MRI and MRA of Vascular Malformations of the cord

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MRI and MRA are currently used in the daily practice in the analysis and management of spinal cord arteriovenous shunts (SCAVSs). MRI with standard sequences is usually the first step performed when a cord lesion is suspected: if a vascular lesion is suspected, it confirms the diagnosis by showing abnormal vascular structures inside or around the cord, as their consequences on the nervous tissue under the form of oedematous reactions or potential associated haemorrhages (acute or revealed under sequellae).

The spinal cord oedema or ischemia is best diagnosed on T2 WI and can involve either the whole cord or specific funiculi according to the localization of the lesion and/or the pathophysiologic phenomena responsible for the oedema. Vascular anatomy and anatomical landmarks help to diagnose the origin of the disease: a disease expressed mainly on the arterial side of the vascular tree will give suffering zones that will be mostly located on the anterior portion of the cord because of the richness of the vascular tree depending from the anterior spinal axis, whilst a venous disorder will create mostly a posterior damage because of the density of the posterior pial venous network.

Standard MRI is however not selective enough to determine with all necessary accuracy the vascular anatomy needed to describe the type and architecture of SCAVSs. Angiography still represents some kind of “gold standard” in this analysis. MRA has however proven currently its potential in the delineation of the gross architecture of the lesion and in the analysis of the regional and lesional anatomies of SCAVSs. It therefore represents an interesting first step procedure that facilitates the angiographic protocol.

In our daily practice, patients with SCAVSs are usually submitted to pre and early post embolisation examinations (within 48 hrs) in order to obtain a first evaluation of the disease, and to analyze the consequences of the therapeutic procedures (decreased flow, thrombosis of worrying architectural factors, reduction of oedema...). The technical parameters have been modified several times since the beginning of our experience in 2002 with MRA of SCAVSs because of various MR upgrades and optimisation of the couple “temporal resolution - spatial resolution”. However the principles and protocols of MRA have remained the same.

From a technical point of view, MRA currently consists in fast TOF GRE/SPGR (contrast enhanced MRA, CEMRA) with 2 phases, evaluating arterial and venous phases, with injection of gadolinium (0.2 ml /kg at an injection rate of 2 cc/ second), using fluoro trigger to detect the contrast arrival in real time acquisition (1 image per second). The coronal plane is usually selected to view the contrast bolus in the descending aorta: as soon as the contrast fills the aortic lumen, the MRA sequence is started. This CEMRA sequence is acquired in a coronal plane centred on the level of the vascular malformation that has been initially detected on sagittal MRI, with two phases during 48s (FOV = 20 cm, FA = 30, matrix 384x320 ZIP 512, slice thickness 1.6 mm ZIP4, Nex 0.5). The K-space is filled using elliptical centric ordering which fills the center lines and center slices first. With this technique, only the first 10% of the sequence is used to acquire the contrast of the images, the other 90 % being used for spatial resolution.
With these data we can obtain an arterial signal on the first part of the sequence and a venous signal on the second one. These phases are controlled by comparing the concomitant appearance of intercostal vessels: one vessel is an artery whilst two vessels represent both artery and vein. We can appreciate therefore the flow and type of phase studied. The first phase detects thus normal arterial enhancement, and veins rapidly enhancing because of rapid shunt (pathologic arterialized veins). The visualisation of the cord vasculature is usually difficult in normal conditions because of the small size of the arteries. The radiculo-medullary artery of the lumbar enlargement (the so-called “Adamkiewicz Artery”) is indeed rarely individualized, and often mistaken with the anterior spinal vein. In SCAVSs however, the increased diameter of vessels associated to these lesions allows more precise descriptions of the vascular anatomy.

On the second phase, the vascular enhancement is mainly venous. These findings will be used to study the effects of endovascular treatments on the lesion and its flow.

In order to suppress all non-vascular structures, and optimise thus the analysis of the MRA, a non-enhanced one-phase MRA with the same parameters is acquired just before injection, and a pixel by pixel subtraction technique is performed. This improves the detection of the pathological vessels. Finally, 3D MIP reconstructions are performed in different angles and orientations.

MRA confirms the diagnosis of SCAVSs and precises its type (nidus-type AVM, arterio-venous fistula, or dural shunt). The absence of any nidus with the early appearance of a venous drainage leads to suspect a fistulous type of lesion. The localisation of the lesion, its feeding arteries and venous drainages help to plan the angiographic protocol.