JMU
Jurnal Medika Udayana

ISSN: 2597-8012 JURNAL MEDIKA UDAYANA, VOL. 15 NO.10, OKTOBER, 2026

Received: 2026-08-13 Revision: 2026-09-13 Accepted: 30-09-2026

CORRELATION BETWEEN LEUKOCYTE COUNT AND THE SEVERITY OF ACUTE ISCHEMIC STROKE AT NGOERAH HOSPITAL

Margaretha Jesslyn Natalie Pantoro[1], Ni Kadek Mulyantari[2], Sianny Herawati[2], Anak Agung Ngurah Subawa[2]
[1.] Bachelor of Medicine Study Program, Faculty of Medicine, Udayana University, Denpasar, Bali
[2.] Department of Clinical Pathology, Faculty of Medicine, Udayana University/Prof. Dr. I.G.N.G. Ngoerah Hospital, Denpasar, Bali

Corresponding Author
Margaretha Jesslyn Natalie Pantoro
Bachelor of Medicine Study Program, Faculty of Medicine, Udayana University, Denpasar, Bali
E-mail: margaretha.jesslyn03@student.unud.ac.id

ABSTRACT

Background: Acute ischemic stroke is a leading cause of disability and death worldwide, with a prevalence that continues to rise, particularly in Indonesia. One important indicator in determining stroke severity is the leukocyte count, which can provide insight into the body's inflammatory response to brain damage. This study aims to evaluate the correlation between leukocyte count and the severity of acute ischemic stroke, measured using the National Institutes of Health Stroke Scale (NIHSS).
Objective: This research aims to determine the relationship between blood leukocyte count and the severity of acute ischemic stroke at Ngoerah Hospital.
Methods: This is an analytical observational study with a cross-sectional design. Data were collected retrospectively using a total sampling technique from the medical records of acute ischemic stroke patients admitted to Ngoerah Hospital from July to December 2023. The leukocyte count and NIHSS score of the patients were analyzed using the Spearman correlation test, considering the non-normal data distribution.
Results: Data analysis showed a significant positive correlation ($r = 0.240$) between leukocyte count and NIHSS score, with a p-value < 0.05. This indicates that the higher the leukocyte count, the more severe the stroke experienced by the patients.
Conclusion: There is a weak but significant correlation between leukocyte count and the severity of acute ischemic stroke in patients at Ngoerah Hospital.
Keywords: Acute Ischemic Stroke, Leukocyte, NIHSS, Correlation

INTRODUCTION

Stroke is the second leading cause of death globally, with 5.5 million deaths annually. [1] Over the past 20 years, stroke cases have risen significantly worldwide [2]. The World Health Organization predicts stroke incidence in Europe will increase from 1.1 million to 1.5 million annually by 2025. [3] Stroke is also the leading cause of disability, with half of survivors living with chronic impairments. [4] Globally, one in four people is at high risk of stroke during their lifetime. [5]

In Indonesia, stroke prevalence has risen sharply, posing a significant public health burden. According to Riskesdas data, ischemic stroke was the leading cause of death in 2007, with a mortality rate of 15.4%. In 2018, stroke prevalence increased 56%, from 0.7% in 2013 to 1.09%. [6] The World Health Organization defines stroke as a disruption of blood flow to the brain due to vascular lesions, causing reduced oxygen and nutrient supply, leading to brain cell death.

Strokes are categorized into ischemic (caused by blocked arteries) and hemorrhagic (caused by ruptured blood vessels). [7] Ischemic stroke is the most common globally, accounting for 80% of cases and 52.9% of strokes in Indonesia. Preventing ischemic stroke is vital, focusing on understanding its mechanisms and indicators. [1] Research shows that leukocyte count, an inflammatory marker, correlates with stroke severity. High leukocyte levels indicate severe brain injury and are associated with increased disability and mortality. [9] During ischemic stroke, leukocytes contribute to further vascular damage through inflammation, known as secondary injury. [9] Leukocyte recruitment and activation worsen brain tissue damage. [10] However, methods for predicting stroke outcomes remain inconsistent. This study aims to explore the relationship between leukocyte count and clinical severity in acute ischemic stroke patients using the NIH Stroke Scale (NIHSS). [11,12]

LITERATURE REVIEW

Ischemic Stroke

Definition

Ischemic stroke is a focal neurological disorder caused by an interruption or reduction of arterial blood flow to specific parts of the brain, spinal cord, or retina. This results in insufficient blood and oxygen supply to brain tissues.[8,13,14] Acute ischemic stroke or transient ischemic attack (TIA) is characterized by neurological deficits lasting less than 24 hours from symptom onset.[15]

Epidemiology

Stroke, as the most common cerebrovascular accident (CVA), is the second leading cause of death globally, with an annual mortality rate of 5.5 million. One in four individuals worldwide is at significant risk of experiencing this pathological condition during their lifetime.[5] Research over the past 20 years highlights a substantial global increase in the number of stroke patients.[2]

Several studies identify ischemic stroke as the most common type of stroke worldwide, accounting for approximately 80% of all stroke cases.[1] A study by INTERSTROKE across 22 countries reported that ischemic stroke constitutes 66% of strokes in developing regions like Africa and 91% in developed countries.[16] In Indonesia, ischemic stroke is also the most prevalent types of stroke, representing 52.9% of all stroke cases, followed by intracerebral hemorrhage, embolism, and subarachnoid hemorrhage.[15]

Etiology and Risk Factors

Ischemic stroke occurs when a clot (thrombus or embolus) blocks blood flow to the brain, often due to fatty deposits (plaques) in arteries like carotid artery (78.1%), middle cerebral artery (60%), and small blood vessels (62.4%) .[15,17]. These plaques form from factors such as a high-cholesterol diet or smoking, leading to thicker, rougher blood vessel walls and reduced blood flow. [15] If the plaque ruptures, it can form an embolus that obstructs brain blood vessels.[21]

There are two types of ischemic stroke: embolic stroke, blockage in artery caused by a clot originating outside the brain (e.g., from the heart due to myocardial infarction, heart valve abnormalities, atrial fibrillation or a ruptured plaque in the carotid artery or damaged aorta, or from proximal arterial atherosclerosis), and thrombotic stroke, caused by blockages in brain arteries due to severe atherosclerosis. [21]

Risk factors for stroke include modifiable and non-modifiable factors. Modifiable risks (according to recent studies from INTERSTROKE account for 90% of strokes) include hypertension (50.56%), hyperlipidemia (15.34%), diabetes mellitus (19.88%), emotional stress, cardiovascular diseases (coronary artery disease, atrial fibrillation) (4.54%, 6.25%), and poor lifestyle (lack of physical activity, high cholesterol diet, and smoking.[17,22,23] Non-modifiable factors include age, race, gender, and family history (1.13%).[17,24,25]

Studies have found a positive and significant correlation between hypertension and ischemic stroke. Hypertension makes an individual three to four times more likely to suffer a stroke due to its effect on cerebral circulation.[26] This condition leads to hypertrophy of the blood vessel walls, reducing the lumen diameter, and alters the endothelial cells' ability to release vasoactive factors, increasing constriction factors in the systemic and cerebral arteries.[26] Diabetes mellitus, the second most common risk factor, is associated with increased stroke incidence. Previous studies reinforce this evidence.[27,28] Study found that 29.3% of stroke patients had hyperglycemia.[28] Diabetic patients are twice as likely to experience a stroke compared to those without diabetes mellitus. Emotional stress has also been shown to affect the heart and blood vessels, increasing the risk of a stroke attack.[28]

Several cardiovascular diseases, such as coronary artery disease, rheumatic heart disease, and patients with synthetic heart valves, also increase stroke risk. Studies have shown that atrial fibrillation causes static blood flow and disturbances in heart pump rhythm, which increases thrombus formation. An embolus can detach and block blood flow in the brain. Smoking contributes significantly to stroke-related deaths, with around 17,800 cases annually in the United States. This indicates the substantial role of smoking in stroke leading to death, with a 12%-14% mortality rate.[29] Additionally, nicotine buildup in smokers' blood vessels leads to atherosclerosis and stroke. People with a high cholesterol diet and low physical activity are prone to obesity, diabetes mellitus, atherosclerosis, and heart disease.[30] Age plays a significant role, as stroke incidence rises with age, especially after 55 years. Most strokes occur in individuals over 55, with rates increasing as people age.[33 31,32]

Pathophysiology

The pathophysiology of ischemic stroke generally consists of two stages: changes in brain blood flow and changes in brain cells due to ischemia. Ischemic stroke, based on its etiology, has two subtypes: embolic stroke and thrombotic stroke in the brain.[16] In thrombotic stroke, the process begins with narrowing of the blood vessel lumen due to thrombosis from severe atherosclerotic plaques, which obstructs blood flow to the brain. In embolic stroke, the obstruction occurs because a clot, initially formed in the heart's blood vessels or other vessels, detaches, travels through circulation, and eventually blocks blood vessels in the brain. The reduction of blood flow to brain areas causes brain cells to experience a deficiency of nutrients and oxygen. Cells deprived of oxygen and glucose will lead to acidosis (increased lactic acid in the cells). This is followed by the influx of sodium chloride and water into brain cells, while potassium compounds exit, resulting in local edema.[21]

Reduced blood flow to the brain causes severe stress and premature cell death (necrosis). Necrosis is followed by disruption of plasma membranes, swelling of organelles, leakage of cellular contents into the extracellular space, and loss of nerve function.[30] Therefore, it can be concluded that important events contributing to stroke pathology include inflammation, energy failure, loss of homeostasis, acidosis, increased intracellular calcium levels, excitotoxicity, toxicity mediated by free radicals, cytokine-mediated cytotoxicity, complement activation, blood-brain barrier disruption, glial cell activation, oxidative stress, and leukocyte infiltration.[30,34]

Sign and Symptoms

Stroke are characterized by sudden weakness or numbness on one side of the body, changes in consciousness, difficulty speaking, and communication problems (slurred speech),

difficulties in understanding speech, and vision disturbances.[7] According to WHO, the signs and symptoms of ischemic stroke depend on the area of the brain affected. Parietal lobe, related to somatic sensations and spatial awareness. Temporal lobe, related to sensory functions and memory. Occipital lobe, related to visual function. Frontal lobe, related to mental, emotional, and intellectual functions.

Stroke can affect body functions, with several disturbances commonly found in patients. Effects on mental status which is unconsciousness. Effects on physical effects are weakness of limbs, facial muscle weakness, difficulty swallowing, sensory disturbances, vision disturbances, hemiplegia (one-sided paralysis). Effects on communication are aphasia (inability to speak), dysarthria (unclear speech, slurred). Additionally, there may be difficulty walking, loss of balance, and prolonged headaches (vertigo).[36]

However, the distinction between ischemic and hemorrhagic stroke is that ischemic stroke does not usually involve headaches, and if there is pain, it is milder compared to hemorrhagic stroke.[37]

Diagnosis

The diagnosis procedure of ischemic stroke involves two stages: confirming that it is a stroke and determining its cause. The diagnosis can begin with an interview with the patient, family, or friends to review history such as family medical history, previous stroke history, onset and frequency of symptoms, and medication use.[14] A physical examination can then be conducted to reveal aspects that may not be detected through an interview.[14] High blood pressure, heart enlargement or murmurs, and vascular bruit are examples of physical findings that influence stroke identification.[14]

For a complete stroke examination, it is recommended to use the NIHSS stroke scale. The NIHSS (National Institutes of Health Stroke Scale) is one of neurological examination which can be conducted to identify and measure the degree of physical impairments and neurological deficits. Severity degrees are as follows: 1-4 mild, 4-20 moderate, and above 20 severe; with a maximum score of 42.[38] Its advantages include being a trained, measurable, certified, and accredited system (http://www.nihstrokescale.org/), with a fast execution time (≤10 minutes).[39]

Once a diagnosis is made, confirming that the patient is indeed experiencing a stroke and not other similar symptoms (such as seizures, sepsis, migraine, or brain tumors) can be supported by neurological examinations and confirmed through brain imaging (CT scan or MRI). Brain imaging should ideally be performed within 20 minutes of patient arrival, as the patient may be a candidate for IV alteplase and/or mechanical thrombectomy.[38] Studies have found that CT scans detect about 90% of ischemic stroke cases.[38] Conventional CT results are sufficient to determine if the stroke is hemorrhagic or not (Powers et al., 2018). [38]However, patients with this condition are more likely to be advised to undergo MRI, as MRI has much greater sensitivity for ischemia compared to CT scans, especially in mild strokes, where it can predict both short-term and long-term adverse outcomes.[40]

The vascular cause can be estimated based on how acute the symptoms are, when they started, how frequent they are, the patient's age, and the presence of stroke risk factors. Tests to confirm the diagnosis of stroke include CT scan, MRI of the brain, while tests to determine the cause of stroke include blood hematology tests, and non-invasive tests such as echocardiography, carotid duplex, EEG, and MRA. Invasive tests include cerebral angiography and cerebrospinal fluid examination. The gold standard for determining the etiology of ischemic stroke is cerebral angiography.[38]

Treatment Approach

The management of patients with acute stroke can be divided into several aspects which are treatment for the stroke itself, management of physiological variables that occur after the stroke (blood pressure, blood glucose, and body temperature), management of medical issues, including airway management, heart function, fluid and metabolic balance, prevention of decubitus ulcers, phlebitis, and sometimes management of increased intracranial pressure and rehabilitation.[41] Specific treatment for acute ischemic stroke includes three main aspects, which are reperfusion of the blocked arterial area, prevention of expansion or worsening of the ischemic area and prevention of recurrent ischemic stroke as soon as possible.[41]

Reperfusion therapy should be initiated as early as possible to restore normal blood flow and prevent further cell damage or death. This can be done through thrombolytic therapy with recombinant tissue plasminogen activator (IV r-tPA). This therapy can be administered intravenously or intra-arterially, or through a more advanced method, which involves removing the blood clot obstructing the blood flow with a device known as mechanical thrombectomy. Then to prevent recurrent strokes, medications such as anticoagulants like heparin or warfarin can be used to prevent thrombus formation, prevent thrombus expansion, and prevent recurrent embolism. Other medications used to prevent recurrent stroke are antiplatelet aggregants, such as aspirin, ticlopidine, and clopidogrel. These drugs primarily work by reducing platelet adhesion, lowering platelet aggregation, and reducing the release of active platelet substances.[41]

Complications

Complications following ischemic stroke can be neurological and medical complications due to the stroke condition; both are major causes of morbidity and mortality during and after the stroke. Neurological complications include hemorrhagic transformation, brain edema, increased intracranial pressure, and seizures. Medical complications include deep venous thrombosis, pulmonary embolism, falls, systemic infections, urinary tract infections, psychiatric disorders such as depression, contractures, and frozen pain.[42]

Prognosis

The prognosis of patients with ischemic stroke can be estimated by assessing the patient's condition at the onset, evaluating the severity of the stroke using the NIHSS score, hematological markers such as the white blood cell count, which reflects the extent of ischemic injury, and considering other comorbid factors associated with the ischemic stroke patient.[12,13]

Leukocytes in the Blood

Production Leukocytes

Leukocytes, or white blood cells, are part of the immune system that protects the body from infections and diseases. They are produced in the bone marrow from hematopoietic stem cells (HSCs), which are special cells that create all types of blood cells, including red and white blood cells. Leukocyte formation happens in two ways: myelocytic (starting from myeloblasts) and lymphocytic (starting from lymphoblasts). Both processes result in the production of white blood cells.[43]

Factors Affecting Leukocyte Count in the Blood

According to Junqueira (2017), leukocyte counts vary with age. In healthy adults, the normal range is 4500-11,000 cells/mm³. Counts below 4500 cells indicate leukopenia, which can result from factors like chronic stress, bone marrow disorders, radiation, chemotherapy, or chronic diseases like lupus, leukemia, thyroid issues, and Cushing's syndrome. [45] In newborns (12 hours old), leukocyte counts range from 13,000-38,000 cells/mm³ but drop to 5000-20,000 cells/mm³ by 2 weeks of age. The count continues to decrease during childhood, reaching the adult range by ages 4-21.

Leukocytosis, a condition where leukocyte counts exceed normal levels, can result from chronic inflammation (e.g., rheumatoid arthritis), bacterial infections, allergic reactions, certain medications, smoking, obesity, injuries, surgery, or bone marrow disorders. .[45] It may also be hereditary, linked to conditions like chronic idiopathic neutrophilia, Down syndrome, or polycythemia vera.[45]

Correlation Between Leukocyte Count and the Severity of Acute Ischemic Stroke

Previous studies have found that the number of leukocytes plays an important role as an indicator of inflammation and shows a positive correlation between the number of leukocytes and the severity of stroke.[13] The higher the number of leukocytes, the more severe the ischemic brain damage, the more brain damage occurs, and the greater the resulting disability and mortality.[10] Leukocytes contribute by increasing sustained vascular injury. In addition, the accumulation of these leukocytes can worsen the patient's condition by releasing pro-inflammatory mediators.[48,49] This happens because of the post-ischemic stroke inflammatory response caused by secondary injury mechanisms stimulated by atherosclerosis.[48,49]

In the case of ischemic stroke, microglia, astrocytes, endothelial cells, and nerves release cytokines such as interleukin-1β (IL-1β) and tumor necrosis factor α (TNFα), which activate leukocyte recruitment, activation, and adhesion to the endothelium of the brain's microvasculature, resulting in an increase in the number of leukocytes, migration of macrophages and neutrophils to the damaged tissue, and peripheral inflammatory markers like serum interleukin-6 and C-reactive protein (CRP). These leukocytes cause obstruction in blood vessels and migrate to the infarct area along with monocytes or macrophages.[11]

The severity of ischemic stroke is generally measured using various clinical scales, one of which is the National Institutes of Health Stroke Scale (NIHSS), which has been proven to be a reliable and valid tool for assessing the severity of ischemic stroke based on the patient's neurological symptoms. The higher the NIHSS score, the more severe the ischemic stroke the patient is experiencing. This scale provides a comprehensive evaluation of the patient's motor, sensory, and cognitive functions, offering a clear picture of the severity of ischemic stroke.[50]

An increased leukocyte count is often associated with the post-stroke inflammatory response. Leukocytosis, or an increase in leukocyte count, can worsen ischemic stroke through inflammatory mechanisms that cause further damage to brain tissue. Studies show a significant positive correlation between the leukocyte count and the NIHSS score, meaning the higher the leukocyte count, the more severe the ischemic stroke. Therefore, measuring the severity of ischemic stroke and evaluating the leukocyte count together can provide a clearer clinical picture of the stroke patient's prognosis.[50]

MATERIALS AND METHODS

This observational analytical research used a cross-sectional design with retrospective data collection. The study focused on acute ischemic stroke patients at Ngoerah Hospital from July to December 2023, selected through purposive sampling. The sample utilized consists of the population selected through total sampling, who meet the inclusion and exclusion criteria. The inclusion criteria encompassed patients aged 18-79 years experiencing acute ischemic stroke (≤72 hours), confirmed by neurological status examination and brain imaging (non-contrast CT scan or MRI brain), and those experiencing their first stroke. Exclusion criteria include condition like hemorrhagic transformation of ischemic stroke, a history of infection (with fever >38°C prior to the onset of stroke), and a history of allergies, immune system disorders, blood disorders, or malignancy. The data used in this study are secondary data in the form of patient medical records obtained from the Medical Record Installation at Ngoerah Hospital.

Leukocyte categories include low (<4,000/μL), normal (4,000-10,000/μL), and high (>10,000/μL). A high leukocyte count (leukocytosis) indicates inflammation. Stroke severity was measured using the NIHSS, categorizing scores into mild, moderate, moderately severe, and severe, with scores >5 indicating greater severity. The study analyzed the correlation between leukocyte count and stroke severity to explore the link between inflammation and neurological outcomes. The NIHSS measures the level of neurological deficit in stroke patients, with scores ranging from 0 to 42. Categorizing into mild (1-4), moderate (5-15), moderately severe (16-20), and severe (>20). The study analyzed correlation between leukocyte count and stroke severity to understand the relationship between the inflammatory response and the neurological condition.

Statistical analysis was performed using SPSS computer software. Variables used such as NIHSS score, age, leukocyte count, and gender. Normality testing was conducted using the Kolmogorov-Smirnov test. Since the data distribution was not normal, nonparametric correlation testing was performed using Spearman's correlation test. The correlation test was used to examine the relationship between leukocyte count and NIHSS score. A p-value <0.05 was considered statistically significant.

RESULT

Based on the inclusion and exclusion criteria, the total sample used in this study amounted to 114 samples. These 114 samples were then grouped according to the required

characteristics, including gender, age, leukocyte count in the blood, and NIHSS score. The study found that the research subjects consisted of 71 male patients (62.3%) and 43 female patients (37%).

The most common age range of the subjects was 61-79 years, with 55 patients (48.2%), followed by the 41-60 years age range with 53 cases (46.5%). The lowest number of cases occurred in the 20-40 years age range, with 6 cases (5.3%). The research results showed a median age of 60 years and an average age of 59.34 years, with a maximum age of 79 years and a minimum age of 23 years.

The number of subjects with normal leukocyte counts was 76 people (66.67%), while 38 people (33.33%) were categorized as having leukocytosis. The median leukocyte count was 9,7650 cells/mm³ and the average leukocyte count was 10,6237 cells/mm³. The majority of the study subjects were in the moderate category, with 83 people (72.8%) of the total subjects. The mild category included 28 people (24.6%), while the severe category included 3 people (2.6%) of the total subjects. The average NIHSS score was 8.19, with a standard deviation of 11.531.

The normality test showed that the age data was normally distributed ($p > 0.05$), while the NIHSS values and leukocyte counts were not normally distributed ($p < 0.05$). The correlation test between leukocyte count and NIHSS score was conducted using Spearman's test because both the leukocyte count and NIHSS score were found to be not normally distributed. Based on the test results, a p-value of 0.010 (< 0.05) was obtained, indicating a significant correlation between leukocyte count and NIHSS score. The correlation coefficient (r) was 0.240, which indicates a positive correlation, meaning the relationship between leukocyte count and NIHSS score is in the same direction, with a correlation strength of 0.240 (24.0%), which falls into the weak correlation category.

Tabel 2. Basic Characteristics of Research Subjects Based on Gender, Age, Leukocyte Count, and NIHSS Score

Variable	Frequency (n)	Percentage (%)	Median (Max-Min)	Mean ±sd
Gender				
Male	71	62,3		
Female	43	37,7		
Age (years)			60,00	59,34±11,531
20-40	6	5,3		
41-60	53	46,5		
61-79	55	48,2		
Min 23 years				
Max 79 years				
Leukocyte Count			9,7650 (4,140 – 36,950)	
(cell/mm^3)				
Normal	76	66,67		
Leukocytosis	38	33,33		
NIHSS Score			6,0 (1-22)	
Mild	28	24,6		
Moderate	83	72,8		
Severe	3	2,6		

DISCUSSION

The data collected in this study show that the occurrence of acute ischemic stroke is more common in male patients, with a proportion of 62.3%, compared to 37.7% in female patients. Stroke occurs more frequently in men than in women, driven by risk factors such as diabetes mellitus, myocardial infarction, smoking, and excessive alcohol consumption among men.[47] This is consistent with the study by Tertia et al., which reported that the majority of the subjects were male (57.9%), with females accounting for 42.1%. Similar findings were also observed in the

research conducted by Tjikoe et al. at RSUP Prof. Dr. R.D. Kandou Manado, which found a higher incidence of ischemic stroke in males (59.5%) compared to females (40.5%).[48] Another study by Barker et al. also found that men are at higher risk of ischemic stroke than women, with a ratio of 133:99 per 100,000.[49]

However, this gender difference disappears in older age groups. Studies suggest that women are protected from stroke at a younger age, and this protection diminishes with age. Although women have a lower stroke risk at younger ages, their risk doubles in the decade after menopause or during midlife (45-55 years). Changes during menopause, including increased Low-Density Lipoprotein (LDL) and triglyceride concentrations, decreased High-Density Lipoprotein (HDL) levels, changes in fat distribution, insulin action, elevated blood pressure, increased prevalence of metabolic syndrome, and higher fibrinolytic and inflammatory markers, contribute to this increased risk.[50–52]

The findings of this study showed the distribution of ages as follows: 5.3% in the 20-40 years age group, 46.5% in the 41-60 years group, and 48.2% in the 61-79 years group. These data indicate that ischemic stroke is more prevalent in the 61-79 years age group. Stroke incidence doubles every decade after the age of 50.[52] With aging, both microcirculation and macrocirculation in the brain undergo structural and functional changes.[52]Age-related microcirculation changes are believed to be mediated by endothelial dysfunction, impaired brain autoregulation, and neurovascular coupling.[32] Endothelial dysfunction promotes neuroinflammation, brain autoregulatory disruption can lead to microvascular injury, and neurovascular coupling impairment accelerates cortical functional decline.[32] The increased oxidative stress and the widespread atherosclerotic processes weaken body functions, especially affecting vascular flexibility.[52] These findings align with studies by Munir et al., which reported the highest stroke incidence in the 51-70 years age group.[53]

Further supporting evidence identified age as one of the most common risk factors. In this study, found that most ischemic stroke cases occurred in patients aged 55 years and older, accounting for 74.4% (113 patients) of the 176 ischemic stroke patients.[54] Although stroke is often associated with older age, one in three cases occurs in individuals under 65 years old. According to Janssen et al., of the 97 patients studied, 49 had ischemic stroke and 48 had TIA, with an age range of 17-50 years, indicating that stroke can affect individuals under 50 as well. In terms of leukocyte count, the study found that 76 patients (66.67%) had a normal leukocyte count, while 38 patients (33.33%) had leukocytosis.[55]

The number of leukocytes is influenced by the size of the infarct lesion; the larger the lesion, the higher the leukocyte count. Thus, it can be inferred that the lesions in this study were relatively small, as the leukocyte count remained within the normal range.[56] Leukocyte recruitment, particularly neutrophils, can be detected as early as 5 hours after stroke onset, peaking within 24 hours.[57]These findings are consistent with previous research conducted at Dr. Moewardi Hospital Surakarta in 2011, which reported a mean leukocyte count of 8.41×10^3 cells/mm³ in acute ischemic stroke patients, within the normal range.[57] Similarly, a study in Italy by Nardi et al. found that the average leukocyte count for ischemic stroke patients upon admission was 8,100/mm³.[58]

The severity of stroke was assessed using the NIHSS score. The study's results showed that the majority of ischemic stroke cases had a moderate degree of severity, with 72.8% (83 cases) classified as moderate, 24.6% (28 cases) as mild, and 2.6% (3 cases) as severe. The most common severity was moderate, typically characterized by NIHSS scores ranging from 6 to 15. This finding is consistent with previous studies. Factors contributing to moderate severity include the accessibility of healthcare services, the size of the arterial blockage, and the efficiency of collateral circulation. Other influencing factors include age, a history of heart disease, hypertension, and diabetes.[59]

The NIHSS score also varies depending on where the stroke is initially identified. Patients with strokes identified in the hospital had higher NIHSS scores (median = 7), whereas those identified outside the hospital had lower scores (median = 1). This suggests that stroke cases identified outside the hospital tend to be less severe than those treated in the hospital.[60] These findings are supported by research from Alawneh et al., who reported that the average NIHSS score for ischemic stroke patients was 7.61 in males and 9.47 in females, indicating a moderate severity level.[54]

In this study, the correlation between leukocyte count and NIHSS score, an indicator of ischemic stroke severity, was analyzed using the Spearman correlation test, as the data were not normally distributed. The correlation analysis revealed a statistically significant positive correlation between leukocyte count and NIHSS score ($p = 0.010$, $r = 0.240$). This positive correlation means that as the leukocyte count in the blood increases, the NIHSS score also increases, indicating a higher severity of stroke. However, the correlation coefficient ($r = 0.240$) suggests a weak correlation, implying that other factors may also influence the clinical outcome.

Higher leukocyte counts are associated with more severe ischemic brain damage, leading to increased disability and mortality risk. This is due to the role of leukocytes in the inflammatory response following ischemic stroke. Immune cells such as basophils and macrophages contribute to brain tissue damage through the release of inflammatory mediators. Pathophysiologically, ischemic stroke triggers a systemic inflammatory response, where leukocytes migrate to the infarcted area of the brain. This process increases blood-brain barrier permeability and causes brain tissue damage. The greater the leukocyte count, the more severe the damage to the ischemic brain tissue. Migrating leukocytes release pro-inflammatory mediators, such as interleukin-1β and TNF-α, which exacerbate endothelial damage and increase the risk of brain edema and other complications.[11,13,48,49]

CONCLUSION AND SUGGESTIONS

Based on the research results and analysis conducted, the researcher concludes that there is a weak positive correlation between the leukocyte count and the severity of acute ischemic stroke in patients at RS Ngoerah. Several suggestions can be made for future research to enhance the usefulness of this study. Future studies are encouraged to add other variables, such as C-Reactive Protein (CRP) levels, Interleukin-6 (IL-6), and cardiovascular risk factors. This is expected to provide a more

comprehensive understanding of the relationship between the inflammatory response and the severity of ischemic stroke.

Additionally, future research could adopt a prospective design, which would allow for the observation of patients from the early stages of stroke to the recovery process. This design would be more effective in evaluating the impact of leukocyte count on the long-term outcomes of ischemic stroke patients, including disability levels and mortality rates.

REFERENCES

1. S.Donkor E. Epidemiology and quality of life. Journal of Reproductive Medicine for the Obstetrician and Gynecologist. 2018;51(3 SUPPL.):227–33.
2. Bushnell C, McCullough LD, Awad IA, Chireau M V., Fedder WN, Furie KL, et al. Guidelines for the prevention of stroke in women: A statement for healthcare professionals from the American heart association/American stroke association. Stroke. 2014;45(5):1545–88.
3. Global WHO, Mechanism C, Prevention ONTHE, Diseases OFN. Progress report 2014–2016. 2016;
4. Katan M, Luft A. Global Burden of Stroke. Semin Neurol. 2018;38(2):208–11.
5. Collaborators, G.B.D.L.R.o.S., Feigin, V.L. N. Global, Regional, and Country-Specific Lifetime Risks of Stroke, 1990 and 2016. New England Journal of Medicine. 2018;379(25):2429–37.
6. Kementerian Kesehatan RI. Hasil Utama Riskesdas 2018.
7. Sarfo FS, Ovbiagele B, Gebregziabher M, Wahab K, Akinyemi R, Akpalu A, et al. Stroke among young West Africans: Evidence from the SIREN (stroke investigative research and educational network) large multisite case-control study. Stroke. 2018;49(5):1116–20.
8. Khandelwal P, Yavagal DR, Sacco RL. Acute Ischemic Stroke Intervention. J Am Coll Cardiol [Internet]. 2016;67(22):2631–44. Available from: http://dx.doi.org/10.1016/j.jacc.2016.03.555
9. Srinivas K KH. Prognostic Significance of Total Leucocytes Count in Acute Ischemic Stroke. International Jorunal of Contemporary Medical Research. 2017;4(4):138–42.
10. Ye L, Cai R, Yang M, Qian J, Hong Z. Reduction of the systemic inflammatory induced by acute cerebral infarction through ultra-early thrombolytic therapy. Exp Ther Med. 2015;10(4):1493–8.
11. Furlan JC, Vergouwen MDI, Fang J, Silver FL. White blood cell count is an independent predictor of outcomes after acute ischaemic stroke. Eur J Neurol. 2014;21(2):215–22.
12. Kalogeris T, Baines CP, Krenz M, Korthuis RJ. Cell Biology of Ischemia/Reperfusion Injury [Internet]. 1st ed. Vol. 298, International Review of Cell and Molecular Biology. Elsevier Inc.; 2012. 229–317 p. Available from: http://dx.doi.org/10.1016/B978-0-12-394309-5.00006-7
13. Sacco RL, Kasner SE, Broderick JP, Caplan LR, Connors JJ, Culebras A, et al. An updated definition of stroke for the 21st century: A statement for healthcare professionals from the American heart association/American stroke association. Stroke. 2013;44(7):2064–89.
14. Caplan L. Posterior circulation ischemia: Then, now, and tomorrow: The Thomas Willis lecture - 2000. Stroke. 2000;31(8):2011–23.
15. Budianto P, Prabaningtyas H, Putra SE, Mirawati diah K, Muhammad F, Hafizan M. Stroke iskemik akut : dasar dan klinis. 2021;(January):84.
16. O'Donnell MJ, Denis X, Liu L, Zhang H, Chin SL, Rao-Melacini P, et al. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): A case-control study. The Lancet. 2010;376(9735):112–23.
17. Aquil N, Begum I, Ahmed A, Vohra EA, Soomro BA. Risk factors in various subtypes of ischemic stroke according to TOAST criteria. Journal of the College of Physicians and Surgeons Pakistan. 2011;21(5):280–3.
18. Heart and Stroke Fondation. (Dis) connected : 2019 Report on Heart, Stroke and Vascular Cognitive Impairment. 2019;
19. Iadecola C, Gorelick PB. Hypertension, Angiotensin, and Stroke: Beyond Blood Pressure. Stroke. 2004;35(2):348–50.
20. Kristianto Wijaya A. PATOFISIOLOGI STROKE NON-HEMORAGIK AKIBAT TROMBUS. E-Jurnal Medika Udayana [Internet]. 2013 Oct [cited 2024 Nov 21];2(10):1652–66. Available from: https://ojs.unud.ac.id/index.php/eum/article/view/6694
21. O'Donnell MJ, Chin SL, Rangarajan S, Xavier D, Liu L, Zhang H, et al. Global and regional effects of potentially modifiable risk factors associated with acute stroke in 32 countries (INTERSTROKE): a case-control study. The Lancet [Internet]. 2016;388(10046):761–75. Available from: http://dx.doi.org/10.1016/S0140-6736(16)30506-2
22. kamajaya GAP, Yasa IWS, lestari AW. Hubungan Antara Profil Lipid dan Hipertensi Pada Penderita Stroke Iskemik Di RSUP Sanglah Denpasar . E-Jurnal Medika Udayana [Internet]. 2016 Nov [cited 2024 Nov 21];5(11). Available from: https://ojs.unud.ac.id/index.php/eum/article/view/30457
23. Alawneh KZ, Al Qawasmeh M, Raffee LA, Abuzayed B, Bani Hani DA, Abdalla KM, et al. A snapshot of Ischemic stroke risk factors, sub-types, and its epidemiology: Cohort study. Annals of Medicine and Surgery [Internet].

2020;59(July):101–5. Available from: https://doi.org/10.1016/j.amsu.2020.09.016
24. Chugh C. Acute ischemic stroke: Management approach. Indian Journal of Critical Care Medicine. 2019;23:S140–6.
25. Polonikov A V., Vialykh EK, Churnosov MI, Illig T, Freidin MB, Vasil'Eva O V., et al. The C718T polymorphism in the 3′-untranslated region of glutathione peroxidase-4 gene is a predictor of cerebral stroke in patients with essential hypertension. Hypertension Research. 2012;35(5):507–12.
26. Khan MI. The Epidemiology of Stroke in a Developing Country (Pakistan). Journal of Neurology & Stroke. 2018;8(1).
27. Hosseini AA, Sobhani-Rad D, Ghandehari K, Benamer HTS. Frequency and clinical patterns of stroke in Iran - Systematic and critical review. BMC Neurol. 2010;10.
28. Goldstein LB, Bushnell CD, Adams RJ, Appel LJ, Braun LT, Chaturvedi S, et al. Guidelines for the primary prevention of stroke: A Guideline for Healthcare Professionals from the American Heart Association/American Stroke Association. Stroke. 2011;42(2):517–84.
29. Santosa A. Buku Ajar Praktik Keperawatan Medikal Bedah. Uny Press. 2019. 540 p.
30. Sun Z. Aging, arterial stiffness, and hypertension. Hypertension. 2015;65(2):252–6.
31. PERDOSSI. Guideline Stroke Tahun 2011. Perdossi. 2011;2(stroke):1–10.
32. Yousufuddin M, Young N. Aging and ischemic stroke. 2019;11(9):2542–4.
33. Woodruff TM, Thundyil J, Tang SC, Sobey CG, Taylor SM, Arumugam T V. Pathophysiology, treatment, and animal and cellular models of human ischemic stroke. Mol Neurodegener. 2011;6(1):1–19.
34. Wells BG. Pharmacotherapy Handbook Ninth edition. AIAA Guidance, Navigation, and Control Conference. 2015. 4485 p.
35. Varghese C, Oyere O, Cowan M, Davis S, Norrving B. World Health Organization. Stroke. 2016;47(8):e210.
36. Defronzo RA, Thier SO. Pathophysiologic Approach to Hyponatremia. Vol. 140, Archives of Internal Medicine. 2016. 897–902 p.
37. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. 2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. Vol. 49, Stroke. 2018. 46–110 p.
38. Hurford R, Sekhar A, Hughes TAT, Muir KW. Diagnosis and management of acute ischaemic stroke. Pract Neurol. 2020;20(4):306–18.
39. Hurford R, Li L, Lovett N, Kubiak M, Kuker W, Rothwell PM. Prognostic value of "tissue-based" definitions of TIA and minor stroke: Population-based study. Neurology. 2019;92(21):e2455–61.
40. Moncayo J, Devuyst G, Guy ;, Melle V, Bogousslavsky J. Coexisting Causes of Ischemic Stroke. Arch Neurol [Internet]. 2000 Aug;57(8). Available from: http://archneur.jamanetwork.com/
41. Balami JS, Chen RL, Grunwald IQ, Buchan AM. Neurological complications of acute ischaemic stroke. Lancet Neurol [Internet]. 2011;10(4):357–71. Available from: http://dx.doi.org/10.1016/S1474-4422(10)70313-6
42. Iba T, Levi M, Levy JH. Intracellular communication and immunothrombosis in sepsis. Vol. 20, Journal of Thrombosis and Haemostasis. John Wiley and Sons Inc; 2022. p. 2475–84.
43. Munker, Erhard H, Jonathan G RP. MODERN HEMATOLOGY Biology and Clinical Management. Modern Hematology. 2007. 401–432 p.
44. Quan K, Wang A, Zhang X, Wang Y. Leukocyte Count and Adverse Clinical Outcomes in Acute Ischemic Stroke Patients. Front Neurol. 2019;10(November):1–13.
45. Li W, Hou M, Ding Z, Liu X, Shao Y, Li X. Prognostic Value of Neutrophil-to-Lymphocyte Ratio in Stroke: A Systematic Review and Meta-Analysis. Front Neurol. 2021;12(September).
46. Dziedzic T. Leukocytosis as a marker of early mortality in acute stroke patients. J Neurol. 2007;14(5):451–6.
47. Tjikoe M, Ali RH, Loho E. GAMBARAN HASIL CT SCAN KEPALA PADA PENDERITA DENGAN KLINIS STROKE NON-HEMORAGIK DI BAGIAN RADIOLOGI FK. UNSRAT / SMF RADIOLOGI BLU RSUP PROF. DR. R. D KANDOU MANADO PERIODE JANUARI 2011-DESEMBER 2011. Jurnal e-Clinic (eCl). 2014 Nov;2:3.
48. Barker-Collo S, Bennett DA, Krishnamurthi R V., Parmar P, Feigin VL, Naghavi M, et al. Sex differences in stroke incidence, prevalence,mortality and disability-adjusted life years: Results from the global burden of disease study 2013. Neuroepidemiology. 2015 Oct 1;45(3):203–14.
49. Polotsky HN, Polotsky AJ. Metabolic implications of menopause. Vol. 28, Seminars in Reproductive Medicine. 2010. p. 426–34.
50. Vega T, Zurriaga O, Ramos JM, Gil M, Álamo R, Lozano JE, et al. Stroke in Spain: Epidemiologic Incidence and Patterns; A Health Sentinel Network

Study. Journal of Stroke and Cerebrovascular Diseases. 2009 Jan;18(1):11–6.
51. Kissela, Ardelt AA, Deveikis JPD, Harrigan M. Acute Ischemic Stroke. In: Handbook of Cerebrovascular Disease & Neurointerventional Technique. New York: Humana Press; 2013. p. 571–605.
52. Munir B, Al Rasyid H, Rosita R. RELATIONSHIP BETWEEN THE RANDOM BLOOD GLUCOSE LEVELS DURING ADMISSION AT EMERGENCY ROOM WITH CLINICAL OUTPUT IN ACUTE ISCHEMIC STROKE PATIENTS. MNJ (Malang Neurology Journal). 2015 Jul 1;1(2):51–8.
53. Alawneh KZ, Qawasmeh M Al, Raffee LA, Al-Mistarehi AH. Ischemic stroke demographics, clinical features and scales and their correlations: an exploratory study from Jordan. Future Sci OA. 2022 Aug 1;8(7):SIII-S4.
54. Janssen AWM, De Leeuw FE, Janssen MCH. Risk factors for ischemic stroke and transient ischemic attack in patients under age 50. J Thromb Thrombolysis. 2011 Jan;31(1):85–91.
55. Hafshoh TY. HUBUNGAN ANTARAJUMLAH LEUKOSIT. 2019.
56. Santoso CN. CHRISTINE NOTONINGTIYAS SANTOSO G.0008029. 2011;
57. Nardi K, Milia P, Eusebi P, Paciaroni M, Caso V, Agnelli G. Admission leukocytosis in acute cerebral ischemia: Influence on early outcome. Journal of Stroke and Cerebrovascular Diseases. 2012 Nov;21(8):819–24.
58. Wouters A, Nysten C, Thijs V, Lemmens R. Prediction of outcome in patients with acute ischemic stroke based on initial severity and improvement in the first 24 h. Front Neurol. 2018 May 7;9(MAY).
59. Reeves M, Khoury J, Alwell K, Moomaw C, Flaherty M, Woo D, et al. Distribution of national institutes of health stroke scale in the cincinnati/northern kentucky stroke study. Stroke. 2013 Nov;44(11):3211–3.