

## PATTERNS OF TRANSCRANIAL DOPPLER FLOW VELOCITIES AND CAROTID INTIMA MEDIA THICKNESS (CIMT) IN JAVANESE ISCHEMIC STROKE

*Patientspolo Kecepatan Aliran Transkranial Doppler dan Carotid Intima Media Thickness (Cimt) Pada Pasien Stroke Iskemik Suku Jawa*

Rivan Danuaji<sup>1</sup>, Subandi<sup>1</sup>, Arif Apriyanto<sup>2</sup>, Endang Kusuma Dewi<sup>3</sup>, Suroto<sup>4</sup>, Diah Kurnia Mirawati<sup>4</sup>, Pepi Budianto<sup>4</sup>, Yetty Hambarsari<sup>4</sup>, Baarid Lukman Hamidi<sup>4</sup>, Hanindya Riani Prabaningtyas<sup>4</sup>, Sulistyani Sulistyani<sup>5</sup>

<sup>1</sup>Students of Medical Science Study Program, Doctoral Degree, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia

<sup>2</sup>Resident of Neurology, Faculty of Medicine, Universitas Sebelas Maret, Surakarta, Indonesia

<sup>3</sup>Neurology Nurse Staff, Dr Moewardi Hospital, Surakarta, Indonesia

<sup>4</sup>Neurology Staff, Dr Moewardi Hospital and Faculty of Medicine, Universitas Sebelas Maret Surakarta, Indonesia

<sup>5</sup> Neurology Staff, Faculty of Medicine, Universitas Muhammadiyah Surakarta, Indonesia

Corresponding Author: dr. Rivan Danuaji, Sp. S. Email: [rivan.danuaji@staff.uns.ac.id](mailto:rivan.danuaji@staff.uns.ac.id)

### ABSTRACT

*Intracranial atherosclerosis is the most common cause of stroke in Asia including Indonesia. Transcranial Doppler (TCD) is a noninvasive tool which able to detect intracranial atherosclerosis. The purpose of this study was to determine the pattern of TCD waves in Javanese ischemic stroke patients and Carotid Intima Media Thickness (CIMT), and its correlation to demographic data. This is a cross-sectional study was conducted at Hospital X Surakarta. All Javanese ischemic stroke treated in stroke unit were examine for flow velocity using TCD and CIMT using ultrasound. Chi square was used to analyzes the relationship between age, gender, stroke type and the thickness of CIMT. A total of 43 ischemic stroke patients were examined for TCD, consisting of 30 (69.77%) men and 13 (30,23%) women. The results showed that 31 (72.09%) had intracranial abnormalities in the form of stenosis or occlusion on MCA (23.26%), ACA (4.65%), PCA (4.65%), vertebral arteries (6.98 %) and other locations (32.56%). Thickening of CIMT was obtained as much as 22 (51,16%) of the patients. Age was a factor associated with CIMT thickening with (P: 0.041), while gender and type of stroke did not (P>0,05)). To sum up Intracranial flow velocity abnormalities often occur in Javanese ischemic stroke patients, while CIMT thickening is not associated with ischemic stroke pathology*

**Keywords:** TCD, Stroke Ischemic, Flow Velocity, CIMT, Javanese

### ABSTRAK

*Aterosklerosis intrakranial adalah penyebab paling umum dari stroke di Asia termasuk Indonesia. Transcranial Doppler (TCD) adalah alat noninvasif yang mampu mendeteksi aterosklerosis intrakranial. Tujuan dari penelitian ini untuk mengetahui pola gelombang TCD pada pasien stroke iskemik suku Jawa dan Carotid Intima Media Thickness (CIMT), dan korelasinya dengan data demografi. Penelitian cross-sectional ini dilakukan di Rumah Sakit X Surakarta. Semua stroke iskemik suku Jawa yang dirawat di unit stroke diperiksa untuk kecepatan aliran menggunakan TCD dan CIMT menggunakan ultrasound. Chi square digunakan untuk menganalisis hubungan antara usia, jenis kelamin, jenis stroke dan ketebalan CIMT. Sebanyak 43 pasien stroke iskemik diperiksa untuk TCD, terdiri dari 30 (69,77%) pria dan 13 (30,23%) wanita. Hasil penelitian menunjukkan bahwa 31 (72,09%) memiliki kelainan intrakranial dalam bentuk stenosis atau oklusi pada MCA (23,26%), ACA (4,65%), PCA (4,65%), arteri vertebral (6,98%) dan lokasi lain (32,56%). Penebalan CIMT diperoleh sebanyak 22 (51,16%) dari pasien. Usia adalah faktor yang terkait dengan penebalan CIMT dengan (p= 0,041), sedangkan jenis kelamin dan jenis stroke tidak (p> 0,05), sehingga ditarik kesimpulan bahwa kelainan kecepatan aliran intrakranial sering terjadi pada pasien stroke iskemik Jawa, sedangkan penebalan CIMT tidak berhubungan dengan patologi stroke iskemik.*

**Kata Kunci:** TCD, Stroke Iskemik, Flow Velocity, CIMT, Suku Jawa

**How to Cite:** Danuaji, R., Subandi, S., Apriyanto, A., Kuusumadewi, E., Suroto, S., Mirawati, D., Budianto, P., Hambarsari, Y., Hamidi, B., Prabaningtyas, H & Sulistyani, S. (2020). Patterns of Transcranial Doppler Flow Velocities and Carotid Intima Media Thickness (CIMT) in Javanese Ischemic Stroke Patients, 12(1), 51-57. doi:<https://doi.org/10.23917/biomedika.v12i1.9924>

**DOI:** <https://doi.org/10.23917/biomedika.v12i1.9725>

## INTRODUCTION

Stroke is still one of the main problems in Indonesia in the category of non-communicable diseases. Stroke is also the first cause of death in hospitals in Indonesia. The prevalence of stroke in Indonesia based on data from the Basic Health Research (RISKESDAS) in 2018 shows a 10.9 percent, where this is increases compared to the prevalence in 2013 which shows a 7 percent (Kemenkes RI, 2009, 2018). Most cases of stroke infarction in Asia are caused by the presence of intracranial stenosis, and this is different from the cases that occur in the European and American continents which are mostly caused by carotid stenosis (Bang, 2014; Londo'o and Chaturvedi, 2016; Banerjee and Chimowitz, 2017).

Transcranial Doppler (TCD) examination is one of the non-invasive examinations that can be used for screening and for the diagnosis of intracranial stenosis, which is widely used in Indonesia (De Silva *et al.*, 2007; Wong *et al.*, 2007; Liu *et al.*, 2018). At Dr Moewardi Hospital, this TCD examination has been carried out since the

end of 2017 in stroke patients, as well as patients with stroke risk factors.

This study was conducted to determine patterns and characteristics of intracranial blood flow and carotid intima media thickness in stroke infarction patients in Javanese ethnicity. This is important to be the basis for screening atherosclerosis risk factors that cause stroke infarction to occur. As far as researchers know, no similar studies have described this pattern in Javanese ethnicity..

## METHODS

A cross-sectional study was conducted at Hospital X Surakarta, a tertiary stroke treatment center in Central Java from January to April 2019. All Javanese ischemic stroke treated in stroke unit were examine for TCD and CIMT. Duplex Carotid examination were performed using Phillips Epiq 5 Ultrasound Machine, with a 12 Mhz frequency transducer probe, and examined in the external carotid artery, internal carotid and extracranial vertebral arteries, by an expert neuro-sonologist. For the carotid artery, the arterial diameter is measured, and the thickness of the far side wall, and peak systolic velocity

(PSV), end diastolic velocity (EDV) and mean flow velocity (MEV) respectively. TCD examination is performed using TDOP Machine with 1.5 MHz probe, covering the anterior circulation (consisting of MCA, ACA and PCA) and posterior (vertebral and basilar artery) both right and left. The parameters measured were PSV, EDV, MEV, Pulsatility Index and Resistance Index (PI and RI) respectively. Bone window visibility were asses as a standard examination and reporting protocol. All measurement done by certified neurosonologist based on protocols of the Society for Vascular Ultrasound Guidelines in 2017 (Ultrasound, 2017). Demographic data recorded by neurologic nurse staff including gender, age, past illness such as hypertension, diabetes mellitus, hyperlipidemia, TIA and smoking. Chi square test was used to test the relationship between demographic factors and the thickness of CIMT.

## RESULTS AND DISCUSSION

A total of 67 patients were treated in the Unit Stroke Ward during the observation time, however, only 43 patients with ischemic stroke and examined for TCD, consisting of

30 (69.77%) men and 13 (30,23%) women. The clinical and demographic data are shown in the table 1. The mean age of patients was 52,09 years.

The results of the examination showed that 31 (72.09%) patients had intracranial abnormalities in the form of stenosis or occlusion on MCA (23.26%), ACA (4.65%), PCA (4.65%), vertebral arteries (6.98 %) and abnormalities in other locations (32.56%). As for carotid thickening, there was 51.16% patients have carotid intima media thickness (CIMT) thickening (more than 0,8 mm). However, only 11.63% had plaque in that carotid artery.

Left MCA arteries have a higher average flow than the right side, as well as for PCA arteries. But for the ACA artery and vertebral artery the opposite occurs, where the left side is lower than the right side (Table 2).

**Table 1. Baseline Characteristic Of The Sample**

Characteristics	Male	Female
Gender (n;%)	29 (67,44)	14 (32,56)
Mean age (yr)	52,2	60,9
Bone Window (n;%)		
Optimal	16 (55,17)	6 (42,86)
Sub-optimal	11 (37,93)	4 (28,57)
Closed	2 (6,9)	4 (28,57)
Hypertension	24 (82,76)	10 (71,43)
Diabetes Mellitus	13 (44,83)	8 (57,14)
Hyperlipidemia	15 (51,72)	6 (42,86)
Smoking	21 (72,4)	0 (0)
TIA	8 (27,59)	5 (35,71)

Abbreviation: TIA, Transients Ischemic Attack

**Table 2. Pattern of Flow Velocities (Time-Average Mean Velocities (TAMV) In Cm/Sec), And Carotid Intima Media Thickness**

Artery	Min	Max	Mean
Right MCA	50	187	95,6
Left MCA	53	189	97,5
Right ACA	44	165	106,7
Left ACA	51	180	104,7
Right PCA	47	179	97,4
Left PCA	47	153	104,7
Right Vertebral	55	179	102,6
Left Vertebral	44	159	96,9
Basilar	53	159	101,3
CIMT (mm)	0,4	1,78	0,87

Abbreviation: MCA, Middle Cerebral Artery; ACA, Anterior Cerebral Artery; PCA, Posterior Cerebral Artery; CIMT, Carotid Intima Media Thickness

The conclusion of the TCD analysis conducted by the examiners, a certified neurosonologist, found that 12 (27.91%) patients were normal. This means that intracranial abnormalities are found in 72,09% (31) patients. Abnormalities were found in the form of stenosis or occlusion on MCA (23.26%), ACA (4.65%), PCA (4.65%), vertebral arteries (6.98%) and abnormalities in other locations (32.56%).

The average thickness of CIMT in this study was 0.87 mm which was obtained from 86 measurements (right and left side). Carotid plaque was found in only 7 patients (8.14%) where it was found on the right side as many as 5 (5.81%) patients and left side 2

(2.33%) examinations. No patient has plaque on either side of the carotid.

Correlation test using eta test and chi square test performed on demographic variables with CIMT thickness showed that only age factors significantly affected the depth of CIMT (Table 3). As for gender and the type of stroke that occurred did not significantly affect the thickness of CIMT.

The data that can be processed is only 40 samples (total 43 samples) because the completeness of the data that can be analyzed is only that number. The other three samples are not complete, so they must be excluded from the statistical calculation.

**Table 3. Correlation Between CIMT Thickening And Demographic Factors**

Variable	CIMT		r	p Value
	NT	T		
Age	46.70 ±16.49	57.25 ±14.95	0,325	0,041*
Gender			0,180	0,490
Female (n=12)	5 (41.7%)	7 (58.3%)		
Male (n=28)	15 (53.6%)	13 (46.4%)		
Type of Stroke			0,352	0,060
TIA	10 (76.9%)	3 (23.1%)		
IS	10 (37%)	17 (63%)		

Abbreviation: NT, Not Thickening; T, Thickening; r, coefficient correlation; TIA, Transients Ischemic Attack; IS, Ischemic Stroke; \*, Significant

In this study we showed that intracranial abnormalities were the most common pathological conditions causing ischemic stroke in the Javanese tribe compared to carotid abnormalities. Pathological disorders in the MCA region are most common, then in the vertebra-bacillary artery area, ICA and PCA, respectively.

Men have a bone window that is easier to detect than women. Even women with almost one third experience bone windows that close and cannot be penetrated by TCD waves. The study in Taiwan by Lin et.al and Japan by Itoh et.al provides the same data where women have more bone windows that close than men (Ringelstein *et al.*, 1990; Itoh *et al.*, 1993; De Silva *et al.*, 2007; Lin, Fu and Tan, 2015).

Intracranial artery stenosis (ICAS) is considered a very important cause of stroke in Asia. The prevalence of asymptomatic ICAS in Asian populations is relatively high, and ICAS is the cause of ischemic stroke, which is more common in Asians than in Caucasians, which reaches more than 56%. This condition shows that ICAS is a major cause of stroke that is important in Asians (Wong *et al.*, 2000; Kamal *et al.*, 2015; Oh, Chung and Rhee,

2015). In our study it was shown that intracranial abnormalities in the Javanese tribe reached 72% more, so this result is in accordance with the population of Southeast Asia. This data is important as a basis for further research for the pathology process and the therapeutic target of ischemic stroke patients in Javanese people. Included in the search for the most influential risk factors triggered the incidence of ischemic stroke in Javanese people.

Carotid plaque in Javanese people suffered from ischemic stroke was found to be almost the same as previous studies, less than 10% of cases. The study conducted by Woo et al in Korea showed data that the carotid plaque was found in 9% of men and 3.1% of women (Woo *et al.*, 2017). This thickening of CIMT is more influenced by the age of the patient compared to the sex and the ischemic stroke process that occurs. Although the current theory is believed that besides age, sex and other factors influence the occurrence of CIMT thickening, other factors cannot be proven in this study.

This condition indicates that the possibility of the pathophysiological process

of ischemic stroke in the Javanese tribe is similar to other ethnic groups in the Southeast Asian region in particular and throughout Asia in general. And this process is different from the pathophysiology of ischemic stroke in the continents of Europe, Africa and America, which is dominated by abnormalities in the carotid system (Lagunju, Sodeinde and Telfer, 2012; Béjot *et al.*, 2016; Thorpe *et al.*, 2018).

To our knowledge, this is the first study related to the characteristics of flow TCD and CIMT in ischemic stroke patients that were specifically carried out in Javanese people published. We still have some limitation in this study, named patients demographic data and has not involved laboratory data as other biomarkers. Sources of data from examination records in neurosonology laboratories, so that the risk factors that exist in patients are obtained from the results of the patient's

history, not directly from the clinical laboratory examination data.

## CONCLUSION

Intracranial flow velocity abnormalities often occur in Javanese ischemic stroke patients, while CIMT thickening is not associated with ischemic stroke pathology. CIMT thickening influenced by age, not gender nor type of stroke. Further research is needed to characterize this disorder completely.

## ACKNOWLEDGEMENT

Thank you to all staff in the Department of Neurology at Dr Moewardi Hospital's and Medical Faculty Universitas Sebelas Maret Surakarta, especially to residents who played a role in this data collection.

## REFERENCES

- Banerjee, C. and Chimowitz, M. I. 2017. Stroke Caused by Atherosclerosis of the Major Intracranial Arteries. *Circulation Research*. doi: 10.1161/CIRCRESAHA.116.308441.
- Bang, O. Y. 2014. Intracranial Atherosclerosis: Current Understanding and Perspectives. *Journal of Stroke*. doi: 10.5853/jos.2014.16.1.27.
- Béjot, Y., Bailly, H., Durier, J., Giroud, M. 2016. Epidemiology of stroke in Europe and trends for the 21st century. *Presse Medicale*. Elsevier Masson SAS, 45(12), pp. e391–e398. doi: 10.1016/j.lpm.2016.10.003.
- Itoh, T., Matsumoto, M., Handa, N., Maeda, HH., Hougaku, H., Hashimoto, H., Etrani, H., Tsukamoto, Y., Kamada, T. 1993. Rate of successful recording of blood flow signals in the middle cerebral artery using transcranial

- doppler sonography. *Stroke*, 24(8), pp. 1192–1195. doi: 10.1161/01.STR.24.8.1192.
- Wong, K.S., Li, H., Chan, Y.L., Ahuja, A., Lam, W.W., Wong, A., Kay, R. 2000. Use of transcranial doppler ultrasound to predict outcome in patients with intracranial large-artery occlusive disease. *Stroke*, 31(11), pp. 2641–2647. Available at: <http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed5&NEWS=N&AN=2000389072>.
- Wong, K.S., Ng, P.W., Tang, A., Liu, R., Yeung, V., Tomlinson, B. 2007. 'Prevalence of asymptomatic intracranial atherosclerosis in high-risk patients', *Neurology*, 68(23), pp. 2035–2038. Available at: <http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed8&NEWS=N&AN=2007274049>.
- Kamal, A.K., Rehman, H., Mustafa, N., Ahmed, B., Jan, M., Wadivalla, F., and Kamran, S. 2015. Diagnostic TCD for intracranial stenosis in acute stroke patients: Experience from a tertiary care stroke center in Karachi, Pakistan. *BMC Research Notes*. BioMed Central, 8(1), pp. 15–20. doi: 10.1186/s13104-015-1289-3.
- Kemenkes RI. 2009. Tahun 2030 prevalensi diabetes mellitus di Indonesia mencapai 21,3 juta orang. 8 November, pp. 1–2. Available at: <http://www.depkes.go.id/pdf.php?id=414>.
- Kemenkes RI. 2018. Laporan Nasional Riset Kesehatan Dasar (Riskesdas) 2018.pdf. Jakarta. Available at: <http://labdata.litbang.depkes.go.id/menu-download>.
- Lagunju, I., Sodeinde, O. and Telfer, P. 2012. Prevalence of transcranial Doppler abnormalities in Nigerian children with sickle cell disease. *American Journal of Hematology*, 87(5), pp. 544–547. doi: 10.1002/ajh.23152.
- Lin, Y. P., Fu, M. H. and Tan, T. Y. 2015. Factors Associated with No or Insufficient Temporal Bone Window Using Transcranial Color-coded Sonography. *Journal of Medical Ultrasound*. Elsevier Taiwan LLC and the, 23(3), pp. 129–132. doi: 10.1016/j.jmu.2015.07.002.
- Liu, L., Ding, J., Pu, Y., Huang, L., Xu, A., Wong, K.S.W., Wang, X., and Wang, Y. 2018. Guidelines for evaluation and management of cerebral collateral circulation in ischaemic stroke 2017. *Stroke and Vascular Neurology*. doi: 10.1136/svn-2017-000135.
- Londo'o, E. M. L. and Chaturvedi, S. 2016. Stroke due to large vessel atherosclerosis Five new things. *Neurology: Clinical Practice*. doi: 10.1212/CPJ.0000000000000247.
- Oh, H. G., Chung, P. W. and Rhee, E. J. 2015. Increased risk for intracranial arterial stenosis in subjects with coronary artery calcification. *Stroke*, 46(1), pp. 151–156. doi: 10.1161/STROKEAHA.114.006996.
- Ringelstein, E. B., Kahlscheuer, B., Niggemeyer, E., Otis, S.M. 1990. Transcranial doppler sonography: anatomical landmarks and normal velocity values. *Ultrasound*, 16(8), pp. 745–761.
- De Silva, D. A., Woon, F., Lee, M., Chen C. P.L.H., Chang, H., Wong, M. 2007. South Asian patients with ischemic stroke: Intracranial large arteries are the predominant site of disease. *Stroke*. doi: 10.1161/STROKEAHA.107.484584.
- Thorpe, S. G., Thibeault, C.M., Canac, N., Wilk, S.J., Devlin, T., and Hamilton, R.B. 2018. Decision criteria for large vessel occlusion using transcranial Doppler waveform morphology. *Frontiers in Neurology*, 9(OCT). doi: 10.3389/fneur.2018.00847.
- Ultrasound, S. for V. 2017. Intracranial Cerebrovascular Evaluation Transcranial Doppler ( Non-Imaging ) and Transcranial Duplex Imaging ( TCDI ). Available at: [www.svunet.org](http://www.svunet.org).
- Woo, S. Y., Joh, J.H., Han, S., and Park, H. 2017. Prevalence and risk factors for atherosclerotic carotid stenosis and plaque. *Medicine*, 96(4), p. e5999. doi: 10.1097/md.0000000000005999.