Carotid dissection (CD): imaging findings on CT, MRI and angiography.

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Learning objectives

To review carotid dissection, the imaging findings on CT, MRI and angiography and to show examples.
Background

The carotid dissection consists in a leakage of blood to the middle layer through an intimal flap of the arterial wall or, alternatively, media haemorrhage from vasa vasorum. Blood usually enters the media at the site of intimal injury, and the dissection usually extends cranially in the same direction as the bloodstream.

The intramural hematoma usually compresses the true lumen of the artery and causes enlargement of the external diameter of the artery.

The aetiology can be traumatic (blunt or penetrating injury) or spontaneous such as in bad postures or cervical manipulation. The latter can be accompanied by an underlying arterial disease: fibromuscular displasia, Ehler-Danlos syndrome type IV, Marfan’s syndrome, autosomal dominant adult polycystic kidney disease, cystic medial necrosis and osteogenesis imperfecta type I.

There are some vascular risk factors also associated with carotid dissection such as hypertension, diabetes mellitus, smoking and hyperlipidemia.

Carotid dissection can occur at any age but is a common cause of ischemic stroke in up to 25% of patients younger than 45 years, making it an important disease with high potential for morbidity in people with high life expectancy.

The classical presentation of extracranial ICA dissection is ipsilateral headache, facial or neck pain and partial Horner's syndrome with late amaurosis fugax. This presentation is only present in less than one third of patients.

Strokes are reported in 40-60% and transient ischemic attack (TIA) in 20-30% of patients with ICA dissection.

In most cases, the clinical presentation can be non-specific so in this cases imaging studies acquire a great diagnostic importance.
Imaging findings OR Procedure details

**Multidetector computed tomography (MDCT)** angiography allows multiplanar reconstructions and volume rendering images and it is noninvasive. The signs found in carotid dissection are:

- A narrow eccentric lumen, Fig. 1 on page 6 Fig. 2 on page 6
- crescent-shaped mural thickening, Fig. 3 on page 7
- enlargement of the overall vessel diameter, Fig. 4 on page 8
- hypodense line separating both lumens (intimal flap), Fig. 5 on page 9
- stenosis, Fig. 2 on page 6
- occlusion,
- aneurysm formation,
- thin rim-like enhancement.

**MRI** allows a wide variety of sequences and modalities to assess carotid dissection. We have the cross sectional T1WI, T2WI and PDWI which allows to study the vessel wall and the intramural haematoma. Also we can study the vessel lumen with imaging techniques which include MR angiography (MRA) after contrast administration (CE-MRA), Time-of-flight MRA (TOF-MRA) and phase-contrast MRA (PC-MRA).

**On cross sectional MRI images**, it is characteristic of carotid dissection a narrowing of the flow void surrounded by "the crescent sign", an eccentric hyperintensity within the wall of the vessel corresponding to methemoglobin in the hematoma wall.

Increase of the external diameter of the vessel is also characteristic in this process. Fig. 6 on page 10 Fig. 8 on page 12

The intramural hematoma signal depends on the stage of the blood products like in other locations. In the early and chronic stage, the hematoma is usually isointense to surrounding structures, whereas between 7 days and 2 months it is almost invariably bright on T1-weighted images. However, fresh thrombus may be misinterpreted as intramural hematoma as they can have the same appearance, so we must look for the other signs described before to characterize the finding. Fig. 9 on page 13

**On the vessel lumen imaging techniques** we can be demonstrated a luminal irregularity, change of the vessel diameter or occlusion and pseudoaneurysm. Fig. 7 on page 11 Fig. 10 on page 14 In addition, on TOF-MRA images not only we can demonstrate subacute intramural hematoma, as well to evaluate the intracranial and extracranial vessels. Fig. 11 on page 15
MRI also allows to complete with other sequences that can demonstrate the repercussion of the Carotid dissection on the cerebral parenchyma such as acute strokes on Diffusion-WI.

**Digital subtraction angiography (DSA)** has been the gold standard imaging technique to diagnose CD and for endovascular treatment. However it is an invasive modality and only displays the endoluminal compartment.

Carotid dissection classical findings are irregular stenosis ("rat's tail sign" or "string sign") aneurysm formation and arterial occlusion. The most frequent location of stenosis is 2-3 cm distal to the carotid bulb.

Focal narrowing with a distal site of dilatation is referred to as the "string and pearl" sign. Fig. 12 on page 16 Fig. 13 on page 17

**Treatment**

The most cases of ischemic strokes in carotid dissection are secondary to distal embolisation, so that anticoagulant therapy is the most accepted treatment. The first week it is administered intravenous heparin and then it is administered during 3-6 months oral anticoagulants and aspirin.

However, anticoagulants are contraindicated in the intracranial carotid dissection, due to the risk of subarachnoid haemorrhage and the risk of rupture in pseudoaneurysm.

Endovascular stents or surgical intervention is reserved for patients with recurrent thromboembolic events and in dissecting aneurysms.

Some of the features above described can mimic others diseases, so it is important to perform a good differential diagnosis. Principally the carotid dissection should be differentiated from fibromuscular dysplasia, dysgenesis of the ICA, and other causes of arterial wall thickening (atherosclerosis, radiation treatment, and vasculitis).
Fig. 1: Dissection of the right cervical ICA in a 45-years old man. Axial image from CT angiography shows narrowed eccentric lumen (blue arrow) and enlargement of the overall vessel diameter.

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Fig. 2: Dissection of the right cervical ICA in a 45-years old man. Curved reformatted image from CT angiography shows a long stenosis with narrowed eccentric lumen (blue arrow).

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Fig. 3: Dissection of the right ICA in a 58-years old man. Axial image from CT angiography shows a narrowed eccentric lumen surrounded by crescent-shaped mural (blue arrows)

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**Fig. 4:** Dissection of the right ICA in a 58-years old man. Curved reformatted image from CT angiography shows extensive and concentric and smooth wall thickening which narrows the lumen of the right ICA.

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Fig. 5: Sagittal reformatted image from CT angiography shows a narrow lumen with a mural thickening and intimal flap in the proximal right ICA in a 41 years old man after motor vehicle accident (blue arrow). Coronal FLAIR MR image shows a cortical hyperintense that correspond a ischemic area with edema (yellow arrow).

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**Fig. 6:** Axial proton density weighted MR image obtained in another patient shows a narrowed eccentric flow void of the left ICA (blue arrow) surrounded by a crescent-shaped circumferential intramural hematoma that expands the vessel diameter (yellow arrow).

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Fig. 7: Sagittal T1-weighted brain MR image of the same patient in the above figure shows slightly hyperintense left ICA (blue arrows)

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**Fig. 8:** Axial proton density-weighted MR image of a 47-years-old man shows a narrowed flow void surrounded by a slightly hyperintense wall thickening of the right ICA (blue arrow). On the other hand, the left internal carotid artery with normal signal intensity (yellow arrows).

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Fig. 9: Coronal T2-weighted MR image of a 47-years-old man shows a narrowed flow void surrounded by a slightly hyperintense wall thickening of the right ICA (blue arrow), compare with normal left side carotid.

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Fig. 10: Sagittal T1-weighted brain MR image of a 47-year-old man with neck ache shows slightly hyperintense right ICA (blue arrows), a finding consistent with an early subacute intramural hematoma (methemoglobin phase). On the other hand, the left internal carotid artery with normal signal intensity (yellow arrows).

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**Fig. 11:** MIP from MR angiography image of a 47 years old man with neck ache shows a lumen irregularity with change of the vessel diameter and an almost complete distal occlusion of the right ICA (blue arrows).

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**Fig. 12:** Anteroposterior digital subtraction angiography (DSA) of a 48-year-old man shows a progressive narrowing of the proximal left internal carotid artery with complete occlusion due to dissection.

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**Fig. 13:** Lateral digital subtraction angiography (DSA) of a 48-year-old man shows a progressive narrowing of the proximal left internal carotid artery with complete occlusion due to dissection.

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Conclusion

The carotid dissection is a major cause of stroke in young patients that may result in significant morbidity without treatment (risk of stroke and long-term sequelae).

It is important for radiologist be acquainted with findings and sources of error to achieve the correct diagnosis with non-invasive techniques.