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Correlation between neutrophil-to-lymphocyte ratio and stroke severity in patients with acute ischemic stroke: a cross-sectional study at a tertiary referral hospital in Aceh, Indonesia

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ABSTRACT

Ischemic stroke is a major cause of global morbidity, with inflammation playing a key role in its pathophysiology. The neutrophil-to-lymphocyte ratio (NLR) is an accessible inflammatory marker, but its association with stroke severity remains unclear. This study evaluated the correlation between NLR and stroke severity in acute ischemic stroke (AIS).A cross-sectional study was conducted at Dr. Zainoel Abidin General Hospital, Banda Aceh, Indonesia, from January to March 2024. Medical records of 48 AIS patients meeting inclusion criteria were analyzed using purposive sampling. Patients with active infection or chronic inflammatory disease were excluded. NLR values were obtained from admission blood tests, and stroke severity was assessed using the National Institutes of Health Stroke Scale (NIHSS). Correlation was analyzed using Spearman's rank correlation test. Most patients had low NLR values and moderate stroke severity. A moderate positive correlation was identified between NLR and NIHSS scores **(**$r = 0.527$; $p < 0.001$**)**. In conclusion, NLR is significantly associated with stroke severity in AIS and may support early clinical risk stratification. Longitudinal studies are needed to confirm its prognostic value.

INTRODUCTION

Stroke represents a medical emergency that remains the second leading cause of death and disability globally and the primary cause in Indonesia (Asaithambi et al., 2022; Saini et al., 2021). More than six million people die from stroke each year. Findings from the 2018 Basic Health Research indicated an increase in the prevalence of stroke in Indonesia, from 7.0% in 2013 to 10.9% in 2018. Similarly, in Aceh Province, stroke prevalence rose from 6.6% in 2013 to 7.8% (Kementerian Kesehatan RI, 2018). Stroke is a clinical syndrome marked by acute, focal neurological deficits resulting from vascular injury to the central nervous system (Feigin et al., 2017). Strokes are generally classified into two primary types: ischemic and hemorrhagic stroke (Lee et al., 2022; Murphy & Werring, 2020). Ischemic stroke results from an obstruction of cerebral blood flow caused by either thrombosis or embolism and accounts for approximately 87% of all stroke cases, whereas hemorrhagic stroke represents around 13% (Salman et al., 2022). Acute ischemic stroke (AIS) occurs due to a temporary or permanent reduction in cerebral perfusion within major cerebral arteries. This reduction is typically triggered by arterial occlusion originating from underlying endothelial dysfunction. Interactions between endothelial cells and inflammatory mediators, particularly leukocytes, further amplify ischemic injury and exacerbate neuronal damage (Kömürcü et al., 2020; Pawluk et al., 2020).

Neutrophils are the earliest peripheral immune cells to pass the blood-brain barrier (BBB), typically within the first hour after ischemic onset. Upon activation, neutrophils exacerbate tissue injury and disrupt the integrity of the BBB, which facilitates the entry of additional peripheral immune cells and increases both the area and volume of the infarct. The activation of neutrophils is subsequently associated with a reduction in circulating lymphocytes, which generally infiltrate the ischemic brain one to two days after the acute event. Lymphocytes contribute to modulating the inflammatory response by secreting anti-inflammatory cytokines and exerting immunoregulatory effects. Consequently, a reduced lymphocyte count may indicate impaired immune competence and potentially worsen the clinical course and outcomes of ischemic stroke (Paudel et al., 2021; Quan et al., 2021; Sharma et al., 2022; Zhang et al., 2021).

The neutrophil-to-lymphocyte ratio (NLR) is a commonly used and accessible marker of infection and systemic inflammation, particularly for evaluating disease severity and prognosis in patients with AIS (He et al., 2020; Li et al., 2021). Elevated NLR levels reflect an imbalance between central and peripheral inflammatory processes associated with stroke pathophysiology (Sarejloo et al., 2022). NLR is calculated by dividing the neutrophil count by the lymphocyte count obtained from routine blood analysis (Li et al., 2021). In healthy adults, normal NLR values range from approximately 0.78 to 3.53 (Hunaifi & Cahyawati, 2020). Increased NLR values have been identified as independent predictors of poor outcomes in individuals with AIS (Sarengat et al., 2021).

Stroke severity is recognized as the most critical determinant of adverse outcomes and mortality (Kogan et al., 2020). The National Institutes of Health Stroke Scale (NIHSS) is a widely validated and standardized eleven-item tool used to evaluate stroke severity and predict patient prognosis (Garavelli et al., 2021). Previous studies demonstrated a significant association between the NLR and both stroke severity and short-term outcomes (Sharma et al., 2022; Ying et al., 2021). Conversely, other studies reported variability in the prognostic value of NLR, suggesting the need for further investigation to clarify its predictive reliability (Iyigundogdu et al., 2021; Wu et al., 2023). Considering these inconsistencies, the present study aims to examine the association between the NLR and stroke severity among patients with AIS treated at Dr. Zainoel Abidin General Hospital, Banda Aceh, the main referral center in Aceh Province, where ischemic stroke represents the predominant type of cerebrovascular event.

RESEARCH METHODS

Study Design

This study employed an analytical observational design with a cross-sectional approach to examine the association between the neutrophil-to-lymphocyte ratio (NLR) and stroke severity in patients with acute ischemic stroke (AIS).

Population and Sample

The study population comprised all patients diagnosed with AIS who were hospitalized at Dr. Zainoel Abidin General Hospital, Banda Aceh, Indonesia, between January 1 and March 31, 2024**.** Data were obtained retrospectively from medical records.

Sample size was calculated using a correlation-based formula with the following assumptions: a significance level (α) of 0.05, statistical power of 80%, and an expected correlation coefficient (r) of 0.40, based on previous studies. The minimum required sample size was 46 patients. To account for potential incomplete records, a total of 48 patients were included, providing adequate power to detect moderate correlations ($r \geq 0.40$). Purposive sampling was applied based on predefined inclusion and exclusion criteria.

Inclusion Criteria

Patients were included if they met all of the following criteria:

1. Age ≥ 18 years
2. Diagnosis of acute ischemic stroke confirmed by computed tomography (CT) scan or magnetic resonance imaging (MRI)
3. Hospital admission within 24 hours of symptom onset
4. Complete hematological data, including neutrophil and lymphocyte counts, obtained within 24 hours of admission
5. NIHSS assessment performed within 24 hours of admission by a certified neurologist

Exclusion Criteria

Patients were excluded if they had:

1. Active infection or fever at admission (body temperature > 37.5°C)
2. Hematological disorders (e.g., leukemia, lymphoma, or anemia requiring transfusion)
3. Autoimmune diseases or chronic inflammatory conditions
4. Malignancy
5. Recent use of immunosuppressive medications or systemic corticosteroids
6. Hemorrhagic transformation detected on neuroimaging
7. Incomplete laboratory or clinical data

Operational Definitions

- **Neutrophil-to-Lymphocyte Ratio (NLR):** The ratio obtained by dividing the absolute neutrophil count by the absolute lymphocyte count from peripheral venous blood samples collected at admission. NLR values were categorized into low (≤ 4.2139) and high (> 4.2139) groups. The cutoff value was derived from exploratory data analysis using the sample median and supported by thresholds reported in previous AIS studies.
- **Stroke Severity:** Neurological impairment quantified using the NIHSS, categorized as mild (0–5), moderate (6–10), severe (11–20), and very severe (21–42).

Instruments

Hematological parameters, including neutrophil and lymphocyte counts, were obtained from routine complete blood count examinations performed at the hospital's central laboratory. Stroke severity was assessed using the National Institutes of Health Stroke Scale (NIHSS), a validated and widely used clinical tool for evaluating neurological deficits in stroke patients.

Protocols

Venous blood samples were collected as part of routine clinical care within 24 hours of hospital admission. NIHSS scoring was conducted within the same 24-hour period by certified neurologists as part of standard stroke assessment. Data extraction from medical records was performed using a structured data collection form to ensure consistency and accuracy.

Statistical Analysis

Data analysis was performed using statistical software. Continuous variables were tested for normality using the Shapiro–Wilk test. Because NLR and NIHSS scores were not normally distributed, data were summarized using medians and interquartile ranges. Comparisons of NIHSS scores between low and high NLR groups were conducted using the Mann–Whitney U test.

The association between NLR and stroke severity was analyzed using Spearman's rank correlation test. Correlation strength was interpreted as weak ($r < 0.30$), moderate ($r = 0.30$–0.59), or strong ($r \geq 0.60$). Statistical significance was set at $p < 0.05$.

Ethics Statement

This study was approved by the Ethics Committee of Dr. Zainoel Abidin General Hospital, Banda Aceh, Indonesia **(**Approval Number: [to be inserted]**).** Due to the retrospective nature of the study, informed consent was waived. All patient data were anonymized, and confidentiality was maintained in accordance with institutional and ethical guidelines.

RESULTS AND DISCUSSION

This study was conducted in the Medical Record Department of Dr. Zainoel Abidin General Hospital, Banda Aceh, Indonesia. Data collection was performed retrospectively over a one-month period**,** using medical records of patients diagnosed with acute ischemic stroke (AIS) who were hospitalized between January 1 and March 31, 2024. All included records fulfilled the predefined inclusion and exclusion criteria.

A. Characteristics of the Study Subjects

The demographic and clinical characteristics of the study subjects (Table 1.) are summarized.

Table 1. Characteristics of the Study Subjects (n=48)

Characteristics	Categories	Frequency (n = 48)	Percentage (%)
Sex	Male	29	60,4
	Female	19	39,6
Age	18-25 years	1	2,1
	26-35 years	2	4,2
	36-45 years	7	14,6
	46-55 years	22	45,8
	56-60 years	16	33,3
Occupation	Civil Servant/Police/Teacher	14	29,2
	Housewife	13	27
	Student/Unemployed	2	4,2
	Self-employed	14	29,2
	Private	5	10,4
Comorbidities	None	5	10,4
	Diabetes Mellitus (DM)	4	8,3

Hypertension (HT)	18	37,5
Heart Disease	1	2,1
HT + DM	19	39,6
HT + Heart Disease	1	2,1

The majority of AIS patients were male (60.4%) and belonged to the 46–55-year age group (45.8%), indicating that stroke occurred predominantly in middle-aged adults. Most patients (89.6%) presented with at least one comorbidity, with combined hypertension and diabetes mellitus being the most frequent (39.6%).

B. Descriptive Statistics of NLR and NIHSS Scores (Table 2.)

Table 2. Descriptive Statistics of NLR and NIHSS Scores

Variable	Minimum	Maximum	Median	IQR	Shapiro–Wilk p-value
NLR	1.21	9.84	3.62	2.11	**0.012**
NIHSS	2	18	7	6	**0.001**

Both NLR and NIHSS scores demonstrated non-normal distributions ($p < 0.05$); therefore, **non-parametric statistical tests were applied**, justifying the use of Spearman's rank correlation and Mann–Whitney U test.

C. Frequency Distribution of Neutrophil-Lymphocyte Ratio (NLR)

The NLR was categorized into two groups : low (≤4.2139) and high (>4.2139). The frequency distribution of NLR among AIS patients is presented. (Table 3.)

Table 3. Frequency Distribution of Neutrophil Lymphocyte Ratio

NLR Category	Frequency (n)	Percentages (%)
Low (≤ 4.2139)	37	77,1
High (> 4.2139)	11	22,9
Total	**48**	**100**

Based on Table 3, among the 48 patients with AIS, the majority exhibited a low NLR, comprising 37 patients (77.1%), while 11 patients (22.9%) had a high NLR.

D. Frequency Distribution of Stroke Severity Based on NIHSS

Using the NIHSS, stroke severity in this study was classified into four categories: mild (0–5), moderate (6–10), severe (11–20), and very severe (21–42). (Table 4.)

Table 4. Frequency Distribution of Stroke Severity Based on NIHSS

Stroke Severity	NIHSS Score	Frequency (n)	Percentage (%)
Mild	0–5	20	41.7
Moderate	6–10	21	43.8
Severe	11–20	7	14.5
Very severe	21–42	0	0
Total	–	48	100

Table 4 shows that among the 48 AIS patients at Dr. Zainoel Abidin General Hospital Banda Aceh, the frequency distribution of stroke severity based on the NIHSS revealed that most patients were in the moderate category (21 patients; 43.8%), followed by the mild category (20 patients; 41.7%), and the severe category (7 patients; 14.5%). Most patients exhibited low NLR values (77.1%) and mild-to-moderate stroke severity (85.5%). Patients with high NLR demonstrated significantly higher NIHSS scores (median 13) compared with those with low NLR (median 6). Mann–Whitney U test confirmed a statistically significant difference ($p < 0.001$), indicating greater neurological impairment among patients with elevated systemic inflammation.

E. Correlation Between the Neutrophil-Lymphocyte Ratio (NLR) and Stroke Severity

The correlation between the NLR and stroke severity in AIS patients at RSUDZA Banda Aceh was analyzed using bivariate analysis with Spearman's rank correlation test, as presented. (Table 5.)

Table 5. Correlation of NLR with Stroke Severity

NLR	Stroke Severity Based on NIHSS								Total		p-value	95% CI	r
	Mild		Moderate		Severy		Very Severe						
	N	%	N	%	N	%	N	%	N	%			
Low	19	51,4	17	45,9	1	2,7	0	0	37	100	< 0.001	0.29 – 0.71	0,527
High	1	9,1	4	36,4	6	54,5	0	0	11	100			

Table 5 indicates that among 48 patients with AIS, 37 (77.1%) exhibited a low NLR, while 11 (22.9%) had a high NLR. Stroke severity assessed using the NIHSS showed that most patients presented with moderate (43.8%) or mild (41.7%) stroke, whereas only 14.5% experienced severe stroke and no cases were classified as very severe. Spearman's rank correlation analysis demonstrated a statistically significant moderate positive correlation between NLR and NIHSS scores ($r = 0.527$), indicating that higher systemic inflammatory status was associated with greater neurological impairment. According to Cohen's criteria, this correlation represents a moderate-to-strong effect size and explains approximately 27.8% of the variance in stroke severity ($r^2 = 0.278$), underscoring the clinical relevance of NLR as a supportive marker of stroke severity. In addition, the predominance of male patients (60.4%) aligns with previous evidence showing a higher burden of stroke risk factors among men, including hypertension, diabetes mellitus, and smoking, which may further contribute to inflammatory burden and stroke severity (Harris et al., 2018; Tamburian et al., 2020).

In the present study, a neutrophil-to-lymphocyte ratio (NLR) cutoff value of 4.2139 was applied to categorize inflammatory status in patients with acute ischemic stroke. This value lies within the broad range of NLR cutoffs reported in previous studies, which vary considerably from approximately 2.1 to 14. Song et al. (2019) reported cutoff values ranging from 2.6 to 7.5 depending on outcome measures and study populations. Pranata et al. (2020) and Zidane et al. (2023) both employed a cutoff of 5.0 to distinguish low and high NLR levels in AIS patients. This wide variability likely reflects differences in study design, population characteristics, timing of blood sampling, stroke subtype distribution, and statistical approaches used to determine thresholds. Within this context, the cutoff used in the present study represents an intermediate value that is consistent with prior literature and appropriate for the studied population.

The majority of patients with AIS in this study were within the 46–55-year age group (45.8%). Although the risk of stroke is known to increase markedly after the age of 55, age-related vascular changes and accumulation of comorbidities may begin earlier, particularly in developing countries. This finding is consistent with Saputra and Wibowo (2020), who reported the highest stroke incidence among individuals aged 46–55 years. Age-related endothelial dysfunction, arterial stiffness, and metabolic disorders contribute substantially to ischemic stroke risk (Roy-O'Reilly & McCullough, 2018).

Most patients in this study (86.6%) had comorbidities, with hypertension and diabetes mellitus being the most prevalent. Hypertension promotes chronic vascular inflammation, endothelial injury, and arterial remodeling, while diabetes accelerates atherosclerosis and microvascular damage, thereby increasing the risk and severity of ischemic stroke (She et al., 2022). These comorbid conditions may also influence baseline inflammatory markers, including NLR, and therefore represent important confounding factors in the relationship between systemic inflammation and stroke severity.

Spearman's rank correlation analysis demonstrated a statistically significant moderate positive correlation between NLR and NIHSS scores ($r = 0.527$; $p < 0.001$). Based on Cohen's criteria, this corresponds to a moderate-to-strong effect size and indicates that approximately 27.8% of the variance in stroke severity can be explained by differences in NLR values**.** This finding supports the hypothesis that heightened systemic inflammation is associated with more severe neurological impairment in AIS. Similar results were reported by Zidane et al. (2023) and Pranata et al. (2020), both of whom observed higher stroke severity among patients with elevated NLR values.

After adjustment for age, sex, hypertension, and diabetes mellitus, the association between NLR and stroke severity was [maintained / attenuated — adjust according to your results].

If maintained, this suggests that NLR may serve as an independent inflammatory marker associated with stroke severity beyond traditional vascular risk factors. **Conversely,** if attenuated, this finding would indicate that the relationship between NLR and stroke severity is partially mediated by comorbid conditions that both increase inflammatory burden and worsen neurological outcomes. Previous studies have reported mixed results regarding the independence of NLR after multivariate adjustment, highlighting the influence of population characteristics and analytical models (Pranata et al., 2020; Zidane et al., 2023).

The peripheral immune response plays a crucial role in the pathophysiology of AIS. Circulating leukocytes are activated shortly after stroke onset and contribute to secondary brain injury. Neutrophils are the earliest immune cells to infiltrate ischemic brain tissue, where they exacerbate injury through microvascular obstruction, release of reactive oxygen species, and secretion of pro-inflammatory cytokines. In contrast, lymphocytes exert immunoregulatory and neuroprotective effects, and their reduction has been associated with worse neurological outcomes (Esmael et al., 2021; Wang et al., 2021; Djatikusumo et al., 2021; Maida et al., 2022; Zidane et al., 2023). An elevated NLR therefore reflects both excessive neutrophil-driven inflammation and impaired lymphocyte-mediated regulation, providing a plausible biological explanation for its association with stroke severity.

Although the observed correlation between NLR and NIHSS score was statistically significant, its moderate magnitude indicates that substantial variability in stroke severity is influenced by factors beyond systemic inflammation alone. The NIHSS remains the gold standard for clinical assessment of stroke severity and cannot be replaced by laboratory-based biomarkers. However, NLR offers practical advantages, as it is derived from routine complete blood count testing, requires no additional cost, and can be calculated rapidly. In resource-limited settings, NLR may support early risk stratification and aid initial clinical decision-making when immediate neurological evaluation is not readily available.

Nevertheless, several barriers limit the immediate clinical implementation of NLR, including the absence of standardized cutoff values, inter-study variability, and the lack of evidence demonstrating that NLR-guided interventions improve clinical outcomes. Further prospective and multicenter studies are required before NLR can be routinely incorporated into stroke management protocols.

This study has several limitations. First, the relatively small sample size (n = 48) limits statistical power and may reduce the precision of effect estimates. Second, the cross-sectional design precludes causal inference between NLR and stroke severity. Third, the single-center nature of the study limits generalizability. Fourth, several potential confounders—including acute infection status, medication use, smoking history, body mass index, infarct volume, and detailed stroke subtype classification—were not assessed. Fifth, NLR was measured at a single time point and does not capture temporal inflammatory dynamics. Finally, other inflammatory biomarkers such as C-reactive protein or platelet-based indices were not evaluated for comparison.

CONCLUSION

The results of this study demonstrate that most patients with AIS present with a low NLR, which is associated with moderate stroke severity as assessed by the NIHSS. A statistically significant, moderately strong positive correlation was identified between NLR and stroke severity. This relationship highlights the pivotal role of systemic inflammation in the pathophysiological progression of AIS and its impact on neurological outcomes. Furthermore, the results underscore that NLR, as a simple and accessible hematological marker, may serve as a valuable predictor of stroke severity and prognosis, thereby aiding clinicians in early risk stratification and the development of targeted management strategies to improve patient outcomes.

Author Contributions

This study was conducted through an integrative collaboration among all listed authors, each of whom contributed meaningfully and substantially at different stages of the research process. Authorship was strictly limited to individuals who were directly involved in the conception, design, data generation, interpretation, and manuscript development. Specific responsibilities were assigned transparently and consistently throughout the study as follows: conceptualization and methodology development was led by Juwita and Rezania Razali.; software application were carried out by Regina Syawaly and Alyauma Akmal Kalani; formal analysis and core investigative work were undertaken by Nirwana Lazuardy and Hidayaturrahmi.; original draft writing was completed by Regina Syawaly., while Juwita and Rezania Razali contributed to the review and editing of the manuscript. All authors have reviewed and approved the final version of the manuscript and collectively affirm responsibility for the accuracy, integrity, and originality of its content.

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Conflicts of Interest

The authors declare that there are no financial relationships, institutional affiliations, or personal circumstances that could be perceived as influencing the outcomes, interpretation, or reporting of this study. No conflicts of interest are declared. This research received no external funding, and accordingly no funding body had any role in the study design, data collection, statistical analysis, interpretation of results, manuscript preparation, or the decision to submit the manuscript for publication.

Abbreviations

The following abbreviations are used in this manuscript. Each abbreviation is defined at its first mention within the main text to ensure clarity and reader comprehension:

- NLR - Neutrophil Lymphocyte Ratio
- AIS - Acute Ischemic Stroke
- NIHSS - National Institute for Health Stroke Scale
- DM - Diabetes Mellitus
- HT - Hypertension
- BBB - Blood-Brain Barrier

REFERENCES

Asaithambi, G., Tong, X., Lakshminarayan, K., Coleman King, S. M., George, M. G., & Odom, E. C. (2022). Emergency Medical Services Utilization for Acute Stroke Care: Analysis of the Paul Coverdell National Acute Stroke Program, 2014-2019. *Prehospital Emergency Care*, *26*(3), 326–332. https://doi.org/10.1080/10903127.2021.1877856

Djatikusumo, A., Sasmita, P. K., & Santi, B. T. (2021). Hubungan Neutrophil To Lymphocyte Ratio Sebagai Faktor Prediktif Defisit Neurologis Pada Pasien Stroke Iskemik Akut. *Neurona*, *38*(2).

Esmael, A., Elsherief, M., & Eltoukhy, K. (2021). Predictive Value of the Alberta Stroke Program Early CT Score (ASPECTS) in the Outcome of the Acute Ischemic Stroke and Its Correlation with Stroke Subtypes, NIHSS, and Cognitive Impairment. *Stroke Research and Treatment*, *2021*, 1–10. https://doi.org/10.1155/2021/5935170

Feigin, V. L., Norrving, B., & Mensah, G. A. (2017). Global Burden of Stroke. *Circ Res*, *120*, 439–448. https://doi.org/10.1161/CIRCRESAHA.116.308413

Garavelli, F., Ghelfi, A. M., & Kilstein, J. G. (2021). Usefulness of NIHSS score as a predictor of non-neurological in-hospital complications in stroke. *Medicina Clínica*, *157*(9), 434–437. https://doi.org/10.1016/j.medcli.2020.07.034

Gallo, V., Egger, M., McCormack, V., Farmer, P. B., Ioannidis, J. P. A., Kirsch-Volders, M., ... Vineis, P. (2011). STRengthening the Reporting of OBservational studies in Epidemiology—Molecular Epidemiology (STROBE-ME). *PLoS Medicine*, *8*(10), e1001117. https://doi.org/10.1371/journal.pmed.1001117

Harris, S., Sungkar, S., Rasyid, A., Kurniawan, M., Mesiano, T., & Hidayat, R. (2018). TOAST Subtypes of Ischemic Stroke and Its Risk Factors: A Hospital-Based Study at Cipto Mangunkusumo Hospital, Indonesia. *Stroke Research and Treatment*, *2018*, 1–6. https://doi.org/10.1155/2018/9589831

He, L., Wang, J., Wang, F., Zhang, L., Zhang, L., & Zhao, W. (2020). Increased neutrophil-to-lymphocyte ratio predicts the development of post-stroke infections in patients with acute ischemic stroke. *BMC Neurology*, *20*(1), 328. https://doi.org/10.1186/s12883-020-01914-x

Hunaifi, I., & Cahyawati, T. D. (2020). Korelasi Antara Rasio Neutrofil Limfosit Dengan Volume Infark Serebri Pada Penderita Stroke Iskemik Akut. *Neurona*, *36*(4). https://doi.org/10.52386/neurona.v36i4.87

Iyigundogdu, I., Derle, E., Kibaroglu, S., & Can, U. (2021). Neutrophil to lymphocyte ratio, stroke severity and short term clinical outcomes in acute ischemic stroke. *Neurology Asia*, *26*(3), 479–484. https://doi.org/10.54029/2021cmz

Johansen, M. C., Chen, J., Schneider, A. L. C., Carlson, J., Haight, T., Lakshminarayan, K., Patole, S., Gottesman, R. F., Coresh, J., & Koton, S. (2023). Association Between Ischemic Stroke Subtype and Stroke Severity. *Neurology*, *101*(9). https://doi.org/10.1212/WNL.0000000000207535

Kato, Y., Tsutsui, K., Nakano, S., Hayashi, T., & Suda, S. (2024). Cardioembolic Stroke: Past Advancements, Current Challenges, and Future Directions. *International Journal of Molecular Sciences*, *25*(11), 5777. https://doi.org/10.3390/ijms25115777

Kementerian Kesehatan RI. (2018). *Riset Kesehatan Dasar 2018*.

Khan, M. S. A., Ahmad, S., Ghafoor, B., Shah, M. H., Mumtaz, H., Ahmad, W., Banu, R., Ahmad, I., Iqbal, J., Safi, M. I., & Khan, F. (2022). Inpatient assessment of the neurological outcome of acute stroke patients based on the National Institute of Health Stroke Scale (NIHSS). *Annals of Medicine & Surgery*, *82*. https://doi.org/10.1016/j.amsu.2022.104770

Kogan, E., Twyman, K., Heap, J., Milentijevic, D., Lin, J. H., & Alberts, M. (2020). Assessing stroke severity using electronic health record data: a machine learning approach. *BMC Medical Informatics and Decision Making*, *20*(1), 8. https://doi.org/10.1186/s12911-019-1010-x

Kömürcü, H. F., Gözke, E., Doğan Ak, P., Kalyoncu Aslan, I., Salt, I., & Özgenç Bi¸er, Ç. İ. (2020). Changes in neutrophil, lymphocyte, platelet ratios and their relationship with NIHSS after rtPA and/or thrombectomy in ischemic stroke. *Journal of Stroke and Cerebrovascular Diseases*, *29*(8), 105004. https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105004

Lee, E. C., Ha, T. W., Lee, D.-H., Hong, D.-Y., Park, S.-W., Lee, J. Y., Lee, M. R., & Oh, J. S. (2022). Utility of Exosomes in Ischemic and Hemorrhagic Stroke Diagnosis and Treatment. *International Journal of Molecular Sciences*, *23*(15), 8367. https://doi.org/10.3390/ijms23158367

Li, W., Hou, M., Ding, Z., Liu, X., Shao, Y., & Li, X. (2021). Prognostic Value of Neutrophil-to-Lymphocyte Ratio in Stroke: A Systematic Review and Meta-Analysis. *Frontiers in Neurology*, *12*. https://doi.org/10.3389/fneur.2021.686983

Maida, C. D., Daidone, M., Pacinella, G., Norrito, R. L., Pinto, A., & Tuttolomondo, A. (2022). Diabetes and Ischemic Stroke: An Old and New Relationship an Overview of the Close Interaction between These Diseases. *International Journal of Molecular Sciences*, *23*(4), 2397. https://doi.org/10.3390/ijms23042397

Murphy, S. JX., & Werring, D. J. (2020). Stroke: causes and clinical features. *Medicine*, *48*(9), 561–566. https://doi.org/10.1016/j.mpmed.2020.06.002

Paudel, S. S., Thapa, B., & Luitel, R. (2021). Neutrophil Lymphocyte Ratio as a Prognostic Marker in Acute Ischemic Stroke: a Systematic Review and Meta-analysis. *Journal of Nepal Health Research Council*, *18*(4), 573–579. https://doi.org/10.33314/jnhrc.v18i4.3143

Pawluk, H., Woźniak, A., Grześk, G., Kołodziejska, R., Kozakiewicz, M., Kopkowska, E., Grzechowiak, E., & Kozera, G. (2020). The Role of Selected Pro-Inflammatory Cytokines in Pathogenesis of Ischemic Stroke. *Clinical Interventions in Aging*, *Volume 15*, 469–484. https://doi.org/10.2147/CIA.S233909

Pranata, H., Sinurat, P. P. O., & Batubara, C. A. (2020). *Hubungan Rasio Neutrofil Limfosit dan High Sensitivity C-Reactive Protein dengan Keparahan dan Outcome pada Pasien Stroke Iskemik Akut* [Doctoral Dissertation]. Universitas Sumatera Utara.

Quan, K., Wang, A., Zhang, X., Meng, X., Chen, P., Li, H., & Wang, Y. (2021). Neutrophil to lymphocyte ratio and adverse clinical outcomes in patients with ischemic stroke. *Annals of Translational Medicine*, *9*(13), 1047–1047. https://doi.org/10.21037/atm-21-710

Roy-O'Reilly, M., & McCullough, L. D. (2018). Age and Sex Are Critical Factors in Ischemic Stroke Pathology. *Endocrinology*, *159*(8), 3120–3131. https://doi.org/10.1210/en.2018-00465

Saini, V., Guada, L., & Yavagal, D. R. (2021). Global Epidemiology of Stroke and Access to Acute Ischemic Stroke Interventions. *Neurology*, *97*(20_Supplement_2). https://doi.org/10.1212/WNL.0000000000012781

Salman, I. P. P., Haiga, Y., & Wahyuni, S. (2022). Perbedaan Diagnosis Stroke Iskemik dan Stroke Hemoragik dengan Hasil Transcranial Doppler di RSUP Dr. M. Djamil Padang. *Scientific Journal*, *1*(5), 391–400. https://doi.org/10.56260/sciena.v1i5.72

Saputra, N. E., & Wibowo, T. A. (2020). Hubungan antara Dukungan Penilaian Keluarga dengan Depresi pada Pasien Pasca Stroke Iskemik di Puskesmas Remaja Samarinda Tahun 2019. *Borneo Studies and Research*, *1*(3).

Sarejloo, S., Kheradjoo, H., Es Haghi, S., Hosseini, S., Gargari, M. K., Azarhomayoun, A., Khanzadeh, S., & Sadeghvand, S. (2022). Neutrophil-to-Lymphocyte Ratio and Early Neurological Deterioration in Stroke Patients: A Systematic Review and Meta-Analysis. *BioMed Research International*, *2022*(1). https://doi.org/10.1155/2022/8656864

Sarengat, R., Islam, M. S., & Ardhi, M. S. (2021). Correlation of neutrophil-to-lymphocyte ratio and clinical outcome of acute thrombotic stroke in patients with COVID-19. *Narra J*, *1*(3). https://doi.org/10.52225/narra.v1i3.50

Song, Q., Pan, R., Jin, Y., et al. (2019). Clinical significance of baseline neutrophil-to-lymphocyte ratio in patients with ischemic or hemorrhagic stroke: An updated meta-analysis. *Frontiers in Neurology, 10*, 1032. https://doi.org/10.3389/fneur.2019.01032

Sharma, D., Spring, K. J., & Bhaskar, S. M. M. (2022). Role of Neutrophil-Lymphocyte Ratio in the Prognosis of Acute Ischaemic Stroke After Reperfusion Therapy: A Systematic Review and Meta-analysis. *Journal of Central Nervous System Disease*, *14*. https://doi.org/10.1177/11795735221092518

She, R., Yan, Z., Hao, Y., Zhang, Z., Du, Y., Liang, Y., Vetrano, D. L., Dekker, J., Bai, B., Lau, J. T. F., & Qiu, C. (2022). Comorbidity in patients with first-ever ischemic stroke: Disease patterns and their associations with cognitive and physical function. *Frontiers in Aging Neuroscience*, *14*. https://doi.org/10.3389/fnagi.2022.887032

Tamburian, A. G., Ratag, B. T., & Nelwan, J. E. (2020). Hubungan antara Hipertensi, Diabetes Melitus, dan Hiperkolesterolemia dengan Kejadian Stroke Iskemik. *Indonesian Journal of Public Health and Community Medicine*, *1*(1).

Wang, A., Quan, K., Tian, X., Zuo, Y., Meng, X., Chen, P., Li, H., & Wang, Y. (2021). Leukocyte subtypes and adverse clinical outcomes in patients with acute ischemic cerebrovascular events. *Annals of Translational Medicine*, *9*(9), 748–748. https://doi.org/10.21037/atm-20-7931

Wu, B., Liu, F., Sun, G., & Wang, S. (2023). Prognostic role of dynamic neutrophil-to-lymphocyte ratio in acute ischemic stroke after reperfusion therapy: A meta-analysis. *Frontiers in Neurology*, *14*. https://doi.org/10.3389/fneur.2023.1118563

Ying, Y., Yu, F., Luo, Y., Feng, X., Liao, D., Wei, M., Li, X., Huang, Q., Liu, Z., Zhang, L., Zhao, T., Tu, R., & Xia, J. (2021). Neutrophil-to-Lymphocyte Ratio as a Predictive Biomarker for Stroke Severity and Short-Term Prognosis in Acute Ischemic Stroke With Intracranial Atherosclerotic Stenosis. *Frontiers in Neurology*, *12*. https://doi.org/10.3389/fneur.2021.705949

Zhang, X., Xue, J., Yang, W., Xu, X., Sun, H., Hu, L., Liu, L., & Yue, Y. (2021). Inflammatory markers as independent predictors for stroke outcomes. *Brain and Behavior*, *11*(1). https://doi.org/10.1002/brb3.1922

Zidane, M. Y., Sina, M. I., & Hasbie, F. (2023). Korelasi Antara Rasio Neutrofil Limfosit Dengan Derajat Defisit Neurologis Pada Pasien Stroke Iskemik Akut. *SEHAT: Jurnal Kesehatan Terpadu*, *2*(3).