

# Posterior Fossa Venous Angiomas with Drainage through the Brain Stem

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**PURPOSE:** To describe 11 cases of posterior fossa venous angiomas with drainage through the brain stem. **METHODS:** Eleven cases of posterior fossa venous angioma with drainage through the brain stem were evaluated using MR. Correlation with known routes of venous drainage for the cerebellum and brain stem is made. **RESULTS:** Six of the 11 venous angiomas were found in the cerebellum, four in the brain stem; one involved both the cerebellum and brain stem. The cerebellar venous angiomas drained to subependymal veins about the fourth ventricle and dorsal pons. These then connected with an enlarged transmesencephalic or transpontine vein, to drain anteriorly to the anterior pontine veins. The brain stem angiomas had variable drainage depending on location. Evidence of hemorrhage was seen in five cases. **CONCLUSION:** Cerebellar and brain stem venous angiomas have several potential routes of drainage, including an enlarged vein traversing the pons, midbrain, or medulla. A knowledge of the normal venous anatomy of this region helps to understand the occurrence of these uncommon routes of venous drainage.

**Index terms:** Posterior fossa, abnormalities and anomalies; Posterior fossa, magnetic resonance; Veins, anatomy; Angioma; Blood vessels, flow dynamics

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Venous angiomas of the posterior fossa are found with relative frequency on cranial magnetic resonance (MR) scans. The majority occur within the cerebellum; involvement of the brain stem is much less common. In most cases the venous drainage of these lesions is to the superficial surface of the cerebellum, although occasionally cerebellar venous angiomas may drain through a dilated vein traversing a portion of the brain stem. We have recently encountered seven cases of such an anomaly and four cases located purely within the brain stem. The purpose of this article is to present these cases and to review the normal venous drainage of the brain stem and cerebellum

in order to better understand this uncommon route of venous drainage.

## Materials and Methods

The MR examinations from 11 patients with brain stem drainage of posterior fossa venous angiomas were retrospectively reviewed. All scans were performed using a 1.5-T magnet. Scanning was performed in the axial plane using T1 400-600/20-30/1-2 (repetition time/echo time/excitations) and T2 2000-3000/30-120/0.75-2 weighting. T1-weighted images were also obtained in the axial, sagittal, or coronal plane after the intravenous administration of gadolinium. In addition, MR angiography was performed in three cases and conventional catheter angiography in one.

All cases were reviewed for the location of the venous angiomas, the number and course of draining veins, the presence of dilated subependymal veins, and the presence and location of hematomas.

## Results

The results are summarized in Table 1. All 11 patients had at least a portion of the venous drainage occurring through a dilated vein traversing the brain stem. In nine cases this was the only route of drainage. In two cases there were also veins leading superficially to the surface of the

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TABLE 1: Features of venous angiomas with drainage through the brain stem

Case	Age (years)	Reason for Scan	Location of Caput Medusa	Location of Draining Vein(s)	Dilated Subependymal Veins?	Hematoma or Cavernous Angioma
1	43	First seizure	Bilateral CH	Central pons	Yes	None
2	33	Headaches	Right CH	1. Central pons 2. Anterolateral CH	Yes	None
3	56	Headaches, left arm numbness	Right CH	1. Central PMJ 2. Anterolateral CH	Yes	None
4	22	Hemiparesis	Dorsal pons	Central pons	Yes	One, adjacent to draining
5	34	Seizure disorder	Right CH	1. Central pons 2. Right anterolateral CH	Yes	Three, unrelated to draining vein
6	68	Headaches after surgery for vascular malformation	Bilateral CH	Central, caudal mesencephalon	Yes	One, adjacent to draining vein
7	25	Evaluation of hemorrhage	Dorsal pons right CH	1. Right anterolateral pons 2. Left PMJ	Yes	One, adjacent to draining vein
8	10	Not available	Central pons	Left anterolateral pons	No	None
9	56	Left leg numbness	Right CH	1. Right lateral mesencephalon 2. Anterolateral mesencephalon 3. Superior, dorsal mesencephalon	Yes	None
10	20	Right-sided weakness	Dorsal mesencephalon	1. Central mesencephalon 2. Dorsal mesencephalon	Yes	One, unrelated to draining vein
11	59	Infratemporal fossa vascular malformation	Dorsal medulla	Lateral medulla	Yes	None

Note.—CH indicates cerebellar hemisphere; PMJ, pontomedullary junction.

cerebellum. The venous angiomas were located in the cerebellum in six cases, in the cerebellum and pons in one, in the pons alone in two, in the mesencephalon in one, and in the medulla in one. Dilated subependymal veins were seen in all but one case.

Evidence of hemorrhage was noted in five cases. In three of these, the hemorrhage was located adjacent to a draining vein. It could not be determined whether these represented hemorrhage from the venous angioma or draining vein, or whether there was an associated cavernous angioma.

## Discussion

The emergence of clinical MR has greatly advanced our understanding of venous angiomas, particularly those in the posterior fossa. Once considered rare, cerebellar venous angiomas are now recognized with relative frequency on MR (1). Reports as recent as from 1984 suggested that cerebellar venous angiomas are unusual lesions having a high propensity for hemorrhage (2). Although the true incidence of hemorrhage in these abnormalities is not known, many non-hemorrhagic cerebellar venous angiomas have now been identified with MR. Thus it is likely that

most cerebellar venous angiomas will not hemorrhage (3). (Although nearly half of our cases had associated evidence of hemorrhage, these were scanned because they were symptomatic. Many asymptomatic cases are found as incidental findings.) A possible exception may exist in the presence of venous stenosis, because increased intraluminal pressure may predispose to hemorrhage (3).

There are several theories concerning the development of these abnormalities. Some have considered venous angiomas to be malformations of the venous system; others have proposed that they represent hamartomas. Another attractive theory is that they are anomalies of venous drainage (4). In support of this theory is the observation that the normal venous drainage pathways around venous angiomas are often absent (4, 5). Also, resection of the venous angioma may result in venous infarction, indicating that the angioma was the only route of venous drainage for that portion of the brain (5).

The normal venous drainage of the cerebellum has been described in detail (6, 7). The majority of the blood from the cerebellar hemispheres and vermis drains superficially to veins on the surface of the brain. These include anterior, posterior, and medial hemispheric veins and superior and

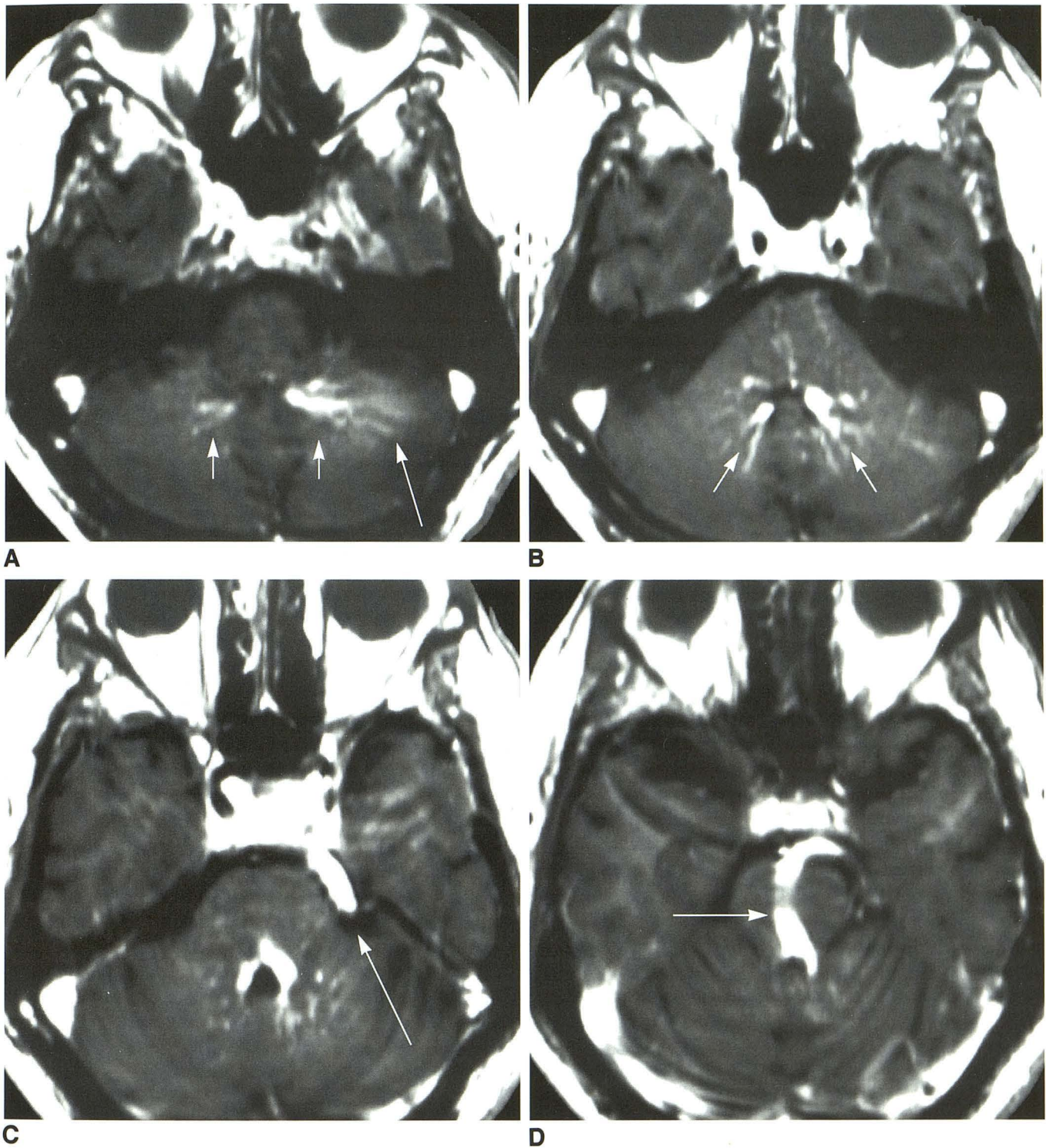


Fig. 1. Bilateral cerebellar venous angiomas with transpontine drainage.

A and B, Axial contrast-enhanced T1-weighted MR images demonstrate bilateral cerebellar venous angiomas converging on the fourth ventricle (*short arrows*). The appearance of parenchymal contrast enhancement about the venous angiomas suggests restriction of venous outflow (*long arrow* in A), although slow flow in small venules could produce a similar appearance.

C, Axial image at a slightly higher level shows the venous angiomas surrounding the fourth ventricle and joining together in the dorsal pons. A large transverse pontine vein appears to narrow abruptly near the left superior petrosal vein, further suggesting restriction of venous outflow (*arrow*).

D, Axial image through the upper pons shows the large vein traversing the central pons (*arrow*).

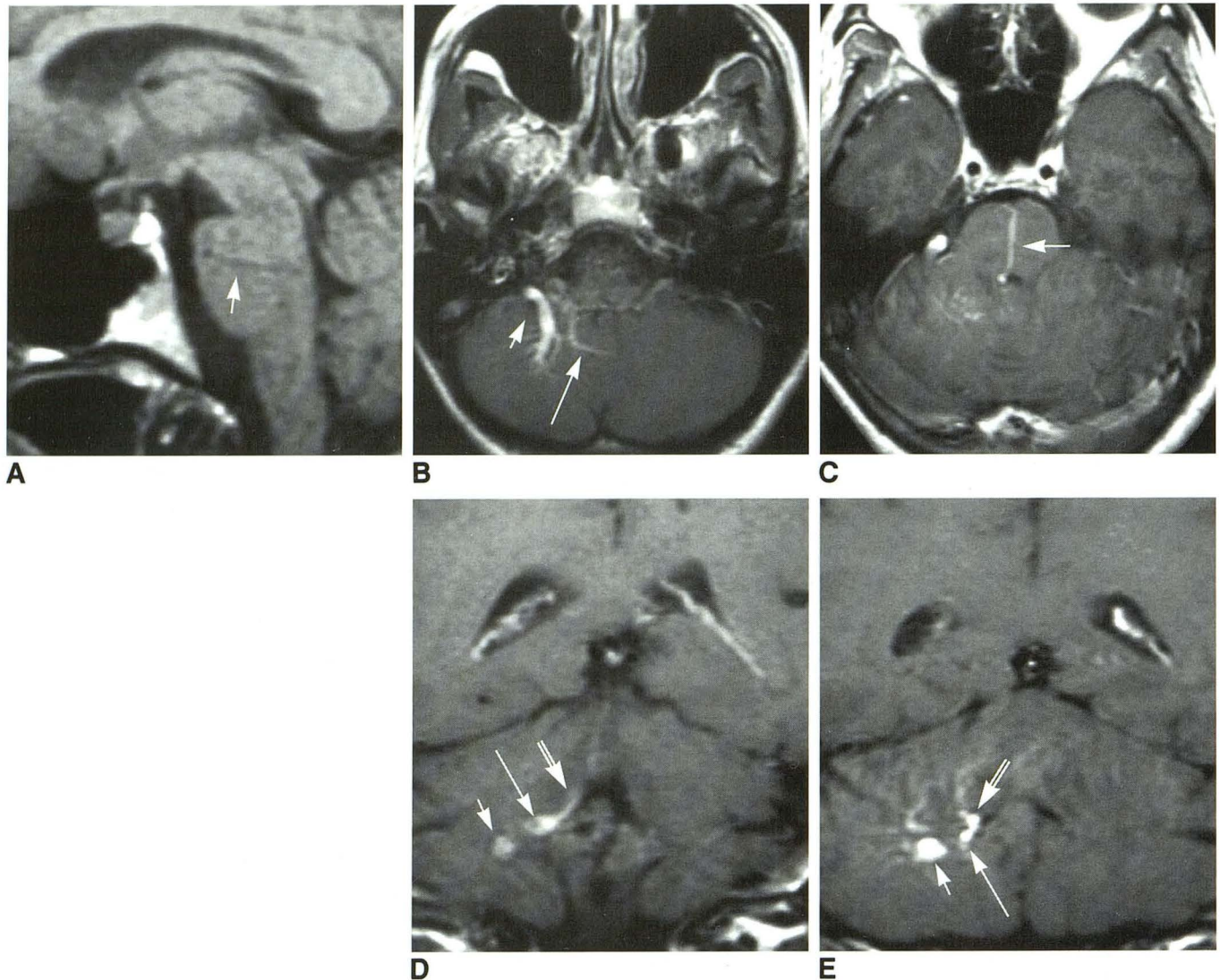


Fig. 2. Superficial and deep drainage of cerebellar venous angiomas.

A, Midsagittal T1-weighted MR image shows a prominent vein traversing the central pons (*arrow*). Compare with Figure 8A.

B, Axial contrast-enhanced T1-weighted MR image shows a right cerebellar venous angioma. There are two prominent draining veins. One courses laterally toward the superior petrosal vein (*short arrow*); the other is directed medially to the margin of the fourth ventricle (*long arrow*).

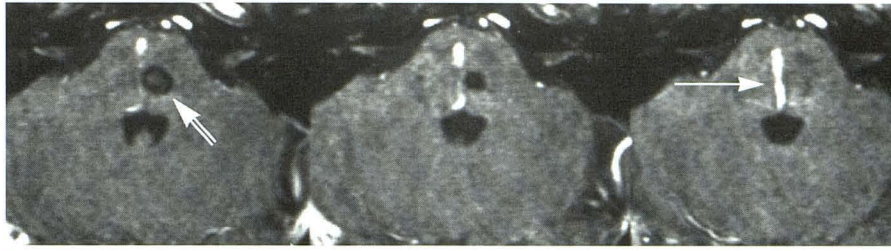
C, Axial contrast-enhanced T1-weighted MR image demonstrates the course of the transpontine vein (*arrow*).

D and E, Coronal contrast-enhanced T1-weighted MR images show two draining veins. The lateral vein (*short arrow*) drains superficially, and the medial vein (*long arrow*) drains to the margin of the fourth ventricle, emptying into a subependymal vein (*double arrow*). The subependymal veins then drain into the transpontine vein.

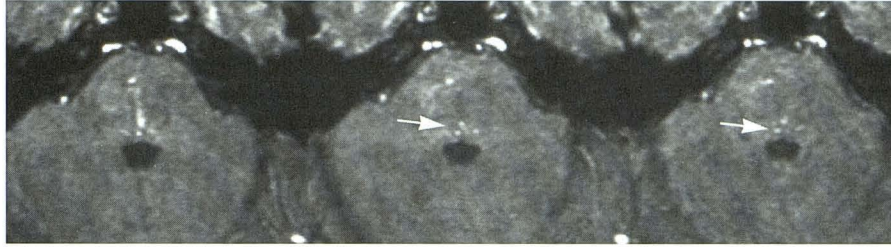
inferior vermian veins and the precentral cerebellar vein. A small portion of the cerebellum, particularly the dentate nucleus and adjacent white matter, drains into the vein of the lateral recess of the fourth ventricle (8). These paired veins form the only true deep venous drainage of the cerebellum. The vein of the lateral recess originates on the superior pole of the tonsil with the union of the transverse and lateral supratonsillar veins and courses anteriorly, just outside the lateral recess of the fourth ventricle. In most instances it empties into the superior petrosal

vein or directly into the inferior petrosal sinus. Tributaries of the vein of the lateral recess drain portions of the tonsils, the fourth ventricular choroid plexus, subependymal regions, and the dentate nuclei and adjacent white matter.

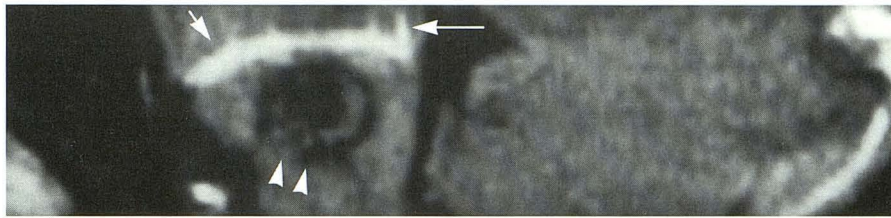
Goulao et al have reviewed posterior fossa venous angiomas (4) and have found that infratentorial venous angiomas, like their supratentorial counterparts, may be classified as deep or superficial. Those with deep drainage characteristically converge on the subependymal region of the fourth ventricle as is seen in all seven of our



**A**



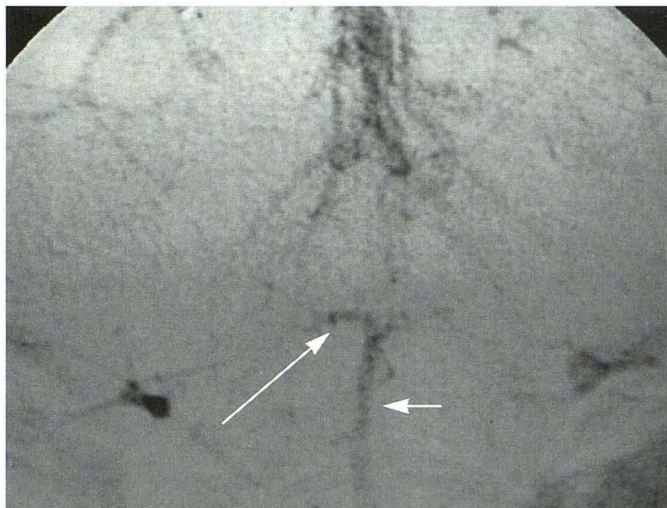
**B**



**C**



**D**



**E**

Fig. 3. Pontine venous angioma.

*A and B*, Axial contrast-enhanced radio frequency spoiled gradient refocused MR images demonstrate several mildly prominent veins in the dorsal pons (*short arrows*) converging on a large transpontine vein (*long arrow*). A small hematoma is noted in the left central pons (*double arrow*).

*C and D*, Sagittal reformations of data set in *A* and *B* show the relationship between the transpontine vein (*short arrow*) and the hematoma (*arrowheads*). Note the origin of the transpontine vein in the dorsal pons (*long arrow*).

*E*, Venous phase of vertebral angiogram, Towne projection, shows the transpontine vein (*short arrow*) and its origin in the dorsal pons (*long arrow*).

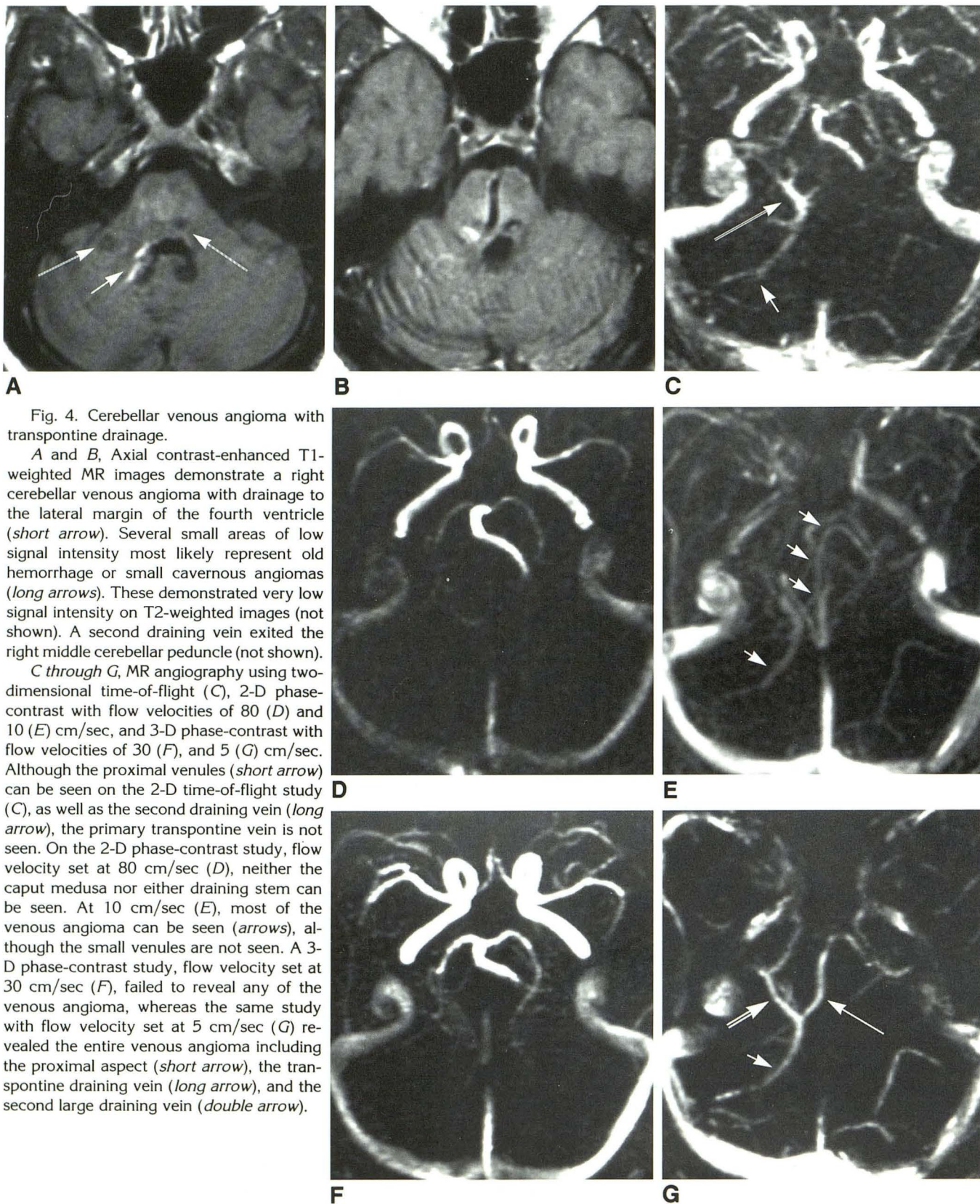


Fig. 4. Cerebellar venous angioma with transpontine drainage.

A and B, Axial contrast-enhanced T1-weighted MR images demonstrate a right cerebellar venous angioma with drainage to the lateral margin of the fourth ventricle (*short arrow*). Several small areas of low signal intensity most likely represent old hemorrhage or small cavernous angiomas (*long arrows*). These demonstrated very low signal intensity on T2-weighted images (not shown). A second draining vein exited the right middle cerebellar peduncle (not shown).

C through G, MR angiography using two-dimensional time-of-flight (C), 2-D phase-contrast with flow velocities of 80 (D) and 10 (E) cm/sec, and 3-D phase-contrast with flow velocities of 30 (F), and 5 (G) cm/sec. Although the proximal venules (*short arrow*) can be seen on the 2-D time-of-flight study (C), as well as the second draining vein (*long arrow*), the primary transpontine vein is not seen. On the 2-D phase-contrast study, flow velocity set at 80 cm/sec (D), neither the caput medusa nor either draining stem can be seen. At 10 cm/sec (E), most of the venous angioma can be seen (*arrows*), although the small venules are not seen. A 3-D phase-contrast study, flow velocity set at 30 cm/sec (F), failed to reveal any of the venous angioma, whereas the same study with flow velocity set at 5 cm/sec (G) revealed the entire venous angioma including the proximal aspect (*short arrow*), the transpontine draining vein (*long arrow*), and the second large draining vein (*double arrow*).

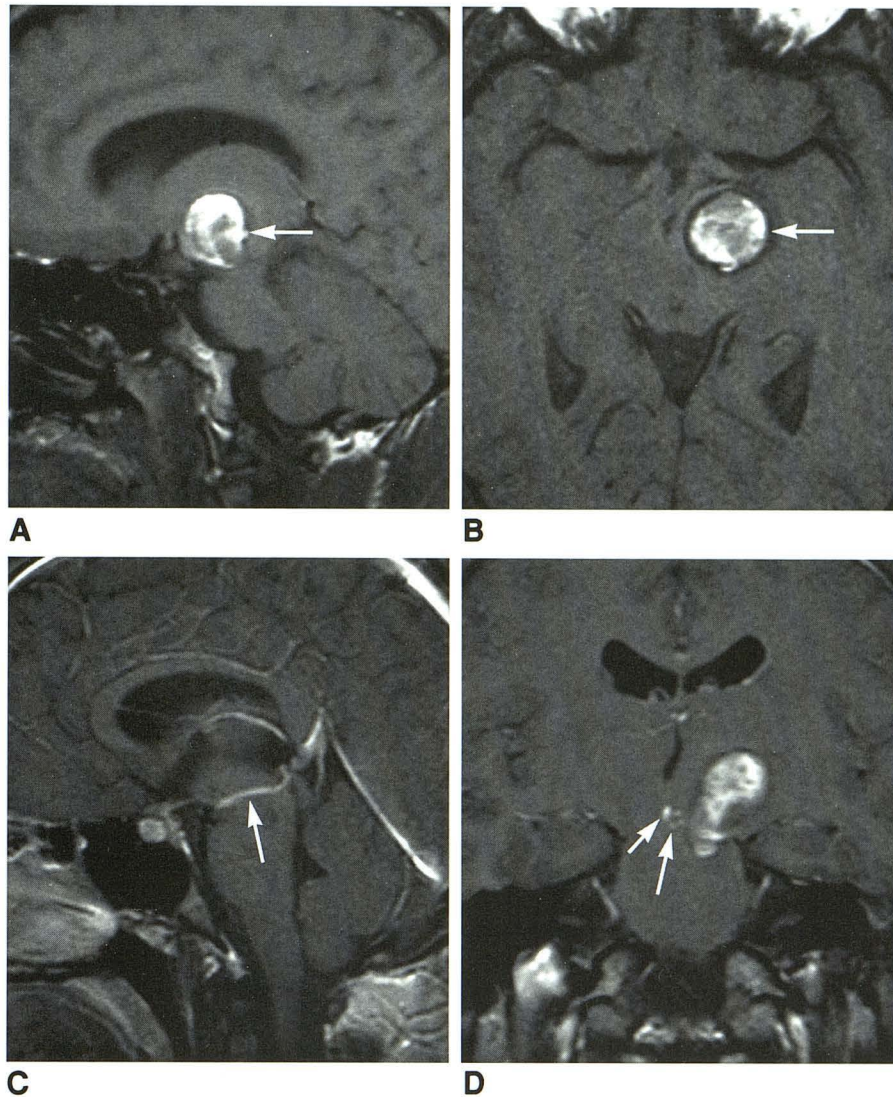


Fig. 5. Mesencephalic venous angioma.

A, Sagittal and B, Axial T1-weighted images demonstrate a subacute hematoma in the left midbrain and diencephalon (*arrows*).

C, Sagittal T1-weighted image with gadolinium shows an enlarged vein traversing the midbrain (*arrow*).

D, Coronal T1-weighted image with gadolinium again demonstrates the enlarged vein traversing the midbrain (*short arrow*) and three additional veins representing the caput of the venous angioma (*long arrow*).

cerebellar cases. From there, venous drainage might be expected to occur via the vein of the lateral recess. However, many alternate paths of drainage from the subependymal region have been described, including superiorly along the sylvian aqueduct (as in case 9, see Fig 6) (9), posterosuperiorly through the anterior medullary velum, posteroinferiorly through the foramen of magendie or posterior medullary velum, anterolaterally through the middle cerebellar peduncle (as in cases 5, 7, and 8) (10), or anteriorly through the pons or midbrain (as in cases 1–5 and 10, Figs 1–4) (15).

The veins of the pons have also been described in detail (11). Except for the most dorsal portion,

these radiate outward from the central, subependymal region of the pons. These may be divided into anteromedial, anterolateral, lateral, and posterior groups. Included in the posterior group are the subependymal pontine veins, the largest of which are the subependymal veins of the locus ceruleus. These course just deep to the floor of the fourth ventricle and may represent the subependymal veins noted in our cases. These subependymal veins allow connections between the cerebellar venous angiomas and the transpontine or transmesencephalic veins.

The anteromedial group of pontine veins include many small veins coursing through the central pons. These extend farther posteriorly

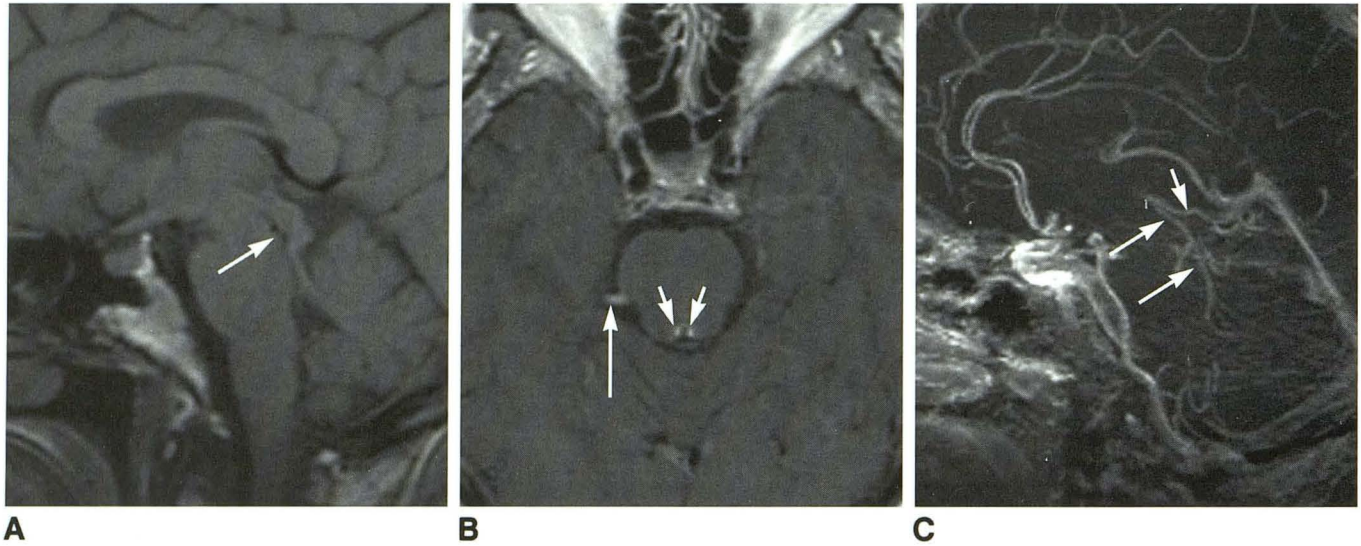


Fig. 6. Drainage of a cerebellar venous angioma through the sylvian aqueduct and mesencephalon.  
 A, Sagittal T1-weighted image demonstrates a dilated vein traversing the sylvian aqueduct (*arrow*). (Venous angioma not shown.)  
 B, T1-weighted axial image with gadolinium shows the enlarged aqueduct veins (*short arrows*) and a prominent lateral pontine vein (*long arrow*).  
 C, Sagittal reconstructed gradient-echo image with gadolinium shows the enlarged draining vein from the region of the fourth ventricle coursing superiorly through the sylvian aqueduct (*long arrows*). In the posterior third ventricle the vein makes a sharp posterior turn toward the confluence of the internal cerebral veins and basal veins of Rosenthal (*short arrow*).

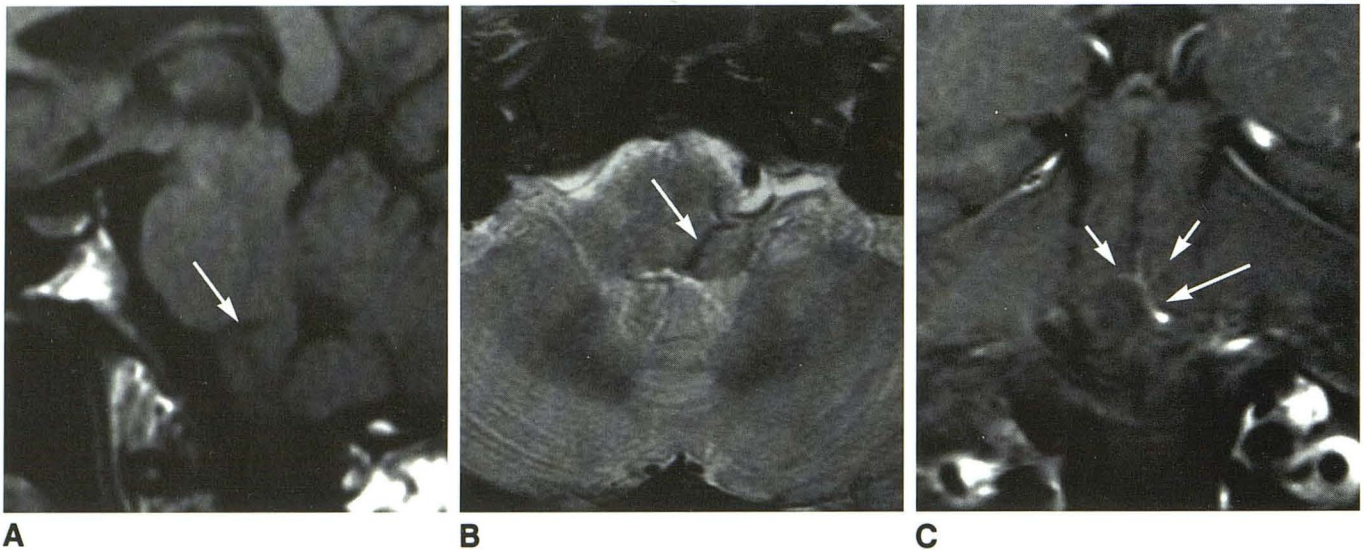
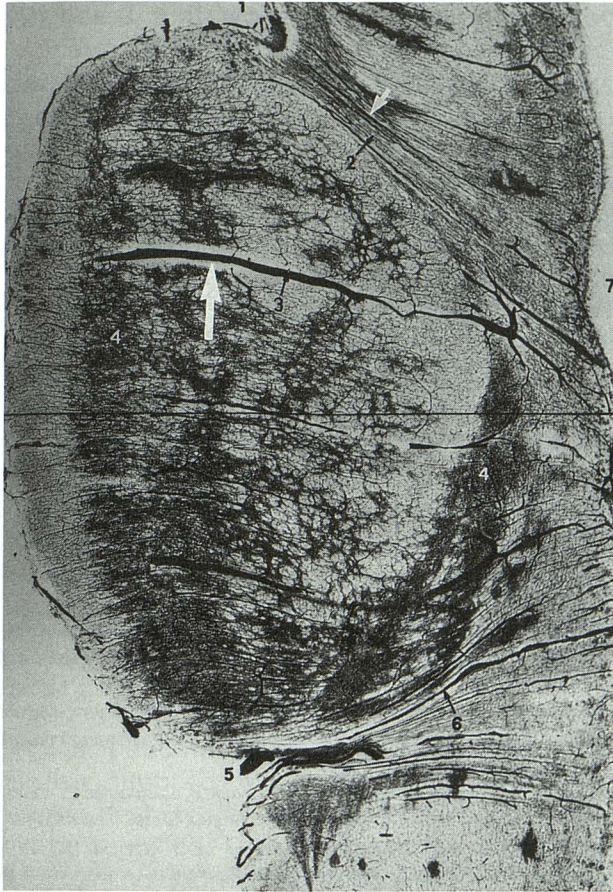


Fig. 7. Medullary venous angioma.  
 A, Midsagittal T1-weighted image shows enlarged veins in the upper medulla (*arrow*).  
 B, Axial T2-weighted image shows the prominent draining vein traversing the left medulla and inferior cerebellar peduncle (*arrow*).  
 C, Coronal T1-weighted image with gadolinium demonstrates several enlarged veins in the dorsal medulla (*short arrows*) joining to drain to the left (*long arrow*).

than their corresponding arteries and may reach the subependymal region of the fourth ventricle to drain or anastomose with subependymal veins. Often, one vein of this group is dominant and is referred to as the *principal anteromedial* vein of the pons (see Fig 8A). We suggest that this vein, or a similar vein, dilates in response to the increased blood flow from the venous angioma and

represents the transpontine vein seen in cases 1, 2, 4, and 5 (Figs 1–4). In cases 3 and 6, the draining vein traverses the inferior mesencephalon to reach the interpeduncular cistern. This represents a dilated member of another group of veins, the inferior veins of the interpeduncular fossa (see Fig 8A). In cases 5, 7, and 8 there is a dilated anterolateral pontine vein. This is often





A



B



C

Fig. 8. Photomicrographs of the brain stem after intravascular injection of India ink (from Duvernoy [11]).

A, Sagittal section of the pons. The arteries and veins of the inferior group of the interpeduncular fossa (*short white arrow*) and the principal anteromedial vein of the pons (*long white arrow*) are shown.

B, Axial section of the pons. Anterolateral veins are demonstrated (*arrows*).

C, Axial section of the medulla. The principal lateral medullary vein is shown (*arrow*).

referred to as the *principal anterolateral vein* (see Fig 8B). Upon reaching the ventral pons, the blood drains into anterior superficial (anteromedial, anterolateral, and transverse) pontine veins, and then most commonly into the superior petrosal vein.

In two cases there was drainage through dilated veins in the dorsal mesencephalon. The venous drainage of the dorsal mesencephalon is divided into two groups: the peripheral collicular veins and the central collicular veins (11). The peripheral collicular veins are small and drain the lateral portions of the colliculi. The central collicular veins are larger and extend to the subependymal region of the sylvian aqueduct. These veins are further subdivided into superior, middle, and inferior central collicular veins and probably represent the dilated veins noted in cases 9 and 10 (Figs 5 and 6). In most instances these veins drain into the lateral pineal veins and then into the vein of Galen or internal cerebral veins.

In case 9 (Fig 6) there was a cerebellar venous angioma with dilated subependymal sylvian aqueduct veins leading to the superior mesencephalon. This is similar to a case reported by Avman et al (9). There is no single vein that follows this course in the healthy adult; it is probably the result of anastomoses of multiple subependymal branches of collicular veins.

As in the pons, the majority of the veins in the medulla radiate superficially from the central and posterior region. These have been divided into anterior, lateral, and posterior groups, as well as subependymal veins (11). The dominant veins are referred to as *principal veins*. The prominent transmedullary vein noted in case eleven represents a prominent principal lateral medullary vein (Figs 7 and 8C).

In four cases the venous angioma was located completely within the brain stem, and in a fifth there was a cerebellar and a pontine component. It has been stated that venous angiomas do not occur in the brain stem (4); however, Pak et al reported a case of a venous angioma of the floor of the fourth ventricle with drainage through the vein of the lateral recess (12). Griffin et al included in their series of brain stem vascular malformations one case that appears very similar to our case 4, although details were not given as to the presence or absence of an associated cerebellar venous angioma (13). Our cases, and perhaps the

above-referenced cases, show that brain stem venous angiomas can occur, although rarely.

There have been several previous case reports of transpontine drainage of cerebellar venous angiomas, most of these occurring as isolated cases in larger series of intracranial venous angiomas (3, 13–15). Hacker et al reported a case discovered with computed tomography that is very similar in appearance to our case 1 (15). These examples demonstrate many of the findings seen in our cases including a centrally draining cerebellar venous angioma, dilated subependymal veins about the fourth ventricle, and a prominent transpontine draining vein.

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