Effects of Pretreatment Cerebral Blood Volume and Time to Recanalization on Clinical Outcomes in Endovascular Thrombectomy for Acute Ischemic Stroke

Tomohide Yoshie, MD, PhD,* Toshihiro Ueda, MD, PhD,* Tatsuro Takada, MD,* Shinji Nogoshi, MD,* Fumio Miyashita, MD,* Satoshi Takaishi, MD, PhD,* Takayuki Fukano, MD,* Daiki Tokuura, MD,* and Yasuhiro Hasegawa, MD, PhD†

Background: Faster time to recanalization leads to better clinical outcomes in patients treated with endovascular thrombectomy. Whether the association between time to recanalization and clinical outcomes depends on cerebral blood volume (CBV) obtained from pretreatment computed tomography (CT) perfusion (CTP) imaging was investigated. *Methods:* In consecutive patients with acute ischemic stroke who achieved recanalization by endovascular thrombectomy for intracranial internal carotid artery or M1 occlusion, the effects on clinical outcome of time to recanalization and the relative CBV value (rCBV) assessed by pretreatment CTP were evaluated. The patient population was divided into 2 groups according to rCBV: normal rCBV group (rCBV ≥ .9) and low rCBV group (rCBV < .9). In each group, time to recanalization was compared between the good and the poor clinical outcome groups. *Results:* Sixty-four patients were eligible for this study. Twenty-six patients (40.6%) achieved good clinical outcomes. In the normal rCBV group, no association was found between clinical outcome and time to recanalization. In the low rCBV group, time to recanalization from CTP (101 minutes versus 136 minutes, $P = .040$) was significantly shorter in the good clinical outcome group. On binary logistic regression modeling, CTP to recanalization time (odds ratio 1.035 [1.004-1.067], $P = .025$) was an independent predictor of good clinical outcome only in the low rCBV group. *Conclusions:* The association between time to recanalization and clinical outcomes depends on rCBV obtained from pretreatment CTP. Time to recanalization is more important for good clinical outcomes in patients with low rCBV than in patients with normal rCBV. **Key Words:** CT perfusion—cerebral blood volume—time to recanalization—endovascular thrombectomy.

Introduction

Time is a critical component in the treatment of acute ischemic stroke. Faster time to recanalization improves clinical outcomes in patients after endovascular thrombectomy.[1] However, some patients can achieve a good clinical outcome even if the time to recanalization is relatively late. One of the reasons for this is that the effect of time to reperfusion on outcome can vary by the extent of collateral flow. Patients with good collaterals may have substantial volumes of salvageable tissue for a relatively long time and achieve good clinical outcomes even if the time to recanalization is relatively late. In contrast,

From the *Department of Strokology, Stroke Center, St. Marianna University, Toyoko Hospital, Kawasaki, Japan; and †Department of Internal Medicine, Division of Neurology, St. Marianna University School of Medicine, Kawasaki, Japan.

Received November 30, 2017; revision received January 8, 2018; accepted February 5, 2018.

Address for correspondence: Tomohide Yoshie, MD, PhD, Department of Strokology, Stroke Center, St. Marianna University, Toyoko Hospital, 3-435, Kosugimachi, Nakaharaku, Kawasaki 211-0063, Japan. E-mail: tomohide.yoshie.1215@marianna-u.ac.jp.

1052-3057/$ - see front matter

https://doi.org/10.1016/j.jstrokecerebrovasdis.2018.02.009

time to reperfusion in patients who have poor collaterals is reported as an important limiting factor for a favorable outcome.[2]

On arrival to the emergency department, patients who have symptoms of acute ischemic stroke are often evaluated with computed tomography (CT) perfusion (CTP) imaging. A recent study showed that relative cerebral blood volume (rCBV) appeared to be a robust marker of leptomeningeal collateral status; rCBV greater than .93 emerged as the predictor of good collateral status, and high rCBV may help characterize durable tissue-at-risk viability in hyperacute anterior circulation ischemic stroke.[3] Therefore, patients who have normal CBV may have good collateral status and substantial volumes of salvageable tissue for a relatively long time.

In contrast, low CBV on pretreatment CTP is reported to be a predictor of poor outcome after endovascular therapy. On CTP imaging, an infarcted core demonstrates significantly decreased CBV, and the penumbra is identified as the area of mean transit time (MTT)–CBV mismatch.[4-6] Thus, patients who have lower CBV may have a smaller penumbra area, and faster time to reperfusion may improve clinical outcomes.

The aim of this study was to investigate whether the association between time to recanalization and clinical outcomes depends on rCBV obtained from pretreatment CTP. Our hypothesis was that time to recanalization is more important for good clinical outcomes in patients who have low rCBV than in those with normal rCBV.

Methods

Subjects

Prospectively collected data from consecutive patients treated with endovascular thrombectomy for acute ischemic stroke in our institution between October 2008 and March 2016 were retrospectively analyzed. Eligibility for inclusion in this study was based on the following criteria: (1) patients who had an acute anterior circulation stroke with intracranial internal carotid artery (ICA) or middle cerebral artery (MCA) M1 occlusion; and (2) patients treated with endovascular thrombectomy. Exclusion criteria were as follows: (1) patients who did not achieve Thrombolysis in Cerebral Infarction (TICI) grade 2 or more reperfusion; (2) contraindication to CTP, such as renal dysfunction, asthma, and allergies; (3) CTP images with poor quality; (4) patients with contralateral ICA occlusion; and (5) the prestroke modified Rankin Scale (mRS) score greater than or equal to 3 or age 90 years or older. The study was approved by the local institutional ethics committee. Written informed consent for the procedure was obtained from all patients or a legal representative before the procedure.

The patient population was divided into 2 groups according to the rCBV value: normal rCBV group (rCBV ≥ .9) and low rCBV group (rCBV < .9). In each group, patient characteristics, including angiographic characteristics, were compared between the good clinical outcome group and the poor clinical outcome group. Good clinical outcome was defined as an mRS score of 2 or less at 90 days. Time to recanalization was defined as the time to visualization of TICI 2A, 2B, or 3 flow in all treatable vessels.

CT Perfusion and Magnetic Resonance Imaging Study

The acute stroke imaging protocol at our institution is plain magnetic resonance imaging (MRI) and CTP. All patients with suspected acute ischemic stroke who do not have a contraindication to MRI undergo plain MRI, including an axial diffusion-weighted imaging sequence, an axial fluid-attenuated inversion recover sequence, and a time-of-flight magnetic resonance angiography. Patients with ICA, M1, or M2 occlusion undergo CTP after MRI if they do not have a contraindication to CTP.

CTP studies were performed on a CT unit equipped with a 64-detector array (Aquilion; Toshiba Medical Systems, Tokyo, Japan). After nonenhanced CT of the whole brain, 4 adjacent 8-mm-thick sections were selected at the level of the basal ganglia. A bolus of 40 mL of iodinated contrast material was injected at a rate of 4 mL/s into the antecubital vein with a power injector. At 5 seconds after the injection, dynamic scanning was initiated with the following parameters: 80 kVp, 60 mA, 4- to 5-mm-thick sections, and 1.5 seconds per rotation for 45 seconds.

For CTP analysis, the CTP imaging data were postprocessed using a commercial software package for CTP imaging analysis (Ziostation 2; Ziosoft, Tokyo, Japan). The MCA contralateral to the occlusion was used as the arterial input function, and the superior sagittal sinuses were used as the venous output function. Identically sized mirrored regions of interest were drawn manually on the reference CT image from the cine dataset over the cortical gray matter of the expected territory of the MCAs. Maps of the cerebral blood flow (CBF), CBV, and MTT were then generated with regions of interest in place using a workstation with CTP software. The rCBV was calculated as ipsilateral CBV divided by contralateral CBV.

Endovascular Treatment

Indications for endovascular treatment at our institution were based on symptoms and admission MRI findings. Endovascular therapy was implemented for patients who arrived within 8 hours after symptom onset with a score of 5 or higher on the National Institutes of Health Stroke Scale (NIHSS), a prestroke functional ability of 4 or less on the mRS, and clinically significant salvageable brain