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MR of Giant Arachnoid Granulation, a Normal Variant Presenting as a Mass within the Dural Venous Sinus

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Summary: We report three cases of masses within the cerebral dural venous sinuses shown with either MR or angiography. The dural venous sinuses of 10 patients without known venous disease were examined at autopsy. In two patients, three giant arachnoid granulations were identified. On the basis of the literature and our limited autopsy series, we suggest that these lesions identified at imaging are giant arachnoid granulations, normal variants of no known clinical significance.

Index terms: Dural sinuses; Brain, anatomy

Because of increasing availability of cerebral venous magnetic resonance (MR) angiography, it has become important to recognize normal variations of the cerebral venous system. We report three cases in which masses were identified within the dural sinuses on MR, MR angiography, or conventional angiography. In all three cases, these findings were believed to be unrelated to the patient's clinical symptoms. On the basis of the literature and our pathologic observations on a limited number of autopsy cases, we suggest that these lesions represent giant arachnoid granulations.

Case Reports

Case 1

A 21-year-old man had recent onset of headache without focal neurologic deficit that coincided with the first week of practice for a college football team. MR scans showed a mass projecting into the left transverse sinus (Fig 1). No other abnormalities were noted on MR. Because venous thrombosis was considered, computed tomography was performed. On this study the mass showed low attenuation, inconsistent with recent thrombosis or hemorrhage. Findings from two follow-up MR studies over the next 2 years were unchanged. The headaches resolved shortly after their onset without treatment.

Case 2

A 7-year-old boy was resuscitated after being found unresponsive in a swimming pool. Previous episodes of staring with fixed upward gaze were reported, and there was a strong family history of seizures. The diagnosis of partial complex seizures was made. MR showed a mass projecting into the superior sagittal sinus that was confirmed with angiography (Fig 2). This was thought to be unrelated to the symptoms. The mass was isointense with brain on T1-weighted images but hyperintense on the T2-weighted scans. There was some irregular enhancement centrally in the mass. The inner table of the skull appeared eroded by the mass. Follow-up MR 4 months later demonstrated no change. No other abnormalities were noted. The seizures responded to medication.

Case 3

A 60-year-old man had a severe headache. CT demonstrated subarachnoid hemorrhage. An angiogram showed a pericallosal, anterior cerebral artery aneurysm. On the venous phase of the angiogram a mass was noted projecting into and deforming the superior sagittal sinus. The patient had no symptoms to suggest venous obstruction, and this mass was thought to represent an incidental finding. Because the patient had a history of an intraocular metallic foreign body, MR was not performed.

Findings in Autopsy Series

On the basis of the literature, which suggests that giant arachnoid granulations are relatively common, we specifically examined the dural sinuses in 10 subsequent autopsy cases. The patients were 30 to 86 years old at the time of death. In 2 of the 10 cases, large arachnoid granulations were found. In one (86 years old), there were two large arachnoid granulations, one in each transverse sinus. The one in the right sinus was located 3.5 cm from the midline and measured $1.2 \times 1.0 \times 0.8$ cm (Fig 3). The other measured $1.5 \times 0.9 \times 0.6$ cm and was 4 cm from the midline. The other patient (34 years old) had only one

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Fig 1. Case 1, 21-year-old man with headache.

A, Coronal T1-weighted MR image (500/20/4 [repetition time/echo time/excitations]) shows an inhomogeneous hypointense mass in the region of the dominant left transverse sinus (*arrows*).

B, Coronal T1-weighted enhanced MR image (500/20/4) shows focal enhancement centrally (*arrow*) without peripheral enhancement.

C, Coronal T2-weighted MR image (2017/80) shows inhomogeneously hyperintense mass (*large arrows*). Linear increased signal along the tentorium probably reflects a slow rate and in-plane direction of flow in a small vein (*small arrows*).

large arachnoid granulation ($0.9 \times 0.8 \times 0.6$) in the posterior portion of the superior sagittal sinus. Grossly, these nodules were white with a smooth outer surface. Microscopically they consisted of loose collagenous stroma with acellular and cellular zones, and a relatively large blood vessel in the center. The outer surface was covered by arachnoid cells.

Discussion

The growth of the arachnoid membrane into the dural sinuses (*glandulae conglobatae*) was described by Pacchioni in 1705 (1). He proposed that these function as secretory glands to facilitate movement of the brain along the meninges. These projections are called *arachnoid villi* or *arachnoid granulations*, depending on their size. Arachnoid villi are microscopic, whereas granulations are visible to the naked eye (2). Current theories argue that the arachnoid villi function as a passive filtration system for cerebrospinal fluid, providing a pathway from the subarachnoid space into the venous system. Arachnoid granulations also provide some filtration but represent distended villi. It is supposed that these enlarge in response to increases in cerebrospinal fluid pressure (3). Arachnoid granulations are not present at birth but are evident by 18 months of age, becoming quite conspicuous by age 4 (3, 4). They enlarge with age, sometimes becoming quite prominent by middle age. These granulations can cause smooth, evenly marginated impressions on the inner table of the skull. They sometimes expand into the diploetic space and rarely even erode the outer table (4). Such erosions can simulate osteolytic lesions of the skull (5, 6). They are most commonly seen in the anterior parietal bone and posterior frontal bone, usually within 3 cm of the midline. However, rarely they occur at some distance from the midline (5).

In one comprehensive study of autopsy material by Browder et al (7), smooth-surfaced nodules were found projecting into the dural sinuses in 32 of 380 cases. These were characterized as different in some respects from arachnoid granulations. On gross examination they had a firm rubbery texture. No cell caps were found on these nodules, as compared with usual arachnoid granulations. In addition, they were found at all ages, from 14 months to 57 years. This differs from a previous study of arachnoid granulations that suggested that they enlarge over time (3). In another series, arachnoid impressions on the skull were not seen before age 7 years (4). In two of the 32 cases with nodules in the dural sinuses reported by Browder et al

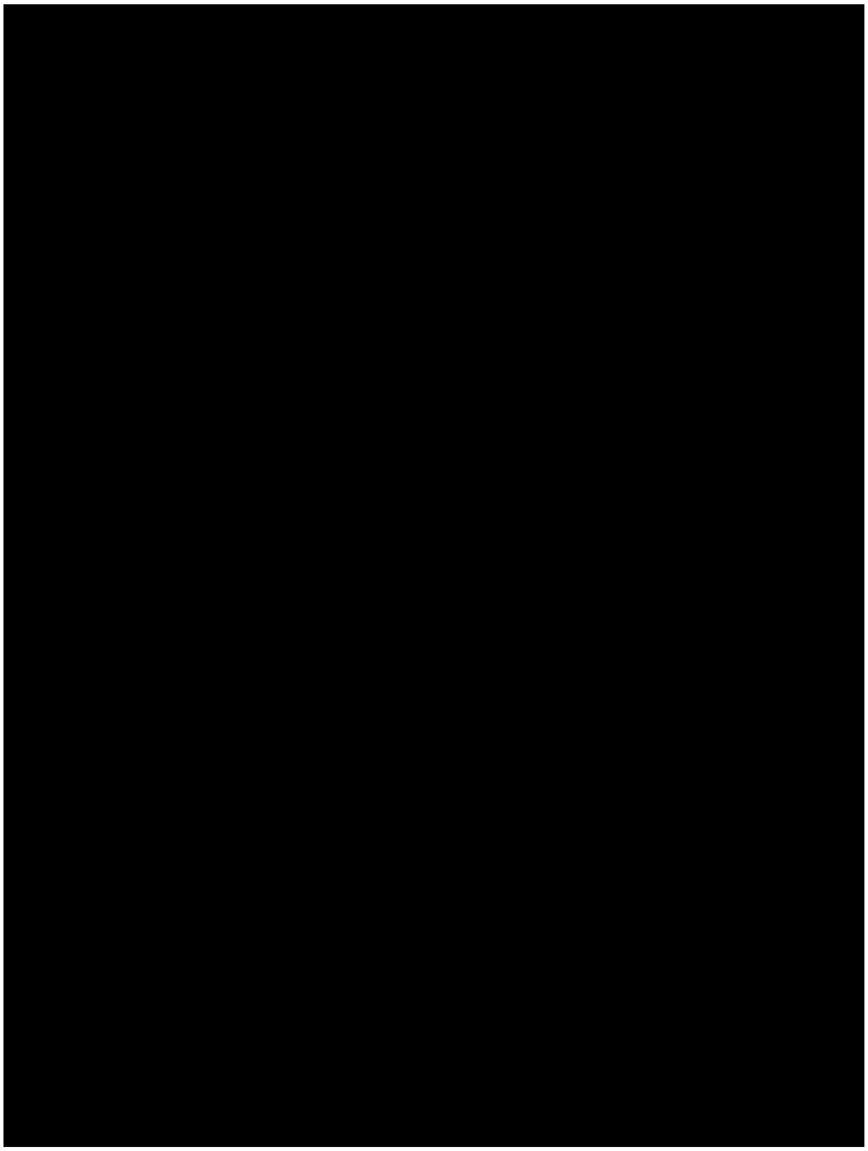

Fig 2. Case 2, 7-year-old boy with seizures.

A, Two-dimensional time-of-flight MR venogram shows a rounded area of absent flow within the superior sagittal sinus and fusiform widening of the sinus around the lesion (*arrow*).

B, Axial T2-weighted MR image (4000/90) shows hyperintense mass (*white arrow*). The linear low-signal structure crossing the right dural margin of the sinus (*black arrow*) from the subarachnoid space probably represents the pedicle of this arachnoid nodule.

C, Axial T1-weighted MR image (660/16/2) shows erosion of the inner table (*arrows*).

D, Postcontrast T1-weighted MR image (660/16/2) shows inhomogeneous enhancement of the lesion.

(7), the nodules were of sufficient size to fill the lumen of the dural sinus and cause dilatation of the sinus locally around the granulation. They suggest that these may reflect either hyperplastic arachnoid granulations or benign nonfunctional neoplasms of mesenchymal origin. The distribution of these nodules was striking in this series, with 26 of the 32 found in the left transverse sinus at its junction with the vein of Labbé. In all 32 cases there were numerous blood vessels within the nodule.

In the differential diagnosis of masses within the dural sinuses it is important to also consider extraaxial cavernous hemangioma. These lesions ("sinus cavernoma") occur primarily in the cavernous sinuses, but they have been reported within the other dural sinuses (8). Although meningiomas commonly involve the dural sinuses, this involvement reflects tumor invasion from a site near the sinus. Although a meningioma arising entirely within a dural sinus is a theoretical consideration, it would be uncommon. The enhanced MR images available in two of our cases showed focal central or inhomogeneous enhancement of the mass, inconsistent with both of these rare entities. We encountered two of our three cases within 1 week, suggesting a less exotic diagnosis.

Artifacts mimicking intravascular masses have been seen on conventional angiograms in one or both transverse sinuses because of inflow of unopacified blood (9). In theory, a similar artifact could be seen on MR angiograms owing to inflow of saturated venous blood or turbu-

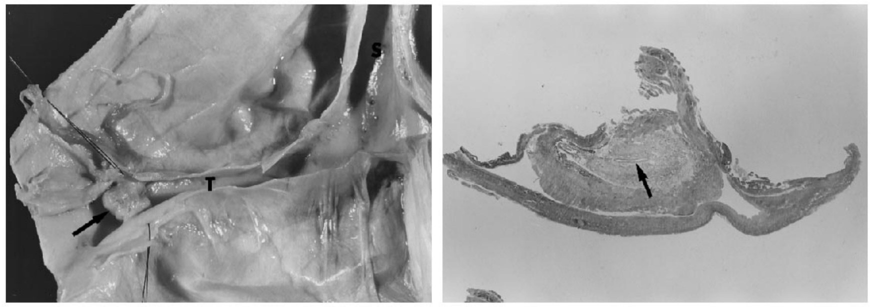

Fig 3. Autopsy findings in a 36-year-old man.

A, Photograph shows the inner aspect of the dura with portions of the superior sagittal and transverse sinuses opened. Note the presence of a giant arachnoid granulation (*arrow*) in the right transverse sinus (*T*). The superior sagittal sinus (*S*) is normal.

B, Photograph of a cross section of the left transverse sinus (Masson trichrome stain) shows the giant arachnoid granulation partially occluding the lumen of the sinus. The *arrow* points to a prominent blood vessel in the center of this nodule.

lence at a venous confluence (10). The findings in the cases we report could not represent these artifacts, because in cases 1 and 2 the abnormality was identified on the conventional spin-echo images as well as MR angiogram and in case 3 there was distortion of the normal contour of the superior sagittal sinus by the mass (Fig 4).

On the basis of literature, we believe that the dural sinus masses seen on MR imaging represent giant arachnoid granulations. Several features support this proposal. In all three of our cases, the mass was an incidental finding. The mass identified in case 1 was followed up with MR for 2 years and remained unchanged. It is interesting that this lesion was on the patient's left side, consistent with the asymmetry of incidence reported by Browder et al (7). The enhancement in case 1 also suggested the presence of central vascular channels, as seen in the cases we identified at autopsy and those reported by Browder et al. The lesions in cases 2 and 3 were both in the caudal portion of the superior sagittal sinus and appeared to expand the sinus. This is also the location and morphology of the largest two nodules reported by Browder et al. No surgical intervention was thought to be necessary in any of our three cases; therefore, histologic confirmation of these lesions is not available. Our experience, as well as the literature on arachnoid granulations, suggests that they are common, incidental findings and should be recognized as such when identified on imaging studies.

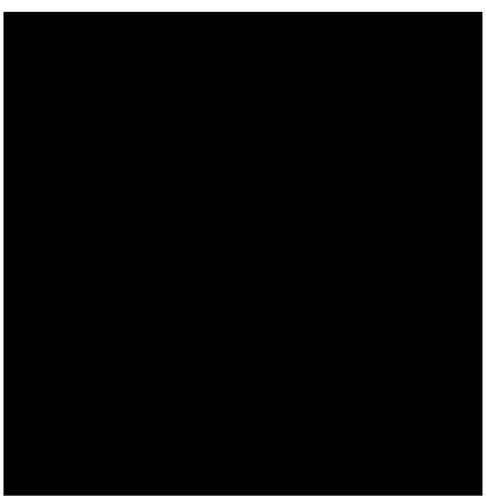

Fig 4. Case 3, 60-year-old man with aneurysm. The venous phase of a digital carotid arteriogram shows a well-marginated, rounded mass (*arrow*) within the superior sagittal sinus (*S*). There is distortion and enlargement of the sinus about the mass, but the sinus is not occluded by the mass. The transverse sinus (*T*) appears normal.

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