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Dynamic Changes in Biochemical Markers in Stroke Management: Tracking Blood Glucose, Lipid Profile, Electrolytes, and Liver Function from Admission to Discharge and Their Association with Initial Stroke Presentation

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ABSTRACT: ***Background:*** Stroke remains one of the leading causes of morbidity and mortality worldwide, particularly in low- and middle-income countries like Bangladesh. It represents a major neurological emergency requiring rapid assessment and management. ***Objective:*** This study aimed to investigate the dynamic changes in biochemical markers during stroke management, specifically focusing on blood glucose, lipid profile, electrolytes, liver function, and their association with stroke presentation in patients admitted to Chittagong Medical College between July and December 2024. ***Methods:*** This prospective observational study included 105 stroke patients aged over 40. Blood samples were collected upon admission and at discharge to assess biochemical markers, including random blood glucose, lipid profile (total cholesterol, triglycerides, HDL-C, LDL-C), electrolytes (sodium, potassium), liver function (ALT, AST), renal function (urea, creatinine), and inflammatory markers (CRP). Changes in these parameters from admission to discharge were analyzed using paired t-tests. ***Results:*** Significant reductions were observed in random blood glucose (182.5 ± 42.1 mg/dL to 134.7 ± 26.3 mg/dL, $p < 0.001$), total cholesterol (202.3 ± 35.4 mg/dL to 188.9 ± 32.5 mg/dL, $p < 0.01$), triglycerides (176.6 ± 46.7 mg/dL to 158.2 ± 40.9 mg/dL, $p < 0.05$), and LDL-C (132.7 ± 30.6 mg/dL to 120.3 ± 28.1 mg/dL, $p < 0.01$), while HDL-C increased (39.4 ± 8.2 mg/dL to 42.1 ± 7.6 mg/dL, $p < 0.05$). Electrolytes showed an improvement, with serum sodium rising significantly (133.8 ± 4.7 mmol/L to 136.2 ± 3.9 mmol/L, $p < 0.01$). Renal function markers, urea and creatinine, also decreased significantly ($p < 0.05$). CRP levels decreased from 12.6 ± 6.2 mg/L to 6.8 ± 3.1 mg/L ($p < 0.001$), reflecting a reduction in systemic inflammation. ***Conclusion:*** This study highlights significant biochemical changes during stroke management, particularly improvements in glucose control, lipid profile, electrolyte balance, and inflammation. The findings underscore the importance of monitoring these biomarkers in the acute phase of stroke to optimize treatment and improve patient outcomes.

Keywords: Stroke, Blood Glucose, Lipid Profile, Electrolytes, Renal Function, C-Reactive Protein, Biochemical Markers, Stroke Management.

INTRODUCTION

The World Health Organization (WHO) characterizes stroke as a rapidly developing clinical signs of focal disturbance of cerebral function lasting more than 24 hours with no apparent cause other than of vascular origin [1]. Stroke is mainly categorized into two types: ischemic and hemorrhagic. Additionally, transient ischemic attacks (TIAs), historically viewed as a distinct cerebrovascular condition due to their shorter duration (less than 24 hours), are more accurately considered ischemic strokes when brain lesions are detected through magnetic resonance imaging (MRI) [2]. Ischemic stroke is the predominant form,

comprising more than 85% of all stroke cases. It typically results from arterial blockage by a thrombus or embolus, reduced blood flow due to hypotension, or oxygen deficiency caused by systemic hypoxia [3]. Hemorrhagic stroke arises from the rupture of a cerebral artery or vein, leading to bleeding within the brain tissue. This bleeding can cause neuronal damage through the mass effect of a hematoma. Common contributors include high blood pressure and cerebral aneurysms. Hemorrhagic strokes encompass intracerebral hemorrhage (ICH) and subarachnoid hemorrhage (SAH). ICH involves bleeding into the brain parenchyma, whereas SAH is bleeding into the space between the brain and the arachnoid membrane. ICH accounts for about 10% of all strokes, while SAH constitutes 1–7%, impacting approximately 30,000 individuals annually in the United States [4]. Although hemorrhagic strokes occur less frequently than ischemic ones, the share of productive life years lost due to each stroke type is similar: ICH: 34.2%, SAH: 27.3%, and ischemic stroke: 38.5% [5, 6].

Stroke remains one of the leading causes of morbidity and mortality worldwide, particularly in low- and middle-income countries like Bangladesh. It represents a major neurological emergency requiring rapid assessment and management [7]. Beyond neuroimaging and clinical evaluation, biochemical markers are increasingly recognized for their potential role in prognostication and management planning. Alterations in metabolic parameters such as blood glucose, lipid profile, electrolytes, and liver function tests are commonly observed during the acute and subacute phases of stroke [8]. These changes may reflect the systemic impact of stroke, underlying comorbidities, or responses to treatment. Understanding the trajectory of these markers from admission to discharge may offer valuable insights into disease severity, treatment response, and potential complications [9]. This study aimed to assess the dynamic changes in key biochemical markers—random blood glucose, lipid profile, serum electrolytes, and liver function tests—among stroke patients during hospitalization and to explore their association with the initial clinical presentation of stroke. Such insights may contribute to improving individualized care and enhancing outcomes in stroke management.

METHODOLOGY

This prospective, observational study was conducted in the Department of Neurology and Medicine at Chittagong Medical College Hospital from July to December 2024. A total of 105 consecutive patients admitted with a confirmed diagnosis of stroke were enrolled. Inclusion criteria included adult patients aged 18 years and older, of either sex, who presented with acute ischemic or hemorrhagic stroke confirmed by neuroimaging (CT/MRI). Patients with pre-existing chronic liver disease, end-stage renal disease, known lipid disorders, or those on medications that significantly influence glucose or lipid metabolism were excluded to minimize confounding variables. Additionally, patients with complicated stroke presentations—such as those with concurrent infections, malignancies, autoimmune diseases, or multi-organ failure—were excluded to ensure homogeneity of the study population and avoid potential biases in the interpretation of biochemical parameters. Following informed written consent from patients or their legal guardians, demographic and clinical data were recorded, including stroke type and clinical severity at presentation. Blood samples were collected within 24 hours of admission and again at discharge. The biochemical parameters analyzed included random blood glucose, total cholesterol, triglycerides, HDL-C, LDL-C, serum sodium, serum potassium, alanine aminotransferase (ALT), and aspartate aminotransferase (AST). All laboratory investigations were conducted in the hospital's central laboratory following standard protocols. The primary objective was to compare changes in these biochemical parameters from admission to discharge. The secondary objective was to assess whether the baseline levels of these markers correlated with the stroke's initial clinical features. The study aimed to evaluate the dynamic changes in these biochemical markers throughout the hospital course and explore their association with the initial clinical presentation of the stroke. Data were analyzed using appropriate statistical tools to assess the significance of changes over time and correlations with stroke characteristics.

RESULTS

A total of 105 stroke patients were included in the study. All were over the age of 40 years. The mean age was 64.3 ± 9.2 years. The majority were male (61.9%), and most patients had low educational attainment and were unemployed or retired. High proportions of patients had a history of smoking, hypertension, and diabetes. Additional risk factors such as alcohol consumption, obesity (as measured by BMI), and family history of stroke were also considered.

Table 1: Demographic and Clinical Characteristics of the Study Population (n = 105)

Variable	Subcategory	Frequency (n)	Percentage (%)
Sex	Male	65	61.9
	Female	40	38.1
Age Group (years)	41–50	15	14.3
	51–60	29	27.6
	61–70	38	36.2
	>70	23	21.9
Education Level	No formal education	24	22.9
	Primary	35	33.3
	Secondary	28	26.7
	Higher Secondary & above	18	17.1
Employment Status	Employed	22	21.0
	Unemployed/Retired	83	79.0
Smoking History	Yes	61	58.1
	No	44	41.9
Alcohol Use	Yes	19	18.1
	No	86	81.9
BMI Category	Normal (18.5–24.9)	38	36.2
	Overweight (25–29.9)	44	41.9
	Obese (≥30)	23	21.9
Hypertension	Present	72	68.6
	Absent	33	31.4
Duration of Hypertension	>5 years	49	47.6 (of 72)
	≤5 years	23	21.0 (of 72)
Diabetes Mellitus	Present	48	45.7
	Absent	57	54.3
Duration of Diabetes	>5 years	31	29.5 (of 48)
	≤5 years	17	16.2 (of 48)
Family History of Stroke/CVD	Yes	33	31.4
	No	72	68.6
Time to Admission After Stroke	≤6 hours	44	41.9
	>6 hours	61	58.1
Stroke Type	Ischemic	78	74.3
	Hemorrhagic	27	25.7
Stroke Severity at Admission (NIHSS)	Mild (1–4)	18	17.1
	Moderate (5–15)	64	61.0
	Severe (>15)	23	21.9
Length of Hospital Stay (days)	Mean ± SD	9.2 ± 3.4	—

The majority of stroke patients were between 61–70 years, with a slightly higher male predominance. About 68.6% had hypertension and 45.7% had diabetes, with many cases of long-standing disease. Over half of the participants had a history of smoking, and 18.1% reported alcohol use. Nearly one-third had a positive family history of stroke or cardiovascular disease. Most patients presented to the hospital more than 6 hours after symptom onset, which may have implications for acute management and outcomes. The majority suffered from ischemic strokes (74.3%) and had moderate severity on admission based on NIHSS scores.

Table 2: Changes in Biochemical Markers from Admission to Discharge

Parameter	At Admission (Mean ± SD)	At Discharge (Mean ± SD)	p-value
Random Blood Glucose (mg/dL)	182.5 ± 42.1	134.7 ± 26.3	< 0.001 **
Total Cholesterol (mg/dL)	202.3 ± 35.4	188.9 ± 32.5	< 0.01 **
Triglycerides (mg/dL)	176.6 ± 46.7	158.2 ± 40.9	< 0.05 *
HDL-C (mg/dL)	39.4 ± 8.2	42.1 ± 7.6	< 0.05 *
LDL-C (mg/dL)	132.7 ± 30.6	120.3 ± 28.1	< 0.01 **
Sodium (mmol/L)	133.8 ± 4.7	136.2 ± 3.9	< 0.01 **
Potassium (mmol/L)	4.1 ± 0.6	4.2 ± 0.5	0.18 (NS)
ALT (U/L)	45.2 ± 21.6	40.5 ± 18.9	0.09 (NS)
AST (U/L)	47.8 ± 23.3	43.2 ± 20.4	0.07 (NS)
Urea (mg/dL)	35.3 ± 12.1	32.8 ± 10.2	0.04 *
Creatinine (mg/dL)	1.2 ± 0.4	1.1 ± 0.3	0.03 *
CRP (mg/L)	12.6 ± 6.2	6.8 ± 3.1	< 0.001 **
Calcium (mg/dL)	8.6 ± 0.7	8.9 ± 0.5	< 0.05 *
Magnesium (mg/dL)	1.7 ± 0.3	1.8 ± 0.2	0.09 (NS)

Statistical tests used: Paired t-test for normally distributed variables. Significance level set at $p < 0.05$. $p < 0.05$ = statistically significant (*), $p < 0.01$ = highly significant (), NS = Not Significant**

As shown in Table 2, significant reductions were observed in random blood glucose, total cholesterol, triglycerides, and LDL-C from admission to discharge, while HDL-C increased significantly, reflecting improvements in lipid profile. Serum sodium levels also showed a marked increase, suggesting better fluid and electrolyte balance for hospitalization. Other electrolyte levels, including potassium, showed no significant change, and liver function markers (ALT and AST) remained stable, with no significant differences between admission and discharge. Key markers of renal function, urea and creatinine, both decreased significantly during hospitalization, indicating improved kidney function or better hydration. CRP levels, a marker of inflammation, decreased markedly, reflecting a reduction in systemic inflammation. Calcium levels showed a small but significant increase, likely reflecting recovery from acute metabolic disturbances.

DISCUSSION

This study aimed to investigate the dynamic changes in biochemical markers during stroke management, specifically focusing on blood glucose, lipid profile, electrolytes, liver function, and their association with stroke presentation in 105 stroke patients. The study revealed significant alterations in several biochemical parameters from admission to discharge, highlighting the importance of monitoring these markers in the acute management of stroke patients. The most striking change observed was in random blood glucose levels, which significantly decreased from an initial value of 182.5 ± 42.1 mg/dL to 134.7 ± 26.3 mg/dL ($p < 0.001$). Hyperglycaemia on admission is a well-known poor prognostic indicator in stroke patients, particularly ischemic strokes, as elevated glucose levels are associated with increased oxidative stress, neuronal injury, and poor recovery [10]. Our findings support this, demonstrating that glycaemic control during hospitalization

contributes to better stroke outcomes. Lipid profile changes also mirrored improvements in stroke management. Total cholesterol dropped significantly from 202.3 ± 35.4 mg/dL to 188.9 ± 32.5 mg/dL ($p < 0.01$), and triglycerides reduced from 176.6 ± 46.7 mg/dL to 158.2 ± 40.9 mg/dL ($p < 0.05$), consistent with prior studies showing that statin therapy—commonly used in stroke management—reduces both total cholesterol and triglycerides, thus improving vascular health. Moreover, LDL-C decreased from 132.7 ± 30.6 mg/dL to 120.3 ± 28.1 mg/dL ($p < 0.01$), while HDL-C increased from 39.4 ± 8.2 mg/dL to 42.1 ± 7.6 mg/dL ($p < 0.05$), reflecting favourable lipid alterations associated with stroke recovery.

The significant changes in electrolytes also deserve attention. Serum sodium increased from 133.8 ± 4.7 mmol/L to 136.2 ± 3.9 mmol/L ($p < 0.01$), indicating a restoration of electrolyte balance, which is crucial for preventing complications such as cerebral edema and seizures in stroke patients. However, potassium levels remained largely stable (4.1 ± 0.6 mmol/L to 4.2 ± 0.5 mmol/L, $p = 0.18$), suggesting that the stroke did not significantly impact potassium homeostasis, which is consistent with findings from other studies [11]. Changes in renal function markers also provided valuable insights. Urea decreased from 35.3 ± 12.1 mg/dL to 32.8 ± 10.2 mg/dL ($p < 0.05$), while creatinine decreased from 1.2 ± 0.4 mg/dL to 1.1 ± 0.3 mg/dL ($p < 0.05$). These reductions indicate improved hydration and possibly better renal perfusion during hospitalization, particularly in stroke patients who often face fluctuations in blood pressure and fluid balance [12]. An important finding in our study was the marked decrease in C-Reactive Protein (CRP) levels from 12.6 ± 6.2 mg/L to 6.8 ± 3.1 mg/L ($p < 0.001$). This suggests that systemic inflammation, which plays a crucial role in stroke progression and recovery, was effectively mitigated during the hospital stay. Elevated CRP levels have been shown to correlate with worse neurological outcomes, and its reduction can be a sign of effective treatment in reducing inflammation post-stroke [13]. Lastly, we observed significant changes in serum calcium, which increased from 8.6 ± 0.7 mg/dL to 8.9 ± 0.5 mg/dL ($p < 0.05$). Calcium plays a critical role in neuronal function and excitability, and its regulation is essential during stroke recovery [14]. While the increase was modest, it could reflect a normalization of metabolic disturbances in the acute phase. Magnesium levels remained unchanged, which is consistent with findings from other studies suggesting that magnesium's role in stroke recovery may not be as pronounced as that of calcium [15-39].

Limitations and Implications for Future Research

Although this study provides valuable insights into the biochemical changes during stroke management, it has certain limitations. The sample size, though adequate, may not be large enough to draw definitive conclusions across broader populations. Additionally, the study did not stratify patients by stroke subtype or severity at baseline, which could have provided more detailed insights into how biochemical markers differ between ischemic and haemorrhagic strokes. Future studies with larger, more diverse cohorts, including stratification by stroke type and severity, are warranted to further validate our findings. Moreover, while we observed significant biochemical changes, the impact of pharmacological interventions such as statins, antihypertensives, and glucose-lowering agents was not analysed. Understanding how these medications affect biochemical markers could provide crucial information for tailoring stroke management protocols.

CONCLUSION

In conclusion, this study highlights the dynamic changes in biochemical markers, particularly blood glucose, lipid profile, electrolytes, renal function, and inflammatory markers, in stroke patients from admission to discharge. The significant reductions in glucose, total cholesterol, triglycerides, and CRP, along with favorable changes in sodium, calcium, and creatinine, suggest that effective management of these parameters plays a vital role in stroke recovery. These findings emphasize the need for continuous monitoring of these biomarkers to optimize stroke management and improve patient outcomes.

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