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ACUTE HEMORRHAGIC STROKE PROGNOSTIC MARKERS BASED ON SERUM FERRITIN LEVELS: A COMPREHENSIVE CROSS-SECTIONAL STUDY

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ABSTRACT –

Background: Accurate prognostic markers are essential for the efficient management of acute haemorrhagic stroke, a serious cerebrovascular event. In order to establish serum ferritin as a prognostic biomarker, this study investigates the connection between acute haemorrhagic stroke patients' admission serum ferritin levels and outcomes.

Materials and Methodology: A cross-sectional study with 72 patients who had an acute haemorrhagic stroke was carried out, and clinical characteristics, neuroimaging results, and serum ferritin levels were examined. The Modified Rankin Scale (mRS) and Glasgow Coma Scale (GCS) scores were used to assess functional outcomes. Studies using correlation and regression statistics were conducted.

Results: When compared to patients who had positive outcomes (150.6 ng/ml), patients with negative outcomes had considerably higher blood ferritin levels (337.8 ng/ml). Elevated ferritin had a positive (r=0.756) and a negative (r=-0.709) correlation with mRS and GCS scores, respectively. Serum ferritin was found by regression analysis to be an independent predictor of decline or death (OR=1.024, $p < 0.0001$).

Conclusion: Severe outcomes in acute haemorrhagic stroke are correlated with elevated serum ferritin levels at admission. A potential independent predictive factor that could help with clinical decisions is serum ferritin. Interventions that aim to raise ferritin levels can potentially enhance patient outcomes, according to future research.

Keywords: Modified Rankin Scale, Glasgow Coma Scale, Prognostic marker, acute hemorrhagic stroke, serum ferritin.

INTRODUCTION –

A stroke, sometimes referred to as a cerebrovascular accident, is a rapid onset neurological condition that can have either an ischemic or a haemorrhagic cause. A subtype of strokes

known as haemorrhagic strokes result from a blood vessel rupture that results in bleeding into the brain. These are further divided into subarachnoid haemorrhages (SAH) and intracerebral haemorrhages (ICH), with ICH being the more prevalent form. Haemorrhagic strokes are notably severe, often resulting in high mortality rates and significant morbidity ***(Chen et al., 2014).*** Early and accurate diagnosis and treatment are imperative as the haemorrhage's rapid expansion can lead to sudden declines in consciousness and neurological functions.

Annually, haemorrhagic strokes account for 10% to 20% of all stroke cases, with varying prevalence across different countries and populations. In Australia, the United Kingdom, and the United States 8-15% of strokes are haemorrhagic, while in Japan and Korea, the percentage rises to 18-24%. People of Asian descent and residents of low- and middle-income nations are more likely to get these strokes. Incidence rates also escalate with age and are more prevalent among men. Studies from Japan have shown that controlling hypertension can reduce the incidence of intracerebral haemorrhages. Although the case fatality rates have increased from 25% to 30% in high-income countries to 30% to 48% in low- to middle-income countries, they remain disturbingly high. ***(Chen et al., 2014, An et al., 2017, Ojaghihaghighi et al., 2017)***

Several risk factors contribute to the occurrence of haemorrhagic strokes, including both modifiable factors such as hypertension, smoking, excessive alcohol consumption, and specific medications like anticoagulants and sympathomimetics. Age, male gender, a history of prior cerebrovascular accidents (CVA), and Asian ethnicity are additional non-modifiable risk factors ***(Ariesen et al., 2003, Sturgeon et al., 2007)***

The diagnosis and prognosis of haemorrhagic strokes depend significantly on clinical assessments and radiological imaging, particularly through computed tomography (CT) scans of the brain. Radiological and Clinical indicators such as blood pressure indices and the Glasgow Coma Scale (GCS) demonstrate equal loss of consciousness regardless of the size, location, and extent of the haemorrhage, are instrumental as early prognostic factors ***(Rådberg et al., 1991).*** Long-term outcomes and the degree of functional disability are systematically assessed using the modified Rankin scale (mRS), a widely validated stroke scoring system. Poor prognostic factors encompass coma, large hematoma volumes (exceeding 30 ml), intraventricular haemorrhage, haemorrhages in the posterior fossa, age surpassing 80 years, hyperglycaemia, and chronic kidney disease ***(van Swieten et al., 1988).***

The versatility of molecular biomarkers' uses in stroke diagnosis has caused the focus of stroke research to shift in recent years, characterizing their severity, estimating long-term prognosis, and selecting suitable treatments (An et al., 2017). Unlike typical neuroimaging biomarkers, which are concentrated on localizing brain injuries, molecular biomarkers offer insights into the systemic physiological mechanisms underlying brain recovery ***(Maas & Furie, 2009).*** Researchers have explored a range of molecular biomarkers, including serum ferritin levels, as potential indicators for predicting stroke outcomes ***(Zheng et al., 2018).*** Studies have demonstrated significant associations between elevated serum ferritin levels and adverse outcomes in various cardiovascular conditions, acute myocardial infarction, ischemic strokes, and intracerebral haemorrhages.

As examples, studies by Salonen et al. and van der A et al. showed that elevated serum ferritin levels were associated with increased risks of acute myocardial infarctions in Finnish males and ischemic strokes in Dutch postmenopausal women, respectively ***(Salonen et al.,***

1992; van der et al., 2005). Additionally, Dávalos et al.'s study supported serum ferritin's subpar predictive role in ischemic strokes. High blood ferritin levels at admission are independently correlated with poor outcomes, according to research on Spanish patients with intracerebral haemorrhages ***(Dávalos et al., 1994).*** The predictive usefulness of serum ferritin levels, along with other molecular indicators, for motor functional recovery following haemorrhagic strokes was highlighted by a comprehensive study by ***Alex Matos Ribeiro et al. in 2021.***

Furthermore, a study by Rajendran et al. delved into the correlation between serum ferritin levels, GCS scores, and ICH volume with 7th and 30th-day mRS scores. Due to the association between elevated serum ferritin levels at admission and poor short- and long-term outcomes in acute haemorrhagic strokes, the results of this study revealed that serum ferritin may be a useful predictive biomarker. ***(Rajendran et al., 2019).***

Despite the mounting evidence supporting serum ferritin's role as a prognostic biomarker in stroke cases, particularly haemorrhagic strokes, there remains a significant research gap, especially in India ***(Pérez de la Ossa et al., 2010).*** By studying the connection between serum ferritin levels at admission and functional outcomes in patients with acute haemorrhagic strokes, this study was launched to close this gap. The purpose of the study is to investigate the relationship between serum ferritin levels and the outcomes of acute haemorrhagic stroke patients by thoroughly examining their clinical profiles and presentations.

Haemorrhagic strokes pose substantial global health risks, leading to severe morbidity and alarming mortality rates. Timely and precise diagnosis, coupled with accurate prognostication, are pivotal for effective management of these cases. While traditional clinical assessments and radiological imaging are foundational in stroke diagnosis and prognosis, the integration of molecular biomarkers, such as serum ferritin levels, offers invaluable insights into predicting stroke outcomes.

The compelling associations between elevated serum ferritin levels and adverse outcomes across various cardiovascular conditions and stroke subtypes underscore its potential as a robust prognostic indicator. However, further research, especially in the context of acute haemorrhagic strokes, is imperative to comprehensively grasp the utility of serum ferritin as a prognostic biomarker. This understanding could significantly enhance stroke patient care, particularly in regions with high incidence rates like India, where the study intends to make a substantial contribution. The purpose of this study is to examine the clinical traits and symptoms of individuals who have experienced an acute haemorrhagic stroke and the association between their blood ferritin levels and functional outcomes.

MATERIALS AND METHODOLOGY –

A cross-sectional observational study between October 2020 and March 2022, 72 patients who had their first episode of stroke and were admitted to the medical ICU underwent the study. These individuals were diagnosed with primary intracerebral haemorrhage through both clinical and radiological assessments.

The study's criteria for patient selection were precise. Patients with acute haemorrhagic stroke symptoms who were hospitalized to the department of medicine within 48 hours after the onset were eligible. Patients had to be at least 18 years old and have a non-contrast CT scan of their brains to prove they had suffered an acute haemorrhagic stroke.

Exclusion standards were established to maintain the study's focus on primary intracerebral haemorrhage cases. Patients who have ischemic strokes, intraventricular and subarachnoid haemorrhages, and body temperatures more than 37.5°C, infections, malignancies, liver disorders, anaemia, or autoimmune conditions were not part of the study.

Through meticulous selection, a total of 72 patients were included, offering a comprehensive dataset for detailed analysis. 72 participants were selected for the study through convenience sampling and adherence to predetermined criteria out of a total of 103 patients that were assessed. The institutional ethics committee gave its approval before the study could begin, and it was carried out in compliance with the ICMR's guidelines, Good Clinical Practice (GCP) standards, and the Declaration of Helsinki's tenets of ethics. Following receipt of comprehensive study information and a patient information sheet, participants or their legal representatives gave informed written consent.

Upon enrollment, participants underwent a series of assessments, including a detailed medical history, general and neurological examinations, brain CT scans, routine blood tests, and serum ferritin measurements. The medical history included details regarding past medical disorders such hypertension, diabetes mellitus, and medication history as well as stroke symptoms like headache, nausea, loss of consciousness, seizures, and focal neurological deficits (FND). Vital signs were taken, the Glasgow Coma Scale (GCS) was administered upon admission, systemic examination results, neurological abnormalities, and indicators of increased intracranial pressure were all part of the clinical examination.

Various investigations were performed, including complete blood counts, serum electrolyte tests, blood sugar tests, liver function tests, lipid profiles, urine analyses, chest radiographs, 12-lead ECGs, and heart 2D echocardiograms for all patients. Neuroimaging using CT scans or MRIs was conducted to identify the location of intracerebral haemorrhage (ICH). Additional tests like abdominal and pelvic ultrasound (USG) and magnetic resonance angiograms (MR angiograms) were carried out when necessary. Serum ferritin levels, used as a prognostic marker, were measured upon admission and on day 7 using the Chemiluminescence Immunoassay (CLIA) method in the Department of Biochemistry. About 2ml of venous blood was collected using standard sampling tubes for serum ferritin estimation.

The management strategy during the hospital stay includes managing hypertension with the proper antihypertensive drugs to keep the systolic blood pressure under 140 mm Hg. Mannitol was used to treat elevated intracranial pressure, and supportive techniques such maintaining the airway, oropharyngeal suction, and Ryle's tube aspiration were also used. General supportive measures were implemented to prevent complications like bedsores and contractures, and any intercurrent infections and associated complications were addressed as necessary.

Prognostic assessment conducted on the 7th day of hospitalization involved a comprehensive physical examination, evaluation of the Glasgow Coma Scale (GCS), and documentation of the modified Rankin Scale (mRS) scores. The mRS scores, which ranged from 0 (which represented ideal health) to 6 (which represented death), showed the degree of functional disability following a stroke. According to their mRS scores, the individuals were separated into three groups: those with favourable prognoses (mRS = 0-2), those with challenging prognoses (mRS = 3-5), and those whose prognoses are the most serious and likely to result

in death (mRS = 6). Based on changes in GCS scores, patients were also divided into three groups: improved, deteriorated, and deceased. These groups' serum ferritin levels were evaluated and shown to be associated with intracerebral haemorrhage (ICH) severity indices.
The statistical analysis was performed using GraphPad Prism Version 8.4.3. Descriptive data including frequencies, means, medians, interquartile ranges, and standard deviations were presented in the study offered. Depending on whether the data were parametric or non-parametric, inferential statistical techniques such one-way analysis of variance and Kruskal-Wallis tests were used to compare serum ferritin and other parameters between research groups. Spearman's correlation analysis was conducted to see if there were any clear relationships between blood ferritin levels and ICH severity measurements. The 0.05 p-value limit was used to determine statistical significance.

RESULTS -

This observational study was conducted at the Krishna Institute of Medical Sciences and Research Hospital in Karad, focused on patients diagnosed with Acute Haemorrhagic stroke. From 103 screened patients based on the study's criteria, 72 were included. The study disclosed demographic information, indicating an average patient age of 63 years, predominantly male (48 patients). The average admission Glasgow Coma Scale (GCS) score was 7.47, which rose to 8.75 on the 7th day. Concurrently, the mean modified Rankin Scale (mRS) score was 3.35. Serum ferritin levels, initially averaging at 233 ng/ml, remained relatively stable at 227 ng/ml on the 7th day.
The age distribution highlighted a higher number of patients in the 61-70 years age group, potentially since risk factors like hypertension are more common, in this age range. Notably, hypertension was the primary risk factor in 68% of the patients, setting apart haemorrhagic stroke cases from ischemic strokes where atherosclerosis, often influenced by conditions like hypertension or diabetes mellitus, plays a significant role. Diabetes Mellitus was reported in 37% of cases, and a small number had rare risk factors like AV malformation (2%) or were on anticoagulant drugs such as warfarin (6%). Additionally, 30% of patients had a history of smoking, and 19% were known alcohol consumers.

The majority of patients (90%) had altered sensorium in terms of clinical presentation, which was followed by motor disturbances, speech disturbances, walking balance issues, sensory disturbances, vertigo, vomiting, diplopia, headaches, and convulsions as shown in table 1.

Table 1: Symptoms that existed when you were admitted

SYMPTOMS	**n = 72(%)**
Headache	25 (34.7)
Vomiting	28 (38.9)
Vertigo	25 (34.8)
Altered sensorium	66 (91.7)
Imbalance of walking	38 (52.8)
Diplopia	9 (12.5)
Speech disturbances	48 (66.7)

Motor disturbances	59 (82.0)
Sensory disturbances	30 (41.7)
Convulsion	12 (16.7)
Visual blurring	6 (8.3)
Others	2 (2.8)

The bulk of the haemorrhagic stroke patients admitted—72 in total—had altered sensorium (88.9%), followed by hemiparesis or hemiplegia (79.2%), speech problems (62.5%), anomalies of the cranial nerves (16.7%), and quadriparesis (9.7%) as depicted in table 2.

During admission, a neurological evaluation is listed in Table 2

During the time of admission, a neurological assessment	**n = 72(%)**
Hemiparesis/hemiplegia	57 (79.2)
Quadriparesis	7 (9.7)
Monoparesis	6 (8.3)
Cranial nerve abnormality	12 (16.7)
Cerebellar signs	11 (15.3)
Speech disorders	45 (62.5)
Altered sensorium	64 (88.9)
Nystagmus	10 (13.9)

Regarding Glasgow Coma Scale (GCS) scores, 71% of patients had scores below 8, 28% scored between 9 and 12, and only 1% had scores ranging from 13 to 15.

In terms of the location of haemorrhage, 82% of cases were supratentorial. Among these, 50% occurred in the basal ganglia internal capsule areas, 20% in the thalamic region, 8% in cortical sites, and 3% in the midbrain. Infratentorial bleeds constituted 18% of cases, with 13% in the cerebellum, 4% in the pons, and 1% in the medulla as listed in table 3.

Table 3: Where the Intracerebral Haemorrhage Is Located

Where the Intracerebral Haemorrhage Is Located		**Number of subjects =72(%)**
Supratentorial	**Basal ganglia and internal capsule**	34 (47.2%)
	Thalamic	17 (23.6)
	Cortical	5 (6.9)
	Midbrain	3 (4.2)

Infratentorial	**Cerebellum**	10 (13.8)
	Pons	2 (2.8)
	Medulla	1 (1.3)

The study compared age, Glasgow Coma Scale (GCS) scores upon admission, and serum ferritin levels in patients at admission and on day seven. There are three categories of prognosis: favourable, terrible, and fatal. The results showed that these factors significantly varied between the groups. Patients with a good prognosis and those with a bad prognosis were considerably diverse in terms of age, and those who died. GCS scores upon admission showed significant differences between patients with excellent and poor prognoses, as well as between patients with favourable prognoses and those who passed away. The mean serum ferritin levels between patients with excellent prognosis and those with a bad prognosis at the time of admission were significantly different, although there was no statistically significant difference between patients with poor prognosis and those who died. between patients who had a good prognosis and those who didn't, as well as between patients who had a good prognosis and those who passed away, serum ferritin levels were observed to differ significantly on the seventh day. Similar significant differences were also noted in serum ferritin levels on day 7 between patients with bad prognosis and those who died as shown in table 4. These findings highlight the importance of age, GCS scores, and serum ferritin levels in predicting the outcomes of patients with haemorrhagic stroke.

Table 4: Comparing the average ferritin level between healthy individuals and those who became ill or passed away

	Patient recovery (n = 40)	**Patients who deteriorated ordied (n=32)**	**P- Value**
Mean Serum Ferritin (ng/dl) on admission	150.6(68.44)	337.8(92.74)	<0.0001
Mean Serum Ferritin at Day 7 (ng/dl)	134.3(64.28)	343.8(81.12)	<0.0001

Figure 1: Correlation between the day-1 serum ferritin level and the day-7 modified Rankin Scale score

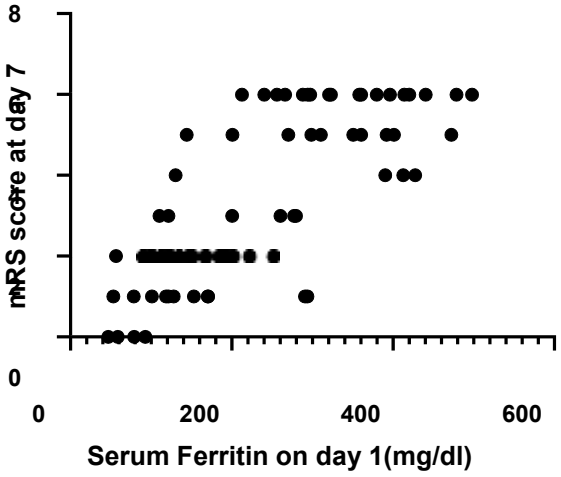
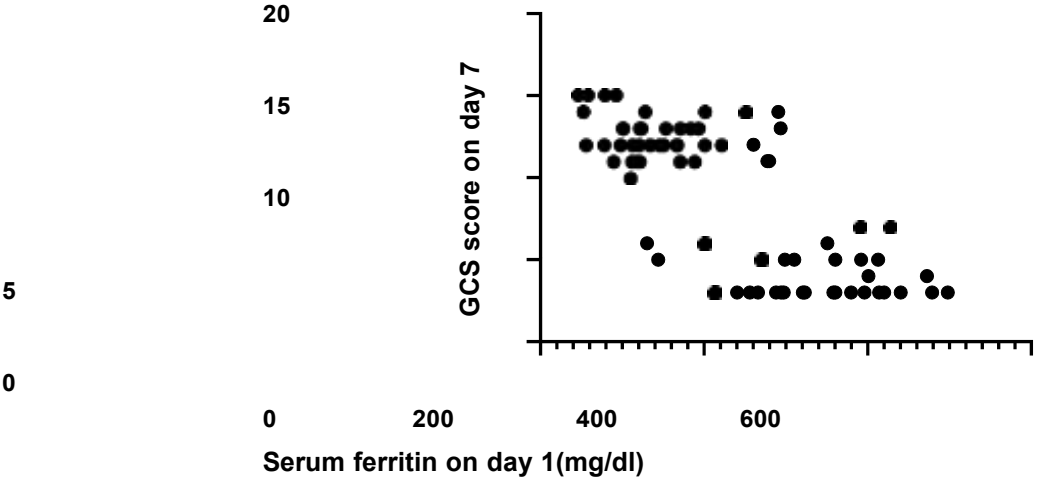


Figure 2: Day 1 serum ferritin and day 7 Glasgow Coma Scale scores are related.



We calculated the average ferritin levels in patients who survived and those who passed away. Through an unpaired t-test, it was determined that in comparison to patients who experienced deterioration or death, patients who demonstrated improvement had considerably lower mean blood ferritin levels upon admission and on day seven as depicted in figure 1 and 2.

DISCUSSION -

In our study, Patients were on average 63 years old, with a sizable number falling between the ages of 61 and 70. We observed a higher incidence of intracerebral haemorrhage (ICH) in males, consistent with prior research reporting male prevalence ranging from 64% to 78%. Hypertension was the predominant risk factor (68%), followed by diabetes mellitus (37.5%) and smoking (30.5%), all contributing to vascular degeneration. Studies by Feigin VL et al. and Mathers et al. highlighted the elevated occurrence of both ischemic and haemorrhagic

strokes in low to middle-income countries like India, attributed to inadequate management of hypertension and diabetes. Enhanced control of these modifiable risk factors could potentially reduce stroke incidence ***(Feigin et al., 2014).***

Upon presentation, typical ICH symptoms were evident, including altered consciousness (90%), motor impairments (86%), speech difficulties (62.5%), sensory deficits (43%), and signs of elevated intracranial pressure like vomiting (41.7%), vertigo (36%), and headaches (32%). Hemiparesis was observed in 82% of patients. Gangliocapsular regions were the most common sites of haemorrhage (50%), followed by the thalamus (21%) and cerebellum (12.5%), aligning with earlier study findings.

To evaluate outcomes on the 7th day, we employed the Modified Rankin Scale (mRS) and Glasgow Coma Scale (GCS). Patients who deteriorated or succumbed displayed higher mean serum ferritin levels upon admission (337.8 ng/dl) in contrast to those who showed improvement (150.6 ng/dl), indicating a significant difference ($p < 0.0001$). This trend persisted on the 7th day. Additionally, we noted significant age differences among patients who improved (57.95 ± 9.72), deteriorated (65.43 ± 5.91), and died (73 ± 4.88). Advanced age often correlates with more underlying health conditions and slower recovery, potentially explaining these variations. A similar relationship between age, serum ferritin levels, and short-term negative consequences of ICH was also discovered by Rajendran et al., underscoring the need for more research into the long-term prognostic significance of age in acute haemorrhagic stroke outcomes ***(Rajendran et al., 2019).***

Elevated serum ferritin levels upon admission demonstrated a strong correlation with 7th day modified Rankin Scale (mRS) scores ($r = 0.7561$, $p < 0.0001$) and results of the Glasgow Coma Scale (GCS) ($r = -0.7346$, $p< 0.0001$). Previous investigations have discovered similar relationships, highlighting the continuity of the link between admission serum ferritin levels and stroke outcomesAn independent predictor of worsening or fatality in acute haemorrhagic stroke has been identified by logit regression research using baseline serum ferritin as the marker (OR=1.024, $p < 0.0001$).

This underscores the significance of admission serum ferritin as a robust prognostic indicator for haemorrhagic stroke outcomes. It can inform clinicians' decisions regarding treatment strategies. Iron-mediated neurotoxicity caused by local iron excess at the hematoma site is most likely the cause of ferritin's negative effects. Iron-driven free radical production during cerebral haemorrhage results in oxidative damage, neuronal degeneration, and perihematomal edema. Iron has also been implicated in ischemic stroke outcomes, where it catalyses free radical formation, causing endothelial damage and brain disease. In experimental stroke models, iron depletion or chelation decreases infarct size and cerebral edema.

Serum ferritin, reflecting stored iron, may indicate the presence of iron, which is largely deposited as ferritin in astrocytes and microglia in the injured brain region. Oxidative stress and hypoxic acidosis may elevate ferritin production, acting as a neuroprotector. Compared to other iron indices, serum ferritin demonstrates less biological variability, ensuring accurate iron storage measurement. Within 72 hours after the beginning of symptoms, it should be assessed to exclude out acute phase reaction spikes ***(Armengou et al., 1998).*** Serum ferritin levels are steady for 72 hours following the beginning of a stroke, in contrast to other acute phase reactants. The neuropathological effects of ICH may be reduced by iron chelators such deferoxamine, which lower body iron. Future research may examine benefits of iron-

lowering treatments and hypoferremia in ICH patients, given the connection between elevated serum ferritin levels at admission and poor ICH outcomes ***(Okauchi et al., 2010).***

In the present study involving 72 patients, those with a poor prognosis or mortality were older, with a mean age of 68.31 years, compared to those with a prognosis of 57.41 years. Patients with a positive prognosis had higher Glasgow Coma Scale (GCS) scores at admission (9) compared to those with a negative prognosis (6). Additionally, In patients with a good prognosis, blood ferritin levels were noticeably lower at admission (150.6 ng/ml) in contrast to those with a negative prognosis (337.8 ng/ml). The study found a substantial negative link with GCS scores and a significant positive link between modified Rankin Scale (mRS) ratings and blood ferritin levels (r=0.756).

Similar patterns were observed in other studies. Rajendran SR's research (n=50) demonstrated that patients with better outcomes had lower serum ferritin levels (121 ng/ml) compared to those with worse outcomes (270 ng/ml). In Pankaj P's study (n=27), a substantial difference in serum ferritin levels was found between patients with positive outcomes (96.4 ng/ml) and those with negative outcomes (463.91 ng/ml) ***(Pankaj et al., 2015).*** Koul RK's study (n=50) showed a strong link between modified Rankin Scale (mRS) ratings and blood ferritin levels (r=0.836) ***(Koul, R.K et al., 2017).*** According to Mohan N's study (n=35), patients who had poorer outcomes had higher blood ferritin levels (369.36 ng/ml) than patients who had better outcomes (139.14 ng/ml) ***(Mohan et al., 2022).*** A substantial difference in serum ferritin levels was found between patients with favourable outcomes (74.6 ng/ml) and those with bad outcomes (270.6 ng/ml) in Natalia Perez's study (n=92) ***(Pérez de la Ossa et al., 2010).*** Similar results were found in Singh SC's study (n=100), which showed a significant difference in serum ferritin levels between patients who had successful outcomes (79.20 ng/ml) and those who had unsuccessful outcomes (158.80 ng/ml).

The study's single-site focus, which limits the applicability of the findings to a wider setting, is its primary drawback. The study's applicability would have enhanced with a larger and more varied sample size. Additionally, a longer follow-up period is required for a thorough assessment of the severity and prognosis of a stroke. Furthermore, significant prognostic markers such hematoma volume and extent were not examined in this study.

CONCLUSION –

The current cross-sectional study aimed to provide further information about the relationship between serum ferritin levels and the outcomes of acute haemorrhagic stroke (AHS). According to the findings, patients with greater blood ferritin levels experienced worse outcomes and more severe AHS after one week. The study discovered a relationship between elevated serum ferritin levels and a poor prognosis as well as a positive link between serum ferritin levels and the modified Rankin Scale (mRS) score in AHS. Higher serum ferritin levels have been linked to lower Glasgow Coma Scale (GCS) scores, which rate the severity of a stroke. Serum ferritin was identified by regression analysis as a separate predictor of mortality and worsening in patients with acute haemorrhagic stroke. Therefore, the course of an acute haemorrhagic stroke can be predicted using serum ferritin. In order to predict the course of the condition, the study advises assessing serum ferritin levels in AHS patients in addition to clinical assessments, laboratory tests, and imaging studies.

REFERENCES –

Alex Matos Ribeiro, J., Fernanda García-Salazar, L., Regina Saade-Pacheco, C., Shirley Moreira Silva, R., Garcia Oliveira, S., Flávia Silveira, A., Sanches Garcia-Araújo, A., & Luiz Russo, T. (2021, November). Prognostic molecular markers for motor recovery in acute hemorrhagic stroke: A systematic review. Clinica Chimica Acta, 522, 45–60. https://doi.org/10.1016/j.cca.2021.08.006

An, S. J., Kim, T. J., & Yoon, B. W. (2017, January 31). Epidemiology, Risk Factors, and Clinical Features of Intracerebral Hemorrhage: An Update. Journal of Stroke, 19(1), 3–10. https://doi.org/10.5853/jos.2016.00864

Ariesen, M., Claus, S., Rinkel, G., & Algra, A. (2003, August). Risk Factors for Intracerebral Hemorrhage in the General Population. Stroke, 34(8), 2060–2065. https://doi.org/10.1161/01.str.0000080678.09344.8d

Armengou, A., Dávalos, A., Fernandez-Real, J. M., & Castillo, J. (1998, January). Serum Ferritin Concentrations Are Not Modified in the Acute Phase of Ischemic Stroke. Stroke, 29(1), 258–260. https://doi.org/10.1161/01.str.29.1.258

Chen, S., Zeng, L., & Hu, Z. (2014, March 5). Progressing haemorrhagic stroke: categories, causes, mechanisms and managements. Journal of Neurology, 261(11), 2061–2078. https://doi.org/10.1007/s00415-014-7291-1

Dávalos, A., Fernandez-Real, J. M., Ricart, W., Soler, S., Molins, A., Planas, E., & Genís, D. (1994, August). Iron-related damage in acute ischemic stroke. Stroke, 25(8), 1543–1546. https://doi.org/10.1161/01.str.25.8.1543

Feigin, V. L., Forouzanfar, M. H., Krishnamurthi, R., Mensah, G. A., Connor, M., Bennett, D. A., Moran, A. E., Sacco, R. L., Anderson, L., Truelsen, T., O'Donnell, M., Venketasubramanian, N., Barker-Collo, S., Lawes, C. M. M., Wang, W., Shinohara, Y., Witt, E., Ezzati, M., Naghavi, M., & Murray, C. (2014, January). Global and regional burden of stroke during 1990–2010: findings from the Global Burden of Disease Study 2010. The Lancet, 383(9913), 245–255. https://doi.org/10.1016/s0140-6736(13)61953-4

Global, Regional, and Country-Specific Lifetime Risks of Stroke, 1990 and 2016. (2018, December 20). New England Journal of Medicine, 379(25), 2429–2437. https://doi.org/10.1056/nejmoa1804492

Hankey, G. J. (2020, March). Population Impact of Potentially Modifiable Risk Factors for Stroke. Stroke, 51(3), 719–728. https://doi.org/10.1161/strokeaha.119.024154

Koul, R.K., Yaseen, Y., Amreen, S., Shah, P.A. and Hakeem, M.M., 2017. Role of serum ferritin in determining the severity and prognosis of stroke: A hospital based study. Int J Sci Stud, 6, pp.142-5.

Maas, M. B., & Furie, K. L. (2009, August). Molecular biomarkers in stroke diagnosis and prognosis. Biomarkers in Medicine, 3(4), 363–383. https://doi.org/10.2217/bmm.09.30

Mohan, N., Murthy, K., Yoganandan, D., Rajalakshmi, K. V., & Kumar, S. M. (2022, February 23). Serum ferritin as a prognostic marker in acute stroke; a cross-sectional observational study. International Journal of Advances in Medicine, 9(3), 253. https://doi.org/10.18203/2349-3933.ijam20220427

Ojaghihaghighi, S., Vahdati, S. S., Mikaeilpour, A., & Ramouz, A. (2017). Comparison of neurological clinical manifestation in patients with hemorrhagic and ischemic stroke. World Journal of Emergency Medicine, 8(1), 34. https://doi.org/10.5847/wjem.j.1920-8642.2017.01.006

Okauchi, M., Hua, Y., Keep, R. F., Morgenstern, L. B., Schallert, T., & Xi, G. (2010, February). Deferoxamine Treatment for Intracerebral Hemorrhage in Aged Rats. Stroke, 41(2), 375–382. https://doi.org/10.1161/strokeaha.109.569830

Pankaj, P., Das, M., & Singh, M. K. (2015, February 7). Association Between Level Of Serum Ferritin And Outcome Of Patients Of Stroke. Journal of Evolution of Medical and Dental Sciences, 04(12), 2023–2036. https://doi.org/10.14260/jemds/2015/292

Pérez de la Ossa, N., Sobrino, T., Silva, Y., Blanco, M., Millán, M., Gomis, M., Agulla, J., Araya, P., Reverté, S., Serena, J., & Dávalos, A. (2010, April). Iron-Related Brain Damage in Patients With Intracerebral Hemorrhage. Stroke, 41(4), 810–813. https://doi.org/10.1161/strokeaha.109.570168

Rådberg, J. A., Olsson, J. E., & Rådberg, C. T. (1991, May). Prognostic parameters in spontaneous intracerebral hematomas with special reference to anticoagulant treatment. Stroke, 22(5), 571–576. https://doi.org/10.1161/01.str.22.5.571

Rajendran, S. R., Periyasamy, S., Manjuladevi, M. T., & George, N. (2019, December 11). Evaluation of Serum Ferritin as a Prognostic Marker in Acute Hemorrhagic Stroke. Journal of Neurosciences in Rural Practice, 11, 72–77. https://doi.org/10.1055/s-0039-1700597

Salonen, J. T., Nyyssönen, K., Korpela, H., Tuomilehto, J., Seppänen, R., & Salonen, R. (1992, September). High stored iron levels are associated with excess risk of myocardial infarction in eastern Finnish men. Circulation, 86(3), 803–811. https://doi.org/10.1161/01.cir.86.3.803

Sturgeon, J. D., Folsom, A. R., Longstreth, W., Shahar, E., Rosamond, W. D., & Cushman, M. (2007, October). Risk Factors for Intracerebral Hemorrhage in a Pooled Prospective Study. Stroke, 38(10), 2718–2725. https://doi.org/10.1161/strokeaha.107.487090

van der, D. L., Grobbee, D. E., Roest, M., Marx, J. J., Voorbij, H. A., & van der Schouw, Y. T. (2005, August). Serum Ferritin Is a Risk Factor for Stroke in Postmenopausal Women. Stroke, 36(8), 1637–1641. https://doi.org/10.1161/01.str.0000173172.82880.72

van Swieten, J. C., Koudstaal, P. J., Visser, M. C., Schouten, H. J., & van Gijn, J. (1988, May). Interobserver agreement for the assessment of handicap in stroke patients. Stroke, 19(5), 604–607. https://doi.org/10.1161/01.str.19.5.604

Zheng, G. R., Chen, B., Shen, J., Qiu, S. Z., Yin, H. M., Mao, W., Wang, H. X., & Gao, J. B. (2018, December). Serum myeloperoxidase concentrations for outcome prediction in acute intracerebral hemorrhage. Clinica Chimica Acta, 487, 330–336. https://doi.org/10.1016/j.cca.2018.10.026