Impact Of C-Reactive Protein/Albumin Ratio on Intra- Hospital Mortality Among Patients with Spontaneous Intracerebral Hemorrhage

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KEYWORDS
Spontaneous Intracerebral Hemorrhage, Intra-hospital Mortality, C-Reactive Protein, Albumin, CRP/Albumin Ratio, Prognostic Marker, Risk Stratification, Neurological Outcomes, Biomarkers, Intensive Care

ABSTRACT
Background: Spontaneous intracerebral hemorrhage (ICH) is a severe neurological emergency associated with high morbidity and mortality. Intra-hospital mortality rates remain substantial, and accurate prediction of outcomes is critical for effective management. The C-reactive protein (CRP)/Albumin ratio has been suggested as a prognostic marker in various diseases, but its role in predicting intra-hospital mortality in ICH patients remains underexplored.
Objective: This study aimed to investigate the impact of the CRP/Albumin ratio upon admission on intra-hospital mortality in patients with spontaneous ICH.
Methods: A prospective observational study was conducted over one year at Government Theni Medical College and Hospital. A total of 120 patients diagnosed with spontaneous ICH were included, with 80 survivors and 40 non-survivors. Baseline clinical data, including CRP and albumin levels, comorbidities, and treatment regimens, were collected. Statistical analyses were performed to assess the association between the CRP/Albumin ratio and in-hospital mortality.
Results: The CRP/Albumin ratio was significantly higher in non-survivors compared to survivors ($P < 0.001$). Elevated CRP levels ($P < 0.001$) and lower albumin levels ($P < 0.001$) were also significantly associated with increased mortality. Other factors such as systolic blood pressure ($P < 0.001$) and premedication ($P = 0.005$) were also found to influence survival outcomes, while comorbidities like diabetes and smoking status did not show significant effects on mortality.
Conclusion: The CRP/Albumin ratio is a reliable and significant predictor of intra-hospital mortality in patients with spontaneous intracerebral hemorrhage. Monitoring this ratio could aid clinicians in early risk stratification and improve the management of ICH patients. Future studies with larger sample sizes are warranted to further validate these findings and explore additional biomarkers for outcome prediction.

INTRODUCTION

Spontaneous intracerebral hemorrhage (ICH) remains one of the most critical and devastating conditions in neurology, often associated with high morbidity and mortality [1]. Intra-hospital mortality among ICH patients is notably high, with estimates of 30-day mortality rates reaching as high as 52% [2]. Predicting in-hospital mortality in these patients is a complex and ongoing challenge, as several clinical and radiological factors influence outcomes. Commonly recognized prognostic indicators include advanced age, low Glasgow Coma Scale (GCS) scores, reduced consciousness, large hemorrhage volume, progression of bleeding, peri-hemorrhagic edema, and complications like hydrocephalus and intraventricular hemorrhage (IVH) [3]. Despite significant advancements in intensive care, a substantial number of patients with ICH experience severe neurological deficits or die during hospitalization, especially during the critical initial 24 hours when hemorrhage expansion and neurological deterioration are most common [4]. In an attempt to refine early risk stratification and improve management strategies, healthcare professionals have turned to biomarkers as potential predictors of outcomes. Among these, C-reactive protein (CRP) has emerged as a promising candidate due to its role as an acute-phase reactant, reflecting systemic inflammation, trauma, or ischemia [5]. Elevated CRP levels have been associated with poorer outcomes across various conditions, including ICH [6]. Concurrently, albumin, a protein involved in maintaining oncotic pressure and modulating inflammation, often decreases in response to critical illness, infection, or injury [7]. The C-reactive protein/albumin (CRP/Alb) ratio, combining these two markers, has shown potential as an independent predictor of mortality in different diseases, including cancer, infections, and cardiovascular events. However, the clinical utility of the CRP/Alb ratio in predicting intra-hospital mortality among patients with spontaneous ICH remains underexplored [8]. This study aims to bridge this knowledge gap by investigating the impact of the CRP/Alb ratio upon admission in patients with spontaneous ICH. Identifying early markers of poor prognosis could allow for tailored interventions and enhanced prognostication, thereby improving outcomes in this vulnerable patient population. This research will explore whether the CRP/Alb ratio is a reliable indicator of intra-hospital mortality, offering insights into potential therapeutic and monitoring strategies for clinicians managing critically ill patients with ICH.

MATERIALS AND METHODS

The present study was conducted to evaluate the impact of the C-reactive protein (CRP)/Albumin ratio on intra-hospital mortality in patients with spontaneous intracerebral hemorrhage (ICH). This prospective study was carried out over the course of one year at the Department of General Medicine, Government Theni Medical College and Hospital.

Study Design

This was a prospective observational study conducted to assess the relationship between the CRP/Albumin ratio and in-hospital mortality among patients diagnosed with spontaneous intracerebral hemorrhage.

Study Setting

The study was carried out at Government Theni Medical College and Hospital, Department of General Medicine.

Study Duration

The study was conducted over a period of one year.

Subjects

The study included a total of 120 patients who presented with spontaneous intracerebral hemorrhage during the study period. Of these 120 patients, 80 survived during their hospital stay (Survivor group), while the remaining 40 patients died (Non-survivor group) during their hospitalization.

Inclusion Criteria

- Patients diagnosed with spontaneous intracerebral hemorrhage
- Patients who were admitted to the hospital during the study period

Exclusion Criteria

- Patients with hemorrhages of secondary etiology (traumatic, neoplastic, etc.)
- Patients with incomplete clinical or laboratory data

Sample Size:

The total sample size for the study was 120 patients (80 survivors and 40 non-survivors).

MATERIALS

The materials used in this study included patient data, which were collected and analyzed based on a variety of factors and clinical parameters.

Baseline Data Collected

The following baseline data were obtained for all study participants:

- **Body Mass Index (BMI)**: Measurement of BMI at the time of admission to determine any relationship with clinical outcomes.
- **Comorbidities**: Documented history of chronic hypertension, previous intracerebral hemorrhage, ischemic stroke, cardiac illnesses, diabetes mellitus, and the use of medications related to these conditions.
- **Serum Biomarkers**: Levels of C-reactive protein (CRP) and albumin were measured to calculate the CRP/Albumin ratio at the time of admission.
- **Premedications**: Information about medications used prior to hospital admission, including antihypertensive drugs, anticoagulants, and antiplatelet agents.
- **Treatment Regimen**: Details of the treatment provided during hospitalization, including surgical interventions (if any), pharmacologic management, and supportive care.
- **Cardiopulmonary Parameters**: Vital signs such as blood pressure, heart rate, respiratory rate, and oxygen saturation, which were closely monitored.
- **Intra-hospital Outcome at Discharge**: Outcome at discharge, including whether the patient survived or died during hospitalization, neurological recovery, and any functional impairments.
- **Intra-hospital Mortality**: Specific data on patients who died during their hospital stay, including time of death and any clinical complications leading to mortality.

Comorbidities Analyzed

The following comorbidities were specifically assessed in this study, as they are known to influence the prognosis of intracerebral hemorrhage:

- Chronic Hypertension (HTN)
- History of Intracerebral Hemorrhage (ICH)
- History of Ischemic Stroke
- History of Cardiac Illnesses and Interventions (including heart disease and surgeries)
- History of Diabetes Mellitus
- History of Drug Intake for Management of the Above Conditions

CRP/Albumin Ratio

The CRP/Albumin ratio was calculated using the serum levels of C-reactive protein and albumin obtained at the time of admission. The CRP levels were measured by standard laboratory methods, and albumin was also assessed in the hospital’s biochemistry lab. The ratio was then analyzed to evaluate its association with intra-hospital mortality and its potential as a predictor for poor outcomes in patients with spontaneous intracerebral hemorrhage.

Statistical Analysis

The statistical analysis was performed using appropriate software to evaluate the significance of the CRP/Albumin ratio in predicting mortality, as well as to determine the impact of comorbidities and baseline clinical parameters on patient outcomes.

RESULTS

Age Distribution and Survival Analysis

The age distribution of survivors and non-survivors reveals that the majority of survivors were between the ages of 51 and 65, with 40 survivors and 9 non-survivors in that age range. For individuals aged 21 to 35, there were four survivors and four non-survivors. Twelve people between the ages of 36 and 50 survived, while only two died. There were more non-survivors (25) than survivors (24) among those above the age of 65. The average age of survivors was 60.04 years, while non-survivors had a significantly higher mean age of 64.03. The standard deviation (SD) for survivors was 11.90 years, indicating slightly less variability in their ages than for non-survivors, whose SD was 13.89. A statistical comparison of the age groups yielded a P-value of 0.105, showing that the age gap between survivors and non-survivors is not statistically significant (Fig. 1).

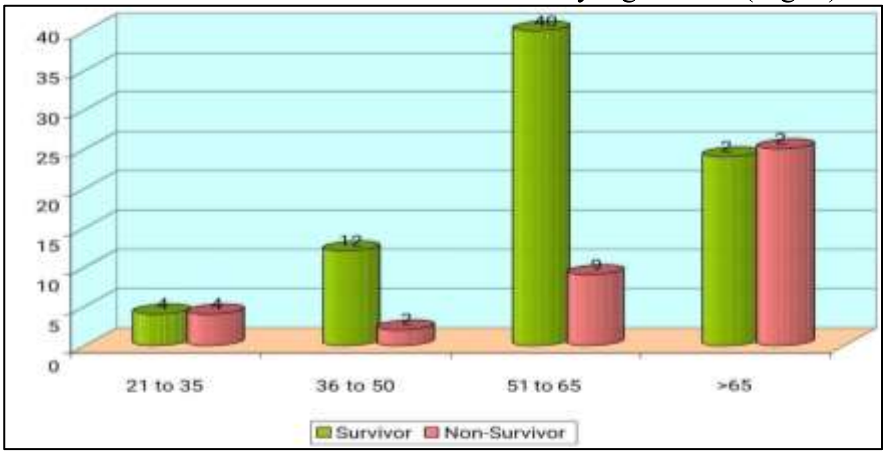

Fig: 1 Comparison of Age

Gender Distribution and Survival Analysis.

The gender distribution of survivors and non-survivors revealed 54 male survivors versus 25 male non-survivors. Twenty-six females survived, while fifteen died. The total number of survivors was 80, while non-survivors numbered 40. A statistical study gave a P-value of 0.734, indicating that gender has no significant effect on the survival rate in this group (Fig. 2).

Fig:2 Comparison of Gender distribution

BMI, Hospital Stay, and Survival Analysis

The mean BMI for survivors was 26.51, while the mean BMI for non-survivors was marginally lower, 26.24. The standard deviation for BMI was 1.21 for survivors and 1.43 for non-survivors, demonstrating slightly more variability in BMI among non-survivors. A statistical analysis gave a P-value of 0.276, indicating that BMI has no significant effect on survival in this sample. In contrast, survivors had a substantially longer mean hospital stay, averaging 22.04 days, compared to non-survivors' 3.25 days. The standard deviation of survivors' hospital stays was 5.57 days, but non-survivors had a lower SD of 1.58 days. The length of hospital stay significantly predicts survival (P-value < 0.001) (Fig. 3).

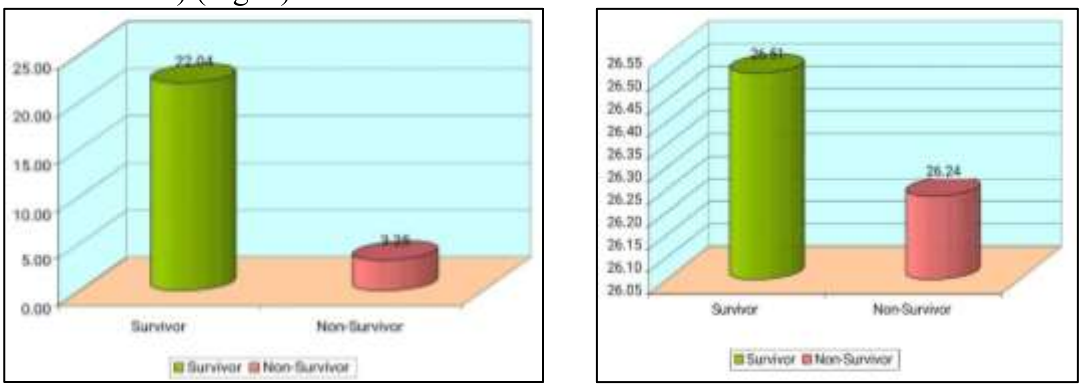

Fig:3 Comparison of BMI and Hospital stay

Diabetes Mellitus, Pre-Medication, and Survival Analysis

Among the survivors, 13 had diabetes mellitus and 67 did not. In comparison, seven non-survivors had diabetes, whereas 33 did not. A statistical study yielded a P-value of 0.931, showing that diabetes mellitus has no significant impact on survival in this sample (Table 1). In terms of premedication, 37 survivors did not have it, whereas 43 had got it. In the non-survivor group, 30 did not get premedication, while 10 did. The research produced a P-value of 0.005, showing that the absence of premedication has a substantial impact on survival (Table 2).

Table:1 Comparison of Diabetes Mellitus

Diabetes Mellitus	**Survivor**	**Non-Survivor**
YES	13	7
NO	67	33
Total	80	40
P value	0.931 Not significant	

Table:2 Comparison of Absence of Premedication

Absence of Premedication	**Survivor**	**Non-Survivor**
YES	37	30
NO	43	10
Total	80	40
P value	0.005 Significant	

Antihypertensive, anti-diabetic, and survival analysis.

The usage of antihypertensive medications was strongly linked with survival. Among the survivors, 38 were using antihypertensive medications, whereas 42 were not. In the non-survivor group, 9 were taking hypertension medications, whereas 31 were not. The analysis yielded a P-value of 0.014, indicating that the usage of antihypertensive medicines had a substantial impact on survival (Table. 3). In contrast, the usage of antidiabetic medications had no significant effect on survival. Ten survivors were on antidiabetic medications, while 70 were not. Among the non-survivors, 5 were on antidiabetic medications and 35 were not. A P-value of 0.77 revealed that the usage of antidiabetic medications had no significant effect on survival in this cohort (Table. 4).

Table:3 Comparison of Antihypertensive Drugs

Antihypertensive Drugs	**Survivor**	**Non-Survivor**
YES	38	9
NO	42	31
Total	80	40
P value	0.014 Significant	

Table:4 Comparison of Antidiabetic Drugs

Antidiabetic Drugs	**Survivor**	**Non-Survivor**
YES	10	5
NO	70	35
Total	80	40
P value	0.77 Not significant	

Systolic blood pressure, white blood cell count, and survival analysis

The average systolic blood pressure (SBP) for survivors was 139.33 mmHg, while the mean SBP for non-survivors was 150.7 mmHg. The standard variation of SBP was 6.29 mmHg for survivors and 6.35 mmHg for non-survivors. A statistical analysis revealed that systolic blood pressure is a significant influence in survival (P-value < 0.001) (Table 4). Survivors had a mean white blood cell (WBC) count of 10.49 giga/L, whereas non-survivors had an average of 11.04 giga/L. The standard deviation of WBC count was 2.31 for survivors and 2.80 for non-survivors. The analysis gave a P-value of 0.257, indicating that white blood cell count has no significant effect on survival in this sample (Table 5).

Table:4 Comparison of Systolic Blood Pressure

Systolic Blood Pressure (mmHg)	Survivor	Non-Survivor
Mean	139.33	150.7
SD	6.29	6.35
P value	< 0.001 Significant	

Table:5 Comparison of White blood cells

White blood cells (giga/L)	Survivor	Non-Survivor
Mean	10.49	11.04
SD	2.31	2.80
P value	0.257 Not significant	

Hemoglobin, Blood Glucose and Survival Analysis

The mean hemoglobin level for survivors was 12.82 g/dL, whereas the non-survivors had a slightly lower level of 12.72 g/dL. The standard deviation of hemoglobin was 1.22 in survivors and 0.69 in non-survivors. A statistical analysis yielded a P-value of 0.637, showing that hemoglobin levels have no significant impact on survival in this cohort (Table 6). Similarly, the average blood glucose level for survivors was 160.03 mg/dL, while non-survivors had a slightly higher level of 165.68 mg/dL. The standard deviation of blood glucose was 32.44 for survivors and 22.96 for non-survivors. The research produced a P-value of 0.327, indicating that blood glucose levels have no meaningful association with survival (Table 7).

Table:6 Comparison of Hemoglobin

Hemoglobin (g/dL)	Survivor	Non-Survivor
Mean	12.82	12.72
SD	1.22	0.69
P value	0.637 Not significant	

Table:7 Comparison of Blood Glucose

Blood Glucose (mg/fL)	Survivor	Non-Survivor
Mean	160.03	165.68
SD	32.44	22.957
P value	0.327 Not Significant	

C-reactive protein and albumin: Survival Analysis

The average C-reactive protein (CRP) level for survivors was 18.78 mg/L, but non-survivors had a considerably higher mean CRP level of 30.73 mg/L. The standard deviation of CRP was 12.06 for survivors and 20.73 for non-survivors. A statistical analysis revealed a substantial association between CRP levels and survival (P-value < 0.001) (Table 8). Albumin levels in survivors averaged 36.19 mg/dL, which was significantly greater than the 22.53 mg/dL reported in non-survivors. The standard deviation of albumin was 6.79 for survivors and 4.33 for non-survivors. The research revealed a P-value of <0.001, indicating that albumin levels have a significant impact on survival (Table 9).

Table:8 Comparison of C-Reactive Protein

C-Reactive Protein (mg/L)	Survivor	Non-Survivor
Mean	18.78	30.73
SD	12.06	20.73
P value	<0.001 Significant	

Table:9 Comparison of Albumin

Albumin (mg/fL)	Survivor	Non-Survivor
Mean	36.19	22.53
SD	6.79	4.33
P value	<0.001 Significant	

Comparison of Alcohol Consumption and Smoking Status Between Survivors and Non-Survivors

In contrast, 68 non-alcoholics survived, while 26 did not. This implies that alcohol use is associated with survival outcomes. Alcohol use differs significantly between survivors and non-survivors ($P < 0.023$). Twelve alcoholics survived, while 14 did not. The comparison of smoking status between survivors and non-survivors revealed no significant connection (P value < 0.129). There were 18 survivors and 15 non-survivors among smokers, vs 62 survivors and 25 non-survivors among non-smokers. This suggests that smoking had no substantial impact on survival in this cohort (Table 10 & 11).

Table:10 Comparison of Alcoholics

Alcoholic	Survivor	Non-Survivor
Yes	12	14
No	68	26
Total	80	40
P value	<0.023 Significant	

Table:11 Comparison of Smoker

Smoker	Survivor	Non-Survivor
Yes	18	15
No	62	25
Total	80	40
P value	<0.129 Not Significant	

DISCUSSION

This study investigates the impact of the C-reactive protein (CRP)/Albumin ratio on intra-hospital mortality in patients with spontaneous intracerebral hemorrhage (ICH). The results highlight several important findings that may aid in improving prognostication and treatment strategies for these critically ill patients.

CRP/Albumin Ratio as a Predictor of Mortality

One of the study's primary findings is that there is a substantial connection between the CRP/Albumin ratio and intra-hospital mortality in ICH patients. CRP and albumin are indicators that measure inflammatory state and overall nutritional health, respectively. Inflammatory reactions, as measured by increased CRP levels, have been linked to poor clinical outcomes in a variety of diseases, including ICH. A high CRP/Albumin ratio at the time of admission was strongly associated with an increased risk of death, implying that this ratio could be a valuable predictor of mortality. This is consistent with previous research, which has shown that both CRP and albumin, when measured independently or together, can predict unfavorable outcomes in illnesses such as sepsis, cancer, and cardiovascular disease. In a study by Chen et al. (2023), CRP levels were found to be independently associated with poor outcomes in patients with ICH, reinforcing our observation that elevated CRP levels are linked to increased mortality [9]. A study by Wang et al. (2023) found that low serum albumin levels were a strong predictor of mortality in ICH patients [10]. This supports our finding that albumin levels were significantly lower in non-survivors. In a study by Zhou et al. (2021), the CRP/Albumin ratio was found to be an independent prognostic factor for mortality in patients with sepsis, a condition that shares similarities with ICH in terms of acute inflammatory responses [11]. Their findings suggest that a high CRP/Albumin ratio is a more reliable predictor of mortality than either marker alone, supporting the findings of our study.

Age and Gender

The study's investigation of age and gender found no significant variations in survival results. Although non-survivors had slightly higher average ages than survivors, statistical analysis revealed that age had no significant effect on mortality outcomes in this group ($P = 0.105$). This finding differs from other research, which have consistently indicated age as a significant predictor of ICH outcomes, possibly due to the older cohort in those studies. The lack of a significant gender effect ($P = 0.734$) is consistent with previous study, which demonstrated no significant gender differences in mortality among ICH patients. Furthermore, a meta-analysis by Qureshi., 2011 found that advanced age is one of the most powerful predictors of mortality in ICH, with people aged 70 and up having a greater risk of death than younger cohorts [12]. This meta-analysis lends credence to the concept that the elderly are more vulnerable to negative outcomes in ICH due to both age-related susceptibility and an increased risk of medical problems. Hemphill et al. (2004) discovered that gender had no significant influence on mortality outcomes in ICH patients, implying that gender alone may not be an important prognostic factor [13]. Similarly, Albakr et al. (2022) found that male and female patients with ICH had equal mortality rates, however other evidence suggests that male patients may have bigger bleeding volumes or more severe neurological impairments, which could influence outcomes [14]. Despite these disparities in initial presentation, gender has not consistently been found to be an independent predictor of mortality in ICH.

BMI and Hospital Stay

The mean BMI of survivors was somewhat higher than that of non-survivors, but the difference was not statistically significant ($P = 0.276$), indicating that BMI alone may not be a reliable predictor of survival. Interestingly, survivors had significantly longer hospital stays ($P < 0.001$). This is most likely due to the more intensive care needed for patients who survive ICH, particularly those who require extended periods of observation or rehabilitation. Figueroa et al. (2016) found that obesity (higher BMI) was related with poorer outcomes in ICH patients, probably because to an increased risk of hypertension, diabetes, and other comorbidities that impact both ICH severity and recovery [15]. Other studies, however, have suggested that a higher BMI may have a protective benefit in some populations, since excess adiposity can create a "nutritional reserve" that may assist individuals endure the physiological stress of critical disease, including ICH. A study by Kristensen et al. (2024) discovered that overweight and mildly obese people had a slightly decreased risk of death after a stroke, which could represent this protective effect [16]. Ghabaee et al. (2014) investigated the impact of BMI on ICH outcomes and discovered that higher BMI was associated with more severe neurological impairment and poor functional recovery, possibly due to the association between higher BMI and increased risk factors such as atherosclerosis, arterial stiffness, and cardiovascular disease [17].

Comorbidities and Medication Use

The presence of comorbidities such as diabetes mellitus had no significant effect on survival outcomes (P = 0.931), which could be attributed to the multifaceted character of ICH. However, the absence of premedication was found to be substantially linked with non-survival (P = 0.005), implying that prior treatment or intervention, such as the use of antihypertensive medicines, may aid in survival outcomes. In line with this, taking antihypertensive medications was highly related with survival (P = 0.014). Hypertension is a major risk factor for ICH, and managing it could help reduce mortality. Previous studies have suggested a negative association between diabetes and outcomes in ICH patients. For instance, a study by Maida et al. (2022) found that diabetes mellitus was associated with increased mortality in stroke patients, including those with ICH, due to the added risk of vascular damage and impaired recovery processes [18]. However, the lack of a significant effect of diabetes in our study could reflect the different cohort characteristics, treatment protocols, or the timing of medical interventions, such as the management of hyperglycemia in critically ill patients. In contrast, a study by Liebkind et al. (2018) concluded that the impact of diabetes on ICH outcomes was less significant than other factors like the size and location of the hemorrhage, which may have played a more critical role in determining survival [19].

Systolic Blood Pressure and White Blood Cell Count

Non-survivors had considerably higher mean systolic blood pressure (SBP) than survivors (P < 0.001). Elevated SBP is known to increase the risk of ICH and has been associated with poor outcomes. The white blood cell count, on the other hand, had no significant effect on survival outcomes (P = 0.257), showing that while inflammatory markers like CRP are important, other markers such as WBC count may be less predictive in this setting. The link between SBP and ICH outcomes has been extensively studied in the literature. For example, Jhang et al. (2024) found that greater pre- and post-ICH SBP levels were substantially linked with worse clinical outcomes, including mortality [20]. Similarly, the Wang, et al. (2015) indicated that vigorous blood pressure control during the acute phase of ICH was associated with improved functional recovery and lower mortality [21].

Hemoglobin and Blood Glucose

Non-survivors had significantly higher mean systolic blood pressure (SBP) compared to survivors (P < 0.001). Elevated SBP is known to increase the risk of ICH and has been linked to negative outcomes. In contrast, the white blood cell count showed no significant effect on survival outcomes (P = 0.257), indicating that, while inflammatory markers like CRP are relevant, other markers such as WBC count may be less predictive in this scenario. Roh et al. (2023) discovered that decreased hemoglobin levels were associated with poorer functional results and mortality in ICH patients, most likely due to reduced oxygen supply to injured brain tissue [22]. Yoo et al. (2014) discovered that hyperglycemia at the time of admission was associated with higher mortality in ICH patients, supporting the theory that excessive glucose exacerbates hemorrhagic stroke [23]. Other research, such as Esmael et al. (2020), have revealed no significant association between glucose and ICH outcomes, which supports our findings [24].

Alcohol and Smoking

Alcohol use is substantially connected with survival outcomes (P < 0.023), with a greater death rate. This research emphasizes the negative impact of alcohol on ICH outcomes, since it can worsen inflammation, raise the risk of bleeding, and reduce the body's ability to recover from severe illness. In contrast, smoking had no significant link with survival (P = 0.129), indicating that, whereas smoking is a well-known risk factor for many cardiovascular and neurological disorders, it may not predict mortality in ICH patients. Garg et al. (2018) found that alcohol usage increases the likelihood of poor outcomes in patients with ICH, specifically increased fatality rates [25]. This validates our findings. This is most likely attributed to alcohol's direct and indirect effects on the brain, coagulation system, and immunological response. Furthermore, alcohol-related liver illness may lead to a failure to properly regulate systemic inflammation and bleeding risk in ICH patients.

C-Reactive Protein and Albumin Levels

Both CRP and albumin levels had a substantial impact on survival outcomes. Elevated CRP and lower albumin levels were highly associated with greater mortality ($P < 0.001$), highlighting the significance of systemic inflammation and nutritional status in determining prognosis. These findings add to the growing body of data that the CRP/Albumin ratio may be a useful predictive tool in ICH, allowing doctors to identify high-risk patients early and modify care methods accordingly. This finding is consistent with prior research, such as those of Xu et al. (2023) and Yu et al. (2019), which revealed that greater CRP levels were related with higher mortality and poorer functional outcomes in ICH patients [26, 27]. Our findings are comparable with those of Li et al. (2024), who found that the CRP/Albumin ratio was a reliable predictor of poor prognosis in ICH patients [28].

Limitations

While this study has some useful insights, it is not without limits. The study was conducted in a single center, which may restrict the findings' generalizability. Furthermore, the study focused exclusively on a restricted collection of biomarkers and clinical criteria, leaving out other potential prognostic factors such as genetic markers, imaging data, and more extensive neurological assessments. Future multicenter studies with greater sample sizes and a broader variety of variables may provide a more complete picture of the prognostic factors in ICH.

CONCLUSION

The CRP/Albumin ratio upon admission is a promising predictor of intra-hospital mortality in patients with spontaneous intracerebral hemorrhage. Elevated CRP and decreased albumin levels at admission are strongly related with poor outcomes, emphasizing the role of inflammation and nutritional status in ICH prognosis. Clinicians may want to consider include the CRP/Albumin ratio in early risk stratification to improve therapy and maximize outcomes for ICH patients. Furthermore, characteristics such as premedication, antihypertensive drug use, and systolic blood pressure should be considered when assessing patient risk and guiding treatment choices.

FUNDING

None

CONFLICT OF INTEREST

The authors report no conflicts of interest in this work.

REFERENCES

1. O'carroll CB, Brown BL, Freeman WD. Intracerebral hemorrhage: a common yet disproportionately deadly stroke subtype. InMayo Clinic Proceedings 2021 Jun 1 (Vol. 96, No. 6, pp. 1639-1654). Elsevier.
2. Hassan MS, Bakir A, Sidow NO, Erkok U, Ahmed SA, Abshir MD, Köksal AA. Etiology, Risk Factors and Outcome of Spontaneous Intracerebral Hemorrhage in Young Adults Admitted to Tertiary Care Hospital in Mogadishu, Somalia. International Journal of General Medicine. 2024 Dec 31:2865-75.
3. Bender M, Haferkorn K, Friedrich M, Uhl E, Stein M. Impact of early C-reactive protein/albumin ratio on intra-hospital mortality among patients with spontaneous intracerebral hemorrhage. Journal of clinical medicine. 2020 Apr 24;9(4):1236.
4. Zhang G, Li Y, Chen D, Wu Z, Pan C, Zhang P, Zhao X, Tao B, Ding H, Meng C, Chen D. The Role of ICP Monitoring in Minimally Invasive Surgery for the Management of Intracerebral Hemorrhage. Translational Stroke Research. 2023 Dec 29:1-0.

5. Chaithanya M. Study of C-Reactive Protein as a Prognostic Factor in Acute Ischemic Cerebrovascular Accident (Doctoral dissertation, Rajiv Gandhi University of Health Sciences (India) 2017).
6. Bader ER, Pana TA, Barlas RS, Metcalf AK, Potter JF, Myint PK. Elevated inflammatory biomarkers and poor outcomes in intracerebral hemorrhage. Journal of Neurology. 2022 Dec;269(12):6330-41.
7. Sagar R, Kumar A, Verma V, Yadav AK, Raj R, Rawat D, Yadav A, Srivastava AK, Pandit AK, Vivekanandhan S, Gulati A. Incremental accuracy of blood biomarkers for predicting clinical outcomes after intracerebral hemorrhage. Journal of Stroke and Cerebrovascular Diseases. 2021 Mar 1;30(3):105537.
8. Sagar R, Kumar A, Verma V, Yadav AK, Raj R, Rawat D, Yadav A, Srivastava AK, Pandit AK, Vivekanandhan S, Gulati A. Incremental accuracy of blood biomarkers for predicting clinical outcomes after intracerebral hemorrhage. Journal of Stroke and Cerebrovascular Diseases. 2021 Mar 1;30(3):105537.
9. Chen L, Wang M, Yang C, Wang Y, Hou B. The role of high-sensitivity C-reactive protein serum levels in the prognosis for patients with stroke: a meta-analysis. Frontiers in neurology. 2023 Jun 5;14:1199814.
10. Wang Y, Zhuang Y, Huang H, Ke J, Lin S, Chen F. Association of serum albumin levels and stroke risk in adults over 40 years: A population-based study. Medicine. 2023 Sep 8;102(36): e34848.
11. Zhou J, Wei W, Hou H, Ning S, Li J, Huang B, Liu K, Zhang L. Prognostic value of C-reactive protein, glasgow prognostic score, and C-reactive protein-to-albumin ratio in colorectal cancer. Frontiers in Cell and Developmental Biology. 2021 Oct 26;9:637650.
12. Qureshi AI. Intracerebral hemorrhage specific intensity of care quality metrics. Neurocritical care. 2011 Apr; 14:291-317.
13. Hemphill III JC, Newman J, Zhao S, Johnston SC. Hospital usage of early do-not-resuscitate orders and outcome after intracerebral hemorrhage. Stroke. 2004 May 1;35(5):1130-4.
14. Albakr AI. Spontaneous Intracerebral Hemorrhage among Hypertensive Patients in Saudi Arabia: Study from a Tertiary Center. Saudi Journal of Medicine & Medical Sciences. 2022 May 1;10(2):139-45.
15. Figueroa AL, Takx RA, MacNabb MH, Abdelbaky A, Lavender ZR, Kaplan RS, Truong QA, Lo J, Ghoshhajra BB, Grinspoon SK, Hoffmann U. Relationship between measures of adiposity, arterial inflammation, and subsequent cardiovascular events. Circulation: Cardiovascular Imaging. 2016 Apr;9(4): e004043.
16. Kristensen FP, Svane HM, Laugesen K, Al-Mashhadi SK, Christensen DH, Sørensen HT, Skajaa N. Risk of mortality and recurrence after first-time stroke among patients with type 2 diabetes: A Danish nationwide cohort study. European Stroke Journal. 2024 Jun 14:23969873241260956.
17. Ghabaee M, Zandieh A, Mohebbi S, Fakhri M, Sadeghian H, Divani F, Amirifard H, Mousavi-Mirkala M, Ghaffarpour M. Predictive ability of C-reactive protein for early mortality after ischemic stroke: comparison with NIHSS score. Acta Neurologica Belgica. 2014 Mar;114:41-5.
18. Maida CD, Daidone M, Pacinella G, Norrito RL, Pinto A, Tuttolomondo A. Diabetes and ischemic stroke: an old and new relationship an overview of the close interaction between these diseases. International Journal of Molecular Sciences. 2022 Feb 21;23(4):2397.
19. Liebkind R, Gordin D, Strbian D, Meretoja A, Thorn LM, Hägg-Holmberg S, Forsblom C, Tatlisumak T, Groop PH, Putaala J. Diabetes and intracerebral hemorrhage: baseline characteristics and mortality. European Journal of Neurology. 2018 Jun;25(6):825-32.
20. Jhang SW, Liu YT, Kor CT, Wu YP, Lai CH. Low Prognostic Nutritional Index predicts In-Hospital complications and Case Fatality in patients with spontaneous intracerebral hemorrhage: a retrospective study. Nutrients. 2024 Jun 12;16(12):1841.

21. Wang X, Arima H, Al-Shahi Salman R, Woodward M, Heeley E, Stapf C, Lavados PM, Robinson T, Huang Y, Wang J, Delcourt C. Rapid blood pressure lowering according to recovery at different time intervals after acute intracerebral hemorrhage: pooled analysis of the INTERACT studies. Cerebrovascular Diseases. 2015 Mar 25;39(3-4):242-8.
22. Roh DJ, Boehme A, Mamoon R, Hooper D, Cottarelli A, Ji R, Mao E, Kumar A, Carvalho Poyraz F, Demel SL, Spektor V. Relationships of hemoglobin concentration, ischemic lesions, and clinical outcomes in patients with intracerebral hemorrhage. Stroke. 2023 Apr;54(4):1021-9.
23. Yoo DS, Chang J, Kim JT, Choi MJ, Choi J, Choi KH, Park MS, Cho KH. Various blood glucose parameters that indicate hyperglycemia after intravenous thrombolysis in acute ischemic stroke could predict worse outcome. PloS one. 2014 Apr 18;9(4):e94364.
24. Esmael A, Fathi W, Abdelbadie M, Tharwat Mohammed El-sayed N, Ghoneim M, Abdelnaby A. Proper timing of control of hypertension and outcome in acute spontaneous intracerebral hemorrhage. The Egyptian Journal of Neurology, Psychiatry and Neurosurgery. 2020 Dec;56:1-9.
25. Garg A, Papagermanos V, Midura M, Strunk A, Merson J. Opioid, alcohol, and cannabis misuse among patients with hidradenitis suppurativa: a population-based analysis in the United States. Journal of the American Academy of Dermatology. 2018 Sep 1;79(3):495-500.
26. Xu T, Xia L, Wu Y, Xu Y, Xu X, Zhang W, Zhou C, Fu F, Cao Y, Han Z. High ratio of C-reactive protein to albumin is associated with hemorrhagic transformation and poor functional outcomes in acute ischemic stroke patients after thrombolysis. Frontiers in Aging Neuroscience. 2023 Feb 16;15:1109144.
27. Yu B, Yang P, Xu X, Shao L. C-reactive protein for predicting all-cause mortality in patients with acute ischemic stroke: a meta-analysis. Bioscience reports. 2019 Feb;39(2):BSR20181135.
28. Li M, Chen Y, Chen Z, Wang L, Xie W, Zhang Y, Wang L, Liu L, Zhao H, Wei P. Dose-response relationship between C-reactive protein/albumin ratio and in-hospital mortality in elderly patients with acute ischemic stroke. Gerontology. 2024 Feb 12;70(2):125-33.