

Moyamoya syndrome, from image to diagnosis. Presentation of a case

Síndrome de moyamoya, de la imagen al diagnóstico. Presentación de un caso

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Summary

Moyamoya disease and moyamoya syndrome refer to a progressive steno-occlusive vasculopathy in the terminal portions of the bilateral internal carotid arteries and/or the proximal parts of the middle and anterior cerebral arteries, with prominent formation of collateral arteries. It can generate irreversible damage to cerebral hemodynamics due to the progressive nature of the affected cerebral vessels. Pathological examination shows no atherosclerotic or inflammatory lesions and the cause of the stenosis is overgrowth of the smooth muscle layer, with thrombotic changes. The disease leads not only to a different degree of stenosis and occlusions of the great arteries in the anterior part of the circle of Willis, but also to the development of collateral vasculature that produces a typical angiographic image, termed 'puffs of smoke' or 'cigarette smoke'. We present the case of a 28-year-old female patient who presents with insidious symptoms and a previous wrong clinical and imaging diagnosis, in whom a follow-up magnetic resonance of the brain was performed, in which imaging and angioresonance findings compatible with moyamoya disease were observed. The imaging findings of the syndrome in the different modalities of radiological studies are analyzed.

Resumen

La enfermedad de moyamoya y el síndrome de moyamoya se refieren a una vasculopatía estenooclusiva progresiva en las porciones terminales de las arterias carótidas internas y/o las partes proximales de las arterias cerebrales media y anterior, con formación prominente de arterias colaterales. Puede generar daños irreversibles en la hemodinámica cerebral debido a la naturaleza progresiva en los vasos cerebrales afectados. El examen patológico no muestra lesiones ateroscleróticas o inflamatorias y la causa de la estenosis es el sobrecrecimiento de la capa de músculo liso, con cambios trombóticos. La enfermedad conduce no solo a un grado diferente de estenosis y oclusiones de las grandes arterias de la parte anterior del polígono de Willis, sino también al desarrollo de la vasculatura colateral que produce una imagen angiográfica típica, denominada "nubes de humo" o "humo de cigarrillo". Se presenta el caso de una paciente de 28 años de edad, quien cursa con una clínica insidiosa y un diagnóstico clínico e imagenológico previo errado; se le realiza resonancia magnética de cerebro y angiorresonancia compatibles con enfermedad de moyamoya. Se analizan los hallazgos imagenológicos del síndrome en las diferentes modalidades de estudios radiológicos.

Introduction

Moyamoya disease (MMD) and moyamoya syndrome (MMS) refer to a progressive steno-occlusive vasculopathy in the terminal portions of the internal carotid arteries and their proximal branches with prominent formation of collateral arteries.

Pathologic examination shows no atherosclerotic or inflammatory lesions in the affected cerebral vessels. The cause of stenosis is overgrowth of the smooth muscle layer, with thrombotic changes (1). The disease leads not only to a different degree of stenosis and occlusions of the large arteries in the anterior part of the polygon of Willis, but also to the development of collateral vasculature that produces a typical angiographic image, called "clouds of smoke" or "puff of cigarette smoke" (2).

The collateral parenchymal vessels - described as "moyamoya" type vessels - are small, twisted and wide vessels that penetrate towards the base of the brain, along the course of the thalamo-striatal arteries and the lenticulostriatal arteries. Transscleral anastomoses develop between the superficial temporal artery and the middle meningeal artery or the ophthalmic artery and the anterior or middle cerebral artery, perforating the

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dura. Thrombotic changes may appear in the vessels of the collateral circulation, which are the cause of ischemic symptoms (3).

Increased blood flow through thin collateral walls during stress, as well as microaneurysms, are the likely causes of intracranial hemorrhages.

All imaging modalities have their advantages and disadvantages and may play a role in certain situations.

Angiographic criteria for the diagnosis of moyamoya disease were established in 1998. They include stenosis or occlusion of the distal parts of the intracranial internal carotid arteries and the proximal parts of the anterior and middle arteries, as well as collateral vasculature in the brain base regions, without clarified etiology; in case of bilateral findings, the diagnosis is considered secure.

Unilateral changes are graded as probable. Naturally, computed tomography (CT) examination is sufficient to diagnose an ischemic or hemorrhagic cerebrovascular event in the course of the disease. Ischemic areas are usually located in the basal ganglia and in the periventricular and subcortical white matter. In case of patients with symptoms of transient ischemic events, the results of the studies are negative.

Occlusions or stenosis of large intracranial vessels and collateral vasculature on routine contrast-enhanced CT should suggest suspicion of the disease, especially in young individuals. In ambiguous cases, magnetic resonance imaging (MRI) is indicated, which not only helps to establish the diagnosis, but also allows a better evaluation of the type and time of evolution of ischemic lesions (4).

The use of diffusion techniques substantially increases the diagnostic value of MRI studies in these cases. The FLAIR sequence is also very useful, as it helps to diagnose the "ivy sign", i.e., an increase in signal along the fissures and convolutions of the cerebral hemispheres, probably as a result of reduced cortical flow. The MRI study is also very useful to visualize late sequelae of previous strokes, i.e., cerebral atrophy and widening of the ventricular system and pericerebral fluid spaces.

Before modern angiographic examinations, angiotomography (Angio-CT) or magnetic resonance angiography (MRA) were introduced into widespread clinical practice, the final diagnosis of vascular changes was based on conventional angiography or digital subtraction angiography (DSA). Currently, the diagnosis of the full range of vascular changes in the course of the disease is mainly based on MRA and CT, using multislice systems. There were also single reports on the use of transcranial Doppler ultrasound. However, this method has no major relevance in the diagnosis of this disease (5).

Angiographic examinations distinguish six grades of severity of vascular changes. The first degree includes only carotid artery stenosis. In the second and third degrees, the moyamoya-type collateral vasculature develops and increases in width. In the fourth and fifth degrees these vessels begin to disappear, and in the sixth degree, in which they become invisible, the collateral vessels branch only from the external carotid arteries.

Quantitative assessment of hemodynamic disturbances of cerebral circulation in the course of moyamoya disease, evaluated on the basis of PET, SPECT, perfusion CT and MRI, is a contested issue.

Comparative studies, including vascular and perfusion examinations, have shown significant correlations between angiographic imaging and regional perfusion. As the disease normally affects both internal carotid arteries, and not the posterior part of the arterial polygon of Willis, individuals with moyamoya disease experience decreased frontal blood flow (dominant under normal conditions), with normal or increased blood flow in the occipital lobes.

On the basis of perfusion studies, it has also been found that in children with moyamoya disease there is a much more pronounced decrease in cerebral blood flow (CBF) and increase in cerebral blood volume (CBV) and O_2 extraction fraction (OEF) than in adult populations. In addition, the reduction in cerebrovascular reserve (CVR) was reported to be greater in children, which was assessed on the basis of acetazolamide or CO_2 testing. These differences may explain the higher incidence of ischemic lesions in the pediatric population versus intracranial hemorrhages, which are more frequent in adults. Piao et al. found that patients with clinical ischemia or collateral circulation experience increased CSV and decreased CVR, in contrast to the group of patients without well-developed collateral vasculature. On the other hand, Nariai et al. cited by Tarasów et al. demonstrated that in cases of ischemic stroke or transient ischemic attack (TIA) there was an increase in CSV and OEF, whereas in patients with hemorrhage or TIA there were no changes in perfusion parameters (6).

Case report

A 28-year-old female patient with a history of type 1 diabetes mellitus, with non-stereotyped and non-rhythmic involuntary movements of five years of evolution, in both upper extremities, lasting seconds, which occurred 3-4 times a month. Also, with episodes of loss of tone in both lower extremities, lasting seconds and occurring 2-3 times a month. She underwent an MRI with findings of white matter lesions in the temporal, occipital, frontal and parietal areas bilaterally, as well as brain atrophy predominantly on the right, with a diagnosis of multiple sclerosis; no treatment was started. Four years ago she presented progressive decrease in visual acuity until bilateral amaurosis, so a control brain MRI was performed, showing bilateral temporoparietooccipital and left frontal encephalomalacia with peripheral gliosis secondary to chronic ischemic vascular event in the territory of the middle, bilateral posterior and left anterior cerebral arteries (Figure 1); right occipital and left parietal acute ischemic vascular event and left temporoparietooccipital cortical laminar necrosis (Figure 2). Multiple collaterals with stenosis of the anterior cerebral circulation, imaging and angioresonance findings compatible with moyamoya disease (figures 3 and 4).

Discussion

Moyamoya is a rare cerebrovascular disease that can have serious consequences, such as cerebrovascular events (CVE) and cerebral hemorrhages; it has been identified as an important cause of CVE in young patients. The etiology of moyamoya disease is poorly understood. Genetic antecedents are frequently related, because in up to 15% of cases the disease is found in other family members. These are most probably cases of autosomal multifactorial inheritance. The *RNF213* gene mutation and association with Down's disease has been identified as a risk factor (7).

Vascular lesions typical of moyamoya disease may also develop in individuals infected with hepatitis C virus, patients with cryoglobulinemia, sickle cell disease and in individuals undergoing radiotherapy of optic chiasm tumors. In those cases in which the etiologic factor was determined, they were termed "moyamoya syndrome"; however, in most patients, the lesions are not caused by any known risk factor, i.e., they develop in healthy individuals, therefore they are classified as moyamoya disease.

The disease is more common in children and young adolescents. Two peaks of incidence are observed in the first, third and fourth decades of life. The disease is more common in females, and the ratio of females to males with the disease amounts to 1.8:1, or even 4.25:1.

The most common clinical symptoms of the disease include sudden onset of hemiplegia, with alterations in sensation and aphasia. Headache, vertigo, seizures and involuntary movements may also occur; cases of cognitive dysfunction or psychoorganic syndrome have been described.

According to the Japanese Ministry of Health classification, there are four clinical forms of moyamoya disease: ischemic, hemorrhagic, epileptic and "other".

The ischemic form is more common in children, while the hemorrhagic form is more common in adults. In children, moyamoya disease has a form of transient ischemia or lacunar cerebrovascular events, leading to mental retardation. In adults, intracranial hemorrhages, including subarachnoid hemorrhages, may occur.

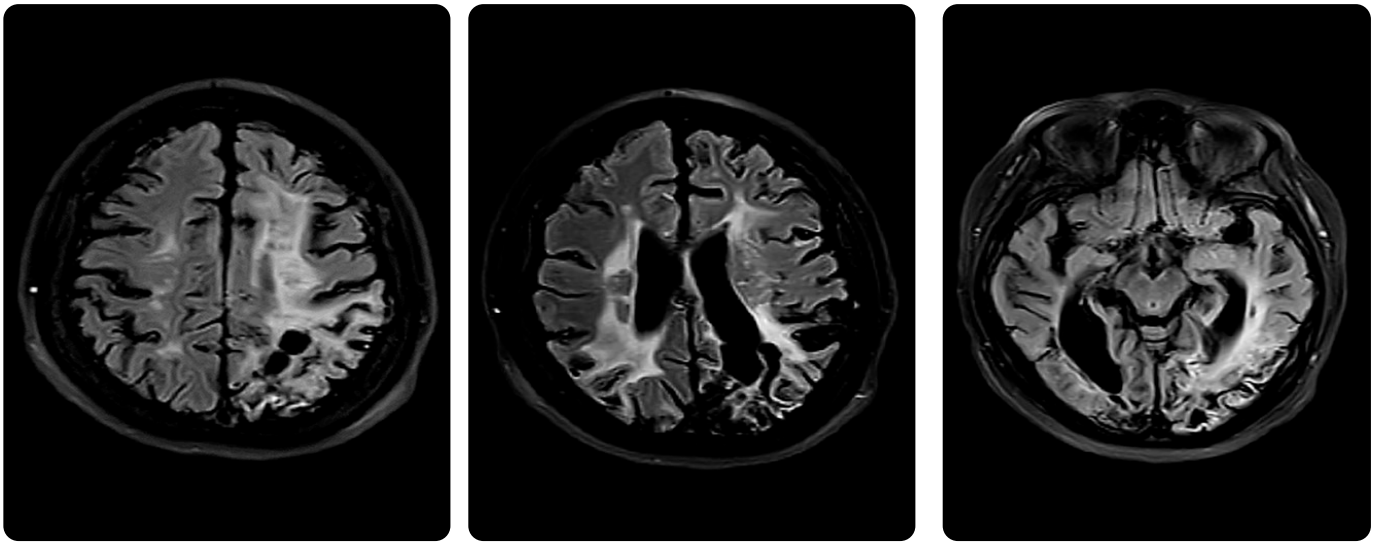


Figure 1. Axial MRI in T2-weighted FLAIR sequence. Areas of bilateral frontotemporoparietooccipital encephalomalacia with peripheral gliosis and retraction of the lateral ventricles due to loss of corticosubcortical volume secondary to chronic ischemic vascular events in bilateral middle and posterior cerebral artery territory. High cortical signal predominantly left frontoparietotemporal due to cortical laminar necrosis.

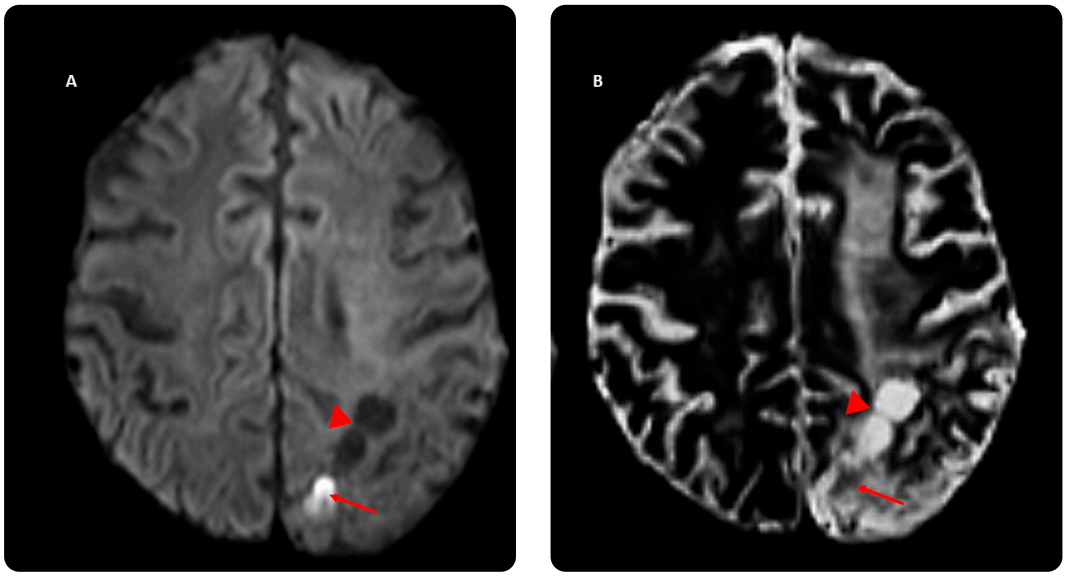


Figure 2. Axial MRI. a) Diffusion sequence; b) ADC. Area of left parietal restriction due to acute ischemic vascular event (arrow), in the territory of the left middle cerebral artery. There is another adjacent image of low signal in diffusion and high signal in ADC related to chronic infarction (arrowhead).

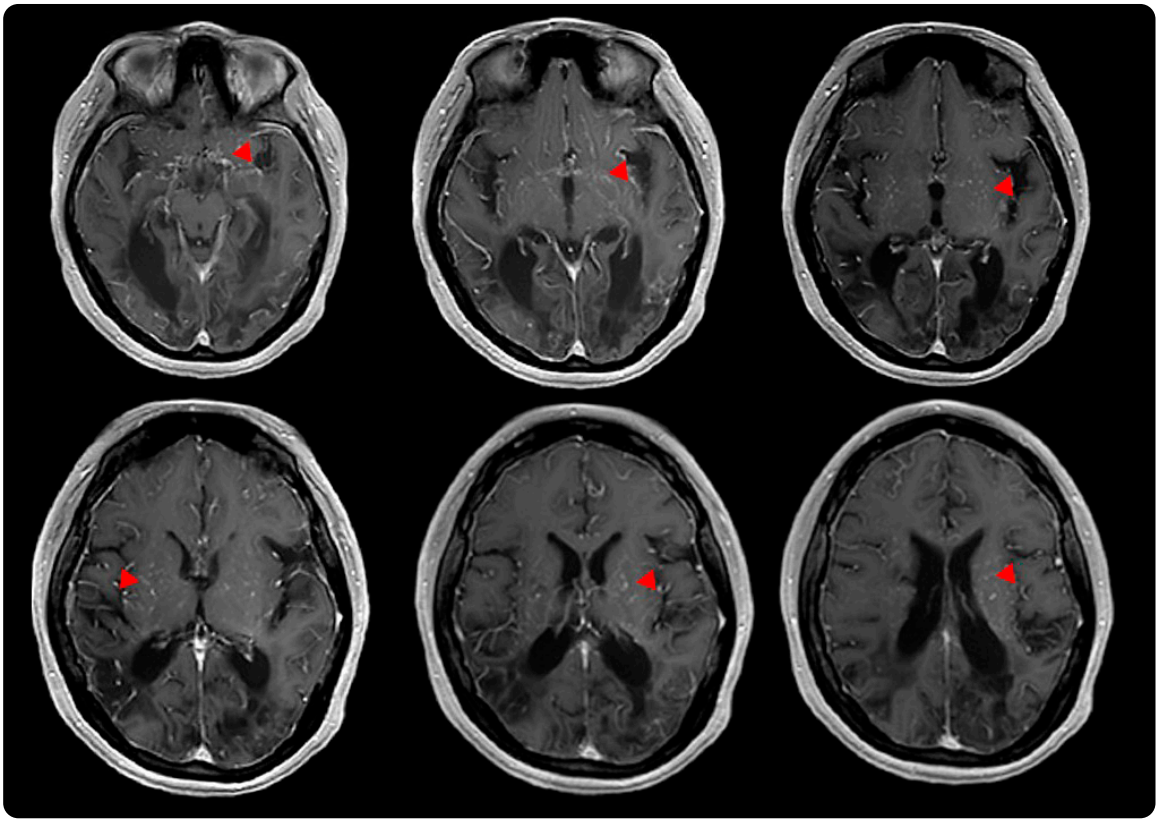


Figure 3. Axial T1-weighted MRI with intravenous contrast medium administration. Multiple collateral vessels (arrowheads) in the basal ganglia and bilateral thalamus.

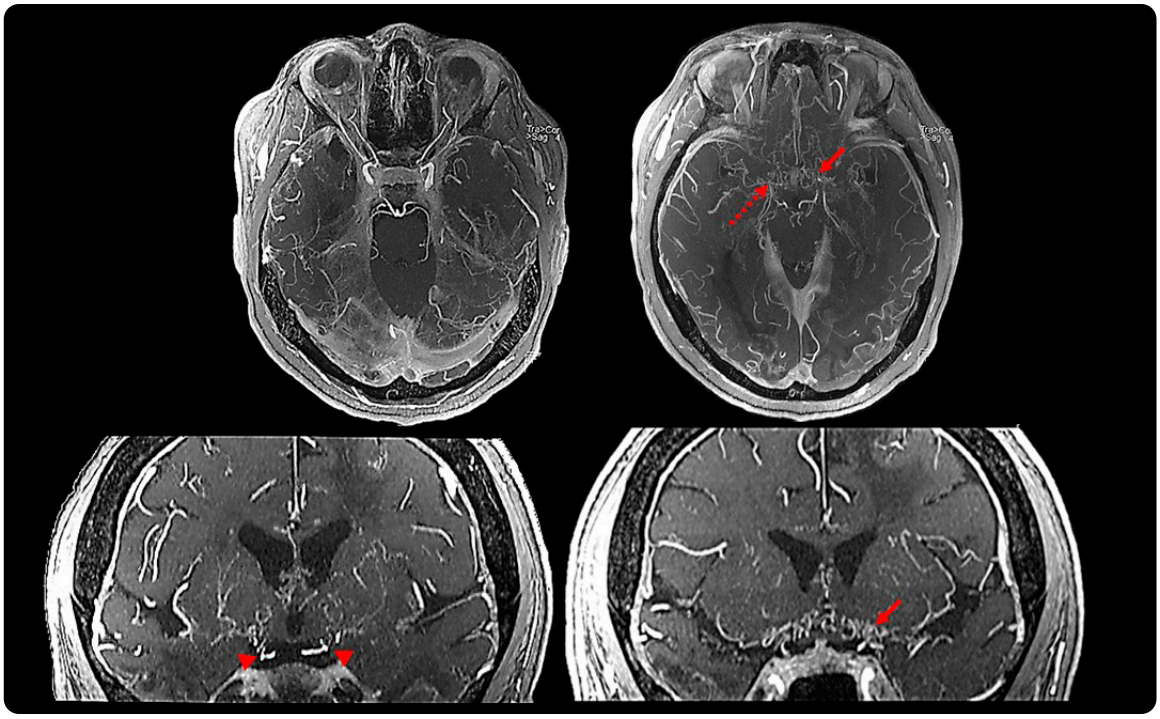


Figure 4. MRI angiography with contrast medium and MIP reconstruction. Middle cerebral artery occlusion (dashed arrow) and bilateral posterior cerebral artery (arrowhead) with formation of collateral vessels (arrows).

The clinical course of the disease is variable, it may progress slowly, with rare incidents of cerebral ischemia, while, in some of the cases, there is a rapid progression with sudden deterioration of the neurological status. Ischemic incidents may recur, especially in the early years of the disease. The risk of repeated ischemic cerebrovascular events is 65% to 82% (for bilateral lesions). On the other hand, repeated hemorrhagic strokes are quite common: the risk of repeated hemorrhage amounts to 30-65 % (6).

A high rate of cerebral hemorrhage is found in patients with moyamoya, highlighting the importance of early diagnosis and proper management of the disease.

Extracranial-intracranial bypass surgery in patients with hemorrhagic moyamoya has been shown to significantly reduce the recurrence rate of cerebral hemorrhage and improve patients' quality of life. These findings support the importance of surgical revascularization in the treatment of the disease (8).

Conclusion

In moyamoya syndrome and disease, radiological imaging plays an important role in determining the diagnosis, as well as the complications and stage of the condition; therefore, it is important to be aware of the clinical signs and symptoms, as well as the radiological findings in this condition.

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