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Hemodynamical Assessment of Cavernous Hemangioma in Cavernous Sinus Using MR-DSA and Conventional DSA

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We report a hemodynamical assessment of the blood turnover pattern as well as the imaging of cavernous hemangioma in a cavernous sinus using time-resolved contrast enhanced 2D projection MRA, also known as MR-DSA, and conventional digital subtraction angiography (DSA), before and after radiotherapy. MR-DSA showed very fast dynamical images of a contrast turnover pattern and was well matched with the findings obtained from DSA. MR-DSA is a non-invasive study, and can replace DSA in examining a vascular tumor for the initial work-up and follow-up examination.

Key Words: Cavernous hemangioma, cavernous sinus, MRA, MR-DSA, hemodynamics

INTRODUCTION

Time-resolved contrast enhanced 2D projection MRA, also known as MR-DSA, offers the ability to observe the dilution of a contrast agent bolus in the intracranial vessels with a temporal resolution considerably below 1 second in a similar way to conventional digital subtraction angiography (DSA).[1,2] Subsecond 2D projection MRA is a reliable technique for imaging the intracranial vessels and provides information on the hemodynamics of a vascular malformation.[3] As cavernous hemangioma is a collection of vascular channels, subsecond images showing the turnover pattern of the blood pool space can be determined in a similar way to DSA using MR-DSA. Even after treatment, such as radiotherapy, MR-DSA can be used to evaluate the effectiveness of the treatment, conveniently and non-invasively i.e. the hemodynamical alternation of the blood pool space such as a thrombosis or the obliteration of the vascular space.

This report presents one rare case of a cavernous hemangioma in a cavernous sinus that was evaluated using MR-DSA for the early hemodynamic pattern, before and after radiotherapy, and compared with DSA.

CASE REPORT

A 55 year old woman with 3 year history of headache visited our hospital. She had already visited another institute one month ago and was diagnosed with cavernous hemangioma in the cavernous sinus by an open biopsy. The initial physical examination showed no neurological signs. MR imaging was carried out using a 1.5 T whole-body unit (Vision, Siemens, Erlangen, Germany) with a standard gradient system (25 mT/m and 600 μs risetime). A standard circularly polarized head coil was used for the radio frequency transmission and detection. The T1 and T2 weighted images were obtained for the routine imaging (TR/TE=600/14 for T1WI and TR/TE/ Acquisition=3477/96/3 for TSE T2WI). Two different dynamic studies were done; a traditional T1-weighted dynamic spin-echo enhancement study for the long-term turnover of

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the contrast for 6 minutes and MR-DSA for the short-term hemodynamic assessment for 25 seconds. A traditional dynamic study was performed first and 6 hours later. The MR-DSA was done to minimize the effect of the intravenously injected Gd-DTPA during the traditional dynamic study. Prior to imaging, an 18- gauge IV catheter was inserted in the right antecubital area for the contrast agent administration. Images from the traditional dynamic study were obtained coronally including one precontrast sequence and the subsequent five dynamic contrast sequences for 6 minutes (TR/ TE=300/ 17, flip angle=90°, thickness 3 mm, FOV 210 mm, matrix 226 × 256).

MR-DSA was performed using a snapshot FLASH optimized for the 2D projection imaging with a minimum TR/TE of 4.2/1.5 ms and a slab thickness of 45 mm. The flip angle was 45°, the field of view (FOV) was 220 mm with a 256 × 256 matrix. A rectangular FOV was used to increase the temporal resolution. A standard clinical dose of Gd-DTPA was injected with an automatic injector (volume 15 ml at 3 ml/sec following the injection of normal saline; volume 12 ml at 3ml/sec). The coronally directed MR-DSA images were obtained using 2 slice slabs to assess the hemodynamic changes separately from the anterior and the posterior circulations in a similar way to DSA. The MR imaging sequence was run continuously for 25 seconds without interval, resulting in 75 images for each slab.

All images were done using same sequences and parameters before and after radiotherapy.

DSA was performed only before radiotherapy via the femoral artery and selective catheterization of both the internal carotid and vertebral arteries was done with the conventional method using the standard anteroposterior and lateral projection format. A Siemens unit (Multistar T.O.P., Siemens, Erlangen, Germany) with an image matrix of 1024 × 1024 and a temporal resolution of 3 frames per second was used.

On the initial workup, the T1 weighted image showed an approximately 6.5 × 6.0 × 5.6 cm sized homogeneous low signal intensity mass in the left cavernous sinus as well as a marked high signal intensity on the T2 weighted image. Marked homogeneous enhancement after the intravenous administration of Gd-DTPA was observed (Fig. 1 A-C). The tumor had a well-defined border. The traditional dynamic contrast enhanced T1-weighted spin echo study revealed a diffuse filling of contrast at the peripheral portion of the tumor initially, which then progressively filled the whole tumor homogeneously for the consecutive 5 minutes (Fig. 2A).

MR-DSA of the anterior circulatory area initially showed puddlings at the peripheral portion circumferentially except for some superior and medial portions, which was filled from the posterior circulation. Puddlings were detected at the early phase, which lasted to the end of the study. Tumor filling from the periphery to the central part was well visualized on MR-DSA (Fig. 3A and 4A). DSA also revealed early puddlings of contrast at the peripheral portion as MR-DSA, as well as delayed central filling (Fig. 3B and 4B). A similar fast hemodynamic pattern of contrast turnover was observed on both MR-DSA and DSA.

The patient was treated with 5040 cGy irradiation at 180 cGy per fraction for 1 month in order to reduce the tumor size prior to surgical management. Two months after treatment, the same MR study as before radiotherapy was performed to evaluate the irradiation effect. The T1 and T2 weighted images showed similar signal intensity but there was marked decrease in the tumor size (5.0 × 5.0 × 4.5 cm), and a more homogenous and denser enhancement was noted after the contrast injection (Fig. 1D-F). Decompression of the left temporal lobe and pons was also noted. The conventional dynamic contrast enhanced T1-weighted spin echo study revealed a filling of all portions of the tumor earlier, which was denser than before treatment (Fig. 2B). DSA was not performed after treatment due to the invasiveness of the study and it was thought that MR-DSA alone was sufficient to evaluate the effectiveness of radiotherapy.

MR-DSA of the anterior and posterior circulatory areas showed less puddlings in both the amount and sharpness than before irradiation. In addition, there was even a delayed appearance and an early disappearance of the puddlings within the shrunken tumor (Fig. 3C and 4C).

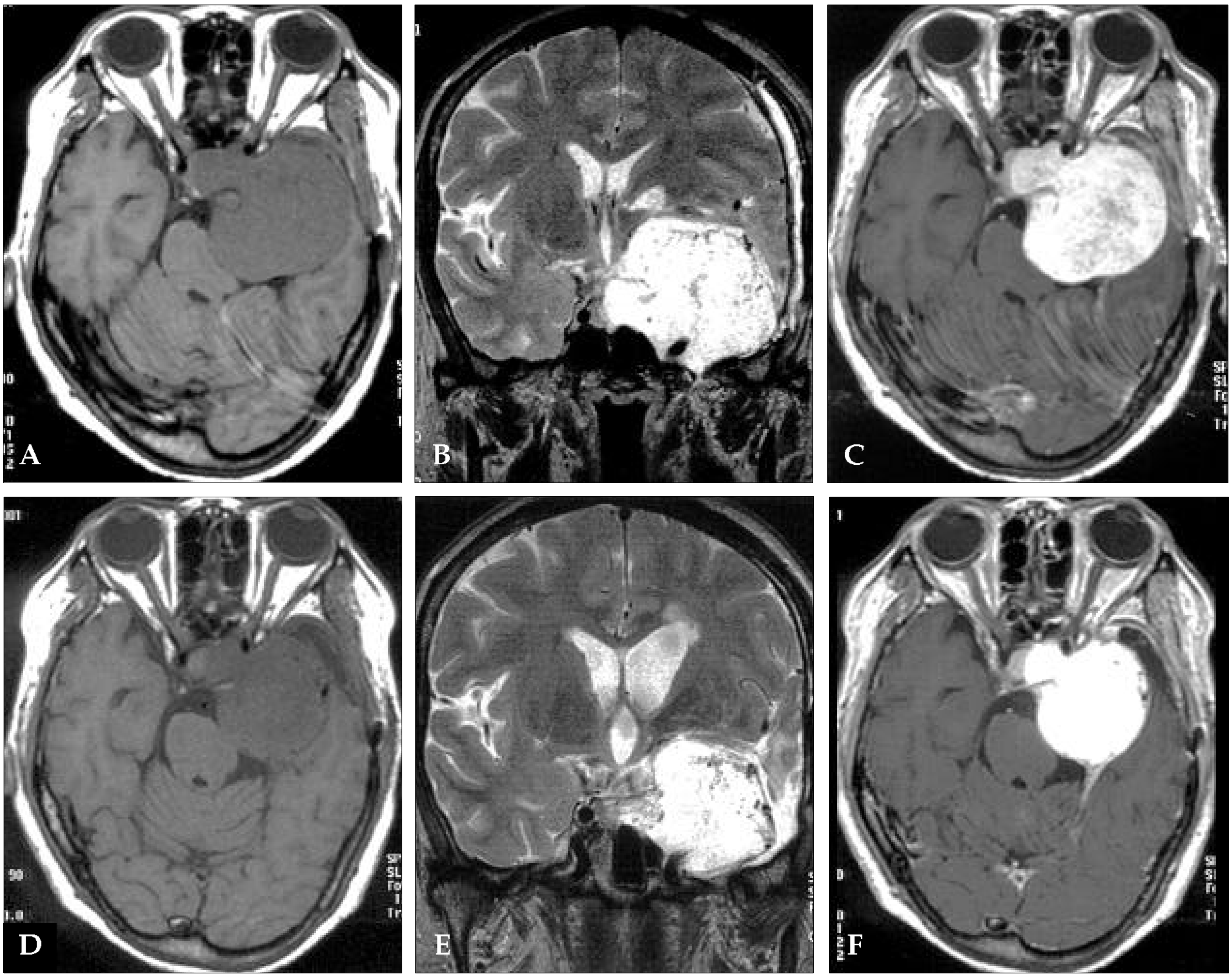

Fig. 1. Before radiotherapy, a large cavernous hemangioma is noted in the left cavernous sinus compressing the left temporal lobe and pons A-C. A marked shrunken tumor is noted after irradiation D-F. (A-C) T1-weighted axial (TR/TE=600/14), T2-weighted coronal image (TR/TE/ Acquisition=3477/96/3 for TSE T2WI) and enhanced T1 axial images obtained before radiation show a relatively homogeneous low signal intensity on the T1 weighted image and a hyperintense signal intensity with some signal void structures within the tumor on the T2 weighted image. Dumbbell shaped tumor from the cavernous sinus to the left temporal area is noted encasing the left carotid artery. Homogeneous enhancement of the tumor is noted after an injection of Gd-DTPA. (D-F) After radiotherapy, a markedly shrunken cavernous hemangioma is noted showing a decompressed left temporal lobe and pons. All sequences were done using the same parameters as A-C. The signal intensities show no definite interval change, but after a Gd-DTPA injection, a denser enhancement can be seen.

DISCUSSION

Compared to DSA, contrast-enhanced MR angiography (CE-MRA) is easily performed and is a safe method that is widely used to obtain high quality angiograms. Recently, MR-DSA after a contrast bolus injection was proposed, and this technique was developed and progressed due to the development of gradient systems for ultra fast imaging and injection methods for the contrast agent bolus.[1,2] MR-DSA can consecutively obtain fast dynamic contrast enhanced vascular images of a selected section, with a temporal resolution of 300-400ms per frame. Therefore, this subsecond technique has the potential to observe the fast hemodynamic changes in the normal or abnormal vascular alteration, such as cavernous hemangioma as in this case or other lesions that contain a blood pool space as in DSA.

Cavernous hemangiomas constitute approxi-

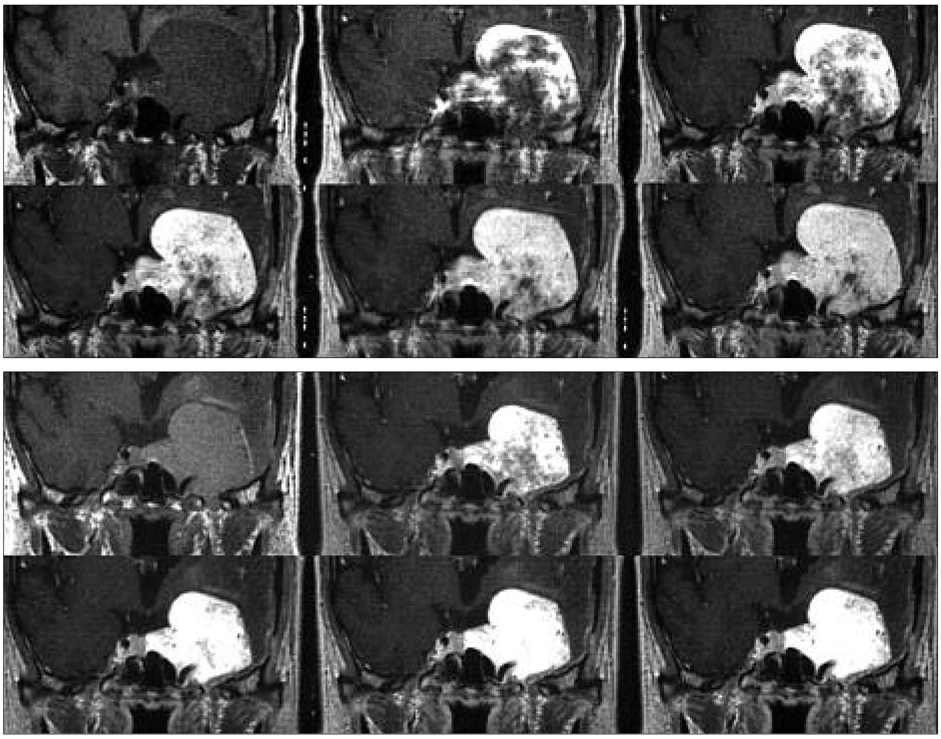

Fig. 2. Traditional T1-weighted dynamic spin echo enhancement studies (TR/TE=300/17) with a one minute gap, before A and after radiotherapy B are shown. (A) Prior to irradiation, the dynamic images for the consecutive 5 minutes show an early and densely filling in the upper part of the tumor and a progressive delayed filling in the remaining portion. Relatively homogeneous enhancement is noted. (B) After irradiation, a more faster and denser filling of contrast than before radiotherapy is noted.

mately 10% of all cerebrovascular malformations and according to the findings of autopsy series and large MR imaging-based studies, they develop in approximately 0.4 to 0.8% of the population.[4] Approximately 1 - 3% of the cavernous sinus lesions are cavernous sinus hemangiomas.[5,6] These lesions have been reported to emerge most frequently in the fourth decade, and a female predominance has been noted.[7] The onset of symptoms is usually insidious, and symptoms are caused by large sized tumors.[8] In contrast to our patient, cavernous hemangioma in the cavernous sinus are usually presented with a headache and dysfunctions of the cranial nerves passing through the cavernous sinus, particularly the ptosis and diplopia.[9] Angiography reveals densely stained pools of various sizes in the midarterial phase, persisting up to the venous phase, with no evidence of arteriovenous shunting.[10]

The tumor in our case had a marked hyperintensity on the T2-weighted images and this finding was helpful in distinguishing it from meningiomas.[6]

A complete resection of cavernous sinus hemangiomas is curative. However, an attempt to remove them may be complicated by excessive blood loss, new cranial neuropathies, and even panhypopituitarism.[6] The current treatment modalities for symptomatic hemangiomas include a resection, fractionated radiation therapy, or a combination of the two.[11] The decreased tumor size and an intratumoral thrombosis will facilitate a tumor resection. Therefore, preopearative radiation therapy can help reduce the tumor size, and/ or evoke an intratumoral vascular thrombosis to reduce the excessive hemorrhage during the operation.[9] However, an unchanged or even enlarged tumor size has been reported after radiotherapy indicating that some tumors are not as radiosensitive as others.[6,9]

Fortunately, a reduced size of the cavernous hemangioma was noted after radiotherapy in our case. The shrunken tumor with a lower number and sharpness of puddlings with the delayed appearance and early disappearance after radiotherapy are probably the effect of an early change in the intratumoral vessels; Endothelial proliferation, vessel wall hyalinization, and subsequent vessel obliteration.[12]

In order to evaluate an intrinsic thrombus formation or the changes in the vascular turnover pattern after radiotherapy, an easy reproducible

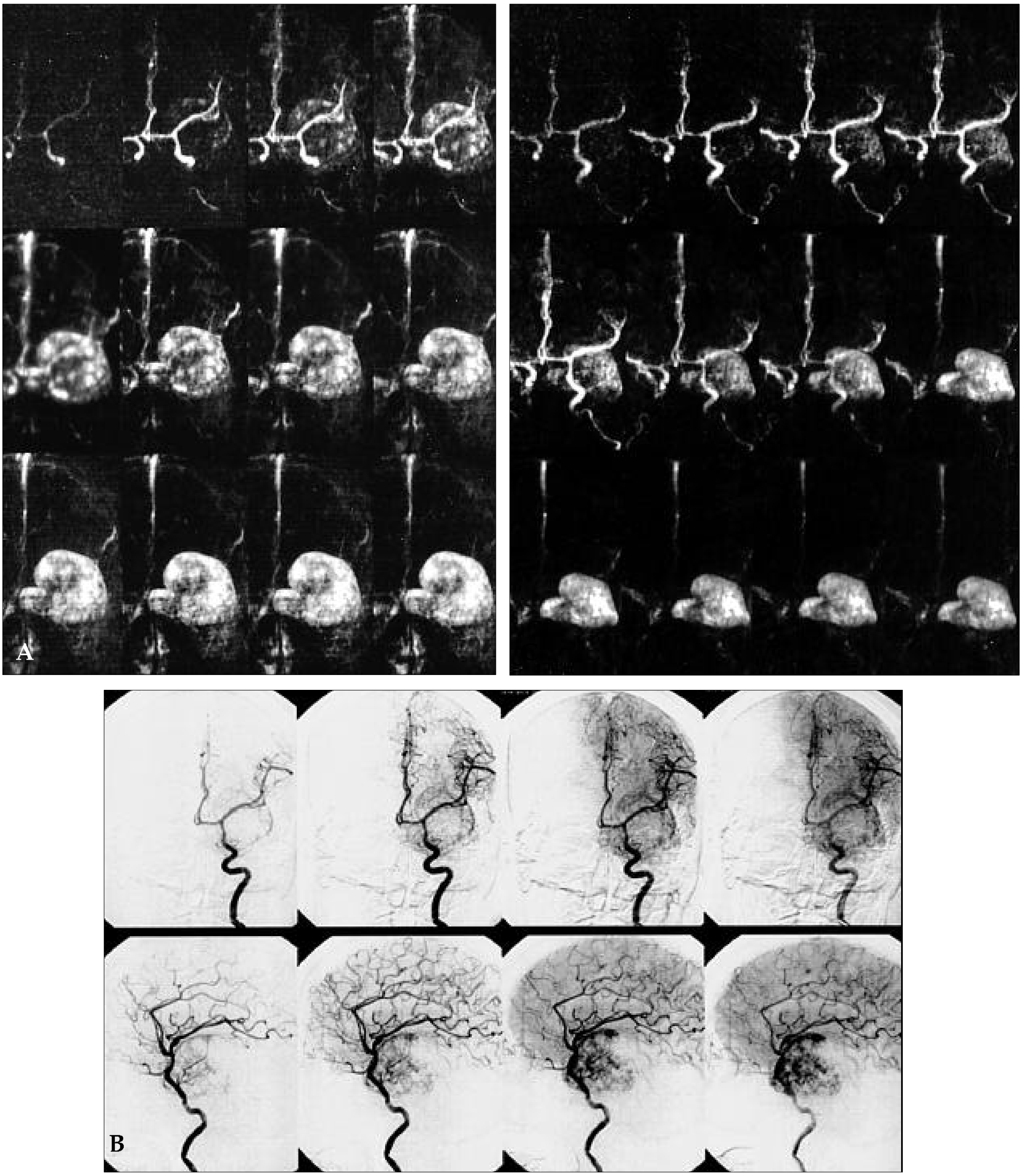

Fig. 3. Anterior circulatory images obtained from the DSA and MR-DSA (Pre and after radiotherapy) are shown. (A) DSA from a left internal carotid artery injection obtained before treatment on the anteroposterior and lateral projections show puddling and delayed filling. Some defects are noted as in MR-DSA. (B) MR-DSA images obtained before radiotherapy, coronally from the anterior circulation show well the fast turnover of contrast in a similar to the DSA shown in A. Circumferential puddlings are noted with some defects in the superior and medial portions of the tumor. Note the early appearance of puddlings with persistent staining. (C) After radiotherapy, MR-DSA images obtained coronally show a reduced tumor size and less puddlings in both number and sharpness than before radiotherapy. Note also the delayed

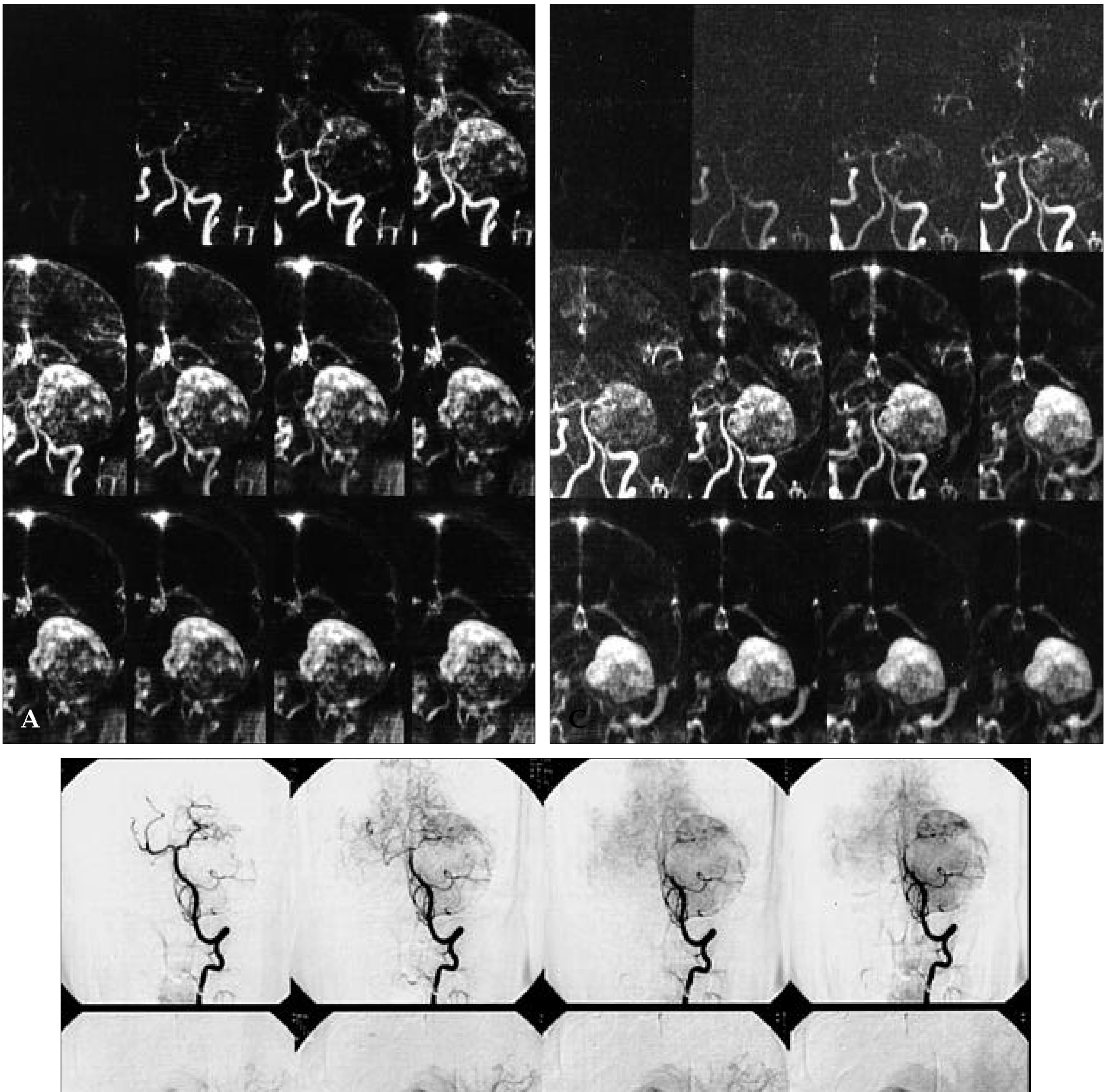

Fig. 4. Posterior circulatory images obtained from DSA and MR-DSA, before B and after irradiation C are shown. The contrast filled area is the defected portion on the anterior circulatory images shown in Fig. 3. A. DSA from the left vertebral artery injection, before radiotherapy on the anteroposterior and lateral projections show a filling in the posterosuperior part of the tumor, which is the defected area on the left ICA injection study that is similar to that of MR-DSA from the posterior circulation. (B) MR-DSA images coronally obtained from the posterior circulation before radiotherapy also show an early hemodynamic change well with puddlings that appear at the early phase and persist to the later phase. The defected area noted on Fig. 3B is filled well in this study. (C) Posterior circulatory images obtained from MR-DSA coronally after

and non-invasive hemodynamical study will be needed. In this aspect, MR-DSA is a good modality for assessing the early hemodynamic changes as well as the treatment effect.

Despite its capability, DSA, which shows multiple small contrast staining (puddling) at the early phase, is an invasive study and requires the patient's hospitalization, careful manipulation during the study and a large amount of contrast medium. Even some complications such as an embolism or a dissection can occur during or after the procedure. However, MR-DSA is safe, less invasive, less time consuming, and easy to perform with the same fast hemodynamic imaging capability as DSA. The effect of radiotherapy, particularly early hemodynamic changes can be easily recognized with MR-DSA. Therefore, MR-DSA is a good modality for evaluating the early hemodynamic changes, before and after radiotherapy.

In conclusion, the early hemodynamic changes in cavernous hemangioma in the cavernous sinus were presented both before and after radiotherapy using MR-DSA and the results were compared with those from conventional DSA. MR-DSA showed a similar fast hemodynamic response to those revealed from the DSA images, and is sufficient for evaluating the effect of radiotherapy. Therefore, this study suggests that MR-DSA can replace DSA for a fast hemodynamic evaluation in the blood pool containing lesions such as cavernous hemangioma in the cavernous sinus.

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