

# Accuracy of Carotid Duplex Criteria in Diagnosis of Significant Carotid Stenosis in Asian Patients

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**Background:** Extracranial carotid stenosis can be diagnosed by velocity criteria of carotid duplex. Whether they are accurately applied to define severity of internal carotid artery (ICA) stenosis in Asian patients needs to be proved. The purpose of this study was to evaluate the accuracy of 2 carotid duplex velocity criteria in defining significant carotid stenosis. **Methods:** Carotid duplex studies and magnetic resonance angiography were reviewed. Criteria 1 was recommended by the Society of Radiologists in Ultrasound; moderate stenosis (50%-69%): peak systolic velocity (PSV) 125-230 cm/s, diastolic velocity (DV) 40-100 cm/s; severe stenosis (>70%): PSV greater than 230 cm/s, DV greater than 100 cm/s. Criteria 2 used PSV greater than 140 cm/s, DV less than 110 cm/s to define moderate stenosis (50%-75%) and PSV greater than 140 cm/s, DV greater than 110 cm/s for severe stenosis (76%-95%). **Results:** A total of 854 ICA segments were reviewed. There was moderate stenosis in 72 ICAs, severe stenosis in 50 ICAs, and occlusion in 78 ICAs. Criteria 2 had slightly lower sensitivity, whereas higher specificity and accuracy than criteria 1 were observed in detecting moderate stenosis (criteria 1: sensitivity 95%, specificity 83%, accuracy 84%; criteria 2: sensitivity 92%, specificity 92%, and accuracy 92%). However, in detection of severe ICA stenosis, no significant difference in sensitivity, specificity, and accuracy was found (criteria 1: sensitivity 82%, specificity 99.57%, accuracy 98%; criteria 2: sensitivity 86%, specificity 99.68%, and accuracy 99%). **Conclusions:** In the subgroup of moderate stenosis, the criteria using ICA PSV greater than 140 cm/s had higher specificity and accuracy than the criteria using ICA PSV 125-230 cm/s. However, there was no significant difference in detection of severe stenosis or occlusion of ICA. **Key Words:** Carotid Doppler—carotid duplex—carotid stenosis—criteria—Asian—Thai.

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## Introduction

Although the prevalence of symptomatic, extracranial carotid stenosis is higher in Caucasian (18%-20%)<sup>1,2</sup> than in Asian patients (6%-10%),<sup>3,5</sup> several trials show the benefit of carotid intervention in patients with symptomatic, significant (>50% stenosis) carotid stenosis, with absolute risk reduction of 6.5%-17% in prevention of recurrent, ipsilateral stroke.<sup>6,7</sup> Extracranial carotid stenosis can be diagnosed by computed tomography angiography, magnetic resonance angiography (MRA), carotid duplex (CD), and digital subtraction cerebral angiography (DSA). Most modalities provide the information about "luminogram" (delineating the inner vessel border) of intracranial or

extracranial arteries, but CD is able to give information about size, surface, characteristics, and motion of plaque, in real time. Velocity criteria are mainly used to evaluate the degree or severity of stenosis. There have been several velocity criteria available in the clinical practice. Whether they are accurately applied to define the severity of stenosis in Asian patients still needs to be proved.

The Society of Radiologists in Ultrasound convened a multidisciplinary panel of experts in the field of vascular ultrasonography (US) to come to a consensus regarding Doppler US for assistance in the diagnosis of carotid artery stenosis.<sup>8</sup> Internal carotid artery (ICA) peak systolic velocity (PSV) 125-230, greater than 230 cm/s were used to define 50%-69% and greater than 70% stenosis, respectively. In Thailand, many academic centers used ICA PSV greater than 140 cm/s and ICA PSV greater than 140 with diastolic velocity (DV) greater than 110 cm/s to define 50%-75% and 76%-95% stenosis.<sup>9</sup> The purpose of this study was to evaluate and compare the accuracy of these 2 CD velocity criteria in defining significant carotid stenosis.

## Methods

CD studies, which were done during September 2014-October 2016, of the patients who had MRA were reviewed. CD studies were done using ultrasound machine (Philips iE 33, linear probe 11-13 MHz) per the following protocol. CD studies were performed by a neurologist, certified by the American Society of Neuroimaging, and a well-trained sonographer, blinded to the MRA findings.

### *Carotid Duplex Protocol*

Common carotid arteries (CCAs), carotid bifurcation, and internal and proximal external carotid arteries were

insonated with color Doppler. The Doppler waveforms were obtained with an angle of insonation equal to or less than 60°. Velocity on each segment was measured and recorded. B-mode was applied in longitudinal and cross-sectional views to visualize the outline of vessels, spontaneous echo contrast, or suspected thrombus and detail of the plaque. Color Doppler imaging was finally done in longitudinal and cross-sectional views to ensure that hypoechoic plaque would not be missed.

Magnetic resonance imaging (MRI)/MRA was done using Siemens Aera (1.5 T) and C Skyra (3 T). Time-of-flight (TOF) MRA (3D TOF brain: slice thickness = .6 mm, Echo time (TE)/repetition time (TR) = 27/7.15 milliseconds, matrix = 210 × 320, field of view (FOV) = 180 × 157.5 mm; 3D TOF neck: slice thickness = 1.2 mm, TR/TE = 27/7.15 milliseconds, matrix = 126 × 256, FOV = 200 × 140.6 mm) and contrast-enhanced MRA (slice thickness = .8 mm, TR/TE = 3.29 × 1.29 milliseconds, matrix = 211 × 384, FOV = 180 × 157.5 mm) were performed in all cases. All vascular neuroimaging was reviewed by a neurovascular radiologist, blinded to the CD results. Degree of stenosis was measured according to the North American Symptomatic Carotid Endarterectomy Trial criteria. The patients who agreed to perform carotid interventions, and those with a blood flow interruption from MRA, had further DSA.

Velocity criteria were used to evaluate the severity of stenosis. Two criteria were used (Table 1). Criteria 1 was recommended by a multidisciplinary panel of the Society of Radiologists in Ultrasound.<sup>8</sup> The panel suggested that ICA PSV and the presence of plaque on grayscale or color Doppler US images are the parameters that should be used when diagnosing and grading ICA stenosis. Tegeler and Ratanakorn also suggested using both ICA PSV, DV, and the presence of plaque, but the cut-off velocity on each degree of stenosis was different.<sup>9</sup>

**Table 1.** Velocity criteria used to define degree of stenosis

Degree of stenosis (%)	Primary parameters	Additional parameters	
	ICA PSV (cm/s)	ICA DV (cm/s)	ICA/CCA PSV ration
Criteria 1 <sup>8</sup>			
Normal < 50	<125	<40	<2.0
50-69	125-230	40-100	2.0-4.0
>70 but less than near occlusion	>230	>100	>4.0
Near occlusion	High, low, or undetectable	Variable	Variable
Total occlusion	Undetectable	Not applicable	Not applicable
Criteria 2 <sup>9</sup>			
<50	<140	<40	<2.0
50-75	>140	<110	2.0-3.0
76-95	>140	>110	>3.0
Near occlusion	Variable	Variable	Variable
Total occlusion	Undetectable	Undetectable	Undetectable

Abbreviations: CCA, common carotid artery; ICA, internal carotid artery; PSV, peak systolic velocity.

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