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J Arch Mil Med. 2026 December; 14(4): e174478 https://doi.org/10.69107/jamm-174478

Published Online: 2026 November 9 **Research Article**

Association of Blood and Inflammatory Factors with Stroke Type and in-Hospital Outcome in Patients Presenting to the Emergency Department of Imam Khomeini Hospital, Urmia

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Received: 18 August, 2026; **Accepted:** 2 November, 2026

Abstract

Background: Stroke is a major cause of hospitalization in neurology wards and a leading cause of disability and mortality from neurological disorders. Hematologic and inflammatory markers may play a role in stroke occurrence and prognosis.

Objectives: This study investigated the association of blood and inflammatory factors with stroke type and in-hospital outcome in patients presenting to the emergency department of Imam Khomeini Hospital, Urmia, in 2022.

Methods: This retrospective analytical cross-sectional study used data extracted from the medical records of 721 patients with stroke. Data were analyzed using SPSS version 27 and appropriate statistical tests.

Results: Of the 721 patients, 590 (81.8%) had ischemic stroke and 131 (18.2%) had hemorrhagic stroke. In the hemorrhagic stroke group, 55.7% were male and 44.3% were female; the proportions of male and female patients were equal in the ischemic stroke group. Mean age was 65.2 ± 16.1 years in the hemorrhagic stroke group and 71.1 ± 14.6 years in the ischemic stroke group. Mean hemoglobin and hematocrit levels in the hemorrhagic stroke group were 14.29 ± 2.18 g/dL and 42.51 ± 5.92%, respectively; both were significantly higher than the corresponding values of 13.71 ± 2.02 g/dL and 41.31 ± 5.64% in the ischemic stroke group. Mean C-reactive protein (CRP) levels were 34.34 ± 25.88 mg/L in the hemorrhagic stroke group and 34.50 ± 27.62 mg/L in the ischemic stroke group. Mean erythrocyte sedimentation rate (ESR) values were 22.084 ± 22.28 mm/h and 22.998 ± 27.79 mm/h, respectively. Neither CRP nor ESR differed significantly between the groups ($P > 0.05$). Mortality was significantly higher among patients with hemorrhagic stroke than among those with ischemic stroke (40.5% vs 18.6%; $P = 0.001$).

Conclusions: Ischemic stroke was more common than hemorrhagic stroke, but hemorrhagic stroke was associated with higher in-hospital mortality. Although hemoglobin and hematocrit levels were higher in the hemorrhagic stroke group, CRP and ESR did not differ significantly between stroke types and were not significantly associated with in-hospital outcomes.

Keywords: Stroke, Ischemic Stroke, Hemorrhagic Stroke, Hemoglobin, Hematocrit, C-reactive Protein, Erythrocyte Sedimentation Rate, In-hospital Outcome

1. Background

According to the World Health Organization (WHO), stroke is defined as the rapid onset of clinical signs and symptoms of focal or global neurological dysfunction of vascular origin, typically lasting more than 24 hours or leading to death, with no apparent cause other than a vascular etiology. Stroke is one of the most common causes of hospitalization in neurology wards, the leading cause of persistent disability of neurological origin, and the second most common cause of death from neurological disorders worldwide (1). Based on the latest global statistics, approximately 12.2 million new cases of stroke occur annually, and nearly 5.6 million people worldwide die from the disease. Moreover, an estimated one in four adults will experience a stroke during their lifetime (2). The greatest burden of stroke—in terms of incidence, disability, and mortality—is observed in low- and middle-income countries, and stroke remains a major challenge for health systems globally (3). In Iran, the incidence of stroke has

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How to Cite: Choobi Anzali B, Samaei S, Rasouli M. Association of Blood and Inflammatory Factors with Stroke Type and in-Hospital Outcome in Patients Presenting to the Emergency Department of Imam Khomeini Hospital, Urmia. J Arch Mil Med. 2026;14(4):e174478. doi: https://doi.org/10.69107/jamm-174478

risen in recent decades, increasing from approximately 50,000 cases in 1990 to nearly 100,000 cases in 2019 (4).

From an etiological perspective, stroke is divided into two main categories: ischemic and hemorrhagic. Ischemic stroke results from reduced or interrupted blood flow to a region of the brain, whereas hemorrhagic stroke results from blood vessel rupture and subsequent bleeding into the brain parenchyma or surrounding spaces. Intracranial hemorrhages are further classified by location as intraparenchymal hemorrhage (ICH), subarachnoid hemorrhage, and subdural or epidural hemorrhage (5). Although approximately 80% of strokes are ischemic and about 20% are hemorrhagic, mortality from hemorrhagic stroke has been reported to be considerably higher than that from ischemic stroke. Ischemic stroke occurs when blood flow to one or more areas of the brain is reduced or completely interrupted. Because neurons depend on oxygen and glucose for normal function, even a few minutes of reduced oxygen supply can cause irreversible damage and the death of many neurons. In addition to the primary ischemic injury, secondary processes, including inflammation, cerebral edema, and other pathological reactions, may persist for hours to days after stroke onset, further exacerbating neurological injury (6).

Acute ischemic stroke is a medical emergency, and favorable outcomes depend on rapid assessment, timely diagnosis, and early initiation of specialized treatment. In eligible patients, intravenous thrombolysis and mechanical thrombectomy can reduce complications and mortality by restoring cerebral blood flow; however, their effectiveness depends largely on the time to treatment initiation and the patient's clinical status (7). Therefore, identifying clinical and laboratory factors associated with stroke type and outcomes can contribute to risk assessment, therapeutic decision-making, and prognosis.

In recent years, particular attention has been directed toward the association of anemia and hematologic markers with stroke incidence, severity, and outcomes. The brain requires a continuous supply of oxygen and nutrients, and hemoglobin is essential for oxygen delivery to tissues. Reduced hemoglobin levels or diminished oxygen-carrying capacity can therefore exacerbate cerebral ischemia and neuronal injury. Anemia may also increase the risk of complications, prolong hospital stay, and increase mortality in patients with stroke, potentially through elevated cardiac output, impaired tissue oxygenation, and worsening of underlying comorbidities (8). For this reason, anemia has been proposed as an important cardiovascular risk factor and has been termed the “fifth cardiovascular risk factor” in some studies (9). Anemia typically results from the interplay of several factors, including iron deficiency, increased production of inflammatory cytokines, renal dysfunction, and blood loss; its underlying cause may therefore vary among patients.

Existing evidence indicates that anemia in patients with stroke is associated with poorer outcomes, more complications, and higher mortality (10). In a study conducted in Greece, approximately 17% of patients with stroke were anemic and had less favorable clinical outcomes than patients without anemia (11). Furthermore, Hatamian and colleagues reported in 2014 that red blood cell count and mean corpuscular volume could help predict stroke-related mortality (12). These findings suggest that assessing hematologic markers, including hemoglobin, hematocrit, RBC count, and red cell indices, may help characterize patients' clinical status and predict outcomes.

Inflammation is a key mechanism underlying the pathogenesis and progression of brain injury after stroke. An enhanced inflammatory response may aggravate neuronal damage, impair vascular function, cause edema, and extend the area of brain injury. Although nonspecific, C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) are simple, readily available indicators of inflammation in clinical practice. Examining their association with stroke type and clinical outcomes may clarify the role of inflammation in the disease course. Given the high incidence of stroke, its substantial burden of disability and mortality, and evidence linking hematologic and inflammatory markers to outcomes, investigating these factors is clinically important. However, previous findings on the association of hemoglobin, hematocrit, red cell indices, CRP, and ESR with stroke type and outcomes have been inconsistent, and few studies have addressed this issue in West Azerbaijan Province.

2. Objectives

This study investigated the association of blood and inflammatory factors with stroke type and clinical outcome in patients presenting to the emergency department of Imam Khomeini Hospital, Urmia, in 2022. The findings are expected to improve understanding of patients' laboratory characteristics, help identify factors associated with unfavorable outcomes, and inform initial assessment and clinical decision-making.

3. Methods

3.1. Study Design and Setting

This retrospective analytical cross-sectional study assessed the association between hematologic and inflammatory factors and stroke type and short-term

patient outcomes. The target population comprised all patients with stroke, and the study population included patients hospitalized with a diagnosis of stroke at Imam Khomeini Hospital, Urmia, in 2022. Census sampling was used, and all eligible patients hospitalized during the study period were included.

3.2. Participants and Sampling

The inclusion criteria were age 18 years or older, a diagnosis of stroke based on clinical presentation and radiologic findings, and confirmation of the diagnosis by a neurologist. The exclusion criteria were incomplete medical records, traumatic strokes, discharge against medical advice before treatment completion, and referral from another medical center. After approval was obtained from the institutional ethics committee (approval number: IR.UMSU.HIMAM.REC.1403.070), the medical records of eligible patients were reviewed, and the required data were extracted from their clinical and paraclinical records.

3.3. Data Collection and Variables

Data were collected using a researcher-developed checklist based on the study objectives and variables of interest. The checklist included demographic information, including age and sex; stroke type; hematologic and inflammatory indices; and in-hospital outcome. The main study variables were age, sex, stroke type, in-hospital outcome, CRP level, ESR, hemoglobin, hematocrit, and the presence or absence of anemia. Stroke was classified as ischemic or hemorrhagic, and in-hospital outcome was defined as discharge or death during the hospitalization, from admission onward. C-reactive protein was recorded in milligrams per liter, ESR in millimeters per hour, hemoglobin in grams per deciliter, and hematocrit as a percentage. Anemia was defined by reduced hemoglobin according to the criteria documented in patients' medical records.

3.4. Statistical Analysis

Data were entered into SPSS version 27 for statistical analysis. Descriptive statistics were used to summarize the data: quantitative variables were reported as means and standard deviations, and qualitative variables as frequencies and percentages. Results were also presented in appropriate tables and figures. Logistic regression was used to examine the association between hematologic and inflammatory variables and in-hospital outcome. The significance level for all statistical tests was set at less than 0.05.

3.5. Ethical Considerations

The study was conducted after approval was obtained from the university ethics committee. Patient confidentiality was maintained, and the data collection checklists did not contain personal identifiers. All data were analyzed and reported in aggregate form.

4. Results

A total of 721 patients with stroke were evaluated. Of these, 590 (81.8%) had ischemic stroke and 131 (18.2%) had hemorrhagic stroke. In the hemorrhagic stroke group, 73 patients (55.7%) were male and 58 (44.3%) were female. In the ischemic stroke group, the numbers of male and female patients were equal, with 295 (50.0%) in each group.

The mean age was 65.2 ± 16.1 years in patients with hemorrhagic stroke and 71.1 ± 14.6 years in patients with ischemic stroke (Table 1).

The mean hematocrit level was 42.51% in patients with hemorrhagic stroke and 41.31% in those with ischemic stroke. Similarly, the mean hemoglobin level was 14.29 g/dL in the hemorrhagic stroke group and 13.71 g/dL in the ischemic stroke group. Both indices were higher in patients with hemorrhagic stroke. The between-group differences were statistically significant for hematocrit ($P = 0.029$) and hemoglobin ($P = 0.006$) (Table 2).

As shown in Table 3, the mean CRP level was 34.33 ± 25.88 mg/L in patients with hemorrhagic stroke and 33.15 ± 27.62 mg/L in patients with ischemic stroke; this difference was not statistically significant ($P = 0.649$). The mean ESR was 22.084 ± 22.28 mm/h in the hemorrhagic stroke group and 22.998 ± 27.79 mm/h in the ischemic stroke group, with no significant between-group difference ($P = 0.063$). Overall, mean CRP and ESR levels did not differ significantly between the two stroke types (Table 3).

Hospital stay was longer in patients with hemorrhagic stroke, with a mean of 26.9 ± 5.50 days, than in those with ischemic stroke, who had a mean stay of 9.23 ± 3.14 days; this difference was statistically significant ($P < 0.05$). The frequency of anemia did not differ significantly between the two stroke types ($P > 0.05$). No significant difference was observed in the mean admission hematocrit level between patients who died and those who were discharged ($P > 0.05$). Mean ESR was higher in patients who died than in those who were discharged, but the difference was not statistically significant ($P > 0.05$). Mean CRP was also higher in patients who died, although this difference was not statistically significant ($P > 0.05$).

According to Table 4, mortality was 40.5% in patients with hemorrhagic stroke and 18.6% in those with ischemic stroke. Mortality was significantly higher in the hemorrhagic stroke group ($P = 0.001$).

Table 1. Demographic Characteristics of Patients by Stroke Type [a]

Variables	Hemorrhagic Stroke	Ischemic Stroke	Total
Number of patients	131 (18.2)	590 (81.8)	721 (100)
Sex			
Male	73 (55.7)	295 (50)	368 (51)
Female	58 (44.3)	295 (50)	353 (49)
Age (y)			
Mean ± SD	65.2 ± 16.1	71.1 ± 14.6	70 ± 15.1
Median	66	72	-
Minimum-maximum	25 - 104	19 - 98	19 - 104

[a] Values are expressed as No. (%) unless otherwise indicated. Abbreviation: SD, standard deviation.

Table 2. Comparison of Hematocrit and Hemoglobin Levels by Stroke Type [a]

Variables	Hemorrhagic Stroke, (n = 131)	Ischemic Stroke, (n = 590)	t	df	P Value
Hematocrit (Hct), %	42.51 ± 5.92	41.31 ± 5.64	2.183	719	0.029
Hemoglobin (Hb), g/dL	14.29 ± 2.18	13.71 ± 2.02	2.755	719	0.006

[a] Values are expressed as mean ± SD. Abbreviations: df, degrees of freedom; SD, standard deviation.

Table 3. Comparison of Mean C-Reactive Protein Levels and Erythrocyte Sedimentation Rates by Stroke Type [a]

Variables	Hemorrhagic Stroke	Ischemic Stroke	t	P Value
C-reactive protein, mg/L	34.33 ± 25.88 (n = 626)	34.33 ± 25.88 (n = 101)	0.455	0.649
Erythrocyte sedimentation rate, mm/h	22.084 ± 22.28 (n = 131)	22.998 ± 27.79 (n = 590)	1.947	0.063

[a] Values are expressed as mean ± SD (n). Abbreviation: SD, standard deviation.

According to Table 5, the mean hospital stay among patients who died was 21.6 ± 35.3 days in the hemorrhagic stroke group and 33.8 ± 40.4 days in the ischemic stroke group. Although the mean stay was longer in the ischemic stroke group, the difference was not statistically significant (P = 0.062).

According to Table 6, the mean hospital stay among discharged patients was 30.5 ± 58.6 days in the hemorrhagic stroke group and 9.9 ± 15.0 days in the ischemic stroke group. Discharged patients with hemorrhagic stroke had a significantly longer hospital stay (P = 0.001).

5. Discussion

This study examined the demographic characteristics, laboratory findings, and clinical outcomes of 721 patients with stroke admitted to Imam Khomeini Hospital, Urmia, to characterize epidemiological patterns and pathophysiological differences between ischemic and hemorrhagic stroke. Ischemic stroke was the predominant subtype, accounting for 81.8% of cases. This distribution is consistent with reports from the American Heart Association/American Stroke Association (AHA/ASA) and global epidemiological studies (13). A notable finding was the absence of a statistically significant difference in mean age between the two groups. This finding may suggest that recent changes in the prevalence of risk factors, such as hypertension, diabetes mellitus, and dyslipidemia, have altered traditional age patterns of stroke occurrence, making both subtypes important health concerns across age groups (14-16).

Hospital stay and mortality were among the main areas of analysis. Patients with ICH had a significantly longer hospital stay and a mortality rate of 40.5%, compared with 18.6% in the ischemic stroke group, indicating a substantially poorer prognosis. This difference may reflect the distinct mechanisms of injury in the two stroke subtypes. In ischemic stroke, impaired cerebral perfusion initiates a destructive cascade within the ischemic penumbra. Microglial activation, the release of

Table 4. Comparison of Mortality by Stroke Type [a]

Stroke type	Discharge	Death	Total	Chi-square	P Value
Hemorrhagic stroke	78 (59.5)	53 (40.5)	131 (100)	29.154	0.001
Ischemic stroke	480 (81.4)	110 (18.6)	590 (100)	29.154	0.001

[a] Values are expressed as No. (%).

Table 5. Comparison of Hospital Stay Among Deceased Patients by Stroke Type [a]

Patient group	Number	Mean (d)	SD (d)	t	P Value
Deceased patients with hemorrhagic stroke	53	21.6	35.3	1.880	0.062
Deceased patients with ischemic stroke	110	33.8	40.4	1.880	0.062

[a] Abbreviation: SD, standard deviation.

proinflammatory cytokines such as IL-1β and TNF-α, and the production of reactive oxygen species are time-dependent processes that, if not managed during the "golden hours," may lead to cellular necrosis and apoptosis (17-20).

In hemorrhagic stroke, blood extravasation into the brain parenchyma causes mechanical tissue destruction, mass effect, and increased intracranial pressure, potentially resulting in severe cerebral edema and herniation (21, 22). Blood degradation products, particularly hemoglobin and iron, exert direct cytotoxic effects and may exacerbate secondary brain injury by disrupting the blood-brain barrier and inducing an extensive inflammatory response (23, 24). The greater extent of tissue injury in ICH may explain the need for prolonged monitoring and more invasive interventions, which contribute to a longer hospital stay.

The inflammatory markers CRP and ESR were also examined. In contrast to previous studies identifying CRP as an independent predictor of mortality (25-30), we observed no significant differences in these markers between the two groups and no direct association with final patient outcome (death or discharge). Several factors may explain this difference from the literature. First, CRP is a nonspecific acute-phase protein influenced by chronic underlying diseases, concurrent infections, and nutritional status (31, 32). Second, the inflammatory response is dynamic and time-dependent; studies by Christensen and Boysen (27) and Winbeck et al. (28) emphasize that the predictive value of CRP peaks when measured within a specific time window after symptom onset, such as 12 to 24 hours. In this study, sampling may have occurred outside the inflammatory peak, reducing the diagnostic value of laboratory markers relative to clinical indicators such as the Glasgow Coma Scale and neuroimaging findings in the emergency setting (33, 34).

Hemoglobin and anemia were examined alongside inflammatory markers. Previous studies have reported an association between anemia and prolonged hospital stay (11, 12, 35), which has been attributed to reduced blood oxygen-carrying capacity and worsening tissue ischemia in the affected area (36). Studies such as that by Barlas and colleagues (37) suggest that optimizing hematologic status and hemoglobin levels in patients with stroke is not merely supportive but may also influence neurological function and reduce complications (38, 39). These findings in the literature highlight the importance of developing hematologic care protocols as part of a multidisciplinary approach to neurological care.

The findings highlight the need to complement treatment with preventive measures, risk-factor control, and systematic monitoring of patients with stroke. Consistent with large-scale studies such as Riksstroke in Sweden, our findings suggest that attention to modifiable risk factors, particularly hypertension, may reduce mortality and improve functional outcomes and quality of life after discharge (40). Given the more aggressive nature of hemorrhagic stroke, closer monitoring, timely therapeutic interventions, and public education about early symptom recognition and prompt referral to specialized centers are essential to improving outcomes. Time remains one of the most critical determinants in controlling the pathophysiological progression of stroke and altering patient prognosis (41-44).

5.1. Study Limitations

The retrospective, single-center design introduced several limitations, including potentially incomplete

Table 6. Comparison of Hospital Stay Among Discharged Patients by Stroke Type [a]

Patient group	Number	Mean (d)	SD (d)	t	P Value
Discharged patients with hemorrhagic stroke	78	30.5	58.6	6.533	0.001
Discharged patients with ischemic stroke	480	9.9	15	6.533	0.001

[a] Abbreviation: SD, standard deviation.

medical-record data, limited generalizability, and incomplete control of some confounding factors. Several important prognostic variables were not assessed, including stroke severity based on the GCS or National Institutes of Health Stroke Scale, lesion volume and location, cerebral edema, midline shift, and treatment type. Inflammatory markers were not measured serially. Nevertheless, the concurrent assessment of laboratory findings, hospital stay, and final outcome across the two main stroke subtypes, together with separate analyses of ischemic and hemorrhagic stroke, represents an important strength. Future studies should use prospective, multicenter designs with larger samples and concurrently evaluate clinical variables, neuroimaging findings, and serial inflammatory-marker measurements.

5.2. Conclusions

Ischemic stroke was more common than hemorrhagic stroke, but patients with hemorrhagic stroke had a poorer prognosis. Hospital stay among discharged patients was significantly longer in the hemorrhagic stroke group (P = 0.001), and mortality was also higher (40.5% vs 18.6%; P = 0.001). No significant differences in CRP or ESR were observed between the groups, and these markers were not significantly associated with death or discharge (P > 0.05). Attention to early diagnosis, close neurological monitoring, risk-factor control, and timely treatment, particularly in hemorrhagic stroke, may help reduce complications, hospital stay, and mortality.

Acknowledgements

We thank the staff of Imam Khomeini Hospital, Urmia, and all those who assisted with this research.

Footnotes

Artificial Intelligence (AI) Use Disclosure: The authors declare that no generative AI tools were used in the creation of this article.

Authors' Contribution: Initial Manuscript Drafting and Sample Collection: M. R.; Consultation, Manuscript Editing, and Study Supervision: B. C. A.; Methodology, Data Collection, Data Extraction, and Manuscript Editing: S. S.

Conflict of Interests Statement: The authors declare no conflicts of interest.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: IR.UMSU.HIMAM.REC.1403.070

Funding/Support: No funding was received for this study.

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