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Study of C-Reactive Protein and Lipid Profile as Morbidity Predictors of Ischemic Stroke Using Modified Barthel Index Scoring

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ABSTRACT

Background: Ischemic stroke is a major cause of adult disability worldwide. Early identification of reliable blood biomarkers may improve clinical risk stratification and individualized rehabilitation. This study evaluated the prognostic value of baseline serum high-sensitivity C-reactive protein (hs-CRP) and fasting lipid profile parameters for predicting 30-day functional morbidity using the Modified Barthel Index (MBI).

Methods: This prospective observational study included 100 patients with acute ischemic stroke presenting within 24 hours of symptom onset at a tertiary care centre. Baseline hs-CRP and fasting lipid parameters, including total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C), were assessed within 24 hours of admission. Functional outcome was evaluated on Day 30 using the 100-point MBI. Multiple logistic regression analysis identified independent predictors of severe functional dependence (MBI ≤40).

Results: The mean age was 61.8 years. Patients with severe disability had significantly higher median hs-CRP (7.4 vs. 2.1 mg/L, $p < 0.001$), higher mean LDL-C (142.3 ± 22.1 vs. 104.5 ± 18.4 mg/dL, $p < 0.01$), and lower mean HDL-C (34.2 ± 6.8 vs. 46.8 ± 7.2 mg/dL, $p < 0.01$) than those with mild disability or functional independence. hs-CRP showed a strong inverse correlation with Day 30 MBI scores ($r = −0.64$, $p < 0.001$). hs-CRP ≥3.0 mg/L and LDL-C/HDL-C ratio ≥3.5 were independent predictors of severe functional dependence.

Conclusion: Elevated hs-CRP and an adverse lipid profile were associated with poorer 30-day functional outcomes. Combined biomarker assessment may help identify patients at high risk of severe functional dependence and facilitate early rehabilitation.

Key-words: Acute Ischemic Stroke; High-Sensitivity C-Reactive Protein; Lipid Profile; Modified Barthel Index; Morbidity; Prognosis

INTRODUCTION

Ischemic stroke triggers an acute neuroinflammatory cascade and is driven primarily by underlying atherothrombotic vascular disease. C-Reactive Protein (CRP): An acute-phase reactant synthesized by the liver, CRP acts as a systemic marker of inflammation.

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Elevated levels reflect the extent of ischemic tissue injury and the intensity of the inflammatory response. Dyslipidaemia accelerates endothelial dysfunction, plaque instability, and macrovascular occlusion.Modified Barthel Index (MBI): A validated, 100-point clinical rating scale assessing a patient's independence in Activities of Daily Living (ADLs) such as grooming, bathing, feeding, and ambulation.

While individual risk factors are well established, evaluating the synergistic predictive power of inflammatory and metabolic markers using a dedicated functional metric like the MBI provides actionable prognostic timelines for clinicians Biomarker Profile & Predictive Trends Clinical studies demonstrate that

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patients who experience severe disability post-stroke exhibita specific biochemical fingerprint at admission: [1,2]

Table 1: Impact of Biomarkers on Functional Outcome in Ischemic Stroke

Biomarker	Observed Level	Impact on Modified Barthel Index (MBI)
High-Sensitivity CRP (hs-CRP)	Elevated (≥ 6 mg/dL or positive assay)	Strongly predicts severe functional disability (MBI score < 41). Reflects larger tissue infarct volume and ongoing systemic inflammation.
Total Cholesterol (TC)	Elevated	Correlates with a 2-fold increased risk of poor functional recovery.
LDL Cholesterol	Elevated	Accelerates atherothrombosis, lowering the odds of recovering independence.
Triglycerides (TG)	Elevated	Linked with metabolic risk factors that delay neurovascular healing.
HDL Cholesterol	Decreased	Loss of protective anti-inflammatory properties leads to poor long-term outcomes.

MATERIALS AND METHODS

Study design and setting- This prospective, hospital-based observational study was conducted in the Department of General Medicine, J.J.M. Medical College and associated Bapuji Hospital and Chigateri General Hospital, Davangere, Karnataka, India. A total of 100 patients with cerebrovascular accident secondary to acute ischemic stroke were included in the study. The study population comprised patients aged 26–85 years who presented with clinical features of acute ischemic stroke.

Patient selection- Patients presenting with clinical features suggestive of acute ischemic stroke and radiological confirmation by non-contrast computed tomography (NCCT) or magnetic resonance imaging (MRI) within 24 hours of symptom onset were included. Patients with hemorrhagic stroke, transient ischemic attack (TIA), intracranial malignancy, active infection, chronic inflammatory disorders such as rheumatoid arthritis, or malignancy were excluded. Patients with pre-existing severe physical or cognitive disability that could interfere with baseline activities of daily living (ADL) assessment were also excluded.

Clinical assessment- A detailed clinical history was obtained at the time of admission. Relevant vascular risk factors, including smoking, hypertension, diabetes mellitus, hyperlipidemia, alcohol consumption, and underlying heart disease, were recorded. A detailed clinical examination was performed, including general examination, assessment of higher mental functions, cranial nerve examination, motor and sensory system examination, cerebellar examination, gait assessment, evaluation for meningeal signs, and examination of the cardiovascular, respiratory, and abdominal systems.

Inclusion criteria

- Patients aged 26–85 years presenting with clinical signs of acute ischemic stroke.
- Radiological confirmation by NCCT or MRI within 24 hours of symptom onset.
- Admission within the acute/therapeutic window.

Exclusion criteria

- Patients with hemorrhagic stroke, transient ischemic attack (TIA), or intracranial malignancies.
- Patients with active infections, chronic inflammatory disorders (e.g., rheumatoid arthritis), or malignancies that could independently elevate CRP.
- Patients with pre-existing severe physical or cognitive disability that prevented baseline ADL evaluation.

Assessment of functional status- Functional status was assessed using the Modified Barthel Index (MBI). The MBI evaluates independence in activities of daily living, including personal hygiene, bathing, feeding, toileting, stair climbing, dressing, bowel control, ambulation, and chair-bed transfer. Functional status was assessed at admission (Day 1), on Day 5, at discharge, and during follow-up at 3 months. The 100 patients were categorized according to MBI score as mildly disabled (>60), moderately disabled (41–60), or severely disabled (<41).

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Laboratory investigations- Routine investigations were performed at the time of admission and included complete hemogram, urine analysis, electrocardiography (ECG), blood glucose, blood urea, and serum creatinine.
A fasting lipid profile was assessed using an early-morning fasting blood sample and included total cholesterol, low-density lipoprotein (LDL), very-low-density lipoprotein (VLDL), triglycerides, and high-density lipoprotein (HDL).

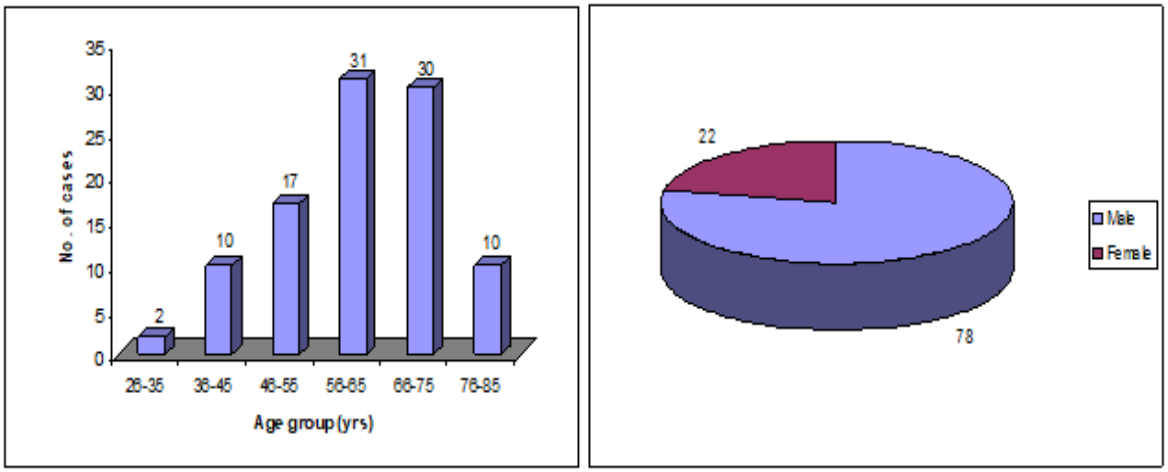
C-reactive protein assessment- Blood samples for C-reactive protein (CRP) estimation were collected within 24–48 hours of admission. CRP was measured using a semi-quantitative latex agglutination method with spectrometric assessment. CRP values were subsequently compared with the severity of functional disability assessed using the Modified Barthel Index.

Follow-up- Patients were followed up for 3 months after the acute stroke episode. Follow-up was conducted through personal interview, telephone conversation, or postal correspondence. Functional status at follow-up was assessed using the Modified Barthel Index and compared with the initial clinical and laboratory findings.

Statistical analysis- Data were analyzed using SPSS version 11.0 and Systat version 8.0. Microsoft Word and Microsoft Excel were used for data presentation and generation of tables and graphs. The Chi-square test and Fisher's exact test were used to assess the significance of categorical study parameters between groups. Odds ratios were calculated to assess the strength of association between study parameters and functional outcome groups. The independent Student's *t*-test was used to compare continuous investigation parameters between groups. A *p*-value <0.05 was considered statistically significant.

RESULTS

A total of 100 patients with cerebrovascular accident secondary to ischemic stroke, aged 26–85 years, were studied. The mean age was 61.8 years. The maximum number of patients belonged to the 56–65-year age group (31 patients), followed by the 66–75-year age group (30 patients). There were 78 male and 25 female patients, with a reported male-to-female ratio of 3.5:1. Fig. 1a & Fig. 1b.



a: Age distribution **b:** Sex Distribution

Fig. 1: Age and Sex Distribution

In this study, 52 patients were mildly disabled, 30 were moderately disabled, and 18 were severely disabled according to the Modified Barthel Index. Among the 31 patients aged 56–65 years, 17 were mildly disabled, 9 moderately disabled, and 5 severely disabled. Among the 30 patients aged 66–75 years, 10 were mildly disabled, 13 moderately disabled, and 7 severely disabled. The association between age and disability was statistically significant ($p < 0.05$), suggesting greater disability with increasing age. Table 2 presents the distribution of Modified Barthel Index severity according to age group.

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Table 2: Distribution of Modified Barthel Index severity according to age group

Age group (years)	Mild, n (%)	Moderate, n (%)	Severe, n (%)	Total
26–35	1 (50.0)	1 (50.0)	0	2
36–45	10 (100.0)	0	0	10
46–55	11 (64.7)	4 (23.5)	2 (11.8)	17
56–65	17 (54.8)	9 (29.0)	5 (16.1)	31
66–75	10 (33.3)	13 (43.3)	7 (23.3)	30
76–85	3 (30.0)	3 (30.0)	4 (40.0)	10
Total	52	30	18	100

$\chi^2 = 19.0; p < 0.05$

At admission, 80 patients were conscious and oriented, 7 were semiconscious, and 13 were comatose. Vomiting was present in 40 patients, headache in 21 patients, and speech disturbance in 9 patients. Left-sided weakness was observed in 55 patients, right-sided weakness in 44 patients, and cerebellar signs in 15 patients (Table 3).

Table 3: Signs and Symptoms

Clinical features		No. of cases
Consious Level	Alert	80
	Comatose	13
	Semiconcious	07
Vomiting		40
Headache		21
Speech distribution		09
Right Side weakness		44
Left side weakness		55
Cerebellar signs		15

In the study population, 47 patients were diabetic, 47 were hypertensive, 23 had underlying heart disease, 23 were smokers, and 7 reported alcohol consumption (Fig. 2).

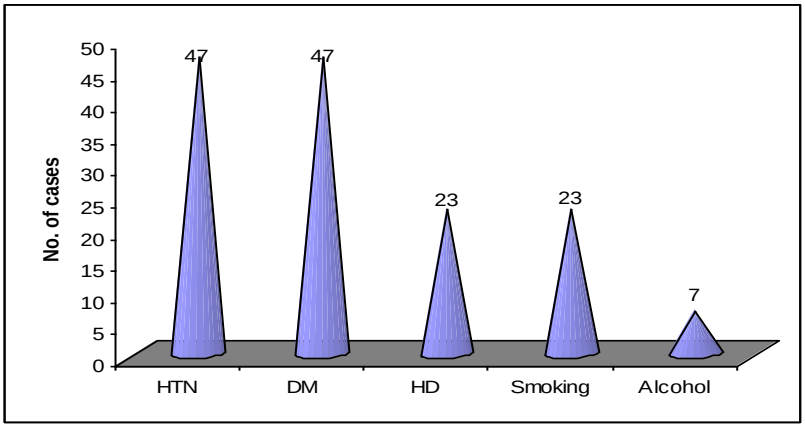

Fig. 2: Risk Factors

According to the Modified Barthel Index, on Day 1, 52 patients were mildly disabled, 30 moderately disabled, and 18 severely disabled. On Day 5, 80 patients were mildly disabled, 6 moderately disabled, and 14 severely disabled. At discharge, 83 patients were mildly disabled, 4 moderately disabled, and 10 severely disabled, while 3 patients died. At 3-month follow-up, 84 patients were mildly disabled, 3 moderately disabled, and 10 severely disabled, with 3 deaths. Table 4 presents the functional status during follow-up.

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Table 4: Functional status according to Modified Barthel Index during follow-up

Severity	Day 1, n	Day 5, n	At discharge, n	3 months, n
Mild	52	80	83	84
Moderate	30	6	4	3
Severe	18	14	10	10
Death	–	–	3	3
Total	100	100	100	100

Mean systolic blood pressure increased significantly across mild, moderate, and severe disability groups (135.0 ± 16.8, 143.4 ± 25.9, and 155.4 ± 20.9 mmHg, respectively; *p* < 0.05). Mean blood sugar also increased with severity (147.0 ± 71.3, 165.6 ± 98.1, and 201.3 ± 121.1 mg/dL). HDL decreased significantly across the groups (40.1 ± 3.4, 38.4 ± 2.7, and 37.3 ± 2.6 mg/dL; *p* < 0.05), while total cholesterol, LDL, and triglycerides showed no significant association with severity.

CRP was significantly associated with MBI severity (χ^2 = 61.9, *p* < 0.05). All mildly disabled patients had CRP <6, compared with 96.7% of moderately and 27.8% of severely disabled patients. Conversely, CRP >6 was observed in 72.2% of severely disabled patients.

Table 5: Association of CRP levels with Modified Barthel Index severity

Severity	Total, n	CRP <6, n (%)	CRP >6, n (%)
Mild	52	52 (100.0)	–
Moderate	30	29 (96.7)	1 (3.3)
Severe	18	5 (27.8)	13 (72.2)
Total	100	86	14

χ^2 = 61.9; *p* < 0.05.

DISCUSSION

Stroke is the major consequence of cerebrovascular disease. The incidence of stroke is increasing in India even in young individuals. In this study of CRP in ischemic cerebrovascular disease consists of a group of 100 patients who are admitted to Bapuji hospital and Chigateri General Hospital attached to J.J.M. Medical College, Davangere. In this study maximum number of patients are in 5th and 6th decade of life. Also there is increasing trend of severity above 7th decade of life. The p-value is < 0.05, showing a significant risk association.

In Copenhangen stroke study reported that age independently influenced initial Barthel Index (BI) (–4 points per 10 years, p < 0.01), and discharge BI (–3 points per 10 years, p < 0.01). ADL improvement was influenced independently by age (–3 points per 10 years, p < 0.01) whereas age had no influence on neurological improvement or on speed of recovery.[3] In Yang *et al.* study they concluded that stroke incidence increases with age, also in the very old [4]. Our study also had similar resultsIn this present study group analysis, showed 47 patients with hypertension, 47 patients with diabetes mellitus, 23 patients with heart disease, 23 patients were smokers and 7 alcoholics. According to the Framingham heart study systolic blood pressures, diabetic mellitus, cigarette smoking and prior cardiovascular disease are predictors of stroke. In this study HDL-C is showing a downward trend with severity of stroke incidence. The mean values are 40.1 (3.4), 38.4 (2.7) and 37.3 (2.6) in mild, moderate and severe cases respectively. The p value is < 0.05, significant. Difference between groups in comparison between mild-moderate, mild-severe is significant with p < 0.05.

Total cholesterol, LDL and TGR, not a significant association with p value of 0.44, 0.81, 0.66 respectively. However TC and HDL are showing an upward trend but not so with TGR. A study by Israeli ischemic heart disease of HDL-C and risk of ischemic stroke mortality, during this 21 year follow-up study, individuals subsequently experiencing a fatal ischemic stroke had a marginally lower age adjusted mean HDL-C (1.05 mmol/l) [5]. In ARIC study by Shahar *et al*. reported that the circulating

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cholesterol to ischemic stroke does not resemble its well-known relation to coronary heart disease. Our study also confirmed this [6].

In this study it there were 52 (100) mild cases on day 1 according to Barthel Index. Their CRP values at admission was < 6 mg/dl. These patients have shown improvement in Barthel scores on day 5, at discharge and at 3 months. There were 30 patients on day 1 with moderate disability. 29 (96.7) patients had CRP value < 6 and one patient > 1 (3.3). Among these 30 patients 29 patients showed improvement in their Barthel scores by day 5, and flowingly. 18 patients on day one in the study group were severely disabled and 13 (72.2) patients had CRP value >6 on day one. p-values in this study of CRP is < 0.05 $\square^2$ = 61.9 showing a significant indicator of stroke outcome. Similar results were observed by Winbeck *et al*. in his study of multiple logistic regression analysis identified. Barthel Index score at admission and CRP at 12 and 24 hours after symptoms onset predicts an unfavorable outcome and is associated with an increased incidence of cerebrovascular and cardiovascular events [7].

In a study conducted by Loewen and Anderson [8] on predictors of stroke outcome. Using modified motor assessment scale (motor status) and the Barthel index (functional outcome) they tested 50 stroke patients □ 3 days, 1 week, and 1 month after their stroke and at discharging from hospital. They found both measures reliable and valued. They suggested that these objectives predictors of recovery be used as adjuncts in prioritizing and directing the rehabilitation management of patients with stroke. In Framingham study by Rost *et al.* they showed that independent of age. Men in the highest CRP quartile had 2 times risk of ischemic stroke / TIA (p = 0.27) and women had almost 3 times the risk (p = 0.003) [9].

Independent of other cardiovascular risk factors, elevated plasma CRP levels significantly predict the risk of future ischemic stroke and TIA in the elderly. Dhamija *et al*. in their study [10]. The difference in CRP levels in cases and control subjects was highly significant (4.78± 0.72 mg/dl vs 0.76 ±0.70, p<0.001). 96.5% of patients with raised CRP had abnormal lipid levels also .Raised CRP levels in stroke patients were significantly associated with large territory infarcts, severe disability and poor functional outcome (p<0.05). Panicker *et al.* studied morbidity prediction in ischemic stroke. The functional status was analysed using Barthal Index of Activities of Daily Living [11]. Patients were grouped in 3 categories using Barthel Index as mild, moderate and severe CRP was measured at admission. Follow up of the patients was achieved through telephone in most of the cases or postal correspondence. They concluded that CRP is an index of increased risk for cardiovascular disease and patients can be targeted with more aggressive therapy for plaque stabilization. In “Bergen stoke study” by Idicula *et al.* Showed that high CRP was associated with poor short-term functional outcomes (BI < 95) (p = 0.03) [12]. Hence CRP is an independent predictor of long-term mortality after ischemic stroke. Napoli *et al*. in his study of C-reactive protein in ischemic stroke. CRP at admission Hazard ratio (HR) 2.78, 95% CI, 1.45 to 5.33 (p = 0.0021) and discharge (HR 9.42, 95% CI 4.27 to 19.05 p < 0.0001) were predictors of the combined end point of new vascular events or death at 1 year [13].

CRP at discharge is better related to later outcome and could be of greater utility for risk stratification predicts future cardiovascular events or death Study by Gussekloo *et al.* showed the CRP is a strong but non-specific risk factors of fatal stroke [14] and the risk of death from stroke increased linearly up to 10 folds in subject with highest levels of CRP at baseline (p < 0.001) after adjusting for age, sex, smoking, medication, total cholesterol, diabetes and hypetension.

CONCLUSIONS

The findings of this study underscore the dual pathophysiological pathways of ischemic stroke: metabolic dysregulation (lipids) and secondary neuroinflammation (CRP). Elevated CRP points to an active inflammatory state that may exacerbate the penumbral tissue injury, expanding the ultimate core infarct diameter. Concurrently, an adverse lipid profile limits structural vascular repair and optimal cerebral perfusion. By measuring both indices against the Modified Barthel Index, clinicians get a holistic view of the patient’s physical trajectory. This helps bridge the gap between abstract laboratory numbers and concrete, real-world functional recovery. Baseline levels of C-reactive protein and a disrupted lipid profile serve as highly effective, low-cost morbidity predictors in acute ischemic stroke. Stratification using the Modified Barthel Index helps identify patients at high risk for severe, long-

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term disability, enabling clinicians to initiate early, aggressive neurorehabilitation and optimized secondary stroke prevention strategies.

CONTRIBUTION OF AUTHORS

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Research design- PruthviRaj S, Likitha Gutta
Supervision- Medhini VJ
Materials- PruthviRaj S, Likitha Gutta
Data collection- PruthviRaj S, Likitha Gutta
Data analysis and interpretation- Medhini VJ
Literature search- PruthviRaj S, Likitha Gutta
Writing article- PruthviRaj S, Likitha Gutta
Critical review- Medhini VJ
Article editing- PruthviRaj S, Likitha Gutta
Final approval- Medhini VJ

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