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MR imaging of dural arteriovenous malformations with ocular signs

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Summary. Four patients with dural arteriovenous malformation (AVMs) draining into the cavernous sinus, who presented ophthalmic manifestations, were studied by magnetic resonance (MR) imaging. In all patients signal decrease in the involved cavernous sinus was demonstrated in coronal spin-echo (SE) imaging. It is attributable to rapid venous flow in the sinus, and this "high velocity signal loss" is a fairly pathognomonic finding in this condition. We stress the validity of MR imaging in the primary diagnosis of dural AVMs with ophthalmic symptoms.

Key words: Arteriovenous malformation - Magnetic resonance imaging - Cavernous sinus - Dura mater

CT findings in dural arteriovenous malformations (AVMs) have been described in several reports [1-3]. While magnetic resonance (MR) images of dural AVMs have not yet been presented, effects of blood flow may be expected in dural AVMs because MR imaging can demonstrate great vessels and pial AVMs on the basis of flow-related imaging phenomena [4-8].

Patients with dural AVMs draining into the cavernous sinus have ocular symptoms such as proptosis, chemosis and diplopia [9, 10]. If MR imaging can demonstrate dural AVMs draining into the cavernous sinus, then it becomes a noninvasive method for investigating those symptoms suggestive of this condition. These we have studied.

Materials and methods

Four patients with dural AVMs draining into the cavernous sinus were examined by MR imaging. All patients had ophthalmic symptoms without history of trauma (Table 1). MR images were obtained by a 0.1-Tesla resistive magnet scanner (Asahi Mark J). For all patients the coronal section was made through the cavernous sinus, using a spin-echo (SE) imaging technique. Multiecho sequences were used with echo times (TE) of 30 or 40 ms, and six serial SE images were obtained at the same intervals. Only one case (case 1) was ECG-gated and in the others repetition times (TR) were 1200-1500 msec. Slice thickness was 10 mm and image matrix 256 x 256. Axial and coronal scans of the brain and orbit were also performed by SE, saturation recovery (SR) or inversion recovery (IR) technique.

Results

The MR findings are summarized in Table 1. All patients had decreased signal in the involved cavernous sinus (including lack of signal in two cases) on the coronal SE image, while the angiographi-

Table 1. Dural arteriovenous malformations of the cavernous sinus

Case	Age/sex	Symptoms	Side	Drainage	MR findings
1	64/F	diplopia, ophthalmic pain	both	IPSs	lack of signal
2	52/M	diplopia, ophthalmic pain, exophthalmos	left	IPS, SOV	lack of signal, dilated SOV
3	55/M	visual loss, exophthalmos, chemosis	left	pial veins	decreased signal, swelling of the rectus muscles
4	63/F	exophthalmos, chemosis, swelling of the eyelids	right	IPS, SOV	decreased signal, dilated SOV, swelling of the rectus muscles

Drainage = main drainage routes from the cavernous sinus, IPS = inferior petrosal sinus, SOV = superior ophthalmic vein, Lack of signal = lack of signal in the involved cavernous sinus, Decreased signal = decreased signal in the involved cavernous sinus.

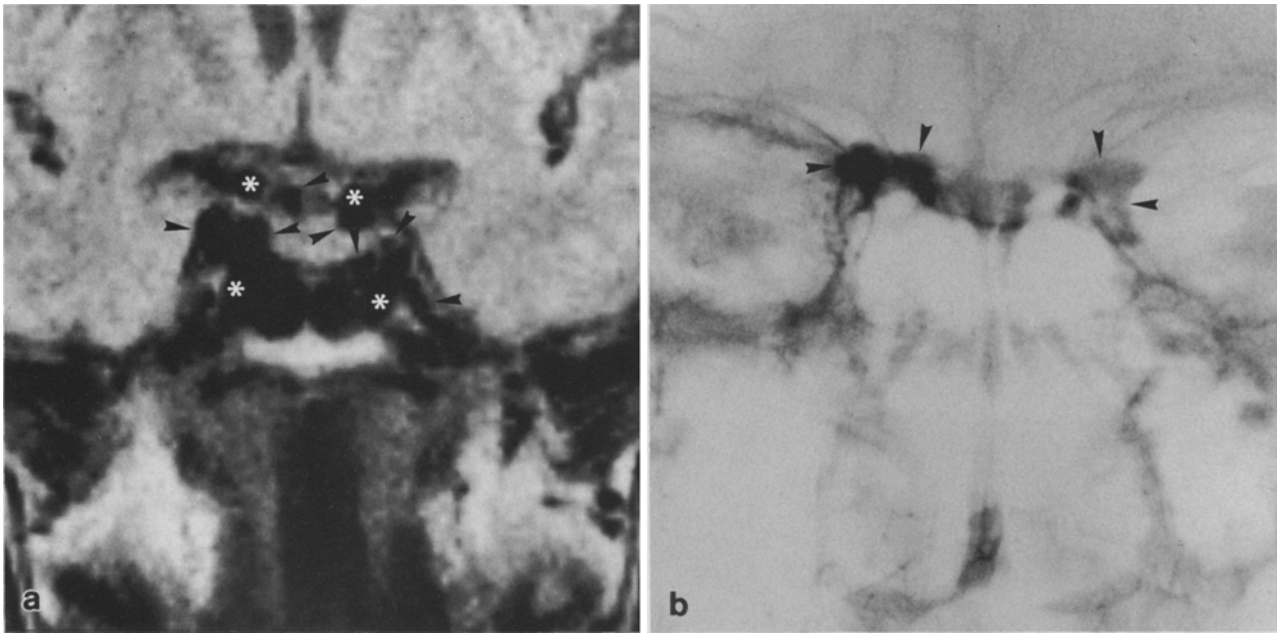

Fig. 1 a, b. Case 1. **a** Coronal SE image (ECG-gate, TE = 60 ms). Multiple signal-void areas *(arrowheads)* equal to the internal carotid arteries *(asterisks)* are seen in and near both cavernous sinuses. **b** Right external carotid arteriogram, late arterial phase, anteroposterior view. Venous drainage *(arrowheads)*, corresponding to absence of signal on the MR image, is demonstrated

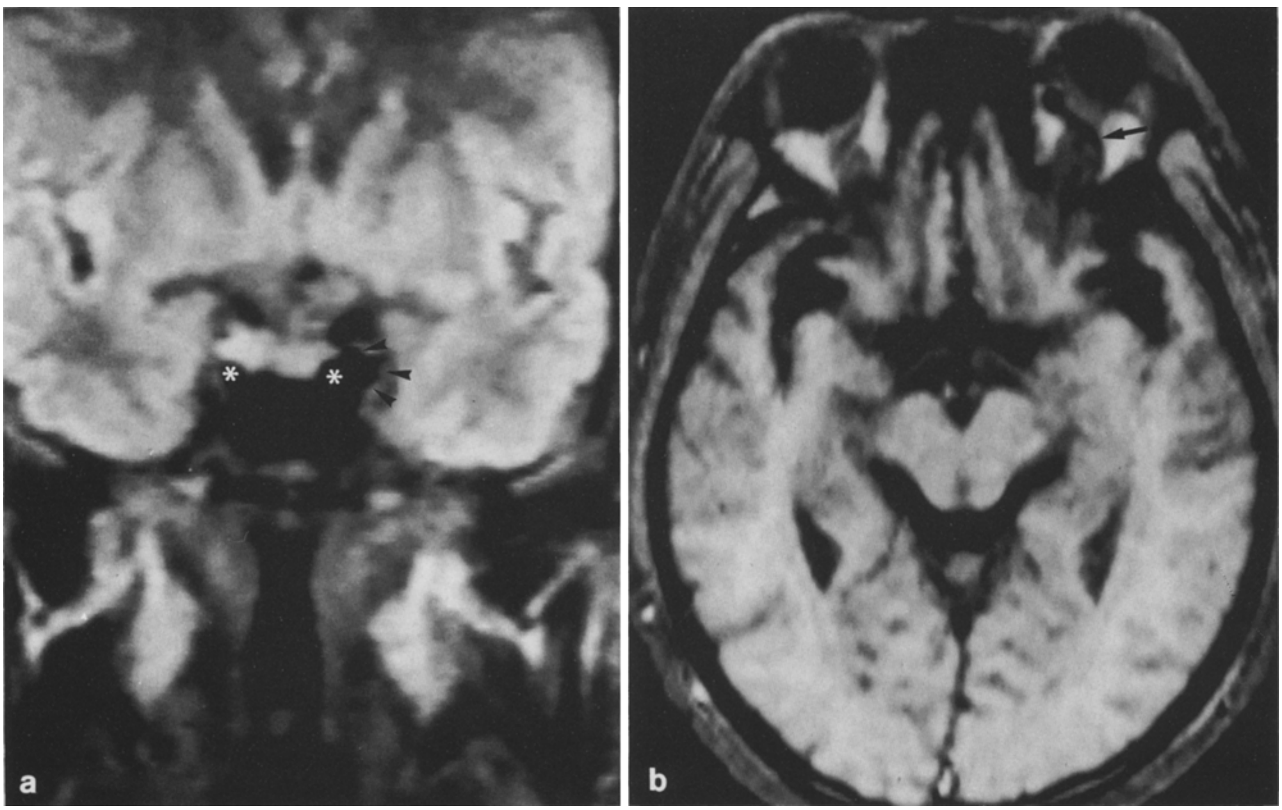

Fig. 2 a, b. Case 2. **a** Coronal SE image (TR = 1400 ms, TE = 60 ms). Signal-void areas *(arrowheads)* are seen in the left cavernous sinus, in contrast with the right cavernous sinus of high intensity. The outer margin of the internal carotid artery *(asterisk)* is obscure, while the right internal carotid artery (asterisk) is well-circumscribed. **b** Axial IR image (TR = 1300 ms). The dilated left superior ophthalmic vein *(arrow)* is clearly shown

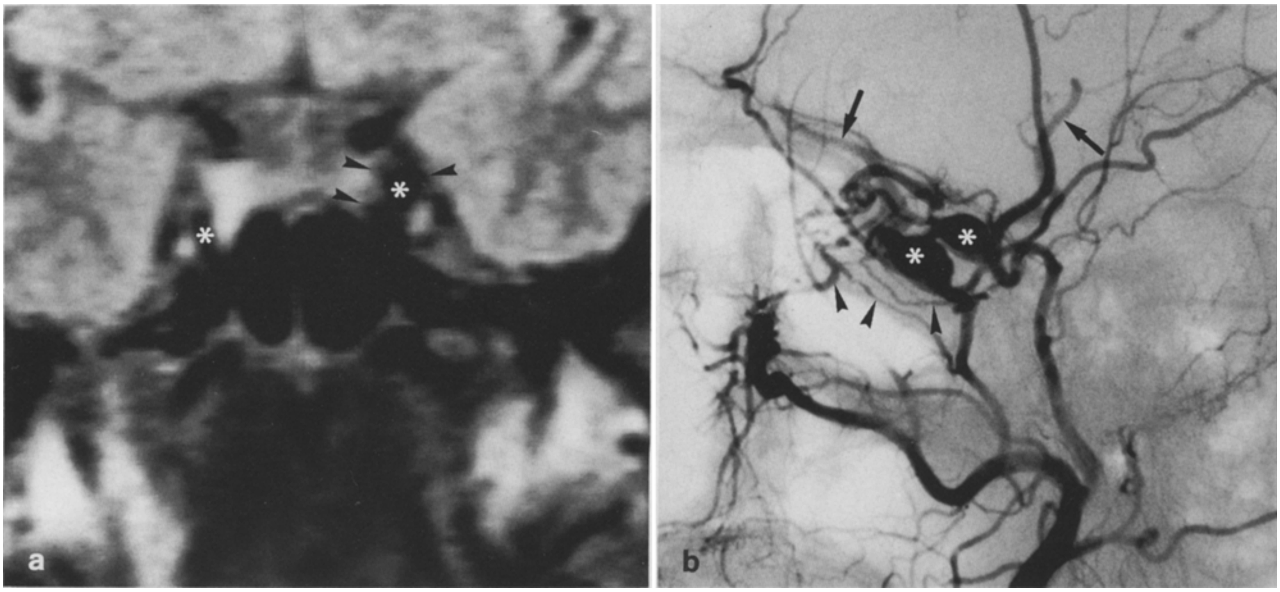

Fig. 3 a, b. Case 3. **a** Coronal SE image (TR = 1200 ms, TE = 80 ms). Decreased signal in the left cavernous sinus *(arrowheads)* is seen around the internal carotid artery, therefore the left internal carotid artery *(asterisk)* is not so well-demarcated as the right *(asterisk)*. **b** Left external carotid anteriogram. Feeders from the middle meningeal artery and the internal maxillary artery *(arrowheads)*, the cavernous sinus *(asterisks)* and venous drainages from the cavernous sinus *(arrows)* are all demonstrated

cally normal cavernous sinus had high intensity. Dilatation of the superior ophthalmic vein and swelling of the extraocular muscles were also demonstrated in two cases respectively.

Case reports

Case 1

A 64-year-old female had suffered from right ophthalmic pain and diplopia for five months. MR imaging revealed multiple signal-void areas in and near the cavernous sinuses on coronal SE images (Fig. 1 a). Angiography confirmed a dural AVM, draining via both cavernous sinuses into the inferior petrosal sinuses (Fig. 1 b).

Case 2

A 52-year-old male had suffered from left ophthalmic pain, exophthalmos and diplopia for eight months. In coronal SE imaging signal-void areas were seen in the left cavernous sinus outside the internal carotid artery (Fig. 2 a). In axial IR imaging the dilated left superior ophthalmic vein was shown (Fig. 2 b). Angiography showed a dural AVM of the left cavernous sinus, which drained into the inferior petrosal sinus, the superior ophthalmic vein and the basal vein.

Case 3

A 55-year-old male had complained of left sided exophthalmos, visual loss and chemosis for half a year. Besides swelling of the extraocular muscles, MR imaging showed decreased signal in the left cavernous sinus on coronal SE images (Fig. 3 a). Angiography confirmed a dural AVM draining into the cavernous sinus (Fig. 3 b). The feeders were the left middle meningeal artery, the meningeal branches of the internal maxillary artery, and the internal carotid artery. The venous drainage from the cavernous sinus was mainly via the cerebral venous system without visualization of the superior and inferior petrosal sinuses. Occlusion of the distal superior ophthalmic vein was also shown.

Case 4

Chief complaints of a 63-year-old female were right exophthalmos, chemosis and swelling of the eyelids with duration of a year. In addition to dilatation of the right superior ophthalmic vein and swelling of the extraocular muscles, MR imaging showed decreased signal from the right cavernous sinus on coronal SE images (Fig. 4 a, b). On angiography a dural AVM was demonstrated with drainage into the right cavernous sinus, and thence into the dilated superior ophthalmic vein and the inferior petrosal sinus.

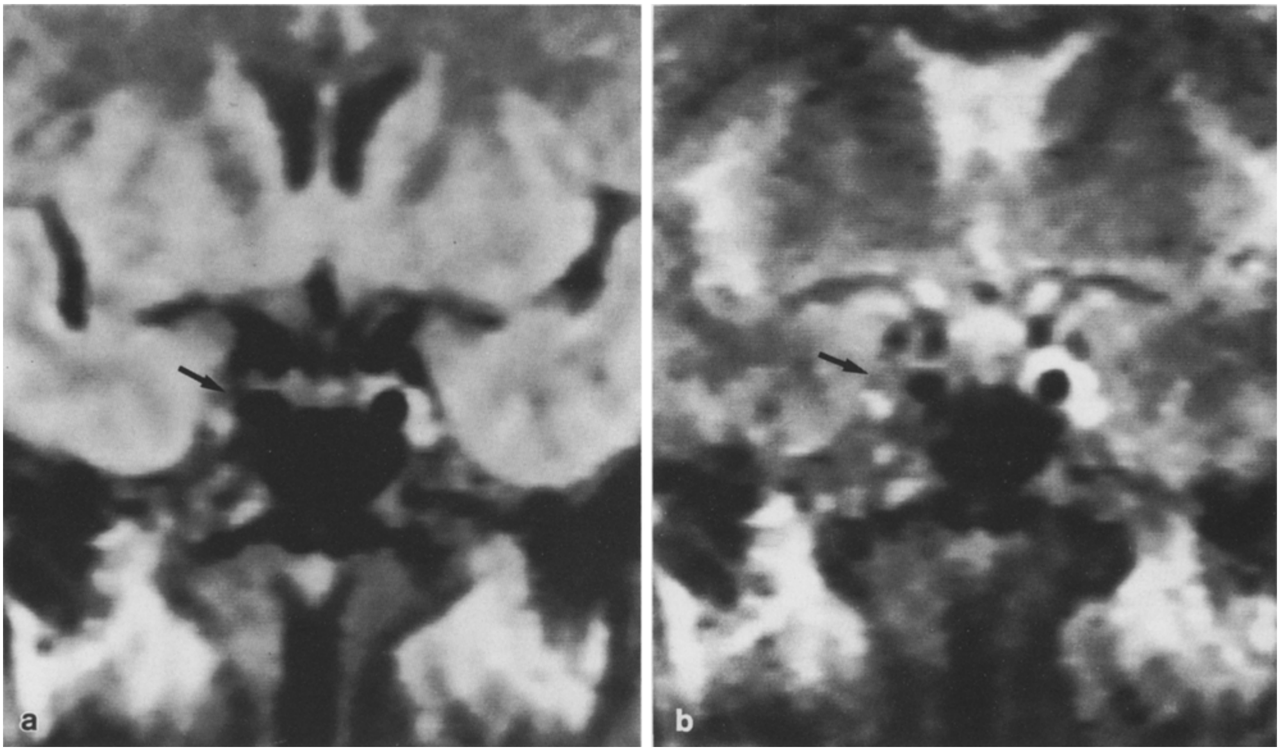

Fig. 4 a, b. Case 4. Multiecho SE images (TR = 1500 ms), with TE = 60 ms (**a**) and TE = 150 ms (**b**). Decreased signal in the right cavernous sinus is recognized on both images *(arrows)*. The contrast with high intensity of the left cavernous sinus is emphasized on the image with longer TE, while spatial resolution gets worse

Discussion

"High velocity signal loss" for rapid flow and "flow-related enhancement" for slow laminar flow are well-known phenomena in SE imaging [5, 6, 11, 12]. These explain why in all of our cases the involved cavernous sinus had decreased signal intensity in contrast with the normal cavernous sinus. The signal loss of the involved cavernous sinus is related to rapid flow due to the arteriovenous shunt, as are the signal-void areas near the cavernous sinus seen case 1. Thus MR imaging, especially coronal SE imaging, can reveal an essential feature of dural AVMs with drainage into the cavernous sinus.

Naturally the appearance of the high velocity signal loss in each case depends on imaging techniques. From our experience, longer echo times emphasized the contrast between flow-related enhancement of the normal cavernous sinus and high velocity signal loss of the involved sinus, while they made anatomical detail obscure (Fig. 4a and 4b). The optimal echo time may be different for each case, depending on its degree of signal loss. In this respect a multiecho SE technique is advantageous because multiple images with different echo times are available. Shorter repetition times accentuate flow-related enhancement [6], and may facilitate detection of dural AVMs.

Although the degree of decrease in intensity will depend on the extent of arteriovenous shunt, dural AVMs producing ophthalmic symptoms with relatively large arteriovenous shunts are almost certain to be detected by an appropriate method. Furthermore the high velocity signal loss excludes other conditions producing similar ocular symptoms and can be diagnostically predictive to a great extent, because sinus thrombosis shows high intensity [13] and juxtasellar masses are likely to have a mass as a feature. In the result, considering the non-invasiveness, we believe that MR imaging can become the first choice for patients with ophthalmic symptoms suspicious of dural AVMs.

If loss of signal is seen in the cavernous sinus, differential diagnosis will include a dural AVM, a pial AVM with drainage into the cavernous sinus and an aneurysm in the sinus. Angiography should then be followed for definite diagnosis.

The other findings obtained by MR imaging were dilatation of the superior ophthalmic vein and swelling of the extraocular muscles. Although they are not essential and less important, they will help the diagnosis.

Change of the high velocity signal loss after arterial embolization or spontaneous thrombosis would be expected. We re-examined two cases after embolization from the external carotid artery, but increase of signal of the involved cavernous sinus was not apparent in either, possibly due to persistent supply from the internal carotid artery. Use of MR imaging for follow-up remains a potential goal for us.

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