

Visualization of Carotid Doppler in Patients with Ischemic Stroke at Dr. Hasan Sadikin General Hospital Bandung Year 2016-2019

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Abstract

Background: Various pathological changes in both the intra and extracranial arteries that supply the brain can cause disturbance of cerebral blood flow and perfusion leading to cerebral dysfunction. Doppler ultrasound is able to assess these changes. This study was performed to evaluate the anatomical and physiological changes found in the carotid arteries of patients with ischemic stroke using Doppler ultrasound.

Methods: The cross-sectional descriptive study design with total sampling method was conducted on the medical records of ischemic stroke patients who had carotid Doppler ultrasound at the Department of Cardiology and Vascular Medicine Dr. Hasan Sadikin General Hospital Bandung from 2016 to 2019. Demographic data, such as stroke diagnoses and plaque characteristics recorded in the Doppler reports were collected.

Results: There were 38 data sets collected. The distribution and characteristics of atherosclerotic plaques were similar between the two carotid systems, with the same percentage of plaque being found in the right (31.6%) and left (36.8%) carotid system. The most common type of plaque found was type III and was located in the common carotid artery. Thrombus was absent in all patients. Intimal media thickening was found in 13.2% right system and 15.8% left system. Stenosis was present in 34.2% of patients, and most had <50% stenosis. Peak systolic velocity increased (>125 cm/s) in 5.3% of the right system and 7.9% of the left system of the internal carotid artery.

Conclusions: Most of the atherothrombotic and thromboembolic type of ischemic stroke patients in this study have normal carotid Doppler ultrasound features. Further study on the presence of plaque in ischemic stroke patients in Indonesia is needed.

Keywords: Atherosclerotic plaque, carotid doppler ultrasound, ischemic stroke

Introduction

Stroke is a non-communicable disease that has been known as the primary cause of disability and vascular death worldwide.¹ The World Health Organization (WHO) defines stroke as rapidly developing clinical signs of focal or global disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than vascular origin, and classified into ischemic and hemorrhagic types.² Nationally, the 2018 Basic Health Research (*Riset Kesehatan Dasar*, RISKESDAS) reported that the prevalence of stroke in

Indonesia was 10.9 per 1,000 population.³

Blood flow to brain region in ischemic stroke patients is disrupted due to pathological changes that occur in blood vessels, mainly caused by advanced atherosclerotic plaques. These plaques may rupture and form a thrombus, which can then become the source of embolus, both of which lead to arterial occlusion resulting in territorial infarcts of variable size.⁴ These arterial pathological changes, both plaque morphological characteristics and blood flow, can be observed using a widely available, economical, non-invasive imaging modality, namely Doppler

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ultrasound.^{5,6}

Pathological changes that occur in the carotid artery as the site of symptomatic lesions most often occur in ischemic stroke patients using Doppler ultrasound.⁷ Therefore, this study aimed to evaluate anatomical and physiological changes found in the carotid arteries of patients with ischemic stroke using Doppler ultrasound.

Methods

This was a descriptive cross-sectional study. Secondary data were collected from medical records of the patients at the Department of Cardiology and Vascular Medicine, Dr. Hasan Sadikin General Hospital Bandung, from January 2016 to December 2019. Inclusion criteria were adult patient >18 years, diagnosed with atherothrombotic or thromboembolic stroke in the carotid system, and underwent carotid Doppler ultrasound examination. Patients with incomplete data were excluded from the study.

The data collected in this study were age, gender, stroke location (left or right carotid system), anatomical assessment, and functional assessment of carotid Doppler examination. Anatomical assessment included plaque characteristics (presence, location, and type), presence of thrombus, intimal media thickening, and degree of carotid artery stenosis which were then classified into six categories (<50%, 50–70%, 70–95%, 90–95%, >95%, no stenosis). Plaque echogenicity was classified as pure hypoechoic (type I), hypoechoic with a small hyperechoic area (type II), hyperechoic with a small hypoechoic area (type III), and hyperechoic (type IV).⁵ The functional assessment included the peak systolic velocity (PSV) of the carotid artery. Data was collected after obtaining ethical approval from the Research Ethics Committee Universitas Padjadjaran (790/UN6.KEP/EC/2020) and

Dr. Hasan Sadikin General Hospital Bandung (LB.02.01/X.2.2.1/19917/2020). Data were presented in tables.

Results

During the study period, 116 ischemic stroke patients underwent carotid Doppler examination. Of these, 73 data were excluded because the type of stroke did not meet the inclusion criteria. Of the 43 eligible data, 5 data were excluded due to incomplete data, so that the remaining 38 records were eligible for analysis.

The median age for ischemic stroke was 59 years (range 49–64), with female patients outnumbering male patients (60.5% vs 39.5%). The carotid system involved in ischemic stroke was found to be almost the same between the right and left carotid systems (Table 1).

Among 38 patients, plaque was found in 18 patients (12 in right carotid system only, 14 in the left, and 8 patients had plaque in both systems). The presence of plaque was slightly more common in the left carotid system. The most common plaque type found in both systems was type III (66.7% on the right, 50.0% on the left), followed by type II (25.0% on the right, 42.9% on the left). Type I plaques were found in 1 right carotid system (8.3%) and type IV plaques in 1 left carotid system (7.1%). Nearly all plaques were found in the common carotid artery (88.3% on the right, 92.9% on the left), and only a small proportion in the internal carotid artery.

Intimal media thickening was found in 5 right carotid systems (13.2%) and 6 left carotid systems (15.8%). Stenosis was present in 34.2% of patients. Among patients with stenosis, most of them had <50% stenosis (Table 2).

Functional assessment showed that there was an increase in PSV in a minority of the patient's internal carotid arteries (5.3% on the

Table 1 Ischemic Stroke Patients Characteristics (n=38)

Characteristics	n(%)
Age (years)–median (IQR)	59 (49–64)
Gender, n (%)	
Male	15 (39.5)
Female	23 (60.5)
Stroke system, n (%)	
Right carotid system	18 (47.4)
Left carotid system	20 (52.6)

Table 2 Anatomical Assessment of Carotid Doppler Examination (n=38)

Carotid Doppler Examination Report	Right carotid system n(%)	Left carotid system n(%)
Atherosclerotic plaque		
Present*	12(31.6)	14(36.8)
Absent	26(68.4)	24(63.2)
Plaque type**		
Type I	1(8.3)	0(0)
Type II	3(25)	6(42.9)
Type III	8(66.7)	7(50)
Type IV	0(0)	1(7.1)
Plaque location**		
Common carotid artery	10(83.3)	13(92.9)
Internal carotid artery	2(16.7)	1(7.1)
Thrombus		
Present	0(0)	0(0)
Absent	38(100)	38(100)
Intimal media thickening		
Present	5(13.2)	6(15.8)
Absent	33(86.8)	32(84.2)
Stenosis		
<50%	11(29)	12(31.6)
50–70%	1(2.6)	0(0)
70–95%	1(2.6)	0(0)
95–99%	0(0)	1(2.6)
>99%	0(0)	0(0)
No stenosis	25(65.8)	25(65.8)

Note: * = 8 patients had bilateral plaques, ** = n subjects were 12 in the right carotid system and 14 in the left carotid system

Table 3 Functional Assessment of Carotid Doppler Examination (n=38)

Peak Systolic Velocity (PSV)	Right carotid system n(%)	Left carotid system n(%)
Location		
Common carotid artery		
<125 cm/s	38(100)	38(100)
>125 cm/s	0(0)	0(0)
Internal carotid artery		
<125 cm/s	36(94.7)	35(92.1)
>125 cm/s	2(5.3)	3(7.9)

right and 7.9% on the left). Common carotid artery blood flow was within normal limits in all subjects (Table 3).

Discussion

Stroke incidence and atherosclerotic plaque formation increases with age, with the highest incidence at age 60 years or older. The median age in this study was 59 years, in accordance with previous studies where most of the patients belonged to the age group of 60–69 years.^{8,9} The incidence was more common

in women, in contrast to what was found in the Riskesdas 2018 which revealed that the incidence was almost the same between men and women.³ Most of the patients had left carotid system stroke. This finding is different from 2 studies conducted in South India, where in the first study, most of the patients had right system stroke, and another study showed the equal numbers of right and left system stroke patients.^{6,9} Another study in the United States of America showed similar results to this study, in which left-hemispheric anterior circulation ischemic strokes were

slightly more common than right-hemispheric stroke.¹⁰ These data revealed that there was no significant difference between the incidence of right and left carotid system strokes. Left system stroke has a slightly higher incidence due to hemodynamic differences in the left carotid artery, the direct branch of the aorta, where there is higher stress and intimal damage.¹⁰

This study specifically involved ischemic stroke patients with atherothrombotic or thromboembolic origin. However, majority of patients had no signs of atherosclerotic plaque in the carotid arteries. This finding differs from previous evidence in which the extracranial carotid artery was the most common plaque location.^{4,11} This is probably due to ethnic differences, where atherosclerotic lesions in Asian people are more frequently found in the intracranial vessels.¹² The causes are still unknown but presumably related to genetics and nutritional factors.¹² A study in the South Korea showed that patients with the genetic variant RNF213, one of the most susceptible genes for Moyamoya disease among East Asians, was associated with an increased risk and early onset of intracranial atherosclerotic disease.¹³ However, study in China shows that the incidence is also different within the country. A higher incidence was found in areas of a more westernized lifestyle, indicating that nutritional factors also play a role in the intracranial lesions formation.¹⁴

In patients with atherosclerotic plaques, plaque characteristics were then assessed. This study has similar findings to a study in India which showed that more plaque is located in the common carotid artery.¹¹ Vulnerable plaque, indicated as plaque with a high degree of echolucency, is prone to rupture and may result in thrombus formation. In this study, the most common plaque found was type III, followed by type II, indicating that the plaque found was more stable.⁵ This could explain the total absence of thrombus in this study. The presence of plaque that was more stable in this study was probably due to the fact that the subjects of this study were stroke patients, while other studies mostly reported plaque formation in non-stroke subjects to predict the stroke incidence. Vulnerable plaque could have already ruptured, causing an embolism leading to the diagnosis of an ischemic stroke. Previous studies have also shown a strong correlation between echolucent plaques and an increased risk of ipsilateral stroke in asymptomatic carotid artery stenosis patients.¹⁵

Intimal media thickening of carotid artery

might be present as the earliest sign of progressive atherosclerosis.¹⁶ In this study, patients were classified as having intimal media thickening when the intimal media thickness found was >1.00 mm. Most patients had normal intimal media thickness. Stenosis was found in a minority of patients. Previous studies have shown that carotid stenosis is clinically important if the stenotic degree is $>60\%$.⁷ In this study, most of the patients with stenosis were included in the criteria for insignificant stenosis ($<50\%$). This finding is similar to a study conducted in India, where most of the subjects had $<50\%$ stenosis.^{6,17}

One of the most accurate predictors of internal carotid artery stenosis is the PSV assessment.⁹ Previous studies have shown that PSV >125 cm/s is correlates with $>60\%$ stenosis of the carotid artery, which is clinically important.⁷ Most of the patients in this study had normal results in their PSV assessment in the common and internal carotid arteries.

This study has several limitations. First, carotid Doppler ultrasound has not yet become part of the standard examination performed in patients with atherothrombotic ischemic stroke, so data are still scarce. Besides, it was done in a single medical center with a limited period of time, hence, the sample size was small and might not represent the actual condition. Second, this study did not record risk factors that could have interfered with the findings. Third, data on the involvement of patients with stroke system in this study were obtained from the referral doctor's statement, not directly from the results of brain imaging. Further studies are suggested to have a larger sample size and risk factors assessment so that more precise results can be obtained.

To conclude, most of the atherothrombotic and thromboembolic type ischemic stroke patients in this study have normal carotid Doppler ultrasound features. Among patients with pathological changes, most prevalent changes found are atherosclerotic plaques, with type III plaques and located in the common carotid artery. Further studies comparing the presence of extracranial and intracranial plaques among Indonesian are needed.

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