HbA1c levels are related to worse outcome and more mortality for stroke. Such differences may obscure the findings comparing results for patient groups, study designs, and time of glycemic testing. Finally, the relationship between high HbA1c levels and bad outcomes in patients with hemorrhagic stroke, remains contradictory. Further extensive prospective research is required to determine if HbA1c can serve as an acceptable prognostic indicator for clinical outcomes and to define the specific role that chronic glycemic control plays in the hemorrhagic stroke prognosis.

Research Objective

The aim of this research was to assess the use of glycated hemoglobin (HbA1c) as a predictor for outcome following a hemorrhagic stroke. This study aims to explore the association between patients who suffer from hemorrhagic stroke concentration of HbA1c level and severity, prognosis, and recovery patterns with both short

term and long-term results on mind. Therefore, we aim to determine the possible use of HbA1c as a chronic glycemic control indicator for hemorrhagic stroke risk stratification, clinical decision making, and treatment approaches. The knowledge of such a correlation may help to develop more individualized, yet efficient treatment plans, which might shed light on how pre-existing glycemic management affects stroke related complications.

Research Questions

1. What is the relationship between glycated hemoglobin (HbA1c) levels and clinical outcomes in patients with hemorrhagic stroke?
2. How do HbA1c levels correlate with stroke severity as measured by the Glasgow Coma Scale (GCS) and National Institutes of Health Stroke Scale (NIHSS)?
3. Does an elevated HbA1c level increase the risk of mortality in patients with hemorrhagic stroke?
4. What is the impact of HbA1c levels on functional recovery, as measured by the modified Rankin Scale (mRS), at 90 days post-stroke?

METHODOLOGY

A qualitative study was conducted from Jan 2025 to May 2025 at Bolan Medical Complex Hospital, Quetta to find out the role of glycated hemoglobin (HbA1c) as a predictive marker for the outcome of hemorrhagic stroke patients. The study called for the enrollment of 300 patients suffering from hemorrhagic stroke in the study using a non-probability purposive sampling technique. Patients were included who were 30 years of age and above and had confirmed diagnosis of hemorrhagic stroke with CT images. No patients with a history of ischemic stroke, chronic kidney disease, or conditions of the HbA1c were included. Demographic data, medical history, and decreased glycemic control status were recorded after obtaining informed consent.

If you consider you are a patient with diabetes, you are placed in one of three groups based upon the HbA1c reading when you come in, Group 1 (<5.7%), Group 2 (5.7% – 6.4%), Group 3 (>6.5%). Patient outcomes were scored by the modified Rankin Scale (mRS) both at discharge and at 90 days. Included were other clinical indicators such as blood pressure, NIHSS, Glasgow Coma Scale. Data were collected through the use of structured questionnaires, and the SPSS software was used to analyze data. If we are dealing with continuous variables the descriptive statistics like mean and standard deviation were used to portray continuous and frequencies and percentages for categorical data. Chi-square and logistic regression analyses were used to find relationships between HbA1c levels and patient outcomes.

RESULTS

Table 1

Baseline Characteristics of Patients

Characteristic	Mean ± SD / n (%)
Age (years)	62.5 ± 10.8
Male	180 (60%)
Female	120 (40%)
Hypertension	210 (70%)
Diabetes Mellitus	140 (46.7%)
BMI (kg/m ²)	27.8 ± 3.5

Table 2

Distribution of Patients by HbA1c Levels

HbA1c Group	n (%)
<5.7%	90 (30%)
5.7%–6.4%	100 (33.3%)
>6.5%	110 (36.7%)

Table 3

Clinical Parameters by HbA1c Groups

Parameter	<5.7%	5.7%–6.4%	>6.5%	p-value
Mean GCS Score	12.4 ± 2.1	10.8 ± 2.5	8.9 ± 3.2	0.001*
Mean NIHSS Score	8.2 ± 3.4	11.5 ± 4.1	14.7 ± 5.2	0.002*
Mean BP (mmHg)	140/85 ± 10	150/90 ± 12	160/95 ± 14	0.001*

Table 4

Patient Outcomes by HbA1c Levels

Outcome	<5.7% (n=90)	5.7%–6.4% (n=100)	>6.5% (n=110)	p-value
Mortality (%)	12 (13.3%)	22 (22%)	40 (36.4%)	0.002*
Functional Independence (mRS ≤2)	58 (64.4%)	42 (42%)	20 (18.2%)	0.001*

Table 5

Logistic Regression Analysis for Predictors of Poor Outcome (mRS >2 at 90 Days)

Variable	Odds Ratio (95% CI)	p-value
Age (>60 years)	1.8 (1.2–2.7)	0.01*
HbA1c >6.5%	2.9 (1.9–4.5)	0.001*
Hypertension	1.6 (1.1–2.3)	0.02*
NIHSS Score >10	3.5 (2.2–5.4)	0.001*

DISCUSSION OF RESULTS

This study involved 300 subjects, 62.5 ± 10.8 years of age, with a previous diagnosis hemorrhagic stroke; 60% of the patients were males, 70% had a history of hypertension and 46.7% were diabetes mellitus. As seen in Table 1, the mean BMI of the study population was 27.8 ± 3.5 kg m².

Accordingly, 30% of the patients had admission glycated hemoglobin (HbA1c) levels less than 5.7%, 33.3% of the patients between 5.7% and 6.4%, and 36.7% of the patients greater than 6.5% (Table 2). A large fraction of these individuals had diabetes which was either undiagnosed or suboptimal glucose metabolism.

However, clinical characteristics differed widely amongst groups of HbA1c (Table 3). Admitted Glasgow Coma Scale (GCS) score was lower (8.9 ± 3.2) among patients with HbA1c >6.5% and was also the poorest neurological status compared to patients with HbA1c 5.7%–6.4% (10.8 ± 2.5) and <5.7% (12.4 ± 2.1) (p=0.001). In fact, the HbA1c >6.5% group had significantly higher NIHSS (North American Association of Stroke Stroke) scores (14.7 ± 5.2) representing the severity of the stroke, when compared to the HbA1c 5.7%–6.4% (11.5 ± 4.1) or <5.7% (8.2 ± 3.4) groups (p=0.002). We also found higher mean blood pressure at admission in the group with higher HbA1c >6.5% 160/95 mmHg ± 14 (P=0.001), which indicated the link between poor glycemic management and higher cardiac stress.

Table 4 also indicates that patient outcomes differ by HbA1c level. Patients with an HbA1c >6.5% had the highest mortality, 36.4%; then HbA1c <5.7%, 22%; and then HbA1c <6.5%, 13.3% (p = 0.002). After 90 days, 64.4% of the group with HbA1c <5.7% achieved functional recovery by mRS score ≤2. Nevertheless, only 42% of patients in the 5.7%–6.4% group and only 18.2% of patients in HbA1c >6.5% group (p=0.001) did so. These results indicate that higher HbA1c levels at admission have a direct association with poorer functional outcomes and more mortal patients in hemorrhagic stroke patients.

Table 5, logistic regression analysis showed that HbA1c > 6.5% was an independent predictor of poor functional recovery (mRS > 2 at 90 days) with an odds ratio (OR) of 2.9 (95% CI: 1.9–4.5, p = 0.001). Other significant predictors of poor outcome were age >60 years (OR: 1.8, p=0.01, hypertension (OR: 1.6, p=0.02), major stroke (NIHSS >10, OR: 3.5, p=0.001)). This is consistent with the idea that chronic hyperglycemia (as measured by HbA1c levels) worsens a stroke prognosis.

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CONCLUSION

Outcomes of individuals with hemorrhagic stroke who present with a glycated hemoglobin (HbA1c) ≥ 6.5 have been shown in this study to be associated with a significant predictor. When HbA1c level upon admission to ICU is higher, it is associated with a higher GCS score, higher NIHSS score, and greater elevation of blood pressure, suggesting worse severity of stroke. Mortality rates and the probability of functional independence were significantly higher and much less when HbA1c was >6.5%. Logistic regression analysis confirmed that HbA1c is an independent predictor of a bad outcome besides age, hypertension, and severity of a stroke. Consistent with this, these results underscore the importance of long term blood sugar control in the preservation of cerebrovascular health. Routine HbA1c screening could help clinicians identify high risk patients earlier so that treatment approaches to reduce stroke outcomes can be tailored to individual patients. These results need to be confirmed by further extensive multicenter research to indicate HbA1c as a standard prognostic marker of hemorrhagic stroke.

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Questionnaire**Demographic Information**

- Age: ___ years
- Gender: Male Female
- BMI: ___ kg/m²
- History of Diabetes: Yes No
- Hypertension: Yes No

Stroke Severity and Clinical Parameters

- Initial Glasgow Coma Scale (GCS): ___
- NIH Stroke Scale (NIHSS) Score: ___
- Blood Pressure at Admission: ___ mmHg

HbA1c Level at Admission

- <5.7%
- 5.7%–6.4%
- >6.5%

Functional Outcomes

- Modified Rankin Scale (mRS) at Discharge: ___
- Mortality during Hospital Stay: Yes No
- Functional Independence at 90 Days (mRS ≤2): Yes No