Adult cerebellar medulloblastoma: imaging features with emphasis on MR findings.

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Adult Cerebellar Medulloblastoma: Imaging Features with Emphasis on MR Findings

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PURPOSE: To describe the MR imaging features of cerebellar medulloblastoma in the adult. **MATERIALS AND METHODS:** The neuroimages and records of 15 adults with proved cerebellar medulloblastoma were retrospectively evaluated. In 12 patients, preoperative MR scans were reviewed; nine had Gd-DTPA-enhanced scans. **RESULTS:** Of the 12 tumors evaluated preoperatively, eight were hemispheric, two hemispheric-vermian, and two vermian. Tumor margins were well demarcated, except in three cases, two of which had large infiltrative tumors. In 10 cases, tumor extended to the brain surface, and in five of these, contiguity with the tentorium or cerebellopontine angle cistern was such that an extraaxial tumor was considered. The tumors were typically hypointense on T1 but a spectrum was seen on T2-weighted images. Enhancement ranged from minimal and patchy to marked. One tumor became isointense after Gd-DTPA. Other features included cystic changes, hemorrhage, exophytic invasion at the cerebellopontine angle, spinal cerebrospinal fluid seeding, intraventricular seeding, and bone metastasis. **CONCLUSION:** Although there is no pathognomonic MR appearance of adult cerebellar medulloblastoma, the finding of a well-demarcated, mild to moderately enhancing hemispheric mass involving the brain surface in a young adult is suggestive of medulloblastoma. Awareness that this tumor may resemble meningioma may avoid misdiagnosis and aid surgical planning.

Index terms: Medulloblastoma; Cerebellum, neoplasms; Cerebellum, magnetic resonance

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Medulloblastoma is usually thought of as a midline vermian tumor occurring in childhood. It represents 15% to 25% of all pediatric central nervous system tumors (1–3) and 40% of posterior fossa tumors in children (4). Cerebellar medulloblastoma accounts for only about 1% of intracranial adult tumors (5–7).

Ever since Bailey and Cushing (8) proposed the term "medulloblastoma" in 1925, differences between the classical childhood medulloblastomas and adult forms have been reported. In most series, adult medulloblastomas occur more commonly in the cerebellar hemisphere than in the vermis (6, 9–11). Histologically, adult medulloblastoma often manifests the desmoplastic variant; tumors which were formerly referred to as "arachnoidal cerebellar sarcoma" (12).

There have been few reports that mention the magnetic resonance (MR) appearance of medulloblastomas in adults (13–15). We have had the opportunity to evaluate the MR scans in 15 adults with proved cerebellar medulloblastoma. It is the purpose of this paper to discuss the MR imaging features and differential diagnosis of adult medulloblastoma.

Materials and Methods

The neuroimages and clinical records of 15 adult patients with pathologically proved cerebellar medulloblastoma were retrospectively evaluated. Twelve patients presented during the years 1986–1991 and three additional patients were diagnosed in 1979–1983. The study group ranged in age from 18 to 53 years (mean = 33) at the time of diagnosis and consisted of nine men and six women.

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Thirteen patients presented with headache accompanied by nausea, vomiting, ataxia, and other cerebellar signs. One patient complained only of postural headaches and had a normal neurologic exam. In one patient, the chief complaint was a 2- to 3-month unilateral hearing loss that was associated with a fifth cranial nerve palsy. Cranial nerve deficit was also evident in another patient with a unilateral hearing loss. The duration of symptoms before presentation ranged from 5 days to 2 years.

In 12 patients, MR scans of the brain were obtained at initial prepresentation. In three patients, MR was obtained at the time of tumor recurrence. Ten patients were imaged at 1.5 T, two at 0.5 T, and 3 at 0.35 T. T1-weighted (TR/TE, 550–800/20–28) and long TR (TR/TE, 2000–2800/20–40/56–100) spin-echo sequences were obtained in all patients. Ten patients had gadolinium (0.1 mmol/kg intravenously) enhanced studies. In 10 patients, cranial computed tomography (CT) scans were available for review. Six patients had preoperative cerebral angiography.

The MR and CT studies were reviewed and evaluated for tumor size, shape, and location. Tumors were classified as hemispheric, hemispheric-vermian, or vermian. They were further defined in terms of their margins, relationship to the brain surface, tentorium, and other dural surfaces; and the degree of surrounding edema. CT density was assessed before and after contrast as were MR signal and degree of gadolinium enhancement. Tumor architecture was examined for evidence of cystic changes, necrosis, or hemorrhage. Presence or absence of hydrocephalus and cerebrospinal fluid (CSF) spread were also evaluated. Finally, imaging features were correlated with the operative reports and pathologic findings.

All specimens were derived from open excisional biopsy. The histologic diagnosis was usually made according to characteristic findings at light microscopy. The tumors were typically hypercellular, packed with small cells sparse in cytoplasm with round, oval, or angulated hyperchromatic nuclei. Mitotic figures were frequent in most cases. Desmoplastic features were often manifested by presence of a characteristic streaming pattern or "Indian file" arrangement of tumor cells. The presence of the desmoplastic variant was corroborated with reticulin staining and confirmed by the presence of the distinctive reticulin-free pale islands. In particular cases, the routine histologic stains were supplemented with electron microscopy or various immunohistochemical methods selected from the following: glial fibrillary astrocytic protein (GFAP), neuron-specific enolase, vimentin, S-100, anti-keratin, cytokeratin, epithelial membrane antigen, neurofilament, chromogranin, Leu 4, Leu 14, immunoglobulin (Ig) (kappa, lambda), AE-1, and synaptophysin.

Results

The imaging findings are summarized in Table 1.

Unoperated Tumors

Tumor Size and Location. The 12 cerebellar medulloblastomas evaluated preoperatively with MR ranged in size from 3.0 to 6.0 cm. In four cases, the tumor mass was predominantly round, and in eight cases, the mass was closest to ovoid in shape. Of the eight tumors classified as hemispheric, four occurred on the right and four on the left. In two cases, large ill-defined tumors involved the hemisphere and vermis and were categorized as hemispheric-vermian. Two tumors were primarily vermian in origin with one a midline vermian lesion (Fig. 1). The other vermian tumor was eccentric toward the left.

Relationship to Brain Surface. In 10 cases, the tumor extended to the brain surface and of these, five showed contiguity with the brain surface adjacent to the tentorium or cerebellopontine angle (CPA) cistern so that an extraaxial or dural-based tumor such as a meningioma was considered in the differential diagnosis (Fig. 2). These were typically located at the superolateral aspect of the cerebellar hemisphere and abutted the inferolateral tentorium. Only one hemispheric tumor did not extend to the brain surface, and appeared entirely intraaxial.

Tumor Extension into Adjacent Structures. In four cases, there was extension of tumor into the middle cerebellar peduncle. In two cases, exophytic invasion at the CPA or internal auditory canal (IAC) was indicated by abnormal gadolinium enhancement (Fig. 3). Invasion of arachnoid and adherence of tumor to the seventh and eight cranial nerves was corroborated at surgery in both cases. There was in no case invasion of the transverse sinus.

Tumor Margins. Tumor margins showed a sharply defined interface with adjacent brain in nine cases. In seven of these, at least some portion of this border showed lobulation or irregularity. Three had ill-defined borders and two of these were large infiltrative tumors with no discrete borders. Edema was variable and was not related to the size or location of the tumors.

CT. Preoperative CT scans were available in nine patients. The masses were hyperdense to gray matter on noncontrast CT in six cases, isodense in two, and hypodense in one case. No tumors exhibited calcification. Contrast enhancement was not appreciable in two cases, moderate in five, and marked in one case.

MR Signal and Architecture. Preoperative T1-weighted images showed the tumors to be hypointense in eight cases, and just slightly hy-

TABLE 1: Adult medulloblastoma

Unoperated tumors	12	MR signal and architecture		
Tumor size (maximum dimension)		Short TR/TE		
≤4.0 cm	8	Hypointense	8	
>4.0 cm	4	Slightly hypointense	3	
Location		Isointense	0	
Hemispheric	8	Hyperintense	1 (hemorrhagic, cystic)	
Hemispheric-vermian	2	Long TR	short TE	long TE
Vermian	2	Hypointense	0	0
Relationship to brain surface		Isointense	5	3
Abut brain surface	10	Slightly hyperintense	3	3
Contiguous with tentorium or CPA cistern	5	Hyperintense	4	5
Entirely within brain	1	Marked hyperintense	0	1 (hemorrhagic)
Tumor extension into adjacent structures		Small bright cystic/necrotic foci	3	
Middle cerebellar peduncle	4	Hemorrhage	2	
CPA or IAC	2	Gadolinium enhancement	9	
Tumor margins		Absent	0	
Sharp	9	Mild	5[a]	
Ill-defined	3	Moderate	2	
Edema		Marked	2	
Absent	1	Hydrocephalus		
Mild	4	Yes	8	
Moderate	3	No	4	
Marked	4	CSF seeding		
CT		Yes	2	
Without contrast	9	No	10	
Hypodense	1	Pathology		
Isodense	2	Classical medulloblastoma	7	
Hyperdense	6	Desmoplastic variant	5	
Calcification	0	Recurrent tumors	3	
With contrast (enhancement)	8	Local recurrence	2	
Absent	2	Intraspinal CSF seeding	1	
Mild	0	Intraventricular CSF seeding	1	
Moderate	5	Bone metastases	1	
Marked	1	Pathology		
		Classical medulloblastoma	0	
		Desmoplastic variant	3	

[a] One tumor became isointense after gadolinium.

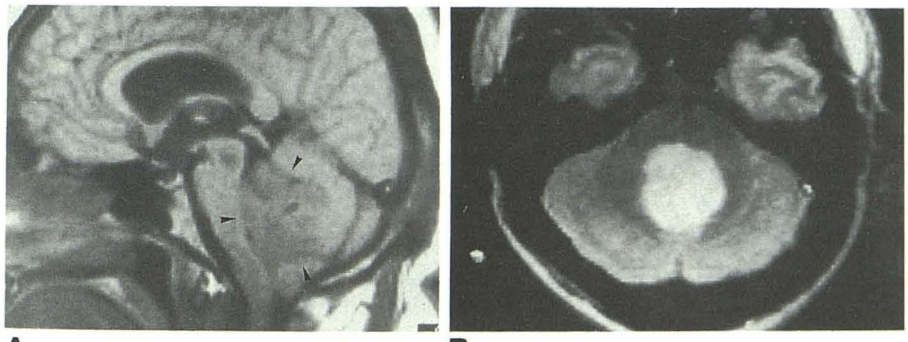

Fig. 1. Case 1: midline vermian medulloblastoma, 34-year-old man.

A, Sagittal T1-weighted image shows a hypointense vermian tumor (*arrowheads*) that fills the fourth ventricle and compresses the brain stem. The posterior tumor margin shows some lobulation.

B, Axial T2-weighted image shows a hyperintense mass filling the fourth ventricle.

pointense to gray matter in three cases; a predominately cystic-appearing hyperintense mass was seen in one case (Fig. 4). At surgery, the central cystic component contained brownish hemorrhagic fluid and was surrounded by a thin rim of friable tumor.

T2-weighted images revealed five hyperintense tumors (disregarding surrounding edema), three tumors slightly hyperintense, and three isointense tumors; one lesion had a dominant markedly hyperintense cystic (hemorrhagic) component and a rim of slightly hyperintense tumor tissue

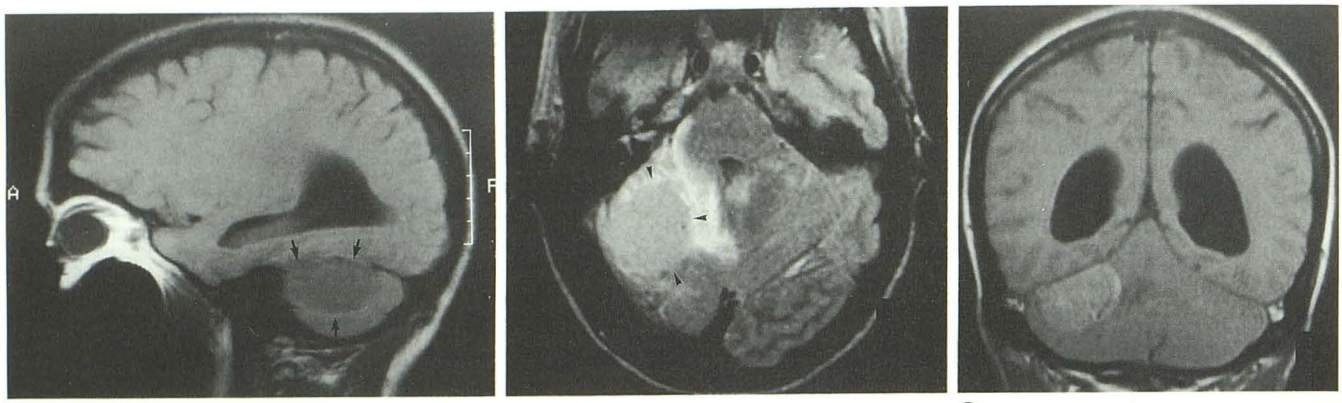

Fig. 2. Case 2: right hemispheric medulloblastoma resembling a meningioma, 35-year-old woman.

A, Right parasagittal T1-weighted image shows a well-demarcated hypointense cerebellar hemispheric mass (*arrows*) with a broad-based contiguity with the tentorium.

B, Axial T2-weighted image shows the laterally situated mildly hyperintense mass (*arrowheads*) and surrounding edema.

C, Coronal T1-weighted image after infusion of Gd-DTPA. There is mild uniform enhancement of the mass that again shows a broad contiguity with the tentorium.

(Fig. 4). Heterogeneous signal manifest as small cystic-appearing foci (bright on T2) was seen in three tumors. In two cases, this corresponded pathologically with sites of necrosis. Surrounding the tumor mass in one case were seen cystic collections that were reminiscent of the peritumoral cysts seen in some extraaxial tumors secondary to trapped arachnoid. Tumor hemorrhage was evident in two cases.

Gadolinium Enhancement. In nine patients, gadolinium-enhanced scans were obtained preoperatively. All nine tumors showed some evidence of enhancement on at least one exam. Two cases showed moderate uniform enhancement and two showed marked enhancement. In five cases, enhancement was mild or patchy. In one case, the tumor, which was slightly hypointense on T1-weighted images, became isointense after gadolinium injection (Fig. 5). In another case, minimal patchy areas of enhancement were seen but the tumor was predominately unenhanced (Fig. 6). In this case, CT showed moderate enhancement but initiation of steroid therapy in the interim before the MR scan most likely decreased gadolinium enhancement. In case of 10 (Fig. 7), initial MR showed poorly defined mass effect with little enhancement but a scan after discontinuation of dexamethasone showed mild uniform enhancement that defined the tumor mass effectively. In two other cases, gadolinium demonstrated invasion of CPA structures and cranial nerves.

Hydrocephalus. Hydrocephalus was seen in eight cases, accounting for the patients' presenting symptoms. In four cases, hydrocephalus was not present, although in two of these partial effacement of the fourth ventricle was evident.

CSF Seeding. Spread of tumor in the CSF pathways had undoubtedly occurred by the time of presentation in case 3 (Fig. 5) as multiple intradural spinal lesions up to 2 cm were imaged immediately postoperatively, 1 week after initial patient presentation. In the subset of 12 patients who presented between 1986 and 1991, only one other patient is known to have developed CSF seeding, although one patient is deceased and autopsy was not performed.

Angiography. Of the group of 15 patients, six had angiograms. In five of the six cases, the medulloblastoma was a hypovascular mass, and in one case, a slight tumor stain was noted. In no case were tentorial or meningeal arteries hypertrophied or seen to supply the tumor.

Pathology. Of the 12 cases in which preoperative MR scans were obtained, seven tumors were classical medulloblastomas and five were the desmoplastic variant.

Recurrent Tumors

Recurrence. All three patients received craniospinal radiation after the initial surgery. In two of these patients, local tumor recurrences developed at 6 and 10 years, respectively. In case 13, the initial MR 4 years after surgery showed a cystic "postoperative cavity" in the left hemisphere. Two years later, a large tumor had recurred at the operative site. In case 14, the recurrent mass was resected but within 1 year there was another lo-

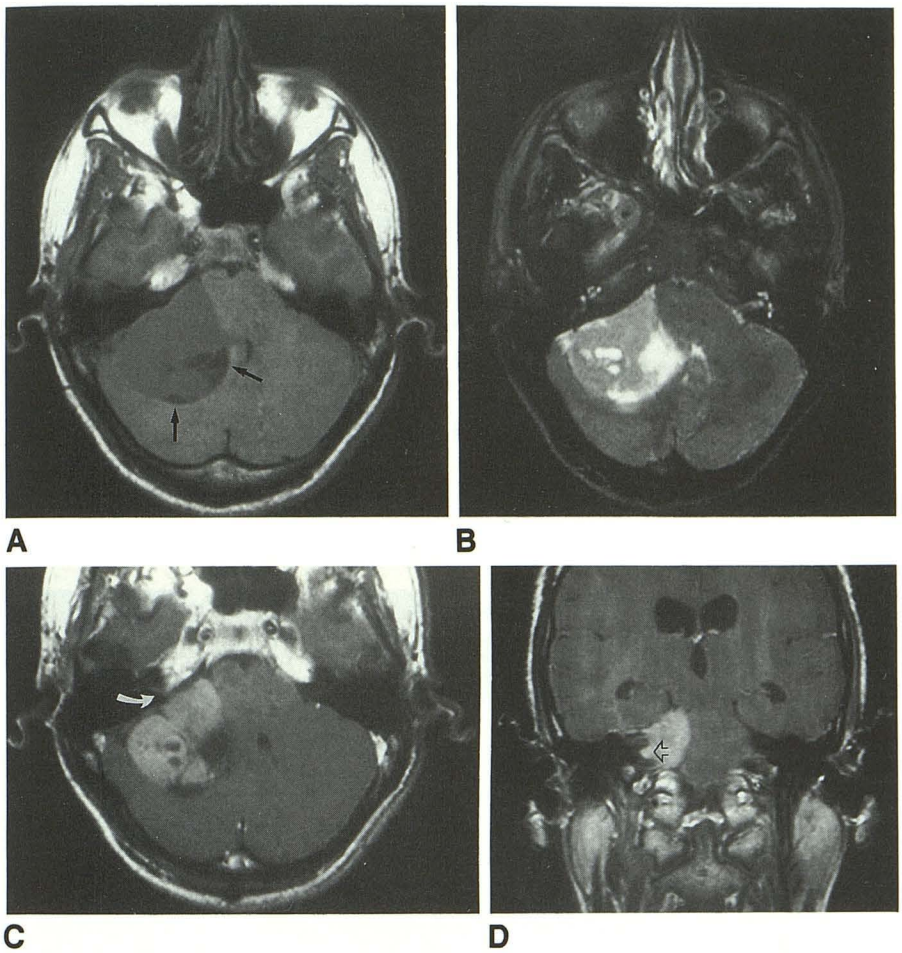

Fig. 3. Case 3: right hemispheric medulloblastoma presenting as a cerebellopontine angle mass in a 21-year-old man with right-sided hearing loss. Spinal "drop metastases" were present at time of presentation.

A, Axial T1-weighted image shows a hypointense well-defined right cerebellopontine angle mass which distorts the brain stem and effaces the fourth ventricle. Peritumoral cystic areas are seen at the medial and posterior tumor margins (*black arrows*).

B, Axial T2-weighted image shows the tumor mildly hyperintense to gray matter with small clustered cystic-appearing foci within it.

C, Axial T1-weighted image after Gd-DTPA infusion shows moderate tumor enhancement and abnormal enhancement at the internal auditory canal (*white arrow*). At surgery, exophytic tumor was adherent to the seventh and eight cranial nerves. Note the peritumoral cystic areas.

D, Coronal T1-weighted image after Gd-DTPA. Exophytic tumor (*open black arrow*) extends into the right IAC.

cal recurrence as well as intraventricular CSF seeding.

In case 15, serial MR scans revealed no local recurrence but the patient developed disseminated lytic and blastic skeletal metastases and intradural spinal "drop metastases." The patient died within 4 years of the initial diagnosis.

Pathology. All three cases that presented between 1979 and 1983 showed desmoplastic features at initial resection as did the two local recurrent tumors.

Discussion

Adult cerebellar medulloblastoma most commonly presents in the third or fourth decade (5), with 80% of adult cases occurring between 21 and 40 years (6, 16), but it has been reported in a patient 73 years old (17). Our data showing a mean age of 33 years at the time of diagnosis would concur with the larger series of Farwell and Flannery (5), which showed an average age of 34 years among 45 cases of adult medulloblastoma. There is a male predominance of cerebellar medulloblastoma in adults, with most series approaching a 2:1 ratio of men to women (7, 8, 16, 18, 19). Our small series consisted of 9 (60%) men and 6 (40%) women.

Tumor Location

Medulloblastomas are overwhelmingly midline tumors in children, with 67% to 93% situated in the cerebellar vermis (1, 7, 20). In adults, a lateral hemispheric location is more common than a vermian one (6, 9–11), although some have found a nearly equal distribution (13, 21). A theoretical basis for the lateral location of the adult tumors has been proposed. Medulloblastomas arise from poorly differentiated cells originating in the roof of the primitive fourth ventricle. Developmentally, these cells migrate upward and laterally to form the external granular layer; it is proposed that the tumors may arise from these germinative cells or their remnants anywhere along their migratory path. Because the migratory process normally proceeds in a lateral direction, it would follow that tumors arising later in life would be

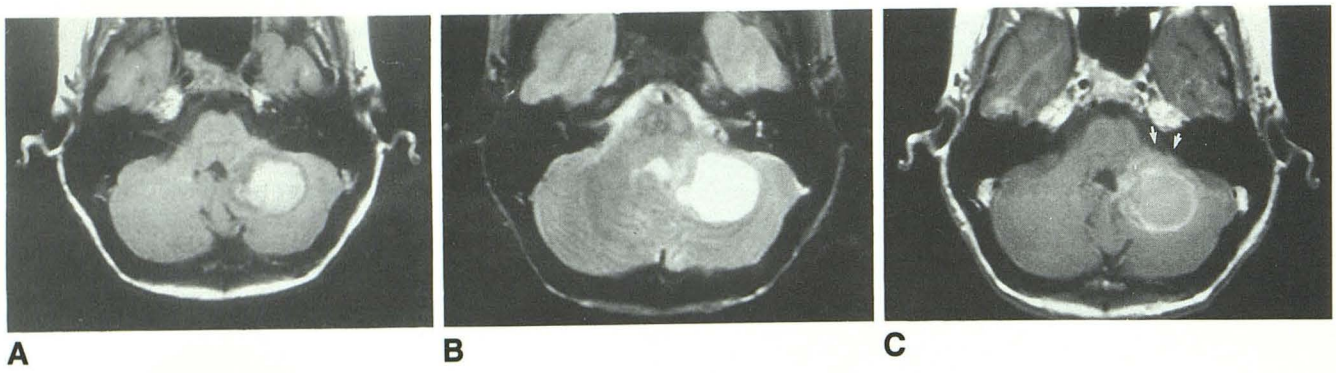

Fig. 4. Case 4: hemorrhagic and necrotic medulloblastoma with invasion at the CPA; 29-year-old woman presenting with ipsilateral hearing loss and fifth cranial nerve palsy.

A, Axial T1-weighted image shows a hyperintense intraaxial mass with an irregular hypointense rim.

B, Axial T2-weighted sequence. The cystic component is markedly hyperintense and the surrounding rim of tissue is mildly hyperintense.

C, Axial T1-weighted image after Gd-DTPA. The surrounding rim of tumor enhances and an irregular margin of enhancing tumor is now seen extending into the CPA (*white arrows*).

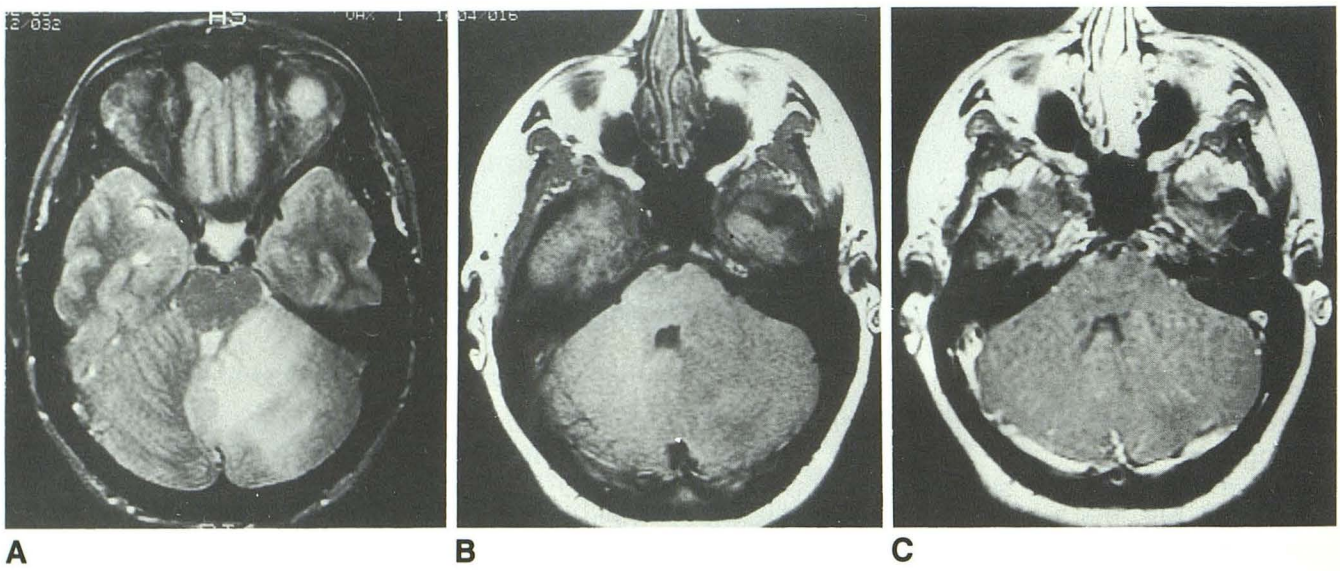

Fig. 5. Case 7: hemispheric-vermian medulloblastoma, 28-year-old woman.

A, Axial T2-weighted image shows diffuse hyperintensity in the left cerebellar hemisphere and vermis. There is no distinction of a tumor "mass" versus edema.

B, Axial T1-weighted image shows ill-defined hypointensity in the left cerebellar hemisphere, vermis, and involvement of the middle cerebellar peduncle.

C, Axial T1-weighted image after Gd-DTPA infusion. Contrast fails to further define the mass that is now isointense. Although the left transverse sinus appears compressed, flow void signal appeared normal on all other sequences and no invasion of the sinus or dura was seen at surgery.

situated more laterally within the cerebellar hemisphere (1, 22).

Relationship to Brain Surface

Of the 12 cases evaluated preoperatively, 10 showed tumor extending to the brain surface. Of particular interest were a subset of five cases (three desmoplastic and two classical medulloblastomas) that showed a broad-based contiguity with the brain surface adjacent to the tentorium or CPA cistern, such that an extraaxial or dural based tumor such as a meningioma was considered in the differential diagnosis (Fig. 2). It is known from pathologic study (1) that the laterally situated medulloblastomas are usually found on the dorsal surface of the cerebellar hemisphere but are not actually attached to the tentorium. Hubbard et al (13) recognized that the laterally placed cerebellar medulloblastomas may mimic

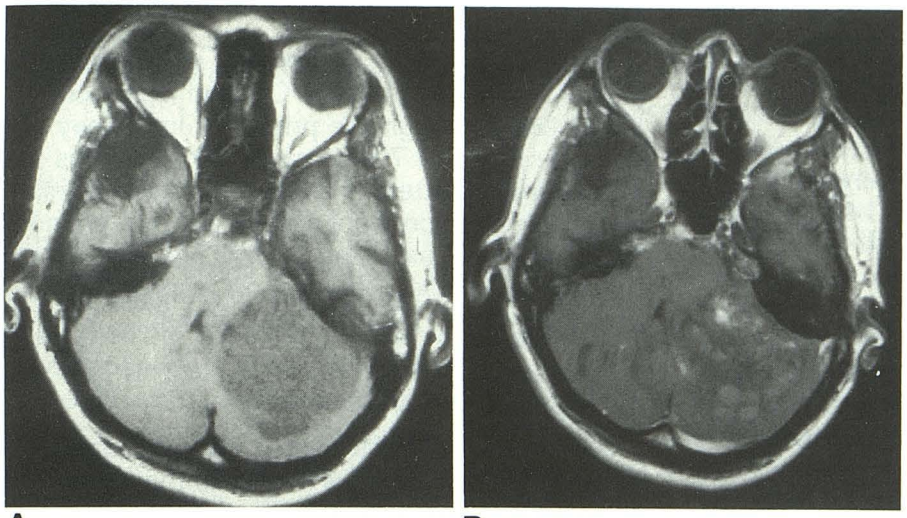

Fig. 6. Case 8: desmoplastic medulloblastoma with minimal gadolinium enhancement possibly due to initiation of steroid medication. Incidental right temporal fossa arachnoid cyst; 25-year-old woman.

A, Axial T1-weighted image shows a well-demarcated hypointense mass.

B, Axial T1-weighted image after Gd-DTPA infusion. There is patchy minimal enhancement of the tumor. CT had shown moderate enhancement. The patient had been started on steroids between the time of the CT and MR.

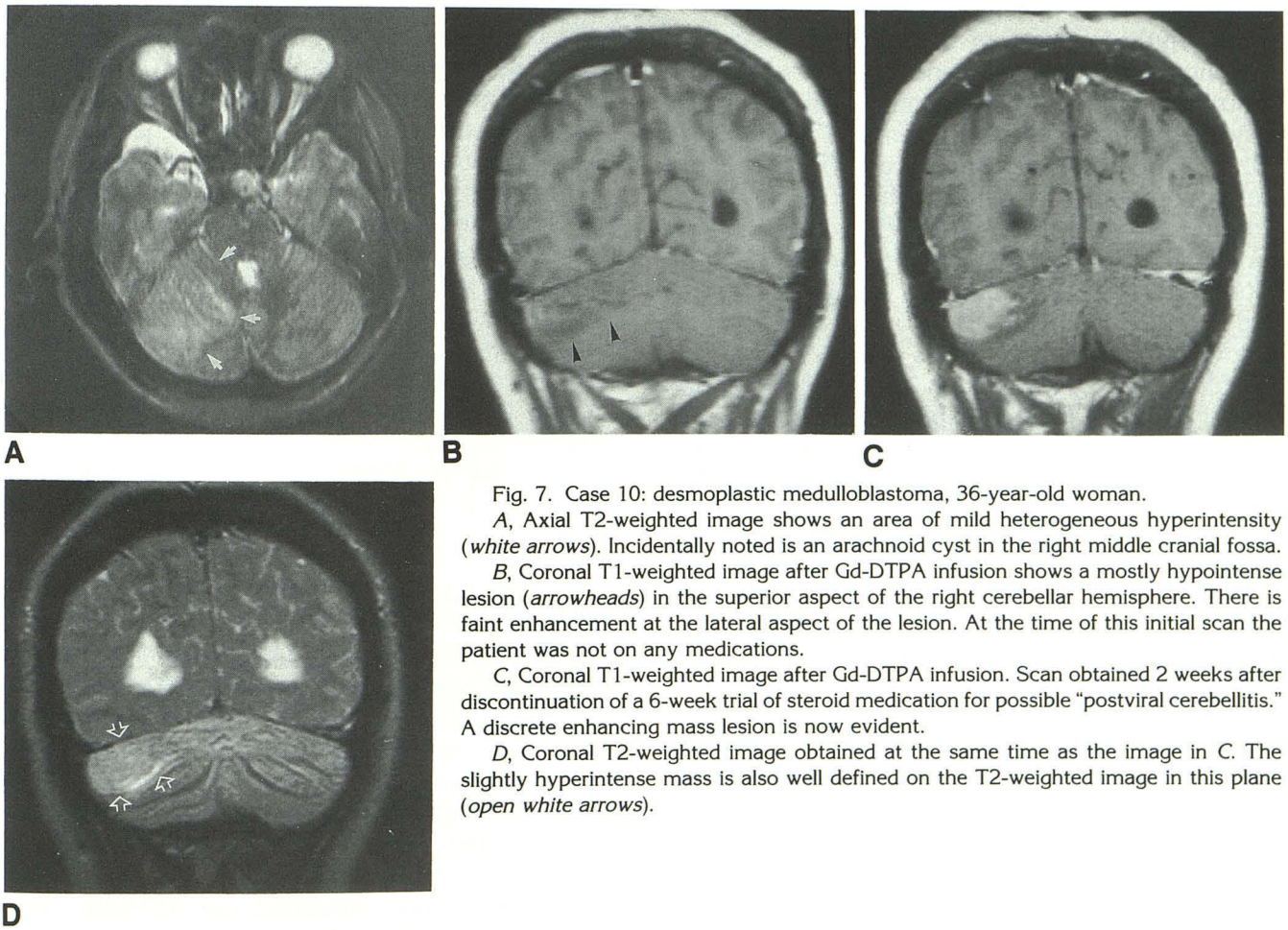

Fig. 7. Case 10: desmoplastic medulloblastoma, 36-year-old woman.

A, Axial T2-weighted image shows an area of mild heterogeneous hyperintensity (*white arrows*). Incidentally noted is an arachnoid cyst in the right middle cranial fossa.

B, Coronal T1-weighted image after Gd-DTPA infusion shows a mostly hypointense lesion (*arrowheads*) in the superior aspect of the right cerebellar hemisphere. There is faint enhancement at the lateral aspect of the lesion. At the time of this initial scan the patient was not on any medications.

C, Coronal T1-weighted image after Gd-DTPA infusion. Scan obtained 2 weeks after discontinuation of a 6-week trial of steroid medication for possible "postviral cerebellitis." A discrete enhancing mass lesion is now evident.

D, Coronal T2-weighted image obtained at the same time as the image in *C*. The slightly hyperintense mass is also well defined on the T2-weighted image in this plane (*open white arrows*).

meningiomas on CT. They encountered five cases in which proximity of the tumor to the tentorium made it difficult to determine whether the lesion was intraaxial or extraaxial by CT; a diagnosis of infratentorial meningioma was suggested in three of those cases.

Although meningioma was considered in the differential diagnosis in five of our cases, in no

case were the tumor features completely typical of meningioma. First, only one of these cases showed the intense uniform gadolinium enhancement commonly seen in meningiomas. Second, in no case was a dural "tail" seen, another sign which would have suggested meningioma (23–26). This, however, is not specific because dural enhancement has also been noted adjacent to superficial intraaxial malignant brain tumors (27). Although these tumors all had a broad contiguity with a dural surface, four of five showed lobulation or irregularity at some portion of the tumor-brain interface, a clue to their true intraaxial location. Finally, in the two cases of these five that had angiograms, neither showed evidence of tumor supply from tentorial or meningeal arteries.

Tumor Extension into Adjacent Structures

Exophytic invasion of medulloblastomas into arachnoid and cisternal spaces is known to occur in both children and adults and medulloblastoma may occasionally present as a CPA mass (1, 4, 28, 29). House (29) reported a case in the otologic literature of a CPA medulloblastoma in a 46-year-old man who presented with vertigo and had an abnormal auditory brain stem response. We encountered two patients with unilateral hearing loss and CPA involvement. In one of these, subtle gadolinium enhancement was seen to extend into the IAC (Fig. 3). Although the lesion did not appear to arise from the porus acousticus, the tumor had cystic loculations around its periphery reminiscent of the arachnoid cysts associated with acoustic schwannomas (30). At surgery, tumor was adherent to the seventh and eight cranial nerves.

Tumor Margins

Pathologically, the laterally situated adult medulloblastomas are usually clearly demarcated masses with a smooth or slightly lobulated outline at macroscopic examination. MR demonstrated this appearance in nine of our cases. The tumors may also infiltrate the cerebellum diffusely, as we observed in two classical medulloblastomas. They may spread en plaque over the cerebellar surface, although we did not encounter this (1).

The degree of surrounding edema was variable and did not appear to correlate with either tumor type, size, location, or presence of invasive or aggressive characteristics.

CT

Medulloblastomas in children are usually hyperdense on noncontrast CT and enhance diffusely (28) although the primary tumor may not enhance in up to 7% of cases (4). This was the predominant pattern among our adult cases as well. However, on noncontrast CT we encountered two isodense tumors and one hypodense tumor. Two cases showed no appreciable enhancement after intravenous contrast.

MR Signal and Architecture

The spectrum of MR signal we encountered in adult medulloblastoma is similar to that described in pediatric medulloblastomas (14, 31). The frequent occurrence of isointense or nearly isointense T2 signal has been attributed to the marked cellularity and high nuclear-to-cytoplasmic ratio in these tumors and the fibrocollagenous nature of the desmoplastic variant (32). Of the five desmoplastic tumors imaged preoperatively, four were isointense or slightly hyperintense and one was hyperintense on T2-weighted images.

Uncommon appearances of both adult and childhood medulloblastomas include cystic or necrotic changes (4, 33, 34), hemorrhage (4, 35, 36), calcification (4, 28), and multifocal cerebellar medulloblastoma (14, 37). In our series, three cases showed small cystic foci within the tumors and one case showed cystic collections surrounding the tumor mass (Fig. 3). One case had a prominent hemorrhagic component (Fig. 4). In no case did we detect calcification and we encountered no cases of multicentric medulloblastoma.

Gadolinium Enhancement

In a series of 25 medulloblastomas (22 children, three adults) of which 11 had Gd-DTPA-enhanced MR, Meyers (14) observed tumor enhancement in all 11 cases, although in 82% this was markedly heterogeneous. Rollins (38) reported nine cases of recurrent medulloblastoma in children, three of which did not enhance with gadolinium. In our series, three of nine tumors showed only subtle gadolinium enhancement. In one case, the tumor became isointense after gadolinium (Fig. 5). Steroid treatment probably accounted for minimal patchy enhancement in another case (which enhanced diffusely on CT presteroids) (Fig. 6). Finally, in one case (Fig. 7), enhancement was not seen before, but only two weeks after,

completion of a 6-week course of steroids. We can only postulate that some alteration of the tumor blood-brain barrier evolved during the 8-week period.

CSF Seeding

Subarachnoid dissemination (CSF seeding) of medulloblastoma is well known. In children, North (39) reported a 30% rate of intracranial subarachnoid seeding detected by high-resolution contrast-enhanced CT at the time of presentation. The utility of gadolinium-enhanced MR in detecting CSF seeding in medulloblastoma has been reported (40–42). In adults, Hubbard et al (13) reported a 29% frequency of central nervous system metastasis with median onset 2.5 years and range from 1.3 to 10.5 years after the initial diagnosis. In our subset of 12 patients presenting between 1986 and 1991, two patients have demonstrated spinal subarachnoid metastases on gadolinium-enhanced MR.

Differential Diagnosis

The differential diagnosis of adult infratentorial tumors begins with the differentiation of intraaxial from extraaxial tumors (30). The propensity for adult medulloblastomas to extend to the brain surface, show exophytic growth into the subarachnoid space, or appear contiguous with the tentorium can make this differentiation challenging. As discussed above, some medulloblastomas have features suggestive of meningioma or even of acoustic schwannoma.

Once the intraaxial location of the tumor is determined, the differential diagnosis is narrowed. Metastases are the most common posterior fossa tumor in the adult (30) and may be indistinguishable from medulloblastoma. Hemangioblastoma is the most common posterior fossa primary brain tumor in adults and presents, on the average, at 33 years (43). The typical hemispheric cystic hemangioblastoma with a mural nodule is readily differentiated from medulloblastoma, but solid hemangioblastomas may closely resemble medulloblastoma. Both tumors are commonly located peripherally, close to a pial surface. The presence of serpentine vascular flow voids at the periphery or within the tumor and marked contrast enhancement of the solid mass are features that would distinguish hemangioblastoma (44). Other less common primary brain tumors to be considered include cerebellar astrocytoma, choroid plexus papilloma, or ependymoma. The rare Lhermitte-Duclos disease (45) is another "mass-like" lesion that specifically involves the cerebellar hemisphere, but its distinctive foliar pattern should not pose difficulty in diagnosis. Finally, central nervous system lymphoma may have a similar appearance to medulloblastoma on either CT or MR (43).

Recurrence and Metastasis

Case 15 showed not only intraspinal metastasis but also disseminated lytic and blastic skeletal metastases. Distant extracranial metastases are reported to occur in 7.1% of medulloblastoma cases. Rochkind (46) found bone to be the most common site with skeletal involvement in 77% of adult cases with metastases. Lymph node metastases were second in frequency (33%).

Pathology

There were no pathognomonic MR criteria that distinguished the desmoplastic variant from the "classical" medulloblastomas. In terms of prognosis, this distinction may not be important. While some authors (47) suggested improved survival for patients with desmoplastic tumors, many studies (2, 11, 13, 48) have refuted this and show no influence of desmoplasia or tumor location on survival. Treatment results in adults are now very similar to those in children (49).

Histologically, medulloblastoma can resemble other "small blue cell tumors" such as lymphoma or small cell (oat cell) carcinoma (50). In most cases the diagnosis of medulloblastoma can be made by light microscopy. When the characteristic features of a streaming pattern of tumor cells, positive reticulin stain, and the presence of reticulin-free pale islands are evident, the diagnosis of desmoplastic medulloblastoma is readily made. Classical medulloblastomas may be recognized by the presence of rosettes. Undifferentiated cerebellar medulloblastomas may present more of a diagnostic challenge with immunohistochemical stains needed to exclude (or confirm) lymphoma or oat cell tumors. In some cases of undifferentiated tumors the term "primitive neuroectodermal tumor" (PNET) (51) is applied, but the more specific designation of medulloblastoma is preferred for these cerebellar tumors. There has been a steady proliferation of immunohistochemical markers that may further elucidate the histogenesis of medulloblastomas (52, 53).

In conclusion, we encountered a broad spectrum of findings in this series of medulloblastomas. Although there is no pathognomonic MR appearance of adult cerebellar medulloblastoma, the finding of a well-demarcated, mild-to-moderate enhancing hemispheric lesion involving the brain surface in a young adult suggests medulloblastoma. Familiarity with both the common and atypical features of these tumors will improve preoperative diagnosis and may stimulate a more thorough pathologic evaluation as well as more extensive evaluation for metastases. In particular, awareness that this tumor may resemble meningioma may avoid misdiagnosis and aid surgical planning.

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