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Relationship between hypertension and pulsatility index in acute ischemic stroke patients

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***Abstract*---**Hypertension is one of the risk factors for stroke. In the United States, stroke is the third leading cause of death, with a death rate of 146,664 people. Pulsatility index (PI) examination on transcranial Doppler is a value generated by blood flow velocity and blood viscosity. Methods: Retrospective analytic observational study with a cross-sectional study design in patients with acute thrombotic stroke with hypertension according to JNC VIII criteria. Data were obtained from secondary data from medical records of patients treated in the nervous room of Dr RSUD. Soetomo, in the period from February 2019 to February 2022, met the inclusion criteria, namely being over 18 years old, undergoing a TCD examination and having a stroke for the first time. Statistical analysis using Spearman correlation test with a significance value <0.05. Results: A total of 46 subjects met the inclusion and exclusion criteria. Tension with a mean of 152.00 ± 20.87 and a mean value of PI 1.08 ± 0.73. The Spearman statistical test showed a positive correlation with a substantial and statistically significant relationship level (rho = 0.712, p=0.002). Conclusion: there is a strong significant relationship

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between hypertension and the pulsatility index in patients with acute thrombotic stroke

***Keywords*---**hypertension, stroke, pulsatility index, transcranial Doppler, blood viscosity.

1 Introduction

A stroke occurs due to acute focal damage to the central nervous system related to vascular disorders. American Heart Association/American Stroke Association (AHA/ASA) in 2013 is an episode of neurological dysfunction due to focal infarction of the brain, spinal cord, or retina, in the form of symptoms lasting 24 hours or until death with a vascular etiology (Virani SS, et al, 2020). Objective findings of a focal infarction can prove this etiology according to vascular distribution with evidence of pathological examination, imaging, or other (Lopes et al., 2017; Sedova, Brown and Zvolsky, 2021). The prevalence of ischemic stroke worldwide is 77.19 million people, with 7.63 million cases per year.DIn the United States, stroke is the third leading cause of death, with a death rate of 146,664 people. Data in Indonesia shows stroke as the third leading cause of death, with a death rate of 138,268 people or 9.7% of the total deaths (Venketasubramanian et al., 2017; Sedova, Brown and Zvolsky, 2021).

Ischemic stroke risk factors can be divided into non-modifiable and modifiable. Age, gender, race or ethnicity, and genetics are non-modifiable risk factors (Boehme, Esenwa and Elkind, 2017). Some modifiable risk factors are hypertension, diabetes, hyperlipidemia, smoking, alcohol consumption, obesity, and lack of physical activity (Winstein et al., 2016; Boehme, Esenwa and Elkind, 2017; Artanti et al., 2020). The top three risk factors for ischemic stroke worldwide and in Southeast Asia, according to the 2019 Global Burden of Disease (GBD) research, are (1) high systolic blood pressure, (2) high fasting blood sugar, and (3) low-density lipoprotein levels. (LDL) high serum (Katan and Luft, 2018; Nastaghfiruka et al., 2021).

Hypertension is a persistent increase in blood vessel pressure characterized by systolic pressure of 140 mmHg and/or a diastolic pressure of 90 mmHg. Based on the cause, 80-95% of patients with hypertension are classified as primary or essential hypertension, i.e. when the cause of hypertension cannot be identified (idiopathic) and mostly is a complex interaction between genetics and environmental interactions. The classification of hypertension is divided into four categories, namely normal with systolic <120 mmHg and diastolic <80 mmHg, pre-hypertension systolic 120-139 mmHg and/or diastolic 80-89 mmHg, stage 1 hypertension with systolic 140-159 mmHg and/or diastolic 90-99, and grade 2 hypertension with systolic 160 mmHg and/or 100 mmHg (Harris, Kurniawan, et al., 2018; Yusuf et al., 2021).

Transcranial Doppler can produce many parameters. One of the parameters obtained is the Pulsatility Index (PI). PI measures vascular resistance and is expressed in the form of spectral waves (Han et al., 2014). The ratio has an average value of 0.85-1.10 (Hartiyo Laksono, 2017). A high TCD-PI indicates

vascular resistance in the cerebral circulation. The most important factors affecting the PI are the speed of blood flow and blood viscosity (BV) (Han et al., 2013). The Pulsatility Index can be affected by several factors, from modifiable and non-modifiable. One of the factors causing the high incidence of stroke is hypertension. The researchers wanted to examine the relationship between hypertension and PI in patients with acute thrombotic stroke at Dr Soetomo Hospital, which had never been done before.

2 Materials and Methods

This study is an observational analytic retrospective study with a cross-sectional design. Sampling was carried out using the total sampling method for acute thrombotic stroke patients at the Nerve Inpatient Unit (IRNA) of RSUD Dr Soetomo. This study involved 40 samples with acute thrombotic stroke. Medical records were used to collect demographic data, medical history, physical examination, neurological examination, and laboratory results for all study samples. Pulsatile index examination using Transcranial Doppler (TCD).

Inclusion criteria were patients with acute thrombotic stroke of the first attack, age > 18 years, and had undergone transcranial Doppler examination. The exclusion criteria for medical records were incomplete, and the patient's PI was not measured. Pulsatility Index was obtained through TCD examination according to the standard Mannheim measurement using transcranial Doppler. The examination technique uses ultrasound B high-resolution mode, black and white model, linear at frequency >7 MHz, average focus depth 30-40 mm, optimal frame rate 25 Hz (>15 Hz) and a gain compensation log of 60 dB (Touboul, 2015). PI measurements were performed on the middle cerebral artery (Fu et al., 2019). This study was analyzed using the Spearman test because the data were not normally distributed. Statistical analysis was performed using SPSS version 24.0. The value of this study is 0.05, so if the value of p <0,05, it can be concluded that there is a significant correlation.

3 Results and Discussions

The study involved 46 patients with acute thrombotic stroke. The sample characteristics assessed in this study included gender, age, hemiparesis, LDL, HbA1c, PI, and hypertension Table 1.

Table 1. Demographic data of acute thrombotic stroke patients

Category	N(%)	mean±SD
Gender		
Male	33 (71.7)	
women	13 (28.3)	
age		57.43±9.59
<60 years old	35 (76.1)	51.19±9.1
60 years	11 (23.9)	67.56 ± 3.1
Hemiparesis		
Right	25 (54.3)	
Left	21 (45.6)	

LDL		132.00± 40.87
Normal (<100 mg/dL)	15 (32.6)	92.60± 5.1
Abnormal (>100 mg/dL)	31 (67.4)	135.4± 40.87
HbA1c		6.76± 1.94
Normal (<6.5%)	35 (78.2)	4.88± 1,53
Abnormal (>6.5%)	11 (21.8)	8.75± 1.66
JNC VIII hypertension		152.00 ± 20.87
Level 1	7 (15.2)	144.45±9.33
Level II	39 (84.8)	165.23±4.54
PI		1.55± 0.81
Normal (<1.1)	16 (34.8)	0.66± 0.30
Increase (>1.1)	30 (65.2)	1.86± 0.91

The correlation between the PI value and the variables in this study is shown in table 2

Table 2: Correlation test of research variables and PI MCA

Variable	rho (ρ)	p
Gender	0.243	0.543
age	0.123	0.234
Hemiparesis	0.345	0.453
LDL	0.032	0.876
HbA1c	0.262	0.155
JNC VIII hypertension	0.712	0.002*

*significant

The results of the Spearman statistical test showed a positive correlation with a strong and statistically significant relationship (rho = 0.712, p = 0.002).
The results of this study from 46 male subjects were more than female where, which has similarities with the research of Han et al. (2019) using a male gender sample of 57% from a total of 125 samples, but different from Farhoudi et al. and Lee et al. al used a sample of men versus women 14:16 and 27 men from 43 women, respectively (Lee et al., 2000; Farhoudi et al., 2011; Han et al., 2019).

The average age of the sample in this study was 57.43 ± 9.59 years with the majority of research subjects aged under 60 years. These results are not much different from several previous studies by Farhoudi et al. (2011) and Han et al. (2019), namely the average age of 57.78 years and 53.13 years, respectively (Lee et al., 2000; Farhoudi et al., 2011). However, in the study by Han et al., the mean age was 68.4 (Han et al., 2019).

This study showed clinical characteristics of right and left hemiparesis with almost the same proportion. This is in line with previous research on the profile of stroke patients by Lopes et al. 2017 which shows the balance between right and left hemiplegia is almost the same, at 21% and 20%, respectively (Lopes et al.,

2017). In addition, only 9.7% of people had a history of statin use. This is in line with previous research by Flach et al. (2019) and Choi et al. (2015), who showed a low pre-stroke statin use of only 20% and 11.6%, respectivele (Choi et al., 2015; Flach et al., 2019). In this study, history of statin use was obtained through recall at the time of history taking, so there could also be bias, especially in medication regularity and adherence.

The results of right and left MCA showed the mean PI of the entire sample was mean1.55± 0.81, in line with the study by Han et al., the mean PI of 0.86 (Han and Nam, 2018), but in contrast to the study by Das et al., which showed a higher PI value of 1.71 ± 0.18 mm. This difference could be because the research subjects had a history of diabetes mellitus (Das et al., 2011). Diabetes mellitus and age are known to be associated with higher MCA PI values because of the possibility of affecting the elasticity of blood vessels (Bill et al., 2020).

In this study, there was a difference in the mean PI that was higher in patients with dyslipidemia, but it was not statistically significant. According to research by Rubba, et al. and Farhoudi, et al., the hypercholesterolemia group showed a higher mean PI, but not statistically significant (Rubba et al., 1993; Farhoudi et al., 2011). Vigen, et al. there is no association of hypercholesterolemia in patients belonging to the highest MCA PI group (Vigen et al., 2020).

Pulsatility Index can be increased by several other factors not studied in the study, such as high fasting glucose, old age, low HDL, diabetes, acute ischemic changes on initial CT scan, and plaque morphology (Chuang et al., 2016; Bill et al., 2020). One study found significantly higher PI values in lacunar stroke than in large-artery atherosclerosis (LAA) or cryptogenic strokes (Wohlfahrt et al., 2014).

In the results obtained, PI increased can be influenced by microcirculation disturbances of the cerebral vasculature during the early phase of cerebral ischemia of stroke, because PI is associated with increased intracranial pressure due to decreased cerebral perfusion pressure (Uzuner, Özdemir and Tekgöl Uzuner, 2013; Kim et al., 2016). In addition, LDL and HDL cholesterol are related to plasma viscosity, but their effect on blood viscosity is still limited. Long-term increase in blood lipids can also cause damage to the artery walls, which correlates viscosity with atherosclerosis. In this study, the hematocrit at the time of examination was not analyzed so that it might also affect the results of the PI indirectly (Kim et al., 2020).

The results on hypertension resulted in blood pressure with a mean of 152.00 ± 20.87 and a mean value of PI 1.08 ± 0.73. In the Spearman statistical test, there was a positive correlation with a strong and statistically significant relationship level (rho = 0.712, p = 0.002). This study is different from the research of Harris et al where the 66 subjects found a weak correlation and not statistically significant (rho = 0.17, p = 0.175). The difference in these results is because the research subjects are not the same (Harris, Reyhan, et al., 2018). The microangiopathic process also releases several inflammatory cytokines, such as endothelin and prostacyclin, and interferes with autoregulation of cerebral blood flow, which impairs blood flow to distal areas. Vicenzini et al. have found that an increase in

PI is associated with a decrease in end-diastolic volume (EDV), which indicates the development of vasoconstriction in the distal vessels (Kim et al., 2020).

The limitation of this study was the small sample size. Considering that there was a weak association in this study that was not statistically significant, further studies on a sample of healthy patients with a prospective-cohort design were needed to achieve the clinical benefit of PI examination.

4 Conclusion

There is a strong significant relationship between hypertension and the pulsatility index in patients with acute thrombotic stroke at RSUD Dr Soetomo.

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Ethical Approval

The ethics committee approved this study of RSUD Dr Soetomo Surabaya with number 1032/114/4/X/2021

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