Clinical case

RELEVANCE OF DIFFUSION AND PERFUSION WEIGHTED MRI FOR ENDOVASCULAR TREATMENT OF VASOSPASM IN SUBARACHNOID HEMORRHAGE

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SUMMARY

The endovascular treatment of vasospasm is effective when implemented rapidly. However its indication often proves difficult on account of the lack of diagnostic arguments or the difficulties in obtaining them in daily practice. We report a case that highlights the relevance of MRI in the decision-making process.

A 37-year-old patient presented with symptomatic vasospasm of the middle cerebral artery and was subjected to morphological, diffusion- and perfusion-weighted MRI. These investigations confirmed the presence of significant oligemia in the MCA territory and revealed onsetting diffusion disorders. Angioplasty was immediately performed, resulting in normal diffusion and hemodynamic parameters and complete regression of clinical signs.

This case highlights the relevance of MRI when assessing vasospasm before treatment. Coupled with transcranial Doppler, it should help teams quickly select patients most likely to benefit from angioplasty.

Key words : vasospasm, angioplasty, MRI, brain perfusion, subarachnoid hemorrhage, Aneurysm.

Vasospasm is one of the most severe complications of subarachnoid hemorrhage induced by ruptured aneurysm [3]. Resulting neurological deficits occurring in 20 to 30% of cases despite medical treatment. An angioplasty has been reported to resolve vasospasm and subsequent deficits, but must be performed shortly after deficits have set in [1]. However tests linking clinical disorders to vasospasm are few or difficult to use. Transcranial Doppler indirectly shows the vasospasm of arteries in the skull base by evidencing higher circulatory velocity, but provides no indication on brain perfusion, as opposed to angiography, which remains the most reliable technique to investigate brain perfusion.

But not only is it invasive, it also provides no information on brain ischemia [2]. As for CT scans and morphological MRI sequences, they only show lesions once they are constituted. Xenon-enhanced CT [10] and SPECT [6] investigations of brain perfusion are complementary of Doppler and help select patients who may benefit from the endovascular treatment of vasospasm, but from a practical point of view, they are difficult to use routinely in patients whose clinical state is often fragile. We report a case in which the combination of diffusion (DWI) and perfusion (PWI) MRI Imaging led us to indicate and perform angioplasty on a patient with symptomatic vasospasm resistant to medical treatment.

CLINICAL CASE

Mrs. HAB..., aged 37, was admitted to the hospital on May 9th for dysphasia and right faciobrachial hemiparesis. Her history disclosed acute and severe headaches on May 1st. Upon admittance, the patient reported a mode-sis. The neurological examination was absolutely normal, and neu- tral perfusion sequences only showed moderate insular hyperintensity in the white matter. This data was confirmed by diffusion imaging, with a relative hypointense insula. The Transcranial Doppler confirmed the vasospasm with mean velocities averaging 200 cm/s in the left middle cerebral artery (MCA). The MRI Flair and T2-weighted sequences showed a perianeurysmal hyperintense signal due to blood collected in the left sylvian fissure. Also seen on the MRI were a relative hyperintensity in the insula and two small rounded hyperintense areas in the white matter. This data was confirmed by perfusion imaging, with a drastic drop in ADC (20% to 30%) in the same areas, evidence of their recent occurrence, and a less marked decrease in the left hemisphere when compared with contralateral areas.

Perfusion weighted imaging very clearly revealed disorders in the entire left MCA territories. The time to peak (TTP) and mean transit time (MTT) were markedly longer (figures 2a, 2b, 2c). The relative cerebral blood volume (rCBV) varied, but was mostly normal in the greater part of the area. As for the relative cerebral blood flow (rCBF), it was depressed in most of the MCA territory. We dealt with this case as we would have a cerebral vascular accident, with areas where a reduced ADC showed that there was marked ischemia most likely progressing to necrosis and an area of oligemia in PWI with a possible progression to necrosis if perfusion was not resumed. These results made us fear a severe outcome and led us to proceed with endovascular treatment. A angiography confirmed the presence of a severe vasospasm of the carotid siphon but especially of the middle cerebral artery, along with a left MCA aneurysm. Circulatory delay was marked (figures 1a, 1b). The endovascular treatment consisted in a 300 mg-papaverine infusion in 100 ml of saline solution through a 6 French guiding catheter, and angioplasty with an Equinox balloon (ACS Guidant). As a result, proximal diameters of the arteries improved along with distal blood circulation, in particular the circulation time decreased drastically (figures 1c, 1d). Immediately after angioplasty, we proceeded with the endovascular treatment of the aneurysm by means of electrically detachable coils (GDC Target Fremont CA).

Upon awakening, the patient no longer showed any deficit. The 24 hours follow-up MRI was unchanged for the insular and white matter lesions. In DWI, the apparent diffusion coefficient was normal outside of these areas. The investigation of brain perfusion showed a quite symmetrical aspect in both MCA territories (figures 2e, 2f). Later on in follow-up, the transcranial Doppler showed that circulatory velocities had returned to normal. The patient was released 6 days after surgery with no deficit whatsoever. A control MRI and examination were performed on July 18th. Flair and diffusion sequences only showed moderate insular hyperintense lesions, as the other images in the white substance had entirely disappeared. Clinically, the neurological examination was absolutely normal, and neuropsychological tests (BEC 96) did not detect any loss whatsoever (BEC : 95/96).

DISCUSSION

Authors all agree that in order for neurological deficits due to vasospasm to regress clinically, treatment should occur rapidly (within 12 hours according to Coyne [4] and within as little as 2 hours according to Rosenwasser [8]). The indication is more often than not based on the combined findings of accelerated velocities on the transcranial Doppler and neurological deficits setting in. This excludes severely affected sedated patients in whom late ischemic lesions secondary to the vasospasm are most likely to occur. The xenon-enhanced CT and the SPECT have proved informative, as they were well correlated with progression with and without treatment in Soucy’s and Yonash’s studies [9, 10]. Yonash measured the absolute blood volume with the Xenon-enhanced CT and found a flow under 15 ml/100 mg/min in 9 patients, 8 of which developed infarct. However none of the 5 patients in whom blood flow exceeded 18 ml/100 mg/min developed infarct.

Although SPECT studies measure relative blood flow (as does PWI), they provide some interesting information. Elliott [5], in a study on 58 patients treated with either papaverine or angioplasty, noted depressed local cerebral blood flow in 86% of patients (50/58) during vasospasm. Blood flow improved 24 hours later in 5 patients (31%) after papaverine injection and in 30 patients (71%) after angioplasty treatment. The problem is that these techniques are not commonly used.

MRI seems to be an interesting alternative, as it more common and easier to use. Brain parenchyma can be studied and ischemic lesions identified simultaneously with a combination of morphological and...
Constituted brain ischemia is easily established on the Flair and T2-weighted sequences. Diffusion weighted images are already commonly used in ischemic vascular accidents, as areas of cytotoxic edema, the first stage of ischemic necrosis, can be quickly identified. Rordorf [7] showed that in cases of vasospasm, areas with abnormal diffusion corresponded...
Fig. 2. — Perfusion weighted MRI. a, b) Parametric maps before angioplasty. a) Time to peak (TTP) map. b) Mean transit time (MTT) map, with a marked delay in the left superficial MCA territory. c, d, e) Concentration versus time curves in symmetric regions of interest. c) Before angioplasty : Times parameters (bolus arrival time, TTP, MTT) are increased on the left side (curve 6) compared with the right side (curve 5).
to areas of ischemic necrosis. In a partially published study currently under way, we found the very same diffusion disorders in areas of ischemic necrosis, but we also noted a reversible drop in ADC in patients with asymptomatic vasospasm. This is far from being classically described, and proves difficult to interpret, as the usual explanation for the fall in ADC is the cytotoxic edema that occurs during the initial phases of ischemic necrosis. Only few cases of short-lasting ischemia have been reported in a human patient during temporary ischemic accidents.

A decreased ADC does not, therefore, necessarily imply that ischemic necrosis has occurred, but it does mean that there has been significant ischemia. DWI may help identify areas at risk. PWI provides an approximate view of local brain perfusion. It is based on the study of the first passage of an intravenous contrast bolus (gadolinium), which causes a lower signal on T2*-weighted sequences. In constituted vasospasm, Rordorf [7] showed that disorders were more extensive than the ischemic areas identified by DWI. Oligemia may not be quantified as accurately, but its qualitative assessment provides an additional argument to indicate the treatment. In our case, perfusion disorders extended throughout the MCA territory and were well correlated with angiographic results. The proximal spasm was severe and the distal circulatory delay significant (delayed throughput of contrast medium and long transit time) (figures 2a, 2b, 2c). Parameters defining brain perfusion became normal after angioplasty (figures 2e, 2f), which is consistent with the SPECT findings of Elliott [5].

Therefore we find MRI to be the ideal investigation to complete the results of transcranial Doppler when attempting to assess brain ischemia due to vasospasm and subsequently select patients that will be most likely to benefit from intracranial angioplasty.

REFERENCES


