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Vascular

Computed tomographic perfusion in assessing postoperative revascularization in moyamoya disease

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Abstract

Background: Our purpose in this study is to evaluate the use of computed tomographic perfusion (CTP) as an imaging modality to assess revascularization after superficial temporal artery (STA) to middle cerebral artery (MCA) bypass in patients with moyamoya disease.

Case description: We present a series of 5 patients (mean age, 35; range, 20-50) with moyamoya disease who underwent STA-MCA bypass for ischemic stroke or transient ischemic attack (TIA). Preoperatively, all patients were evaluated with CTP; all showed clinically significant hypoperfusion in the MCA territory. All surgeries were performed by the senior author (ASB) and there were no periprocedural complications. Postoperative CTPs were performed to assess improvement after the bypass. The postoperative CTP images clearly demonstrated patency of the bypass and restoration of flow, particularly in the MCA distribution. At follow-up (mean, 18 months), 3 patients continued to be asymptomatic, one patient's hemiparesis improved, and another patient's hemiparesis improved but remained aphasic (mean Glasgow Outcome Score, GOS = 4.5). All displayed a reduced risk of recurrent stroke; no MCA strokes were observed.

Conclusion: This study demonstrates that CTP, a more convenient and less expensive imaging test than other available options, can provide an assessment of cerebral blood flow after cerebral bypass that appears to correlate with postoperative clinical and angiographic findings. In addition, in this small series of moyamoya patients, STA-MCA bypass appeared to prevent recurrent TIAs and strokes.

Keywords: Moyamoya; Computed tomographic perfusion; STA-MCA bypass; Stroke; TIA

1. Introduction

Moyamoya is a cerebrovascular disease causing progressive occlusion of the supraclinoid internal carotid arteries and subsequently, the proximal middle and anterior cerebral arteries [1,2,9,13]. In the United States and Korea, there appears to be a bimodal distribution with one pediatric group in the first decade of life and another adult group with patients in their 30s and 40s [4,10,17]. Once the diagnosis of moyamoya has been made, the goal is for prompt treatment to prevent an ischemic or hemorrhagic event via a direct or indirect procedure [2]. At our institution, we use a direct anastomosis via superficial temporal artery (STA) to middle cerebral artery (MCA) bypass for moyamoya in adults to provide additional collateral blood flow to hypoperfused areas [1,5].

Although there is no standard treatment of moyamoya, there is also no standard method for assessing cerebral blood flow (CBF) postoperatively or even bypass patency. Many modalities can be used as follows: single photon emission

Abbreviations: CBF, cerebral blood flow; CBV, cerebral blood volume; CTA, computed tomographic angiography; CTP, computed tomographic perfusion; EDAS, encephaloduroarteriosynangiosis; EMS, encephalomyosynangiosis; EMAS, encephalomyoarteriosynangiosis; GOS, glasgow outcome score; MCA, middle cerebral artery; MRA, magnetic resonance angiography; MRI, magnetic resonance imaging; MRP, magnetic resonance brain perfusion; MTT, mean transit time; PET, positron emission tomography; SPECT, single photon emission computed tomography; STA, superficial temporal artery; TIA, transient ischemic attack

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Table 1
Patient characteristics and revascularization procedures

Patient	Age/sex	Preoperative symptoms	Postoperative symptoms	Anastomosis	Postoperative perfusion	Postoperative stroke
1	33/female	Left hemiparesis	Improved left-sided strength	Right STA-MCA bypass	Improved	No
2	50/female	Minimal sensory changes	Unchanged	Left STA-MCA bypass	Improved	No
3	36/female	Asymptomatic, history of stroke	Unchanged	Right STA-MCA bypass	Improved	No
4	38/female	Asymptomatic, history of stroke	Unchanged	Left STA-MCA bypass	Improved	No
5	20/female	Right hemiparesis, aphasia	Hemiparesis improved, aphasia unchanged	Left STA-MCA bypass	Improved	No

computed tomography (SPECT) [6,7,8,11], positron emission tomography (PET) [3], xenon computed tomography, cerebral angiography [6,18], computed tomographic perfusion (CTP) [9], and magnetic resonance brain perfusion (MRP). Our purpose in this study is to evaluate the use of CTP as an imaging modality to assess revascularization after STA to MCA bypass; a more expeditious and less expensive alternative to the aforementioned imaging techniques.

2. Methods

We received institutional review board approval to perform a retrospective review of the charts of a series of 5 female patients (mean age, 35; range, 20-50) who underwent STA-MCA bypass for ischemic stroke or transient ischemic attack (TIA).

Preoperatively, all patients showed clinically significant hypoperfusion in the MCA territory. Indications for surgery included history of stroke or TIA and MCA hypoperfusion on CTP. All of the patients also had moyamoya disease. All surgeries were performed by the senior author and there were no periprocedural complications. Preoperative computed tomographic angiography (CTA) was done initially to identify moyamoya disease; cerebral angiography was done to assess STA size and patency and to confirm the diagnosis of moyamoya. Preoperative and postoperative CTP was performed to assess improvement after the bypass. Computed tomographic angiography was done postoperatively with the CTP to assess bypass patency as well. Cerebral angiography was done in one patient postoperatively.

Although there can be disease within the posterior circulation in moyamoya patients, previous studies have recommended the use of vessels of the posterior circulation as a reference point to prevent greater error in the data sets [9]. As such, we used the posterior circulation as reference points in this study when reading the CTP. Mean transit time (MTT), cerebral blood volume (CBV), and CBF were calculated. In addition, a comparison of the absolute values before and after treatment was made using a paired t test. $P < .05$ was considered a statistically significant difference.

2.1. Imaging protocol

The General Electric LightSpeed VCT scanner (GE Healthcare, Waukesha, WI) was used to perform the CTA/CTP. After the scout film was done, a noncontrast axial head CT was performed from the base of the skull through the apex of the head. For the CTP, a contrasted CT was done with an axial shuttle mode. For the CTA, a contrasted no angle CT was performed from the aortic arch to the apex of the head.

Images were then downloaded to the Vitrea 2 workstation (Vital Images, Plymouth, Minn). The circle of Willis algorithm was used first to assess patency of the bypass. After this, the perfusion algorithm was used to assess CBF, MTT, and CBV. As stated previously, vessels of the posterior circulation were used to calculate the above values. Regions of interest were identified using automated sets

Table 2
Absolute CT perfusion data (mean, SD, and P Value) for the symptomatic hemisphere

Time of measurement	MTT (s)	CBV (mL/100 g)	CBF (mL/100g per minute)
Before treatment	6.53 ± .075	4.53 ± .55	67.6 ± 4.93
After treatment	4.16 ± 1.0	2.96 ± .92	92.3 ± 13.2
P	.03	.065	.039

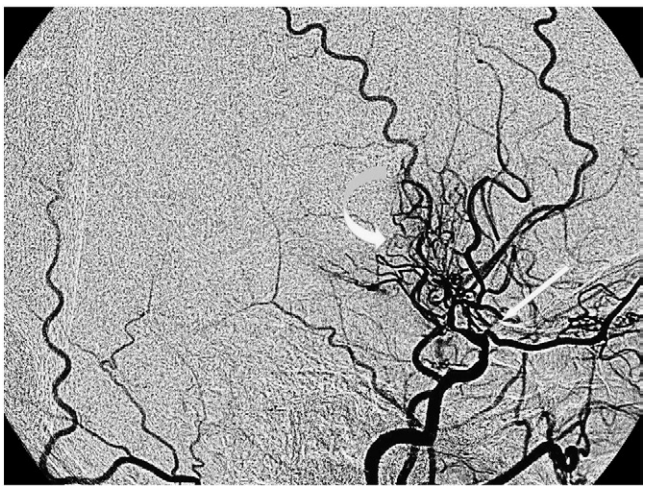

Fig. 1. Preoperative lateral cerebral angiogram. A 33-year-old female with history of moyamoya, multiple strokes refractory to medication, and left hemiparesis. Note the occlusion of the right internal carotid artery at approximately the ophthalmic segment (straight arrow) as well as the characteristic "puff of smoke" seen in moyamoya patients (curved arrow).