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Association of Routine Blood Biomarkers with Stroke Severity among Newly Diagnosed Patients in Bangladesh: A Hospital-Based Cross-Sectional Study

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Abstract:

Stroke remains a major cause of mortality and disability in low- and middle-income countries, where access to advanced diagnostic tools for early severity assessment is often limited. This hospital-based cross-sectional study aimed to examine the association between routinely measured blood biomarkers and stroke severity among newly diagnosed stroke patients in Bangladesh. The study was conducted at a tertiary care neurological center in Dhaka from January to December 2024 and included 200 adult patients with first-ever ischemic or hemorrhagic stroke confirmed by clinical evaluation and neuroimaging. Sociodemographic, clinical, and lifestyle-related information was collected using a pretested questionnaire. Stroke severity was assessed at admission using the National Institutes of Health Stroke Scale (NIHSS). Routine laboratory parameters, including complete blood count, fasting blood glucose, serum creatinine, fasting lipid profile, and serum electrolytes, were analyzed as part of standard clinical care. Ischemic stroke was the predominant subtype (75.5%), and most patients presented with mild stroke severity (75.0%). Hypertension and diabetes mellitus were the most common comorbidities. Abnormalities in routine biomarkers were frequent, including anemia, leukocytosis, dyslipidemia, and altered renal and electrolyte parameters. Increasing stroke severity was significantly associated with elevated white blood cell count, raised serum creatinine, adverse lipid profiles, abnormal potassium levels, and altered bicarbonate concentrations, while hemoglobin and serum sodium showed no significant association. Stroke severity also differed significantly by stroke subtype, with hemorrhagic stroke patients presenting with higher NIHSS scores. These findings indicate that routinely available blood biomarkers are significantly associated with stroke severity and may serve as practical adjuncts to clinical assessment for early risk stratification in resource-limited healthcare settings.

Key words: Stroke; Biomarkers; Stroke severity; NIHSS; Routine blood tests; Bangladesh.

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Introduction

Stroke remains one of the leading causes of mortality and long-term disability worldwide, with a disproportionate burden borne by low- and middle-income countries (LMICs)[1]. Globally, more than 12 million new stroke cases occur each year, and over 70% of stroke-related deaths are reported from LMICs, where healthcare resources and access to timely diagnosis remain limited[2]. Bangladesh faces a growing stroke burden driven by rapid urbanization, population ageing, and a high prevalence of uncontrolled vascular risk factors such as hypertension, diabetes mellitus, and dyslipidemia[3].

Early assessment of stroke severity is critical for clinical decision-making, prognostication, and allocation of limited healthcare resources. The National Institutes of Health Stroke Scale (NIHSS) is widely used to quantify neurological impairment and predict short- and long-term outcomes[4]. However, reliance on clinical scoring alone may not fully capture the underlying biological processes influencing stroke severity, particularly in settings where advanced neuroimaging and specialized stroke services are not universally available[5].

Blood-based biomarkers offer a practical adjunct to clinical assessment by reflecting key pathophysiological mechanisms involved in acute stroke, including inflammation, metabolic dysregulation, endothelial dysfunction, and organ injury[6]. While advanced biomarkers such as neuron-specific enolase and S100B protein have shown prognostic value, their routine use is limited in resource-constrained settings due to cost and availability[7]. In contrast, routinely measured laboratory parameters—such as complete blood count, serum creatinine, lipid profile, fasting blood glucose, and serum electrolytes—are widely accessible and inexpensive, making them attractive candidates for early risk stratification in LMICs[8].

Previous studies have demonstrated associations between inflammatory markers, renal function parameters, lipid abnormalities, and stroke outcomes, but most evidence originates from high-income countries or focuses on isolated biomarkers rather than comprehensive routine panels[9,10]. Data from Bangladesh and similar settings remain limited, and the relationship between commonly available blood biomarkers and stroke severity has not been adequately explored.

Therefore, this study aimed to assess the association between routinely measured blood biomarkers and stroke severity, as determined by NIHSS, among newly diagnosed stroke patients admitted to a tertiary care hospital in Bangladesh. Understanding these associations may support early severity stratification, improve clinical decision-making, and enhance stroke care in resource-limited healthcare settings.

Materials and method:

A hospital-based cross-sectional study was conducted at the Department of Neurology, National Institute of Neurosciences and Hospital (NINS), Dhaka, Bangladesh, from January to December 2024. The study included newly diagnosed adult stroke patients admitted to the inpatient neurology unit, with stroke confirmed by clinical assessment and neuroimaging. Patients aged 18 years or older with first-ever ischemic or hemorrhagic stroke who provided written informed consent were eligible for inclusion, while those with a previous history of stroke or transient ischemic attack, advanced chronic kidney disease, active malignancy, severe systemic infection, or other conditions likely to independently influence biomarker profiles were excluded. The sample size was calculated using a single population proportion formula based on the estimated prevalence of hemorrhagic stroke, incorporating a 5% margin of error and allowance for non-response, and a total of 200 participants were consecutively enrolled using a convenience sampling technique. Data were collected through face-to-face interviews and medical record review using a pretested semi-structured questionnaire to document sociodemographic characteristics, medical history, and lifestyle-related factors, with lifestyle information recorded following standardized WHO STEPS definitions. Stroke severity was assessed at admission by a trained neurologist using the National Institutes of Health Stroke Scale (NIHSS), and patients were categorized into mild, moderate, or severe stroke based on established NIHSS thresholds. Venous blood samples were collected under aseptic conditions as part of routine clinical care and analyzed in the hospital's central laboratory using standard automated methods. Laboratory parameters included complete blood count, fasting blood glucose, serum creatinine, fasting lipid profile (total cholesterol, low-density lipoprotein, high-density lipoprotein, and triglycerides), and serum electrolytes (sodium and potassium). Data were entered, cleaned, and analyzed using IBM SPSS Statistics version 27.0, with continuous variables summarized as means and standard deviations and categorical variables expressed as frequencies and percentages. Associations between stroke severity and biomarker parameters were examined using chi-square tests and independent sample t-tests as appropriate, and a p-value of less than 0.05 was considered statistically significant. Ethical approval was obtained from the Ethical Review Committee of Bangladesh University of Health Sciences, written informed consent was secured from all participants, and confidentiality was maintained throughout the study in accordance with ethical research principles.

Results:

Among the 200 newly diagnosed stroke patients included in the analysis (Table I), the mean age was 61.9 ± 12.3 years, with nearly one-third of participants aged below 55 years and similar proportions in the 55–65 and >65-year age groups. Males accounted for 53.5% of the study population, and the majority were married with primary or secondary level education.

Table 1: Sociodemographic characteristics of the participants, n=200

Variables	**n (%)**
Age Group, *years, Mean±SD*	61.9±12.3
<55 years	64 (32.0)
55-65 years	68 (34.0)
>65 years	68 (34.0)
Sex	
Male	107 (53.5)
Female	93 (46.5)
Level of Education	
Up to Primary (Class 1-5)	102 (51.0)
Secondary (Class 6-10) and ¶SSC	74 (37.0)
Higher secondary/†HSC/ Graduate and above	24 (12.0)
Monthly Family Income, *BDT# Mean±SD*	37322.5±16549.7
The Interquartile Range (IQR), *BDT**	23,500
Lower Class Income (10000 BDT)	7 (3.5)
Lower Middle-Class Income (10000-40000 BDT)	20 (10.0)
Upper Middle-Class Income (40000-126000 BDT)	166 (83.0)
High Class Income (>126000 BDT)	7 (3.5)
Family History of Stroke	
Yes	63 (31.5)
No	137 (68.5)

*Bangladeshi Taka, ¶Secondary School Certificate, †Higher Secondary Certificate
#According to the 2023 per-capita gross national income calculated by the World Bank Atlas method

Ischemic stroke was the predominant subtype, comprising 75.5% of cases, while hemorrhagic stroke accounted for 24.5%.Based on National Institutes of Health Stroke Scale (NIHSS) assessment at admission, mild stroke severity was observed in 75.0% of patients, followed by moderate and severe stroke in smaller proportions. Hypertension was the most common comorbidity, present in 79.0% of participants, followed by diabetes mellitus in 49.5%, and approximately one-third reported a positive family history of stroke (Table 2).

Table 2: Medical history of the participants, n=200

Variables	n (%)
Comorbidities Among Participants	
Hypertension	158 (79.0)
Diabetes Mellitus	99 (49.5)
Cardiovascular diseases§	21 (10.5)
Other pre-existing conditions†	19 (9.5)
Duration of Suffering from Hypertension (n=158)	
Mean±SD	9.5±9.8 years
<5 years	86 (43.0)
5-15 years	45 (22.5)
>15 years	27 (13.5)
Duration of Suffering from DM (n=99)	
Mean±SD	9.9±10.9 years
<5 years	64 (32.0)
5-15 years	15 (7.5)
>15 years	20 (10.5)

†Chronic kidney disease, liver disease, or malignancy, §ischemic heart disease, and heart failure

Lifestyle-related factors, including current smoking and physical inactivity, were also frequently reported (Table 3).

Table 3: Lifestyle-related factors of participants, n=200

Lifestyle factors	n (%)
Smoking Status (n=160)	
Current Smoker	41 (20.5)
Past Smoker	21 (10.5)
Smoking Exposure at Home or Workplace	98 (49.0)
Physical Activity	
Inadequate	125 (62.5)
Adequate*	75 (37.5)
Vigorous-Intensity Physical Activity	33 (16.5)
Moderate-Intensity Activity	62 (31.0)
Walking or Using a Bicycle Continuously for at Least 10 Minutes	155 (77.5)
Extra Salt Intake[#]	
Yes	132 (66)
No	68 (34)
Weekly frequency of vegetable and fruit consumption (In days)	
Days	**n (%)**
Mean±SD	4.5±2.8 days
≥ 5 days/week	165 (82.5)
< 5 days/week	35 (17.5)
Average Number of Vegetables and Fruits Servings on Consumption Days	
Servings Mean±SD	3.3±0.8
< 5 servings	190 (95.0)
≥ 5 servings	10 (5.0)

Abnormalities in routinely measured blood biomarkers were common, with anemia observed in 74.5% of patients, leukocytosis in 61.5%, and elevated erythrocyte sedimentation rate in 72.5% (Table 4).

Table 4: Biomarkers profile of the participants (n=200)

RBC (n=171)	**n (%)**
Mean±SD	4.5±0.5 million/µL
Low (< 4.2 million/µL)	68 (34.0)
Normal Range (4.2 – 5.9 million/µL)	103 (51.5)
Platelet Count	
Mean±SD	286.5±87.7 ×10³/µL
Thrombocytopenia (< 150 ×10³/µL)	8 (4.0)
Normal Value (150 – 450 ×10³/µL)	184 (92.0)
Thrombocytosis (> 450 ×10³/µL)	8 (4.0)
WBC (n=199)	
Mean±SD	12.9±4.2 ×10³/µL
Normal Value (4.0 – 11.0 ×10³/µL)	76 (38.0)
Leukocytosis (> 11.0 ×10³/µL)	123 (61.5)
Hb Percentage	
Mean±SD	12.2±1.8 g/dL
Anemia (< 13.5 g/dL)	149 (74.5)
Normal Value (13.5 – 17.5 g/dL)	51 (25.5)
^ESR Count	
Mean±SD	29.8±20.5 mm/hr
Normal Value (0 – 15 mm/hr)	55 (27.5)
Elevated ESR (> 15 mm/hr)	145 (72.5)
Serum Creatinine Count	
Mean±SD	1.2±0.4 mg/dL
Low Creatinine (< 0.6 mg/dL)	2 (1.0)
Normal Range (0.6 – 1.2 mg/dL)	121 (60.5)
High Creatinine (> 1.2 mg/dL)	77 (38.5)
Fasting Glucose Level	
Mean±SD	9.0±3.3 mg/dL
Hypoglycemia (< 70 mg/dL)	200 (100.0)
Total Cholesterol Level (n=191)	
Mean±SD	180.1±47.8 mg/dL
Hypocholesterolemia (< 150 mg/dL)	64 (32.0)
Desirable (150 – 199 mg/dL)	58 (29.0)
Hypercholesterolemia (≥ 200 mg/dL)	69 (34.5)
Total **HDL Level (n=191)	
Mean±SD	50.6±17.6 mg/dL
Low HDL (< 40 mg/dL)	56 (28.0)
Normal Level (≥ 40 mg/dL)	135 (67.5)

Total LDL Level (n=191)	
Mean±SD	112.1±37.1 mg/dL
Normal Level (< 100 mg/dL)	83 (41.5)
High LDL (≥ 130 mg/dL)	108 (54.0)
Triglyceride Level (n=191)	
Mean±SD	159.1±82.2 mg/dL
Normal Value (< 150 mg/dL)	120 (60.0)
Hyperlipidemia (≥ 150 mg/dL)	71 (35.5)
Serum Sodium Level	
Mean±SD	137.5±9.9 mmol/L
Hyponatremia (< 135 mmol/L)	25 (12.5)
Normal Value (135 – 145 mmol/L)	172 (86.0)
Hypernatremia (> 145 mmol/L)	3 (1.5)
Serum Potassium Level	
Mean±SD	4.6±6.9 mmol/L
Hypokalemia (< 3.5 mmol/L)	23 (11.5)
Normal Value (3.5 – 5.0 mmol/L)	171 (85.5)
Hyperkaliemia (> 5.0 mmol/L)	6 (3.0)
Serum Chloride Level	
Mean±SD	99.2±5.7 mmol/L
Hypochloremia (< 98 mmol/L)	70 (35.0)
Normal Value (98 – 106 mmol/L)	125 (62.5)
Hyperchloremia (> 106 mmol/L)	5 (2.5)
Serum Bicarbonate Level	
Mean±SD	27.8±4.1 mmol/L
Metabolic Acidosis (< 22 mmol/L)	20 (10.0)
Normal Value (22 – 29 mmol/L)	84 (420)
Metabolic Alkalosis (> 29 mmol/L)	96 (48.0)

Dyslipidemia was prevalent, characterized by raised total cholesterol, low high-density lipoprotein cholesterol, and elevated triglyceride levels, alongside abnormalities in fasting blood glucose and serum creatinine. Analysis of associations demonstrated that increasing stroke severity was significantly associated with higher white blood cell counts ($p = 0.019$), elevated serum creatinine levels ($p = 0.023$), raised total cholesterol ($p = 0.024$), low high-density lipoprotein cholesterol ($p = 0.006$), elevated triglycerides ($p = 0.006$), abnormal serum potassium levels ($p = 0.001$), and altered serum bicarbonate levels ($p = 0.016$). In contrast, hemoglobin concentration and serum sodium levels did not show statistically significant associations with stroke severity. Stroke severity also differed significantly by stroke subtype, with hemorrhagic stroke patients more likely to present with higher NIHSS scores compared to those with ischemic stroke. Overall, the results indicate a high burden of abnormal routine blood biomarkers among newly diagnosed stroke patients and demonstrate their significant relationship with stroke severity in this tertiary care setting.

Discussion:

This study demonstrates a high burden of abnormal routinely measured blood biomarkers among newly diagnosed stroke patients and identifies several significant associations between these biomarkers and stroke severity, as assessed by the NIHSS. The predominance of ischemic stroke and the high prevalence of mild stroke severity observed in this cohort are consistent with patterns reported from other tertiary care settings in South Asia and similar low- and middle-income countries (LMICs), where improved survival and earlier hospital presentation have shifted the severity spectrum toward less disabling forms of stroke[1,2]. Nevertheless, the substantial proportion of patients presenting with moderate to severe neurological impairment underscores the ongoing need for early risk stratification and targeted management.

Inflammatory markers reflected through elevated white blood cell counts showed a significant association with increasing stroke severity in this study. This finding aligns with existing evidence suggesting that systemic inflammation contributes to larger infarct size, secondary brain injury, and poorer neurological outcomes following acute stroke[3]. Leukocytosis has been linked to endothelial dysfunction, microvascular obstruction, and blood–brain barrier disruption, all of which may exacerbate neurological damage[4]. Similarly, the observed association between elevated serum creatinine and greater stroke severity highlights the role of renal dysfunction as an important modifier of stroke outcomes, potentially reflecting shared vascular pathology, impaired metabolic clearance, and heightened systemic inflammation[5].

Dyslipidemia, particularly elevated total cholesterol, low high-density lipoprotein cholesterol, and raised triglyceride levels, was significantly associated with stroke severity in this cohort. Lipid abnormalities are known to influence atherosclerotic plaque stability, thrombus formation, and cerebral perfusion, thereby affecting both stroke occurrence and clinical severity[6]. While some studies have reported inconsistent relationships between lipid fractions and stroke outcomes, growing evidence from LMIC settings supports their relevance in determining early neurological impairment[7]. Electrolyte disturbances, notably abnormal potassium and bicarbonate levels, were also associated with greater stroke severity. These findings may reflect acute metabolic stress, renal involvement, and autonomic dysregulation following severe cerebrovascular injury[8].

Importantly, this study focused exclusively on routine laboratory parameters that are inexpensive and widely available, enhancing the clinical applicability of the findings in resource-constrained settings. In contexts where immediate neuroimaging or advanced biomarker testing is limited, such routinely measured blood indices may provide valuable adjunctive information to support early severity stratification and clinical decision-making[9]. However, the cross-sectional design, single-center setting, and lack of longitudinal outcome assessment limit causal inference and prognostic extrapolation. Future multicenter and prospective studies incorporating functional outcomes and mortality endpoints are warranted to validate these findings and inform biomarker-guided stroke care pathways in LMICs[10].

Conclusion:

This study demonstrates that abnormalities in routinely measured blood biomarkers are common among newly diagnosed stroke patients and are significantly associated with stroke severity. Inflammatory indices, renal function markers, lipid abnormalities, and selected electrolyte disturbances showed meaningful relationships with higher NIHSS scores. These findings suggest that routinely available laboratory parameters may serve as practical adjuncts to clinical assessment for early severity stratification, particularly in resource-limited settings where access to advanced diagnostics is constrained. Integrating such biomarkers into early stroke evaluation may support timely clinical decision-making and more efficient allocation of healthcare resources. Further prospective, multicenter studies are required to confirm these associations and to evaluate their prognostic value for long-term outcomes.

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