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Rapid Diagnosis of Carotid Intramural Hematoma with HR-MRI

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Abstract

Carotid intramural hematoma, a type of carotid artery dissection, is hard to detect with traditional imaging examinations including color ultrasonography, computed tomography angiography (CTA), and digital subtraction angiography (DSA) because of the unaffected tunica intima. In this article, we report and discuss two cases of carotid intramural hematoma. In the first case, the patient experienced sudden-onset dysarthria with difficulty chewing and sucking. The diagnosis of ischemic stroke was further supported with the clinical presentation, physical examination, and a head CT scan. Later, the head and neck CTA examination detected the left carotid vessel had an irregular vascular wall and luminal stenosis, which was ultimately confirmed as intramural hematoma after performing neck high-resolution MRI (HR-MRI). Another patient was rapidly diagnosed with acute ischemic stroke using a head MRI scan, but the qualitative nature of the responsible vessel could not be distinguished by CTA and DSA. They could only demonstrate full occlusion of the carotid artery. HR-MRI was needed to identify the intramural hematoma-type ICA dissection. In conclusion, compared with CTA and DSA, HR-MRI is a cost-effective imaging examination with high resolution and easy repeatability. It can more accurately determine the nature of the vascular wall, the relationship of vessels and surrounding tissues, and effectively assists in the clinical judgement for intramural hematoma and other atypical carotid artery dissections.

Keywords: Carotid intramural hematoma; Diagnosis; CTA; DSA; HR-MRI

Introduction

When there is injury to the internal carotid intima or intervascular nutrient arteries rupture, blood leaks between the intima and media layers or between the media and the outermost vascular wall. This is known as internal carotid artery (ICA) dissection and can be observed in patients of all ages, with the highest incidence seen in 30-50 year-old individuals. ICA dissection leads to the formation of vascular stenosis, aneurysm, or thrombosis. Carotid artery dissection has been recognized as the most common cause of juvenile stroke and is commonly misdiagnosed due to the various clinical manifestations [1,2]. Patients can present with headache, neck pain, or Horner's syndrome, while other patients have symptoms caused by cerebral infarction. Definitive diagnosis based solely on clinical symptoms alone is challenging and often results in misdiagnosis or delayed treatment. Imaging plays an important role in aiding the diagnosis of ICA dissection, including. Color doppler ultrasound, computed tomography angiography (CTA), magnetic resonance imaging (MRI), Magnetic Resonance Angiography (MRA), and digital subtraction angiography (DSA) are several imaging modalities used to assist in the diagnosis. These imaging modalities are able to appreciate hematostenosis and atherosclerotic plaques. However, diseases such as moyamoya, vasculitis leading to the stenosis, is not detectable using these imaging techniques. To effectively treat patients, information on the pathological nature of the vessel wall is needed. More recently, High resolution- MRI (HR-MRI) has been of great diagnostic value in the diagnosis of cranial carotid artery lesions compared with other imaging modalities, as it can determine the nature of the vessel wall [3,4].

Patients and Methods

Case 1

A 41-year-old man with a history of first-degree hypertension was admitted October 2016 due to the presentation of sudden dysarthria with difficulty sucking and chewing. In addition, the patient complained he had two days of a left temporal-orbital paroxysmal pulsating pain prior to admission. On admission, that patient's blood pressure (BP) was 151/86 mm Hg. He had dysarthria and left tongue deviation. There was no tongue atrophy or tremors, and the pharyngeal reflex was normal. No other positive symptoms were noted on the neurological exam. One day prior to admission he received a head MRI at an outside hospital and no acute cerebral hemorrhage or cerebral infarction was noted.

Routine examinations were performed after admission, including a routine blood examination, routine urine test, coagulation factors, extracranial carotid color ultrasonography, and an enhanced head and neck MRI. No obvious abnormalities were documented. The head and neck CTA was performed: The distal extracranial segment of the left ICA was found to have luminal stenosis greater than 50% and an irregular vascular wall surrounded by a suspicious low-density soft plaque. The left ICA in the clinoid process near the skull base exhibited local atherosclerosis. Despite stabilizing lipid-plaques, improving circulation, nutrition, administering anti-platelet aggregation therapies, and symptomatic treatment, the patient's tongue paralysis did not resolve.

Normal values for a lumbar puncture, erythrocyte sedimentation rate, C-reactive protein (CRP), anti-nuclear antibody spectrum, and anti-neutrophil antibodies did not support an intracranial infection or autoimmune vascular inflammation. Considering the patient's age, history of hypertension, CTA findings, and the acute onset of ipsilateral headache, and ipsilateral paraplegia, the possibility of an atypical carotid artery dissection couldn't be excluded. This led clinicians to select cervical HR-MRI (3.0T) examination (Figure 1). On imaging, short T1 and long T2 signal shadow strips appeared around the distal extracranial segment of the left ICA (near the carotid artery) lumen. 3D-Time of Flight (TOF) and proton density weighted imaging (PDWI) sequence showed high signal with an upper and lower luminal diameter measuring 2.6 mm. The normal luminal diameter of the ICA in males is 5.11 +/- 0.87 mm (1). ICA dissection (intramural hematoma type) was most likely causing the severe luminal stenosis. Treatment included a regimen of anticoagulation injections of low molecular weight heparin sodium for 6 days and clopidogrel combined with cilostazol to prevent platelet aggregation. The patient's dysarthria and temporal pain symptoms were relieved, but the tongue paralysis and chewing difficulties remained. Vascular and neurosurgery were consulted and recommend the patient continue oral clopidogrel and cilostazol for blood pressure control. He was then discharged home and instructed to follow up in the outpatient setting.

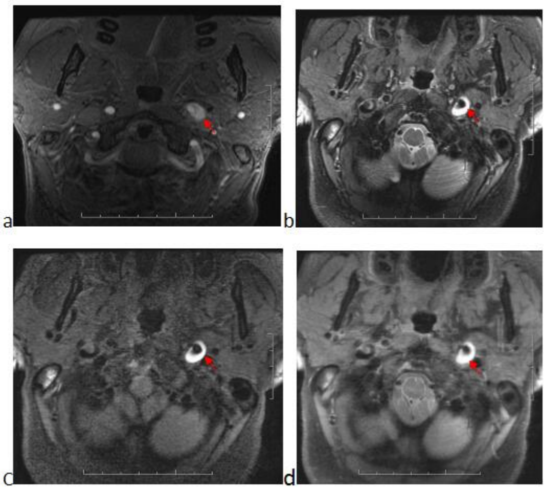

Figure 1: The short T1 (a) and long T2 (b) signal shadow strips appeared near the left ICA extracranial distal segment. PDWI sequence(c) and TOF sequence (d) showed high signal, with an upper and lower luminal diameter of 2.6 cm. An intramural hematoma-type ICA presents with severe luminal stenosis and is consistent with the HR-MRI findings.

In the outpatient setting, follow-up calls were made with the patient. He endorsed clear sputum with no sucking or chewing difficulties. Within one month his tongue paralysis resolved. In January 2017, imaging studies of the ICA using HR-MRI were performed (Figure 2). A portion of the distal extracranial segment of the left ICA luminal wall showed a thin strip of high signal. Compared to imaging studies performed in November 2016, the lesion size was significantly reduced.

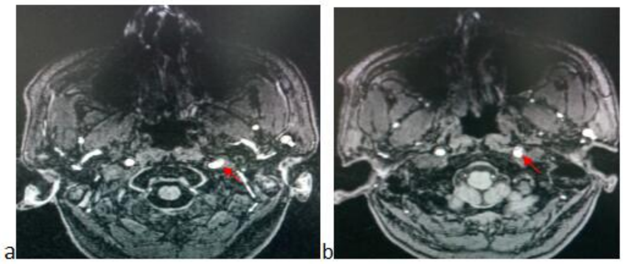

Figure 2: A portion of the luminal wall of the left ICA extracranial distal segment near the common carotid artery demonstrated a thin strip of high signal. Compared to prior imaging studies, the lesion size was significantly reduced.

Case 2

A 45-year-old man was definitively diagnosed with multiple acute ischemic infarcts in the left cerebral hemisphere in another hospital three days prior to admission. The patient was found to have occlusion of the left ICA C1 segment on head and neck CTA. Digital subtraction angiography (DSA) demonstrated occlusion of the C1 segment of the left ICA just like "tail of mouse sign" (Figure 3a). HR-MRI identified an intramural hematoma-type ICA dissection as causing the occlusion (Figures 3b-d). After identifying the ICA dissection, the treatment strategy changed from antiplatelet therapy to anticoagulation therapy. Identification of the ICA dissection using HR-MRI improved the overall prognosis for this patient.

Discussion and Imaging Studies

The patient in the first case presented with manifestations consistent with single cranial nerve damage and headache, making a definitive diagnosis challenging without additional studies. The head and neck CTA found an irregular vascular wall in the left ICA surrounded by an annular low-density circumferential shadow. The CTA values of the shadow were mixed and no contrast enhancement was appreciated. The presentation on CTA couldn't distinguish between a vascular dissection or arterial fibrous plaques, but HR-MRI was able to appreciate the specific pathological features.

HR-MRI demonstrates how the hypoglossal nerve is anatomically adjacent to the ICA in the posterior cranial section (Figure 4). This anatomic relationship explains how an ICA dissection can compress the ipsilateral sublingual nerve. Judging from several MRI views, the sublingual nerve exited adjacent to the intracranial section and arrived at the ICA dissection (Figure 5), resulting in ipsilateral tongue paralysis and affected the patient's sucking and chewing functions. In first case, the patient's HR-MRI (Figure 1) results show formation of an ICA intramural hematoma with the hematoma compressing the internal jugular vein and decreasing the distance between the vascular structures. HR-MRI is also a valuable clinical tool to help appreciate anatomical relationships of vessels and tissues. After anticoagulation therapy was administered to the patient described in Case 1, his symptoms improved significantly. A neck HR-MRI reexamination two months later showed diminution of the intramural hematoma

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compared to former images, further supporting the diagnosis of left ICA dissection.

The second patient was diagnosed as having an acute ischemic stroke secondary to occlusion of the left ICA on CTA and DSA. HR-MRI helped identify an inter-wall-hematoma dissection. A visible limitation of CTA and DSA is that if the tunica intima is intact, contrast agents can't identify the dissection. HR-MRI can accurately capture the shape of the vascular wall in multiple sequences and anatomical levels. HR-MRI was able to assist in diagnosing the specific type of carotid artery dissection present.

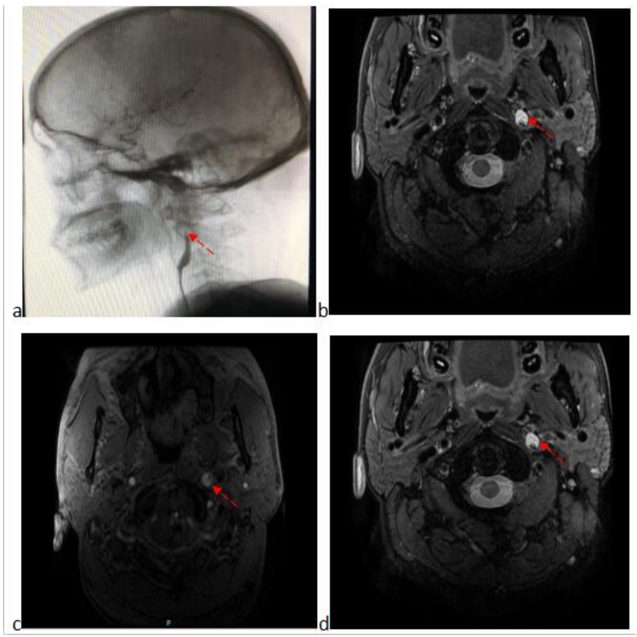

Figure 3: (a) DSA demonstrating the occluded C1 segment (the red arrow) in the left ICA; (b-d) HR-MRI demonstrating the ring and crescent signal (red arrow) consistent with an ICA dissection (intramural hematoma type).

Digital subtraction angiography

DSA is currently recognized as the gold standard for the diagnosis of ICA dissection and grading carotid atherosclerotic disease [5]. However, it is an invasive and high-risk procedure. It is also costly and cumbersome to operate and poses limitations in patients whose renal function is poor or those allergic to contrast agents.

Complications include femoral artery injuries, peri- and post-procedure bleeding, infections, and hematomas at the puncture site. DSA can determine the degree of arterial stenosis and the shape of different dissections. However, intramural hematoma-type dissections are not visualized using DSA.

A study by Wang Y et al. also founded some twisted changes, occlusion or some indescribable forms could not be clearly identified as ICA by DSA [11]. Because of the inherent risks associated with this imaging modality, DSA will likely be replaced by other noninvasive imaging modalities such as CTA, MRA, or HR-MRI.

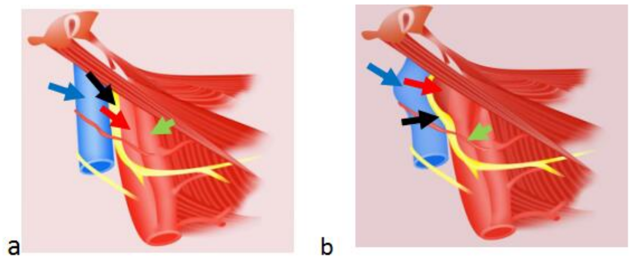

Figure 4: (a) The sublingual nerve (black arrow) is anatomically adjacent to the ICA in the posterior cranial section. (b) Carotid artery dissection (red arrow) in the extracranial carotid artery near the carotid canal leads to moderate-to-severe stenosis of the lumen. An ICA dissection adjacent to the sublingual nerve can compress the ipsilateral sublingual nerve resulting in ipsilateral tongue paralysis and inflexible tongue movements. The blue arrow point to the jugular vein and the green arrow point to the external carotid artery.

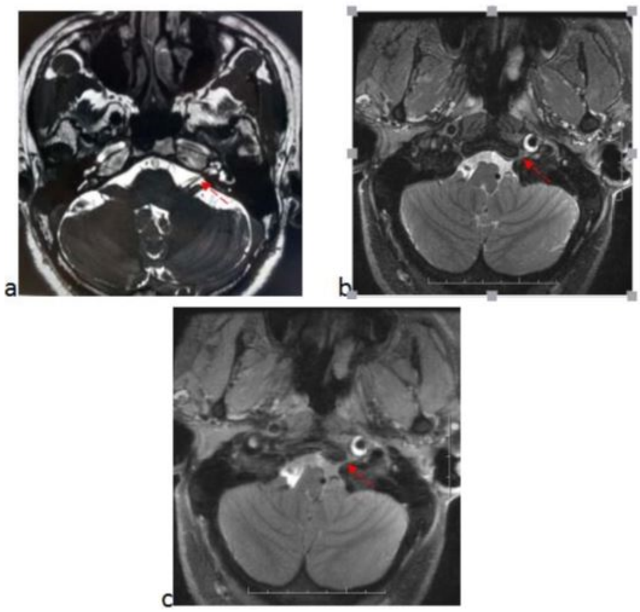

Figure 5: These images demonstrate the sublingual nerve exiting adjacent to the intracranial section and arriving at the ICA dissection. (a) Susceptibility weighted imaging (SWI) - MRI (b-c) HR-MRI.

Color ultrasonography

Carotid color ultrasonography (US) is not only affordable, but can clearly show blood velocity, lumen stenosis, and wall features such as atherosclerotic plaques, calcification, or a hematoma. Certain risk factors lead to the pathological process of atherosclerosis and its complications. Atherosclerosis and its progression can be supervised by US to allow clinicians a non-invasive way to offer timely interventions and reduce the risk of complications [6]. US is relatively reliable when it is operated by a well-trained technician and doesn't require patient exposure to contrast material or radiation [5]. Asymptomatic patients with risk factors such as hypertension, smoking, and hyperlipidemia can receive a real-time assessment of carotid artery stenosis at the bedside and symptomatic individuals can also get a rapid general assessment through US. Due to the skull and the anatomical position, applications of the color Doppler US in evaluating intracranial arteries are limited. An example of an area that disallows this modality is the submandibular angle [7]. In addition, it judges the stenosis through measuring the blood velocity instead of measuring the diameter of the vessel like HR-MRI. When carotid vessel lesions are suspected on US, patients require a CTA, DSA, or HR-MRI examination.

Computed tomography angiography

CTA can clearly show the extent of vascular stenosis with a 100% sensitivity and 63% specificity (95% CI: 25%-88%) [5]. CTA values can be used to determine blood vessel wall components. For example, CT values below 50 suggest lipid plaques, CT values between 50-119 often suggest mixed plaques, and CT values above 120 suggest calcified plaques. Hematomas, vasculitis, and atherosclerosis can be difficulty to differentiate because the contrast medium disappears quickly once injected. CTA can demonstrate calcified components more accurately than non-calcified components. Soft plaques, an intimal flap, a false lumen, or other cardinal features of an arterial dissection are not well identified using CTA [8].

Magnetic resonance angiography

MRA has the advantage of showing arterial flow data without a contrast agent, which has a high sensitivity range of 97%-100% and a higher specificity range of 82%-96% compared to DSA [5]. MRA has a shortcoming in that it exaggerates or reduces the degree of luminal stenosis [9]. There is no radiation or contrast agents using with MRA, making it a good choice for pregnant women or patients allergic to iodine contrast agents. Using MRA along with other radiological modalities can help obtain better results when trying to diagnose an ICA dissection. However, in the acute phase, the hematoma signal is the same as the brain parenchyma, often making it difficult to determine a pathological condition [2].

High-resolution magnetic resonance imaging

Compared with traditional MRI sequences, HR-MRI provides a cross-sectional image formed under the focus of a small field of view. Its thin layers and interlayer scanning allows for a high-resolution image of the cranial vessels, allowing clinicians to analyze the pathological or inflammatory responses of the vessel wall. HR-MRI can also reveal the relationship between the vessel wall and the surrounding tissues, further aiding clinicians in determining the location, number, shape, pathogenesis, and impact of the lesions. Studies have shown how HR-MRI provides details of the vessel walls required to determine whether there is a dissection or other internal vascular lesions such as moyamoya [4], which may not be visualized by DSA and CTA. DSA and CTA are not able to pick up an intramural hematoma, and typical imaging signs used with the DSA and CTA are not necessarily seen in all patients with an ICA dissection, such as an intimal flap and false lumen. Patients with smaller vascular lesions may be misdiagnosed or go undetected [2]. Compared with DSA, HR-MRI is a cost effective, noninvasive, non-contrast modality that offers high resolution, multi-sequence comparisons and repeatability. Compared with DSA, HR-MRI reduces the risk of intraoperative and postoperative bleeding Clinicians are able to diagnosis and treat in a timely manner using HR-MRI.

There have been similar cases reported where HR-MRI provided higher sensitivity and specificity for identification of ICA dissection. The pattern of the arterial dissection is presented clearly on the HR-MRI, with images of the intimal flap, double lumen, intramural hematoma, aneurysmal dilatation, tapered stenosis, and occlusion [10,11]. Compared with DSA and CTA, HR-MRI could enhance the diagnostic rate of carotid artery dissection and even identify diverse vascular diseases such as vasculitis or atherosclerosis [4,12]. Studies show that atherosclerotic plaques on HR-MRI show an eccentric growth and strengthening signal in the enhanced sequence and arteritis plaques show a concentric circle and strengthening signal in the enhanced sequence. In addition, idiopathic moyamoya disease won't show thickened arterial walls and strengthening signal after being enhanced [13]. T1-weighted MRI and 3D-Time of Flight Magnetic Resonance Angiography (TOF-MRA) images are sensitive to plaque hemorrhage, while T2-weighted and perfusion weighted sequences are more suitable for identifying the lipid centers and the fibrous cap [14]. 3D TOF-MRA sequence has a short repetition and echo time. The blood is seen as high signal in this sequence, but plaque is low signal, and this phenomenon is beneficial to identify confusing carotid artery plaques [15]. Noninvasive HR-MRI could identify plaques and increase the detectable rate of vulnerable and potential high-risk plaques [16].The extracranial arteries are more visible on HR-MRI images because their diameters are relatively broad. As for the intracranial arteries, studies have indicated that it is difficult to obtain the accurate longitudinal and horizontal axis since the intracranial arteries are more tortuous and have a narrower diameter. As a result, HR-MRI for use in detecting intracranial artery pathologies may be limited and insufficient [10]. Researchers reported that compared with plain scan HR-MRI, 3D HR-MRI provides a more comprehensive understanding of vessel walls [4,14,17]. Determining the best imaging technique to view intracranial vessels is still under investigation, but studies and case reports using HR-MRI for detecting extracranial vessel pathologies offer successful results. HR-MRI has been a reliable predictor of ischemic stroke and atypical carotid artery dissection, favoring its use in the clinical setting [16,18].

Conclusion

In general, ICA dissection is commonly located in the extracranial segment, approximately 2-3 cm away from the end of the bifurcation of the common carotid artery [19]. HR-MRI is currently applied to the extracranial segment. Through our discussion of two cases of intramural hematoma-type dissection, we described the diagnosis of atypical extracranial ICA dissection through HR-MRI. In clinical practice, patients who are suspected to have dissection of the extracranial ICA or vertebral artery should complete the HR-MRI examination. HR-MRI results will guide clinicians in making the correct diagnosis, implementing the appropriate treatment, assessing risks precisely, and judging prognosis effectively.

Conflict of Interests

Authors declare no conflict of interest.

Ethical Approval

This study was approved by the First Affiliated Hospital of Chongqing Medical University ethics committee. The data we submitted conforms to the ethical principles of experimental animal research and the Helsinki declaration. The researching methods do not bring unnecessary injury to the patients and have scientific basis for the research.

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