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ROLE OF COMPUTED TOMOGRAPHY IN THE ASSESSMENT OF EXTRA-INTRACRANIAL MICROANASTOMOSIS IN PATIENTS WITH MOYAMOYA DISEASE

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Abstract
This article describes CT angiography of the brachiocephalic arteries supplying the brain and CT perfusion of the brain before and after extra-intracranial microanastomosis surgery in patients with moyamoya disease.
Keywords: computed tomography angiography, brachiocephalic arteries, extra-intracranial microanastomosis, moyamoya disease.

Introduction

Moyamoya disease is an idiopathic, non-inflammatory, progressive, non-atherosclerotic occlusive vascular disease affecting the vessels of the circle of Willis, most commonly the supraclinoid segment of the internal carotid arteries.

Moyamoya disease (MMD) is a rare cerebrovascular disorder (idiopathic arteriopathy) characterized by progressive narrowing of the terminal segments of the internal carotid arteries and/or the proximal segments of the arteries of the circle of Willis (mainly the middle cerebral arteries and anterior cerebral arteries), with formation of an abnormal vascular network at the base of the brain. The disease was first described in 1957 by the Japanese physicians Takeuchi and Shimizu. In 1967, it received the name “moyamoya,” a Japanese term meaning “a puff of cigarette smoke in the air,” reflecting the angiographic appearance of the abnormal vascular network.

The disease is most prevalent in East Asia, especially in Japan and Korea, where the prevalence is reported at approximately 3.16 cases per 100,000 population, which is 7-10 times higher than in many other countries. The pathogenesis of MMD is still not completely understood. Histologically, the affected arteries show fibrocellular intimal thickening with corrugation and contraction of the internal elastic lamina, proliferation of smooth-muscle cells, and thinning of the media, without inflammatory or atherosclerotic changes.

At present, no effective drug therapy can stop or substantially slow disease progression. Therefore, conservative treatment remains supportive, while surgical cerebral revascularization is recognized worldwide as the main treatment strategy. The purpose of surgical treatment is to improve cerebral perfusion by creating new pathways for extra-intracranial blood flow. Numerous studies have shown that surgical treatment is highly

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effective, significantly reduces the risk of ischemic and hemorrhagic brain injury, and improves rehabilitation outcomes and quality of life.

Two major approaches are used for surgical cerebral revascularization: direct extra-intracranial microanastomosis (EIICMA) and indirect synangiosis between the cerebral cortex and well-vascularized tissues. Based on contemporary international practice, current trends favor combined revascularization using both direct and indirect techniques.

Patients with internal carotid artery occlusion most often suffer from cerebral hypoperfusion. Creation of an extra-intracranial microanastomosis improves collateral circulation and, consequently, regional cerebral blood flow.

Cerebral perfusion can be assessed by several methods, including perfusion CT, perfusion MRI, positron emission tomography, and single-photon emission computed tomography. Among these, perfusion CT is one of the most accessible and sufficiently informative methods.

Research objective: to evaluate the role of CT angiography in the postoperative assessment of cerebral revascularization in patients with moyamoya disease.

Materials and Methods

Multislice CT angiography of the intra- and extracranial arteries supplying the brain was performed on a Revolution CT scanner (GE, 128-slice). Ten patients with occlusion zones and/or stenosis of the internal carotid artery were examined. Among the 10 patients, 6 were men and 4 were women. The mean age was 35 years in men and 40 years in women.

Results

All patients underwent non-contrast CT, CT angiography, and CT perfusion both before and after surgery.

On non-contrast CT, five patients (50%) had ischemic zones in the subcortical portions of the parietal and temporal lobes (Fig. 1).

a) axial projection	b) coronary projection	c) sagittal projection

Fig. 1. Female patient, 27 years old. Moyamoya disease. Subcortical hypodense areas in the left frontal-parietal region, density +26+27 HU..

Preoperative CT angiography demonstrated hypoplasia of the left internal carotid artery throughout its course (segments C1-C7) in all patients (Fig. 2).

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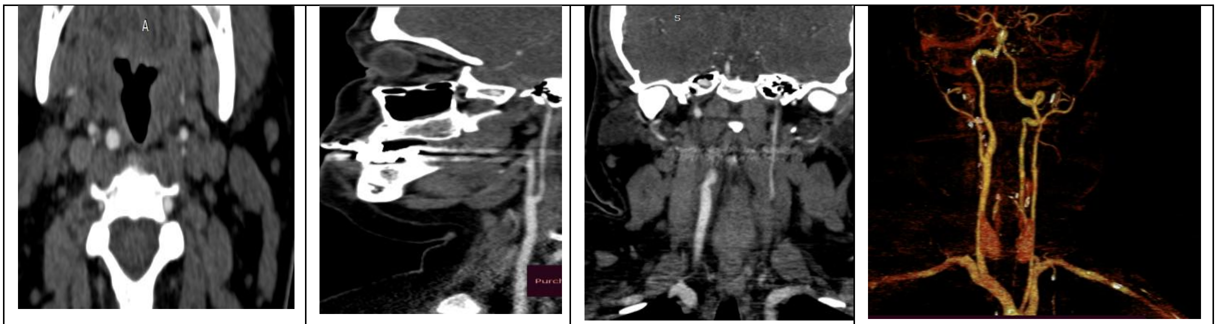

a) axial projection	b) coronary projection	c) sagittal projection	d) 3D reconstruction - angular pathological tortuosity (kinking) and pathological tortuosity in the form of a loop (coiling) of the left BCA

Fig. 2. Female patient, 27 years old. Moyamoya disease. CT angiography of the extracranial vessels of the brain prior to surgery. Hypoplasia of the left internal carotid artery.

All patients underwent CT perfusion of the brain. In all patients, cerebral blood volume (CBV) was reduced, although not critically. A decrease in CBV on CT perfusion reflects a reduction in the total blood volume in a given area of brain tissue and is an important marker of impaired blood supply and potential infarct core when interpreted together with cerebral blood flow (CBF). In all patients, CBF was reduced to 20±0.03 mL/100 g/min on the right and to 15±0.04 mL/100 g/min on the left. Tmax and mean transit time (MTT) remained within normal ranges **(table 1.)**

Table 1. Perfusion CT values in patients with moyamoya disease before EIICMA surgery

Region	Hemisphere	CBV (mL/100 g)	Tmax (s)	CBF (mL/100 g/min)	MTT (s)
MCA territory, temporoparietal region, lateral sections	Right	1.8±0.012	3.4	20±0.03	4.2
MCA territory, temporoparietal region, lateral sections	Left	1.7±0.015	4.0	15±0.04	5.1

Reference ranges: CBV 2-4 mL/100 g (typical normal tissue values 4-5 mL/100 g); infarct threshold <1.0-1.5 mL/100 g when interpreted with CBF. Tmax 12-15 s. CBF 25-55 mL/100 g/min (typical normal values 50-80 mL/100 g/min); ischemia threshold <20 mL/100 g/min, infarct threshold <12 mL/100 g/min. MTT approximately 4-5 s.

All patients with MMD underwent combined extra-intracranial microanastomosis surgery. On the second postoperative day, CT angiography of the brachiocephalic arteries was performed to evaluate the extra-intracranial anastomosis.

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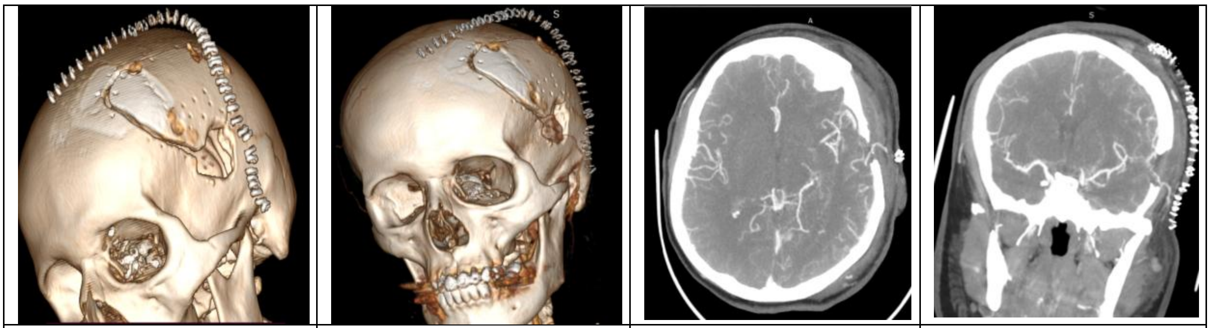

a) 3D reconstruction	b) coronary projection	c) axial projection	d) coronary projection

Figure 4. CT angiography of the cerebral vessels on postoperative day 2 after extra-intracranial microanastomosis.

Three months after surgery, follow-up CT perfusion of the brain demonstrated a marked improvement in CBF on both sides. Left-sided CBV remained low at 1.8±0.011 mL/100 g, whereas the right-sided CBV corresponded to the lower limit of normal. Over time, Tmax decreased on the left, while MTT showed a slight increase on the right **(table 2.).**

Table 2. Perfusion CT values in patients with moyamoya disease three months after EIICMA surgery

Region	Hemisphere	CBV (mL/100 g)	Tmax (s)	CBF (mL/100 g/min)	MTT (s)
MCA territory, temporoparietal region, lateral sections	Right	2.1±0.012	3.4	32±0.01	5.3
MCA territory, temporoparietal region, lateral sections	Left	1.8±0.011	3.4	27±0.03	5.1

Reference ranges: CBV 2-4 mL/100 g (typical normal tissue values 4-5 mL/100 g); infarct threshold <1.0-1.5 mL/100 g when interpreted with CBF. Tmax 12-15 s. CBF 25-55 mL/100 g/min (typical normal values 50-80 mL/100 g/min); ischemia threshold <20 mL/100 g/min, infarct threshold <12 mL/100 g/min. MTT approximately 4-5 s.

Conclusions

1. Multislice CT angiography makes it possible to determine the extent of brachiocephalic arterial occlusion and thereby supports selection of an appropriate management strategy.

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2. Multislice CT angiography enables objective assessment of the patency of the extra-intracranial microanastomosis.
3. CT perfusion assesses cerebral blood supply through absolute quantification of key parameters: CBV (blood volume in tissue), CBF (blood-flow rate), MTT (mean transit time), and Tmax (contrast delay time). These parameters help identify ischemic stroke zones, determine the penumbra, and provide quantitative follow-up before and after surgery.

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