Acta Biomed 2025; Vol. 96, N. 4: 17321 DOI: 10.23750/abm.v96i4.17321

Original article

Atherogenic index of plasma as a predictor of Hounsfield unit attenuation, infarct lesion number, and stroke severity in acute ischemic stroke

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Abstract. *Background and aim:* The triglyceride (TG)/high-density lipoprotein (HDL) cholesterol Log (TG/HDL-C) ratio is characterized as the serum atherogenic index of plasma (AIP). A high TG/HDL-C ratio is associated with vascular conditions, insulin resistance, and metabolic syndrome. Cerebrovascular diseases have recognized the importance of the lipid profile linked to AIP. However, there are still relatively few studies exploring the AIP about these conditions, especially ischaemic stroke (IS). This study aims to find out the association between AIP with Hounsfield unit (HU), CT (Computed Tomography) cerebral lesion burden and neurological impairment in IS. *Methods:* Patients with acute ischemic stroke (AIS) admitted between January until December 2023 were retrospectively enrolled in this study. The AIP was determined using the subsequent formula derived from blood test: AIP=log [TG (mg/dL)/HDL cholesterol (mg/dL)]. AIP was classified into low risk (<0.11), moderate risk (0.11-0.21), high risk (>0.21). Statistical analysis was performed using SPSS version 26.0 software, and the results are presented in frequency distribution tables, which are then discussed. *Results:* 103 AIS patients, average age was 60.20 years, with 51 females (49,5%) and 52 males (50,5%). The Association between AIP and CT cerebral lesion burden, as well as neurological impairment using National Institutes of Health Stroke Scale (NIHSS) score, is statistically significant with a positive relationship with HU (acute phase) r=+0.612; p<0.001, CT cerebral lesions and neurological impairment, respectively r= +0.825; p<0.001 and r=+0.602; p<0.001. *Conclusions:* This study demonstrates a significant association between high serum AIP with HU (acute phase), multiple CT cerebral lesions and severe neurological impairment of ischemic stroke. This simple, inexpensive and effective test method can prevent the occurrence of ischemic stroke. (www.actabiomedica.it)

Key words: atherogenic index of plasma, Hounsfield unit, cerebral lesion, ischemic stroke

Introduction

The World Health Organization (WHO) defines stroke as a "clinical syndrome with rapid development of clinical symptoms/signs of focal or global loss of cerebral function, with no apparent cause other than of vascular origin and symptoms lasting greater than 24 hours or leading to death." Stroke is typically classified into two types: haemorrhagic and ischemic. Haemorrhagic stroke (HS) consists of intracerebral, intraventricular as well as subarachnoid haemorrhage. In contrast, ischemic stroke (IS) is caused by an embolism or thrombosis in cerebral vessels, leading to blockage of blood supply to the brain (1). Stroke remains one of the leading causes of death and long-term disability worldwide. In 2013, there were approximately 25.7 million stroke survivors, 6.5 million stroke-related deaths and 10.3 million new cases of stroke. Roughly 113 million years of life were lost as a result of stroke-related disability and premature mortality (2). This burden is particularly high in Asia, containing more than 60% of the global population, with higher level of stroke-associated fatalities as compared to Western Europe, North America, and Australasia, excluding nations like Japan (3,4). In Indonesia, the prevalence of stroke in rural and urban areas is reported to be 0.0017 and 0.022% respectively. Risk factors include both modifiable factors, such as hypertension, dyslipidaemia, diabetes mellitus, prior cardiovascular disease, smoking, alcohol consumption, and illicit drug use, and non-modifiable factors, including age, sex, ethnicity, family history, and race (5). Atherosclerosis is a chronic vascular condition characterised by the accumulation of lipids, fibrosis, and calcification of the arterial walls, leading to a cascade of inflammatory responses resulting in atheroma formation, local stenosis and thrombosis. This pathological process is a major contributor to cardiovascular and cerebrovascular events (6). Numerous epidemiological and cohort studies have shown significant associations between atherosclerosis and lipid profiles, including total cholesterol (TC), low density lipoprotein (LDL), and high-density lipoprotein (HDL). Recent evidence also highlights the predictive value of lipid ratios, such as TC/HDL, LDL/HDL, and TG/HDL, in risk stratification for vascular risk (7,8). Dyslipidaemia with high TC, LDL-C, and TG, and low HDL-C constitutes a major risk factor for atherogenesis. HDL-C is atheroprotective, while high TG are correlated with cholesterol-rich lipoproteins, which are associated with atherothrombosis (9). The Atherogenic Index of Plasma (AIP), defined as the logarithmic ratio of TG to HDL-C, reflects the presence of small, dense LDL particles and is a reliable marker of cardiovascular risk. AIP provides insight into the balance of atherogenic and protective lipoproteins, correlating with lipoprotein particle size and plasma cholesterol esterification (10). AIP is categorized as low (<0.11), intermediate (0.11–0.21), and high (>0.21) risk. Elevated AIP values suggest increased vulnerability to unstable plaque rupture, predisposing to thrombotic events, including cerebral artery occlusion and subsequent ischaemic stroke (11). In acute stroke management, non-contrast computed tomography (NCCT) of the brain remains the first-line imaging modality due to its accessibility and ability to exclude haemorrhage. CT imaging also enables identification of infarct burden and severity. Hounsfield Unit (HU) values quantify tissue attenuation, aiding in the classification of infarct stage: acute (>19.13 HU), subacute (9.55–19.13 HU), and chronic (<9.55 HU) (12,13). The location and size of infarcts—particularly in regions such as the insular ribbon, thalamus, and brainstem—are closely associated with the extent of neurological impairment (14). The National Institutes of Health Stroke Scale (NIHSS) is a validated tool for evaluating neurological deficits and stroke severity. Comprising 15 items ranging from motor and sensory function to cognition and visual fields, it yields a total score from 0 to 42. NIHSS scores classify stroke severity as no symptoms (0), mild (1–4), moderate (5–15), moderate to severe (16–20), or severe (21–42), correlating with infarct volume, treatment response, and prognosis (15-17). As the atherogenic lipid profiles have been indicated to play a role in vascular disease, and considering the significance of early evaluation in acute stroke, the present study will determine the predictive value of the AIP in predicting HU attenuation values, cerebral lesion burden on NCCT imaging and neurological impairment. in patients with acute ischaemic stroke.

Material and Methods

Study design

This study was designed as an analytical observational investigation with a retrospective cross-sectional approach, conducted at Wahidin Sudirohusodo Hospital from January to April 2025. Data collection covered four months and was based on a retrospective review of medical records from January to December 2023. The cross-sectional design was adopted to address practical time constraints while maintaining methodological rigour and data validity. A calculated sample size of 103 subjects was established in advance to ensure adequate statistical power for correlation analysis. Informed consent was not required, as the study involved retrospective analysis of anonymised data. Subjects were included based on the following criteria: a first confirmed diagnosis of acute ischaemic stroke (AIS), age between 18 and 70 years, and symptom onset within one week prior to hospital admission. Diagnosis of AIS was established through neurological examination supported by neuroimaging, allowing for accurate case identification and inclusion in the analysis.

Patient selection

The study population included patients who presented with clinical syndrome corresponding with AIS and head NCCT evidence of cerebral infarction. Several key parameters were assessed: the AIP, the HU values, total number of cerebral lesions and the clinical severity of stroke. The severity of stroke was evaluated using the NIHSS on admission. Patient enrolment was guided by predefined criteria to achieve a quite homogeneous group. Strict exclusion criteria were adopted to minimise the impact of confounding factors on AIP levels and stroke outcomes. Patients with recurrent stroke, patients diagnosed as transient ischemic attack (TIA) and patients with accompanied cardiac disease or having other coagulation disorder were excluded. Patients with active infections, chronic kidney disease, malignancy, autoimmune disease, or diabetes mellitus were also excluded, as the presence of these clinical conditions might affect AIP levels and subsequently invalidate the study results.

Research procedures

The clinical data were extracted from patient records by the attending physicians of the selected patients who fulfilled the predetermined inclusion and exclusion criteria. Radiological assessment included NCCT of the head with quantitative analysis of imaging parameters to support the diagnosis of AIS. The relationship between AIP (also referred to as the log (TG/HDL-C) ratio) and HU values as well as the number of cerebral lesions has been specifically investigated in this study. The AIP value reflects the combined effect of pro-atherosclerotic and atheroprotective mechanisms, which are divided into three risk criteria: low risk <0.11, moderate risk: 0.11-0.21, high risk >0.21 (18). Lesion number was defined as the number of coordinate hypodense areas with similar HU values (in the same phase range of infarct) on axial NCCT that appeared in different anatomic structures. Among these were infarcts in the anterior and posterior circulation. Lesions were categorized as single (1 lesion) or multiple (>1 lesion). CT-based infarct staging was performed according to HU values: acute infarct>19.13 HU, subacute infarct 9.55–19.13 HU and chronic infarct <9.55 HU (12). Moreover, the association between AIP with stroke severity at admission was rated with NIHSS. All images were acquired on a 128-slice CT scanner (Siemens SOMATOM Definition AS+) with an axial slice thickness of 0.62 mm. The HU values were recorded by standardised region of interest (ROI) in the infarct regions traced by a trained neuroradiologist according to our previous work. For consistency and reproducibility, these parameters were normalised (19). Details of the study flow of atherogenic index predicts hu, lesion burden, and severity are shown below in Figure 1 which outlines the methodology followed for the study.

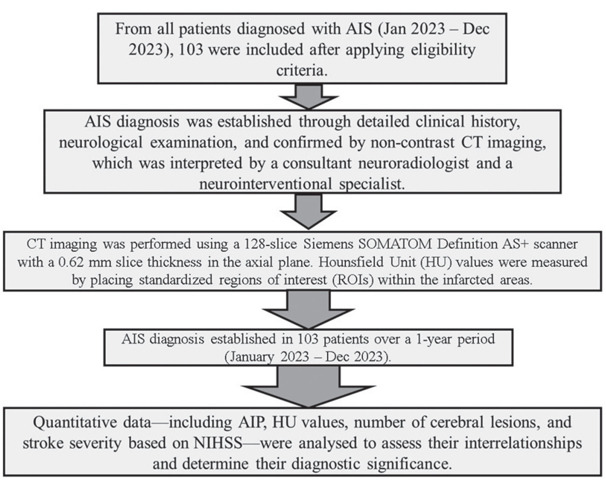

Figure 1. Study flow of atherogenic index predicts hu, lesion burden, and severity

Data and statistical analysis

Quantitative variables—including the AIP, HU values, number of cerebral lesions, and stroke severity as measured by the NIHSS—were subjected to comprehensive statistical analysis to determine their interrelationships and evaluate their diagnostic relevance. Before analysis, the data were tested for normality using the Kolmogorov-Smirnov test, which is appropriate for datasets comprising more than 30 subjects. All statistical analyses were conducted using IBM SPSS Statistics version 26.0. A p-value of less than 0.05 was considered indicative of statistical significance. For normally distributed variables, Pearson's correlation coefficient was employed to assess linear associations. In contrast, for data that did not meet the assumption of normality, Spearman's rank-order correlation was utilized. Furthermore, to measure the strength of the relationship and to identify the unidirectional comparison between two ordinal variables, gamma correlation is used. The choice of statistical method was rigorously based on the distributional characteristics of each variable, thereby ensuring analytical precision and methodological validity.

Results

A retrospective cross-sectional study was performed to evaluate the prognostic relationship between the AIP, HU values, number of cerebral lesions, and stroke severity assessed by the NIHSS in patients with AIS presenting with increased attenuation on head NCCT scans (Figure 2). The study included 103 patients admitted to Wahidin Sudirohusodo Hospital between January and December 2023, who fulfilled the inclusion criteria. The demographic and clinical characteristics of the patients are summarized in Table 1. The study cohort had a nearly equal gender distribution, comprising 52 males (50.5%) and 51 females (49.5%). The predominant age group was 56–65 years, accounting for 43.7% of the patients. In terms of lipid-derived markers, a high AIP level (>0.21) was observed in 48 patients (46.6%), while 43 patients (41.7%) had a low AIP (<0.11). The median HU value was 17, ranging from 6 to 28, with the majority of patients (60.2%) classified in the subacute infarct range (HU 9.55–19.13), followed by 38.8% in the acute infarct category (HU >19.13). Regarding stroke burden, 66 patients (64.1%) exhibited multiple cerebral lesions on neuroimaging. The severity of neurological impairment at admission, assessed using the NIHSS, revealed that 52.4% of patients had moderate strokes. In comparison, 18.4% were classified as either minor or severe, and 10.7% presented with moderate-to-severe deficits. These findings reflect a population

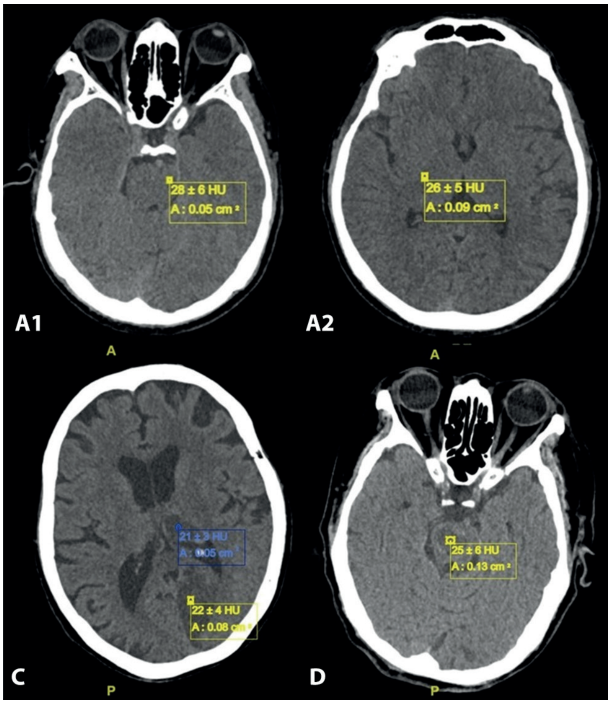

Figure 2. Non-contrast computed tomography (CT) imaging in patients with acute ischemic stroke (AIS), illustrating Hounsfield Unit (HU) values and lesion distribution corresponding to infarct burden. A1. Demonstrates multiple hypodense lesions consistent with acute infarction in the left pons, with a Hounsfield Unit measurement of 28; A2. Shows more than one acute hypodense lesion located in the right internal capsule, with an HU value of 26; C. Reveals extensive acute ischemic involvement, with multiple lesions identified in the left thalamus, the posterior limb of the internal capsule (HU 21), the left temporo-occipital lobe, and the splenium of the corpus callosum (HU 22); D. Presents a single hypodense lesion in the right pons, with an HU of 25, observed in a patient with a markedly elevated Atherogenic Index of Plasma (AIP). Lower HU values on non-contrast CT reflect cytotoxic edema and correlate with infarct phase: >19.13 HU indicates acute infarction, 9.55–19.13 HU corresponds to the subacute phase, and <9.55 HU suggests chronic infarction.

Table 1. Characteristics of Acute Ischemic Stroke (AIS) Patients Population for the Period January-December 2023

Variables	**n=103 (%)**
Age (years old)	61 (25-93)
• 18-25	1 (1)
• 26-35	3 (2.9)
• 36-45	7 (6.8)
• 46-55	18 (17.5)
• 56-65	45 (43.7)
• >65	29 (28.2)
Sex	
• Male	52 (50.5)
• Female	51 (49.5)
High-density lipoprotein (HDL) level	15.492 (10-99)
Triglyceride (TG) level	124 (39-644)
National Institutes of Health Stroke Scale (NIHSS)	10 (1-27)
• Minor	19 (18.4)
• Moderate	54 (52.4)
• Moderate-severe	11 (10.7)
• Severe	19 (18.4)
Atherogenic Index of Plasma (AIP) scores	0.18 (±0.28)
• low risk (<0.11)	43 (41.7)
• moderate risk (0.11-0.21)	12 (11.7)
• high risk (>0.21)	48 (46.6)
Hounsfield unit (HU)	17 (6-28)
• acute infarct >19.13	40 (38.8)
• subacute infarct 9.55-19.13	62 (60.2)
• chronic infarct <9.55	1 (1.0)
Lesion number	
• single (1 lesion)	37 (35.9)
• multiple (>1 lesion)	66 (64.1)

with a significant burden of stroke, both in terms of lesion load and clinical severity, associated with dyslipidaemia profiles and neuroimaging correlates.

Table 2 demonstrates a statistically significant correlation between the AIP and the HU values observed on NCCT scans. The strength of the correlation was classified as strong, with a positive directionality, as indicated by a Pearson correlation coefficient of r = +0.612 and a p-value of less than 0.001. This finding suggests that higher AIP values are closely associated with increased HU measurements, which are characteristic of the acute phase of IS. Accordingly, it may be inferred that elevated AIP levels tend to correlate with the occurrence of acute-stage cerebral infarction, highlighting the potential role of atherogenic dyslipidaemia in the early pathophysiology of ischemic stroke.

Table 2. Association between the atherogenic index of plasma (AIP) and Hounsfield unit (HU) values on non-contrast head CT scans

			AIP	**HU**
Spearman's rho test	**AIP**	Correlation Coefficient	1.000	0.612
		Sig. (2-tailed)	.	0.000**
		N	103	103
	HU	Correlation Coefficient	0.612	1.000
		Sig. (2-tailed)	0.000**	.
		N	103	103

**P<0.001

Table 3 illustrates a statistically significant correlation between the AIP and the number of cerebral lesions identified on head NCCT scans. The correlation is classified as very strong and positive in direction, with a Pearson correlation coefficient of r = +0.825 and a p-value of less than 0.001. These findings indicate that higher AIP values are strongly associated with an increased number of hypodense cerebral lesions in patients presenting with acute ischemic stroke. This relationship suggests that elevated atherogenic lipid profiles may contribute to a greater burden of ischemic injury within the brain, reinforcing the relevance of AIP as a potential marker in evaluating stroke severity and lesion distribution.

Table 4 demonstrates a statistically significant association between the AIP and stroke severity as measured by the NIHSS. The correlation was classified as strong and positive, with a gamma correlation analysis, the correlation coefficient of r = +0.620 and a p-value of less than 0.001. These findings indicate that higher AIP values are associated with increased NIHSS scores, suggesting more severe neurological

Table 3. Gamma correlation analysis of the association between the atherogenic index of plasma (AIP) and the number of cerebral lesions on non-contrast head CT scans

		Lesion number		Correlation coefficient (r)	*p*-value
		single (1 lesion)	**multiple (>1 lesion)**		
Atherogenic Index of Plasma (AIP) scores	**low risk (<0.11)**	29 (28.2%)	14 (13.6%)	0.825	<0.001**
	moderate risk (0.11-0.21)	3 (2.9%)	9 (8.7%)		
	high risk (>0.21)	5 (4.9%)	43 (41.7%)		
Total		37 (35.9%)	66 (64.1%)		

**P<0.001

Table 4. Correlation between the atherogenic index of plasma (AIP) and stroke severity level (NIHSS) in patients with acute ischemic stroke (AIS)

			AIP	NIHSS
Spearman's rho test	**AIP**	Correlation Coefficient	1.000	0.602
		Sig. (2-tailed)	.	0.000**
		N	103	103
	NIHSS	Correlation Coefficient	0.602	1.000
		Sig. (2-tailed)	0.000**	.
		N	103	103

**P<0.001

impairment in patients presenting with AIS. Therefore, in addition to its significant correlation with HU values and the number of cerebral lesions, AIP also shows a meaningful association with clinical severity. This underscores the potential role of AIP as a comprehensive biomarker reflecting both radiological burden and neurological deficit in the acute phase of IS.

Discussion

This retrospective cross-sectional study of 103 patients with AIS admitted to Wahidin Sudirohusodo Hospital from January to December 2023 revealed important insights into demographic, metabolic, and neuroimaging profiles within this population. The median age was 61 years, with the highest proportion of cases between 56 and 65 years, aligning with global data indicating that stroke incidence rises significantly with age due to the cumulative burden of vascular risk factors such as hypertension, diabetes mellitus, and dyslipidaemia (20). The nearly equal distribution between males (50.5%) and females (49.5%) is comparable to findings in other cohorts, although hormonal and physiological differences may influence clinical manifestations and outcomes (21). In terms of stroke severity, over half of the patients presented with moderate neurological deficits based on the NIHSS, and nearly one-fifth were classified as severe, mirroring hospital-based stroke registries where moderate-to-severe strokes account for the majority of admissions (20). The AIP, a marker reflecting lipid metabolic imbalance and endothelial dysfunction, showed elevated levels in nearly half of the cohort (>0.21), supporting previous evidence that AIP is strongly associated with IS risk and adverse outcomes due to its link to small dense LDL particles and atherosclerosis (22,23). Furthermore, the analysis of infarct density using HU values revealed a median of 17, with most patients showing subacute infarction; this underscores the utility of HU in estimating infarct age, as lower values often represent more advanced tissue damage, while higher HU suggests recent cytotoxic oedema (13,24). The presence of multiple lesions in 64.1% of cases raises the likelihood of embolic stroke mechanisms, including extensive artery atherosclerosis and cardio embolism, consistent with previous studies indicating that multifocal infarcts are frequently linked to cardioembolic sources and associated with worse functional outcomes (25). These findings collectively highlight the clinical relevance of integrating metabolic indices and CT-based biomarkers into the early evaluation and risk stratification of AIS, particularly in resource-constrained settings. In this study, it was found that AIP was correlated with HU values in the acute phase, suggesting that AIS is more likely to occur with high AIP values. The value of coefficient correlation was +0.602 with the significancy (*P*) <0.001. Rao et al. also demonstrated a significant association between the AIP and hyperintensity in the cerebral white matter in Cerebral Small Vessel Disease (CSVD), indicating the potential of AIP as a new plasma biomarker and predictive indicator for assessing CSVD progression and guiding clinical management of stroke patients (26). Ali et al showed that a significant association was identified between CT phase and HU values in cerebral infarction. The results demonstrated the clinical significance of HU values in diagnosing and managing cerebral infarction. Understanding the relationship between HU measurements and CT phase may be helpful in accurately evaluating cerebral infarction and subsequently making appropriate decisions regarding patient management and care. The results also emphasise the importance and potential of HU values in evaluating cerebral infarction, guiding for improving patient outcomes in cerebral infarction diagnosis using CT (27). Through its association with lipid profiles, the AIP is used as a biomarker to identify stroke risk. An increase in this index is considered an important indicator of dyslipidaemia and increased risk of cardiovascular diseases, including ischaemic stroke (4). Studies have shown that AIP is a biomarker for atherosclerosis, metabolic syndrome, and coronary heart disease. Additionally, research has found that AIP is associated with unstable carotid plaques and symptomatic carotid stenosis, providing prognostic value for long-term outcomes in AIS (28). Then, regarding the high AIP values above 0.21 with 46.6%, these results were also significantly associated and strongly correlated with the number of cerebral lesions on head NCCT scans, with results showing the coefficient correlation +0.825; with the significancy (*P*)<0.001. Dyslipidaemia is a significant risk factor for atherosclerosis, which is the most common cause of AIS. One of the core lipid components is small and dense LDL cholesterol (sdLDL-C), which has a higher atherosclerosis rate than LDL-C. Previous studies have shown that sdLDL-C is positively correlated with the risk of IS and can accelerate stroke progression, thereby impacting patient prognosis. However, methods for detecting sdLDL-C have not been widely used in clinical practice due to their complex and expensive procedures (29). Accumulating evidence suggests that AIP is a substitute for sdLDL-C and inversely correlates with LDL-C particle size, which is directly associated with foam cell formation and atherosclerosis progression. Low HDL cholesterol (HDL-C) levels are a strong and independent risk factor associated with cardiovascular disease (CVD) incidence. Increasing HDL-C levels is expected to prevent and/or reverse CVD (30). The AIP is a biomarker for identifying stroke risk through its association with lipid profiles. Therefore, an increase in this index is considered a significant marker for determining dyslipidaemia and increasing cardiovascular risk, including IS. Several studies have shown that AIP is a biomarker for coronary heart disease, atherosclerosis, and metabolic syndrome. Additionally, research has found that AIP is associated with unstable carotid plaques and symptomatic carotid stenosis and can predict poor long-term prognosis in acute ischemic stroke patients (4, 31,32). High TG levels can compromise cerebral blood flow by triggering inflammation and microvascular injury, or by affecting blood flow in brain blood vessels, ultimately promoting the formation of white matter hypodense lesions (WMHs). Low HDL cholesterol levels may be associated with larger WMH volumes, possibly because they can trigger inflammation, promote damage to small intracranial blood vessels, and increase the risk of WMHs. The accumulation of cholesterol within cells can trigger an inflammatory response and produce inflammatory mediators, such as interleukin (IL)-1β (26). This may also be related to the interaction of various mechanisms that influence the progression of CSVD, atherosclerosis, triggering inflammatory responses and oxidative stress, impairing endothelial function, increasing blood clot formation and plaque instability, and affecting vascular autoregulation, all of which exacerbate blood-brain barrier (BBB) damage. Additionally, endothelial dysfunction can affect cerebral perfusion, leading to myelin damage and changes in the microstructure of cerebral white matter, which ultimately develop into what is observed in imaging (33). In this study, significant results were obtained between AIP and NIHSS, with a strong correlation strength and a positive correlation direction. It can be concluded that the higher the AIP, the higher the NIHSS, with respective values of r=+0.620; p=<0.001. The NIHSS scale is the most widely used deficit rating scale in modern neurology, with over 500,000 neurological professionals using NIHSS as the gold standard for determining stroke severity both before and after acute stroke therapy (34). NIHSS scores are the gold standard for assessing stroke intensity. Initially, the NIHSS was utilized in research to assess the degree of neurological deficits based on clinical manifestations from the National Institute of Neurological Disorders and Stroke (NINDS) Recombinant Tissue Plasminogen Activator (r-tPA) study. However, since then, the NIHSS has been more widely used to assess initial (baseline) neurological deficits and monitor treatment progression. Initial NIHSS scores are associated with early and long-term clinical outcomes, response to therapy, neurological deterioration, and mortality (35). Rajashekar et al.'s demonstrated that Lesion-symptom mapping (LSM) of the total NIHSS score captures the cumulative effects of all NIHSS categories and not merely post-stroke motor deficits. Therefore, utilizing sub-scores from widely available assessment scales for LSM analysis is feasible and may enhance our understanding of clinical stroke outcomes (16). The NIHSS is a validated and reliable tool for assessing the initial severity of AIS upon admission, with established predictive value for both mortality and long-term clinical outcomes. It enables a rapid yet structured evaluation—typically completed within five to eight minutes—and examines multiple neurological domains, including level of consciousness, gaze, visual fields, facial symmetry, motor strength, limb ataxia, sensory function, language, dysarthria, and neglect. Despite its utility, the NIHSS may underestimate posterior circulation strokes, underscoring the importance of comprehensive neurological assessment in suspected cases to guide emergency management decisions appropriately (15,34). NIHSS scores are categorized as follows: 0–4 (minor stroke), 5–15 (moderate), 16–20 (severe), and 21–42 (very severe), with proper administration requiring trained clinicians to ensure consistency and reproducibility. In the present study, conducted at Wahidin Sudirohusodo General Hospital in Makassar, a statistically significant association was identified between the AIP, the number of cerebral lesions, and stroke severity. Several limitations must be acknowledged in this study. Limitations of causal inferences and temporal relationships among variables are unavoidable due to the retrospective cross-sectional nature of the study design. Being a study performed at a single tertiary referral hospital, the result may represent institutional practice, and thus, may not be applicable to other diverse or community settings. This approach of excluding co-morbidities such as diabetes mellitus, chronic kidney disease, malignancy, autoimmune diseases and cardiac conditions to minimize confounding influences may have resulted in a study population that does not reflect the clinical complexity frequently encountered in patients presenting with acute ischaemic stroke. Furthermore, lipid components were analysed only at the baseline; therefore, dynamic changes of AIP over time could not be obtained, and whether AIP could be modified in response to treatment remains unknown. Lastly, although head NCCT scan and HU analysis have practical utility in the acute condition, these studies may be less sensitive than advanced modalities, such as MRI, for detecting smaller or evolving lesions which may result in an underestimation of infarct burden.

Conclusion

This study provides compelling evidence that the Atherogenic Index of Plasma (AIP) is significantly correlated with key neuroimaging and clinical parameters in patients with acute ischemic stroke (AIS). AIP showed a strong positive association with Hounsfield Unit (HU) values in the acute infarct phase, indicating its potential role in reflecting the stage and density of infarcted brain tissue. Furthermore, elevated AIP levels were significantly associated to an increased burden of cerebral lesions as visualized on non-contrast CT scans, suggesting a relationship between dyslipidaemia profiles and infarct multiplicity. A similar positive correlation was observed between AIP and stroke severity as assessed by the National Institutes of Health Stroke Scale (NIHSS), underlining AIP's prognostic utility in estimating neurological impairment at presentation.

Collectively, these findings underscore the clinical relevance of AIP as a low-cost, accessible, and reproducible biomarker that may aid in early risk stratification and prognostic evaluation of patients presenting with AIS. The integration of AIP into initial stroke assessment protocols may be particularly beneficial in resource-limited healthcare settings, where advanced neuroimaging or extended laboratory profiling may not be readily available.

Ethic Approval: This study was approved by the institutional review board and conducted in accordance with the principles of the Declaration of Helsinki. Ethical clearance was obtained from the Health Research Ethics Committee, Faculty of Medicine, Hasanuddin University (344/UN4.6.4.5.31/ PP36/2025) on April 16, 2025.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Authors Contribution: MYA (Concept, Design, Supervision, Resources, Materials, Data Collection and Processing, Analysis and Interpretation, Literature Search, Writing Manuscript), ML (Supervision, Resources, Materials, Data Collection and Processing, Analysis and Interpretation), AWLP (Resources, Materials, Data Collection and Processing, Analysis and Interpretation, Literature Search, Writing Manuscript), and II, MA, AWS (Analysis and Interpretation, Supervision, Resources). All authors read and approved the final version of the manuscript.

Declaration on the Use of AI: None.

Consent for Publication: All subjects have provided consent for publication.

Funding: This research received no external funding.

Data Availability Statement: All the data are available from the corresponding author upon a reasonable request [MYA].

Abbreviations

WHO: World health organization
HS: Haemorrhagic stroke
IS: Ischaemic stroke
TC: Total cholesterol
LDL: Low-density lipoprotein
HDL: High-density lipoprotein
TG: Triglyceride
AIP: Atherogenic index of plasma
NCCT: Non-contrast computed tomography
HU: Hounsfield unit
NIHSS: National institutes of health stroke scale
AIS: Acute ischemic stroke
TIA: Transient ischemic attack
CSVD: Cerebral small vessel disease
sdLDL-C: small and dense LDL cholesterol
HDL-C: HDL cholesterol
CVD: Cardiovascular disease
WMHs: White matter hypodense lesions
BBB: Blood brain barrier
NINDS: National institute of neurological disorders and stroke
r-tPA: recombinant tissue plasminogen activator
LSM: Lesion-symptom mapping

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Received: 1 June 2025
Accepted: 13 July 2025
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