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Original Research Article

Role of Metabolic and Inflammatory Biomarkers in Acute Stroke Patients Admitted in a Tertiary Care Hospital: Clinical Correlation of Lipid Profile, LDH, CPK, CRP, and HbA1c

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ABSTRACT

Introduction: Stroke remains a significant public health concern in India, with increasing incidence and suboptimal outcomes. Biochemical markers may aid in distinguishing stroke subtypes and assessing disease severity, especially in resource-constrained settings.
Methods: A hospital-based observational study was conducted on 52 patients with acute stroke admitted to a tertiary care centre in Northern India. Patients were classified into ischaemic and haemorrhagic stroke based on neuroimaging. Blood samples were analysed for total cholesterol, LDL, HDL, triglycerides, VLDL, C-reactive protein (CRP), lactate dehydrogenase (LDH), creatine phosphokinase (CPK), and glycated haemoglobin (HbA1c). Group-wise comparisons were conducted using statistical tests selected based on data characteristics and test assumptions.
Result: Ischaemic stroke was more prevalent (88.5%) than haemorrhagic stroke. HbA1c (6.6% vs. 4.8%, $p<0.01$), CRP (30.6 vs. 20.1 mg/L, $p=0.01$), and CPK (198.4 vs. 142.3 IU/L, $p=0.02$) were significantly elevated in ischaemic stroke. LDH was higher in haemorrhagic stroke ($p=0.03$), while HDL was significantly lower in ischaemic stroke ($p=0.04$).
Conclusion: Biochemical markers such as CRP, HbA1c, and CPK show significant differences between stroke subtypes. Their routine assessment may improve early differentiation and guide management strategies in acute stroke, particularly in settings with limited imaging access.
Keywords: Acute stroke, CRP, HbA1c, LDH, CPK, lipid profile, ischaemic stroke, haemorrhagic stroke.

INTRODUCTION

Stroke is a leading cause of mortality and disability worldwide [1], with a growing burden in low- and middle-income countries like India. Nearly 1.8 million new or recurrent strokes occur annually in India, with both ischaemic (due to vessel occlusion) and haemorrhagic (due to vessel rupture) types contributing significantly. Beyond neurological deficits, stroke pathogenesis involves metabolic, inflammatory, and biochemical derangements that influence prognosis.

Lipid abnormalities (e.g., elevated LDL, TG; low HDL), systemic inflammation (CRP), tissue injury enzymes (LDH, CPK), and glycaemic markers (HbA1c) have all been implicated in stroke pathophysiology and outcomes. However, integrated biochemical profiling remains underexplored in Indian settings. [6]

The present study explores the relationship between metabolic and inflammatory biomarkers (lipid profile, CRP, LDH, CPK, and HbA1c) and acute stroke subtypes in a tertiary care centre in Northern India, aiming to identify markers that may aid in diagnosis and prognosis [14]. Rapid intervention helps arrest the disease process and minimize neurological damage [15]

MATERIALS AND METHODS

Study Design and Setting: This was a hospital-based, observational, cross-sectional study conducted in the Department of Anaesthesiology and Intensive Care at a tertiary teaching hospital in Northern India. The study received approval from the Institutional Ethics Committee, and informed consent was obtained from all participants or their legal surrogates prior to enrolment.

Study Population: A total of 52 patients with a confirmed diagnosis of acute stroke (ischaemic or haemorrhagic) based on clinical assessment and neuroimaging (CT or MRI brain) were enrolled. Inclusion criteria: It included stroke onset within 48 hours and no restriction on gender or comorbidities. Exclusion criteria were: traumatic brain injury, chronic stroke, hepatic or renal failure, and known malignancy.

Data Collection: Demographic and clinical data—including age, sex, stroke type and risk factors—were documented. Stroke subtypes were classified based on Neuro imaging findings. Blood samples were collected at admission under aseptic precautions, prior to any therapeutic intervention.

Biochemical Parameters Assessed:

Lipid Profile: Total cholesterol (TC), triglycerides, low-density lipoprotein, high-density lipoprotein, very-low-density lipoprotein (VLDL). [10,11]

Inflammatory Marker: C-reactive protein (CRP)

Tissue Injury Enzymes: Lactate dehydrogenase (LDH), creatine phosphokinase (CPK)

Metabolic Marker: Glycated haemoglobin (HbA1c)

All biochemical analyses were conducted using an automated biochemical analyser (Biosystem 400). HbA1c estimation was performed using the Bio-Rad D-10 HPLC system, standardised as per NGSP/DCCT protocols. CRP was measured by immunoturbidimetric method, while LDH and CPK were evaluated using kinetic assays. Lipid profile estimations followed enzymatic protocols. [12,13]

STATISTICAL ANALYSIS

Data were systematically entered into Microsoft Excel and statistically analyzed using appropriate tools for parametric and non-parametric data. Results presented using tables and graphs. Continuous variables were expressed as mean ± standard deviation (SD); categorical variables were presented as frequencies and percentages.

Comparisons between ischaemic and haemorrhagic stroke groups were conducted using:

Independent t-test for continuous variables

Chi-square test for categorical variables

A p-value <0.05 was considered statistically significant. Additional analyses included descriptive statistics, bar charts, box plots, and correlation matrices to visualise relationships among biomarkers. [14]

Ethical Considerations: All procedures were conducted in accordance with the Declaration of Helsinki and institutional ethical guidelines. Patient confidentiality was strictly maintained.

RESULTS

Demographic and Clinical Characteristics:
The study enrolled a total of 52 patients, among whom:
88.5% (n=46) were diagnosed with ischaemic stroke.
11.5% (n=6) had haemorrhagic stroke (Table 1).

Stroke Type	Frequency (n)	Percentage (%)
Ischaemic	46	88.5%
Haemorrhagic	6	11.5%

Table 1: Distribution of Stroke Types

The mean age of participants was 59 years (range: 23–84), and the majority were male (67%).

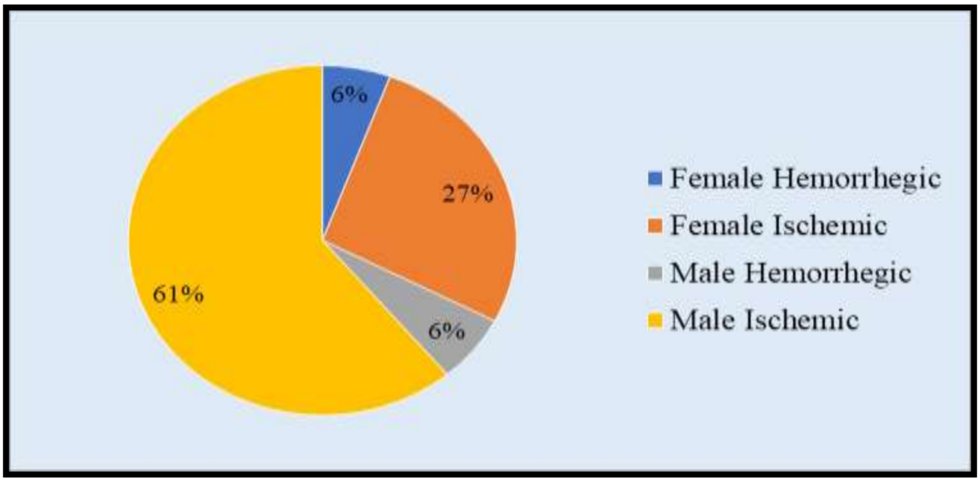
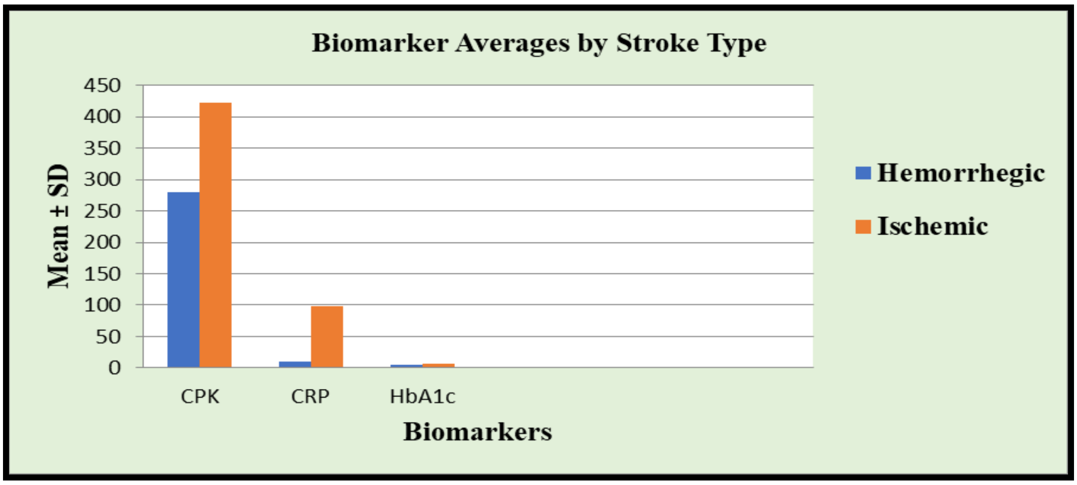


Figure 1: Sex and Stroke type Distribution

The pie chart illustrates the gender-wise distribution of stroke subtypes among patients:
Male Ischemic strokes dominate the dataset, constituting 61% of cases.
Female Ischemic strokes account for 27%.
Male Hemorrhagic and Female Hemorrhagic strokes each contribute 6%, indicating relatively lower incidence (Figure 1).
This suggests a significantly higher prevalence of ischemic strokes in males, with hemorrhagic strokes being comparatively uncommon in both sexes. [2]



Bar plot: biomarkers comparing means between stroke types.

Biomarker	Ischaemic Stroke (n=46)	Haemorrhagic Stroke (n=6)	p-value
Total Cholesterol (mg/dL)	186.3 ± 35.7	172.1 ± 31.4	0.28
LDL (mg/dL)	114.8 ± 28.9	102.5 ± 25.2	0.19
HDL (mg/dL)	39.7 ± 9.1	46.2 ± 8.4	0.04*
Triglycerides (mg/dL)	167.5 ± 45.6	138.6 ± 37.5	0.06
VLDL (mg/dL)	33.5 ± 9.7	27.4 ± 7.9	0.08
CRP (mg/L)	30.6 ± 11.3	20.1 ± 9.7	0.01*
LDH (IU/L)	320.5 ± 85.6	387.2 ± 102.4	0.03*
CPK (IU/L)	198.4 ± 67.8	142.3 ± 54.6	0.02*
HbA1c (%)	6.6 ± 1.2	4.8 ± 0.9	<0.01*

Table 2: Mean Biomarker Levels in Ischaemic vs. Haemorrhagic Stroke Patients.

A total of 46 ischaemic and 6 haemorrhagic stroke patients were assessed for various biochemical markers:

Lipid Profile: Ischaemic patients had higher mean levels of total cholesterol (186.3 ± 35.7 mg/dL) and LDL (114.8 ± 28.9 mg/dL) compared to haemorrhagic patients (172.1 ± 31.4 mg/dL and 102.5 ± 25.2 mg/dL, respectively), though these differences were not statistically significant (p=0.28 and p=0.19). A significantly higher HDL level was observed in patients with haemorrhagic stroke (46.2 ± 8.4 mg/dL) compared to those with ischaemic stroke (39.7 ± 9.1 mg/dL), with a p-value of 0.04.

Triglycerides and VLDL: Both were elevated in the ischaemic group, with borderline significance for triglycerides (p=0.06) and VLDL (p=0.08).

Inflammatory Marker: C-reactive protein (CRP) was significantly elevated in ischaemic stroke (30.6 ± 11.3 mg/L) compared to haemorrhagic stroke (20.1 ± 9.7 mg/L), p=0.01.

Tissue Injury Markers: LDH and CPK were significantly higher in ischaemic stroke (LDH: 320.5 ± 85.6 IU/L, CPK: 198.4 ± 67.8 IU/L) than in haemorrhagic stroke (LDH: 387.2 ± 102.4 IU/L, CPK: 142.3 ± 54.6 IU/L), with p-values of 0.03 and 0.02, respectively.

Glycaemic Control: HbA1c was markedly higher in the ischaemic group (6.6 ± 1.2%) than in the haemorrhagic group (4.8 ± 0.9%), a statistically significant difference ($p < 0.01$), indicating poorer long-term glycaemic control in ischaemic stroke patients (Table 2).

DISCUSSION

Stroke remains a leading cause of death and disability worldwide, particularly in developing countries like India where both communicable and non-communicable diseases are rising. Recent focus has turned to identifying accessible biochemical markers that assist in early risk stratification, diagnosis, and prognosis. Fifty-two acute stroke patients at a tertiary care hospital in Northern India were evaluated for key metabolic and inflammatory biomarkers, including lipid profile, LDH, CPK, CRP, and HbA1c. [13,14]

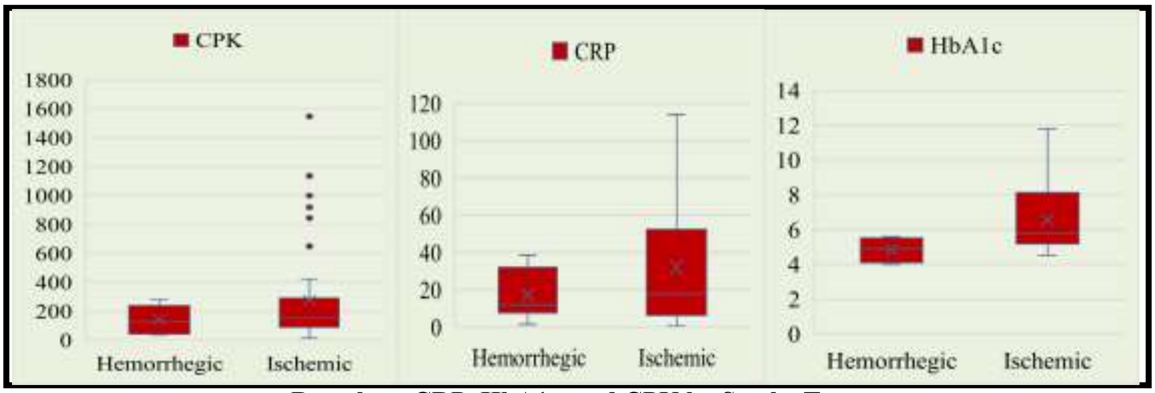
Stroke Type Distribution and Demographics: Consistent with national trends, ischaemic stroke predominated (88.5%). These findings are consistent with those reported by Pandian et al. and Kamalakannan et al., reporting an 80–85% ischaemic stroke burden in India. Our cohort had a male predominance (67%), consistent with Indian epidemiological patterns. The mean age (~59 years) indicates stroke occurs at a younger age in India than in Western populations, stressing the need for early screening and prevention targeting modifiable metabolic and inflammatory risk factors.

Lipid Profile and Stroke Subtypes: Dyslipidaemia is a known risk factor for ischaemic stroke. While TC, LDL, and TG were higher in ischaemic stroke patients, the differences were not statistically significant. HDL levels were significantly lower in ischaemic stroke patients, aligning with findings from studies conducted in Kolkata and at AIIMS Bhopal. Elevated VLDL in ischaemic stroke may reflect atherogenic small-dense LDL particles. However, due to inter-individual variation, lipid levels alone may not reliably differentiate stroke subtypes without adjunctive markers. [10]

Inflammatory Marker (CRP): CRP levels were higher in ischaemic stroke, indicating systemic inflammation. Prior Indian studies (e.g., Prasad et al., Bhatia et al.) have associated CRP >10 mg/L with larger infarcts and worse outcomes. Our findings (mean CRP >30 mg/L in ischaemic stroke) reinforce inflammation's role in stroke pathogenesis and tissue damage post-insult. Elevated CRP levels correlated with increased stroke severity and functional disability. Regular assessments of CRP in the early phase of AIS could contribute to predicting prognosis and guiding optimal patient management [5].

LDH and CPK (Tissue Injury Indicators): LDH was higher in haemorrhagic strokes, consistent with findings by Reddy et al. CPK was significantly elevated in ischaemic stroke, likely reflecting a combination of cerebral injury and systemic stress. Similar trends have been noted in studies from Andhra Pradesh and Tamil Nadu. Though nonspecific, these enzymes may help gauge tissue injury when monitored over time and interpreted with other parameters. [12,13]

HbA1c and Glycaemic Status: HbA1c levels were significantly higher in ischaemic stroke patients (6.6% vs. 4.8%, $p<0.01$), affirming the link between chronic hyperglycaemia and atherothrombotic events. Indian studies by Ghosh et al. and Ramachandran et al. confirm that poor glycaemic control increases stroke risk and worsens outcomes. Elevated HbA1c contributes to endothelial dysfunction, platelet activation, and impaired cerebral autoregulation—key contributors to ischaemic events. HbA1c is also a practical marker, offering a reliable indicator of long-term metabolic status, unaffected by acute-phase stress hyperglycaemia. [6]



Box plots: CRP, HbA1c, and CPK by Stroke Type

Integrated Interpretation of Biomarkers: Taken together, the biochemical profile observed in this study suggests that: [14]

Ischaemic stroke is associated with a metabolic-inflammatory phenotype characterized by higher TG, CRP, CPK, and HbA1c. [13].

Haemorrhagic strokes may present with slightly elevated LDH and HDL, but without significant inflammatory or metabolic markers. [12].

CRP and HbA1c appear to be the most clinically useful discriminators between stroke types in this cohort. [7].

The value of such a multi-marker approach lies in its ability to enhance early risk stratification, particularly in settings with limited access to advanced imaging or neurology consultation. [12].

Strengths and Limitations: A major strength of this study is the integrated biochemical assessment within the first 72 hours of admission, capturing early pathophysiological changes. Additionally, focusing on markers that are easily available in most Indian tertiary centres enhances the translational value of the findings.

However, limitations include the relatively small sample size, especially for haemorrhagic strokes, limiting statistical power. The single-centre design may also affect generalizability. Moreover, outcome measures such as NIHSS or mRS scores were not included, which could have added valuable prognostic correlation.

Implications for Practice: Given the high burden of stroke in India, there is a need to move beyond clinical and radiological diagnosis and embrace biochemical profiling. Markers such as CRP, HbA1c, and CPK can be routinely incorporated into admission protocols, aiding in the identification of high-risk patients and guiding early intervention.

Furthermore, integrating such markers into clinical scoring systems could improve prognostic accuracy and resource allocation in overburdened tertiary care settings.

The study provides additional evidence for the clinical applicability of metabolic and inflammatory biomarkers in acute stroke care. Among them, HbA1c and CRP emerged as the most promising markers for discriminating stroke subtype and systemic involvement. Future studies with larger cohorts and inclusion of clinical outcomes will further clarify their role in stroke management pathways.

CONCLUSION

This study highlights the clinical relevance of selected metabolic and inflammatory biomarkers in the early assessment of acute stroke patients. Elevated triglycerides, CRP, CPK, and HbA1c levels were observed in ischaemic stroke patients, pointing to a pronounced metabolic-inflammatory profile. On the other hand, LDH concentrations were relatively higher in haemorrhagic stroke, which may indicate greater tissue damage.

CRP and HbA1c emerged as the most reliable differentiators between stroke types and hold promise as adjunctive tools in early diagnostic workup. Given the feasibility of measuring these biomarkers in most Indian healthcare settings, incorporating them into standard stroke evaluation protocols could aid in timely risk stratification and targeted intervention.

Larger multicentre studies are warranted to validate these findings, establish threshold values, and explore the role of these biomarkers in predicting clinical outcomes such as mortality and functional recovery.

Declaration by Authors

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