Posterior Fossa Glioblastoma Multiforme: MR Findings

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PURPOSE: To characterize the MR findings of glioblastoma multiforme in the posterior fossa. **METHODS:** MR studies of nine patients with surgically proved posterior fossa glioblastoma multiforme were retrospectively evaluated. MR characteristics studied included tumor location, signal intensity, enhancement pattern, and presence of intratumoral hemorrhage, as well as presence of secondary hydrocephalus or metastatic spread. **RESULTS:** The tumors were located in the median portion of the cerebellum or brain stem in eight cases. Six extended into the fourth ventricle. Hydrocephalus was seen in four cases. Six cases demonstrated decreased T1- and increased T2-weighted signal intensities. Three cases demonstrated mixed signal intensities suggesting intratumoral hemorrhage. All of the eight patients who received contrast showed moderate to marked heterogeneous ringlike enhancement suggesting intratumoral necrosis. Multicentric/multifocal lesions or extraaxial metastases were identified in three of the nine cases, and there was extracranial extension into the cervical region in one case. **CONCLUSION:** Glioblastoma multiforme is a rare tumor in the posterior fossa. Differentiating it from metastatic tumor or malignant astrocytoma was difficult. However, combination of heterogeneous and ringlike enhancement, midline location, poorly defined margin, tumoral hemorrhage, concomitant multicentric/multifocal lesions, and extraaxial or extracranial metastasis may be clues for the prospective diagnosis of glioblastoma multiforme.

Index terms: Glioblastoma multiforme; Posterior fossa, magnetic resonance; Posterior fossa, neoplasms

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Glioblastoma multiforme usually arises in the supratentorial region; it rarely occurs in the posterior fossa, although its prevalence is unknown (1–3). There have been several reports of its occurrence in the cerebellum (4–10) or brain stem (11–13); a few reports have described the computed tomographic (CT) findings of cerebellar glioblastomas (5–7).

The purpose of the present study is to analyze the magnetic resonance (MR) findings of nine patients with glioblastoma multiforme of the cerebellum and the brain stem.

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Materials and Methods

From 1986 to 1993, 236 patients were diagnosed at our institution as having glioblastoma multiforme. Among them, 9 patients had histologically proved glioblastoma multiforme in the posterior fossa. Pathologic specimens were obtained from the resected tumors in 6 cases, and from excisional biopsies in 3. The histologic diagnoses were made according to characteristic findings on light microscopy, including moderate to marked hypercellularity, moderate and marked pleomorphism, and necrosis with or without pseudopalisading. Tumor necrosis was an indispensable factor in differentiating glioblastoma multiforme from anaplastic astrocytoma (14).

MR studies were performed on 1.5-T units in seven cases and at 1.0-T in two. T1-weighted images with 400–600/20–28/2 (repetition time/echo time/excitations) and T2-weighted images with 2000–2500/56–100/1 were obtained in all patients. Contrast MR studies using gadopentetate dimeglumine (0.1 mmol/kg) intravenously were performed in eight of the nine cases.

The MR studies were retrospectively separately reviewed by three neuroradiologists and analyzed for tumor size, location, shape, signal intensity, type and extent of contrast enhancement, and degree of peritumoral edema.

Clinical summary of nine patients with glioblastoma multiforme in the posterior fossa

Case	Age, y/ Sex	Clinical symptoms	Location/Size, cm	CT Appearance	MR Appearance		Edema	Contrast Enhancement	Other Findings
					T1-weighted images	T2-weighted images			
1	40/M	Unsteady gait, ataxia	Cerebellar vermis/ 1 × 1	Isodense, no contrast enhancement	Hypointense	Hyperintense	+	. . .	Extension into fourth ventricle with hydrocephalus
2	2 /F	Unsteady gait, truncal ataxia	Cerebellar vermis/ 3 × 4.5	. . .	Hypointense, Hyperintense	Hyperintense, Hypointense	+	+++	Extension into fourth ventricle with hydrocephalus
3	30/M	Ataxia, headache	Cerebellar vermis, pons/ 1.2 × 1.8	Slightly high density, contrast enhancement	Hypointense	Hyperintense, Isointense	+	++	Extension into fourth ventricle
4	46/M	Headache, slurred speech	Cerebellar vermis, hemisphere/1.2, 1.3	Ringlike contrast enhancement	Hypointense	Hyperintense, Isointense	+++	+++	Multiple enhancing lesions in cerebellar vermis, extension into fourth ventricle and middle cerebellar peduncle
5	7/M	Headache	Cerebellar vermis/ 3 × 4.5	. . .	Hypointense	Hyperintense, Isointense	+	+++	Extension into cervical region, middle cerebellar peduncle, and fourth ventricle with hydrocephalus
6	28/M	Neck pain, dizziness, imbalance	Cerebellar hemisphere/ 4.5 × 5.5	High and low density, ringlike contrast enhancement	Hypointense, Hyperintense	Isointense, Hyperintense, Hypointense	++	+++	Hydrocephalus, multiple enhancing lesions in the right cavernous sinus and supravermian cistern in follow-up study
7	57/M	Imbalance, left facial weakness	Cerebellar vermis, pons/2 × 2	. . .	Hypointense	Hyperintense	+	+++	Extension into fourth ventricle
8	6/M	Dysarthria, headache	Pons, cerebellar hemisphere/1.5 × 2.5, 0.7	Low density, ringlike contrast enhancement	Hypointense	Hyperintense	+++	++	Multiple enhancing lesions in the pons and cerebellar hemisphere
9	3/M	Ataxia, frequent falling	Pons/2 × 2.5	Low and high density, contrast enhancement	Hypointense	Hyperintense, Hypointense	+	+++	Extension to the middle cerebellar peduncle

Note.—+ indicates mild; ++, moderate; and +++, marked.

Fig 1. Case 2. *A*, Sagittal T1-weighted image and *B*, axial T2-weighted image. Mixed hyperintense and hypointense mass of the cerebellar vermis and cerebellar hemisphere, indicating intratumoral hemorrhage. The mass compresses the brain stem anteroinferiorly, and there is obstructive hydrocephalus.

C, Sagittal T1-weighted image after gadopentetate dimeglumine administration demonstrates heterogeneous enhancement with poorly defined margins.

The presence or absence of intratumoral hemorrhage, hydrocephalus, and metastatic spread also were evaluated.

Results

The table is a summary of the clinical and radiologic findings of the nine patients in our series. Eight patients were male and 1 female; their ages ranged from 3 to 57 years, with a mean of 24 years. Four patients were younger than 10 years of age. The major clinical manifestations related to cerebellar dysfunction, such as unsteady gait, imbalance, and ataxia, were observed in six cases. Other symptoms included headache, dizziness, and slurred speech. Among the nine cases, the primary tumors were located in the cerebellar vermis in six (Figs 1–3); extended to the middle cerebellar peduncle in 2 (Figs 2, 3); and demonstrated a second cerebellar vermian lesion in one patient. In only one case was the tumor located solely in the cerebellar hemisphere (Fig 4). Both brain stem glioblastomas were located in the pons, one of which had a second lesion present in the cerebellar hemisphere (Fig 5). Tumors were smaller than 3 cm in maximal diameter in six cases and larger than 3 cm in three.

On T1-weighted MR images, the signal intensity of the tumor was hypointense to the white matter in seven cases. Two showed mixed hyperintensity and hypointensity, suggesting subacute intratumoral hemorrhage (Figs 1 and 4).

Fig 2. Case 4. *A*, Axial T2-weighted image shows irregular hyperintense areas in the cerebellar vermis extending to the right cerebellar hemisphere. There is peritumoral edema. An isointense area is seen within the tumor (*arrows*).

B, The axial postcontrast T1-weighted image shows multiple patchy areas with ringlike enhancement (*arrows*). Phase shift artifacts crossing the lesions are also demonstrated.

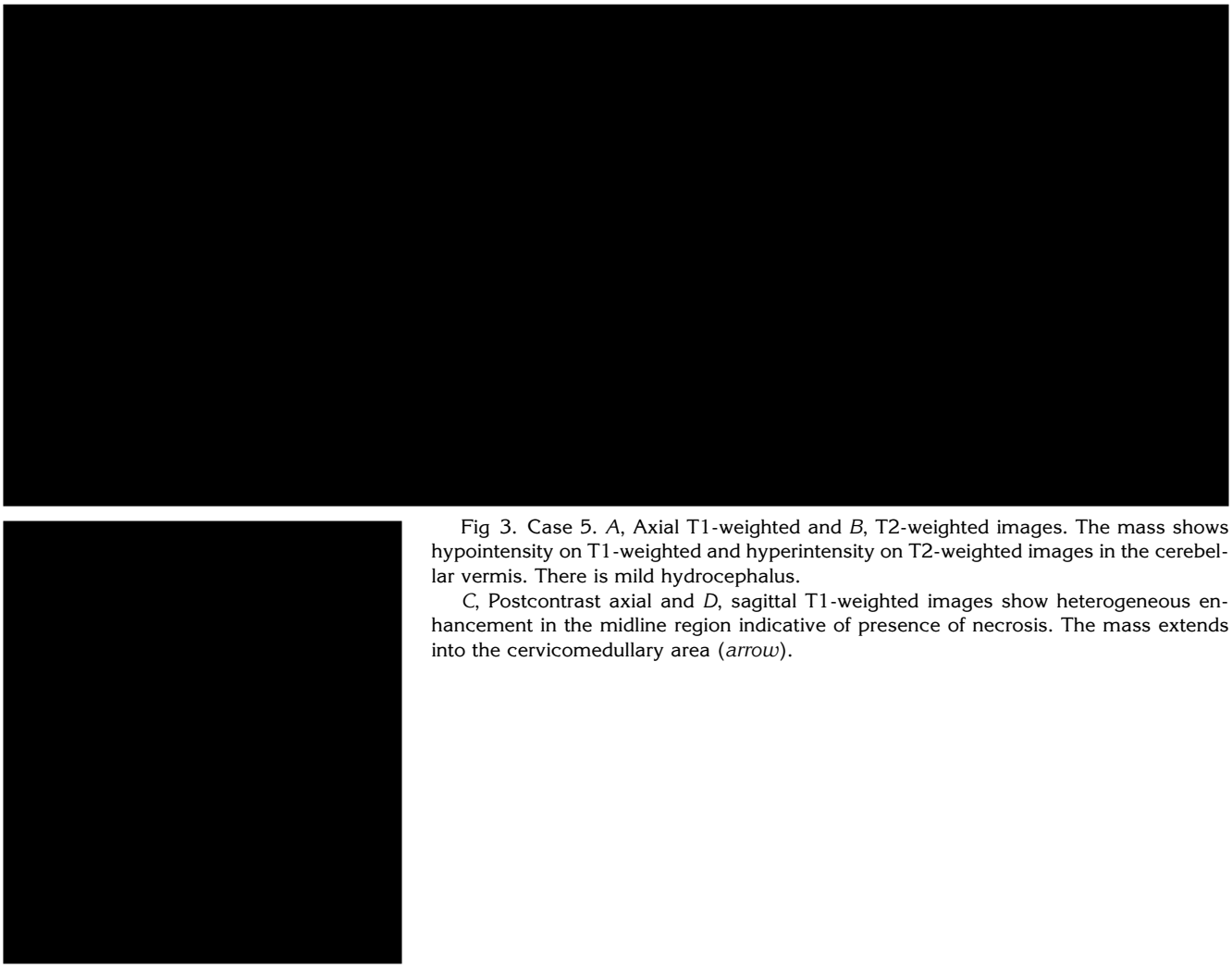


Fig 3. Case 5. *A*, Axial T1-weighted and *B*, T2-weighted images. The mass shows hypointensity on T1-weighted and hyperintensity on T2-weighted images in the cerebellar vermis. There is mild hydrocephalus.

C, Postcontrast axial and *D*, sagittal T1-weighted images show heterogeneous enhancement in the midline region indicative of presence of necrosis. The mass extends into the cervicomedullary area (*arrow*).

On T2-weighted images, the tumors were predominantly hyperintense relative to the white matter in all cases, but in four of the nine cases, the tumors also contained intermediate intensity areas. In three cases, mixed hypointensity and hyperintensity suggested intratumoral hemorrhage. Peritumoral edema was mild in six and moderate to marked in three. Tumor margins were ill-defined in all cases and difficult to differentiate from surrounding edema. Deformity of the fourth ventricle was observed in all cases. Of the eight cases receiving gadolinium, all revealed moderate to marked heterogeneous and ring like enhancement. The tumor extended directly into the fourth ventricle in six cases, and hydrocephalus was observed in four of these six. Extracranial tumor extension into the cervical region was seen in one (Fig 3). A remarkable finding was the presence of multicentric intracerebellar lesions or extraaxial metastases, seen in three cases (Figs 2, 4, and 5). In case four, the primary ring-enhancing tumor was located in the superior vermis, with another lesion in the right paravermian region demonstrating solid and heterogeneous enhancement (Fig 2). In case six, a large mass located in the right cerebellar hemisphere was associated with unusual metastases in the right cavernous sinus and the suprasellar region as well as in the superior vermian cistern, found 10 months later (Fig 4). In case eight, the primary tumor in the pons showed marked ringlike enhancement, whereas another lesion in the left cerebellar hemisphere demonstrated subtle ringlike enhancement (Fig 5).

Discussion

Dohrmann and Dunsmore reviewed 33 patients with primary glioblastoma of the cerebel-

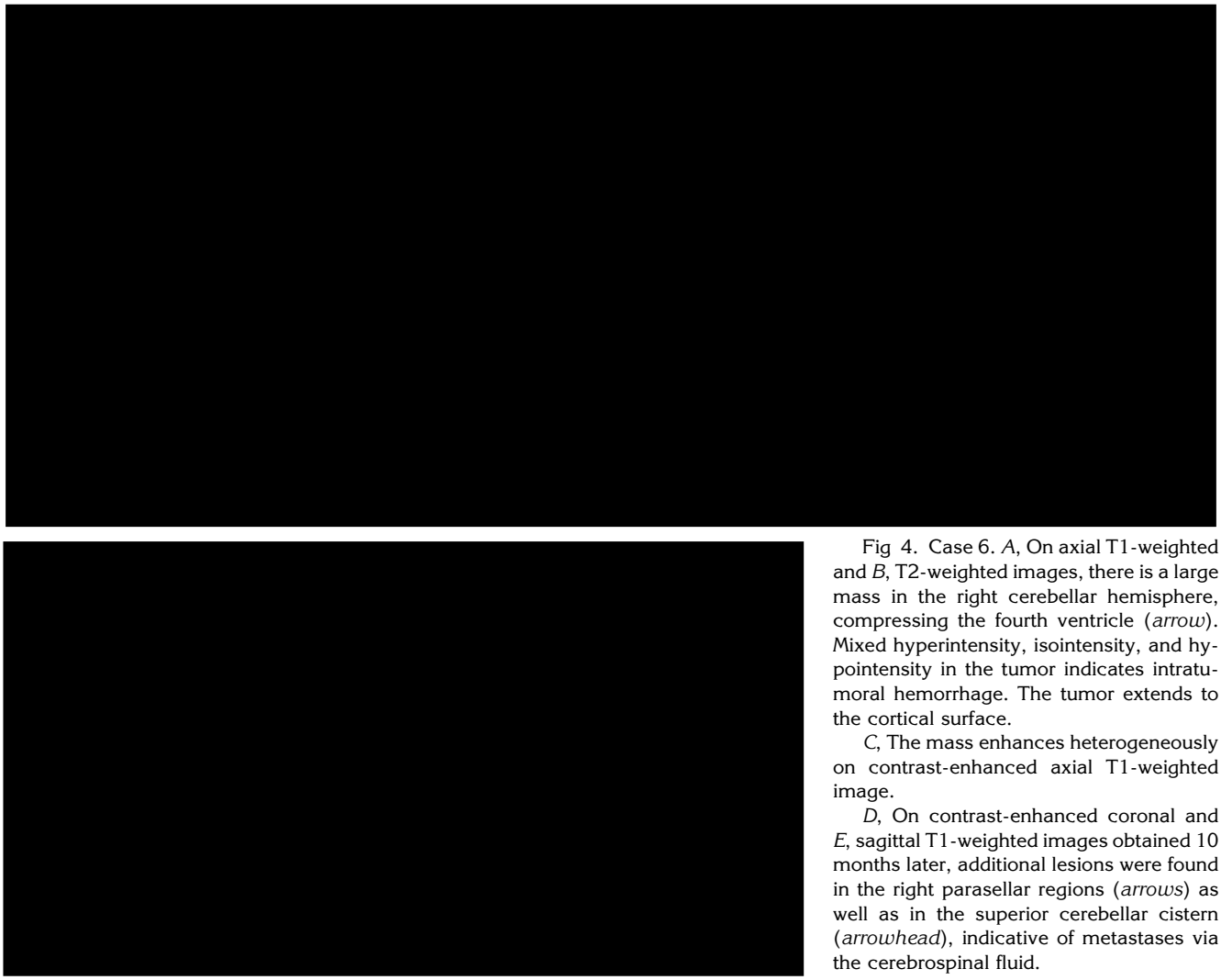


Fig 4. Case 6. *A*, On axial T1-weighted and *B*, T2-weighted images, there is a large mass in the right cerebellar hemisphere, compressing the fourth ventricle (*arrow*). Mixed hyperintensity, isointensity, and hypointensity in the tumor indicates intratumoral hemorrhage. The tumor extends to the cortical surface.

C, The mass enhances heterogeneously on contrast-enhanced axial T1-weighted image.

D, On contrast-enhanced coronal and *E*, sagittal T1-weighted images obtained 10 months later, additional lesions were found in the right parasellar regions (*arrows*) as well as in the superior cerebellar cistern (*arrowhead*), indicative of metastases via the cerebrospinal fluid.

lum in 1975 (4). The male-to-female ratio was 2:1, and approximately 70% of the tumors occurred in adults whose average age was 46.7 years; 30% were in children with an average age of 10.4 years. Approximately 80% of the tumors were laterally located; the remaining 20% were near midline. Two (6%) of the 33 patients had multiple glioblastomas. The prognosis of survival was approximately 1 year after the onset of symptoms (4). There were 7 cerebellar glioblastomas in our cases, whose average age was 30 years (range 2 to 57). Overall, there was male dominance of 6 to 1. Contrary to previous reports (4), which were based on surgical or pathologic findings, most of our cerebellar glioblastomas were located in or near midline; only 1 originated from the cerebellar hemisphere. Two of the 7 patients had multicentric/multifocal tumor or metastases.

Few histologically confirmed reports of brain stem glioblastoma were available in the previous literature because the indication for surgery or biopsy of brain stem tumors remains controversial (11). Nearly 80% of brain stem gliomas occur in patients younger than 20 years of age, and pathologically these tumors usually arise in the pons (13). Berger et al (11) reported 6 glioblastomas multiforme of 21 pediatric brain stem gliomas (ages ranging from 2.5 to 18 years), and Nishio et al (12) also reported 5 glioblastomas multiforme of 15 pontine tumors in a clinicopathologic analysis of 23 histologically proved cases (ages, 3 to 37 years). Both of our patients with brain stem glioblastoma were boys; their ages were 6 and 3, respectively. Both tumors originated from the pons, with one showing multicentric foci or metastasis in the left cerebellar hemisphere.

Fig 5. Case 8. *A*, Axial T1-weighted and *B*, T2-weighted images show a pontine mass including the areas suggestive of necrosis (*arrowheads*). A small nodule in the left cerebellar hemisphere represents intraaxial metastasis (*arrow*).

C, A postcontrast axial T1-weighted image shows ringlike enhancement in the pontine mass. The small nodule in the hemisphere also demonstrates a subtle ring enhancement (*arrow*).

According to Kernohan's histologic classification (15), glioblastoma multiforme was included in the category of astrocytoma grade 3 to 4; another classification uses three divisions: well-differentiated astrocytoma, anaplastic astrocytoma, and glioblastoma multiforme (14). We adopted the latter classification and obtained histologic diagnoses in all cases. Subtotal removal was usually performed for cerebellar tumors, with open biopsy obtained for brain stem sites. When histologic differentiation between glioblastoma multiforme and anaplastic astrocytoma was difficult, the key criterion used to distinguish glioblastoma was the presence of necrosis (14).

Because it has good tissue resolution, lack of major bone artifacts, and multiplanar capability, MR imaging is far superior to CT for evaluating posterior fossa masses (16, 17). On precontrast MR, tumors and surrounding edema generally demonstrated prolonged T1 and T2 relaxation times: low signal on T1-weighted, and high signal on T2-weighted images. However, partially isointense areas were observed in four of nine tumors on T2-weighted images, perhaps reflecting the compact cellularity of these lesions. Three lesions demonstrated mixed hypointensity and hyperintensity on both T1- and T2-weighted images, presumably reflecting intratumoral hemorrhage (18). On contrastenhanced MR studies, solid components usually showed marked ringlike enhancement in most cases, usually with irregularly thickened walls and central necrosis. These findings were similar to those of supratentorial glioblastomas (19). Although glioblastoma multiforme may metastasize (20) or arise from multicentric foci (21, 22), only one case of metastasis from a cerebellar glioblastoma has been previously reported (23).

The most common differential diagnosis for posterior fossa brain masses in adults is metastatic tumor (16). Metastatic tumor nodules usually occur at the corticomedullary junction and are often multiple and of nearly equal size. When solitary, it is difficult to diagnose metastases if there is no history of primary lesion. However, the margins of metastases are relatively sharply demarcated, with relatively extensive surrounding edema. Metastases may sometimes demonstrate cystic components or show hypointensity on T2-weighted images, suggesting intratumoral hemorrhage, calcification, or mucinous components (18, 24). In contrast, glioblastomas grow infiltratively with an indistinct margin. Metastatic tumors may enhance in a ringlike fashion and may be irregular, mimicking glioblastoma. Metastatic or multicentric foci associated with glioblastoma multiforme usually differ from the original tumor in size and shape. Peritumoral edema is rather mild, compared with that of metastatic brain tumors (7). Intratumoral hemorrhage is com-

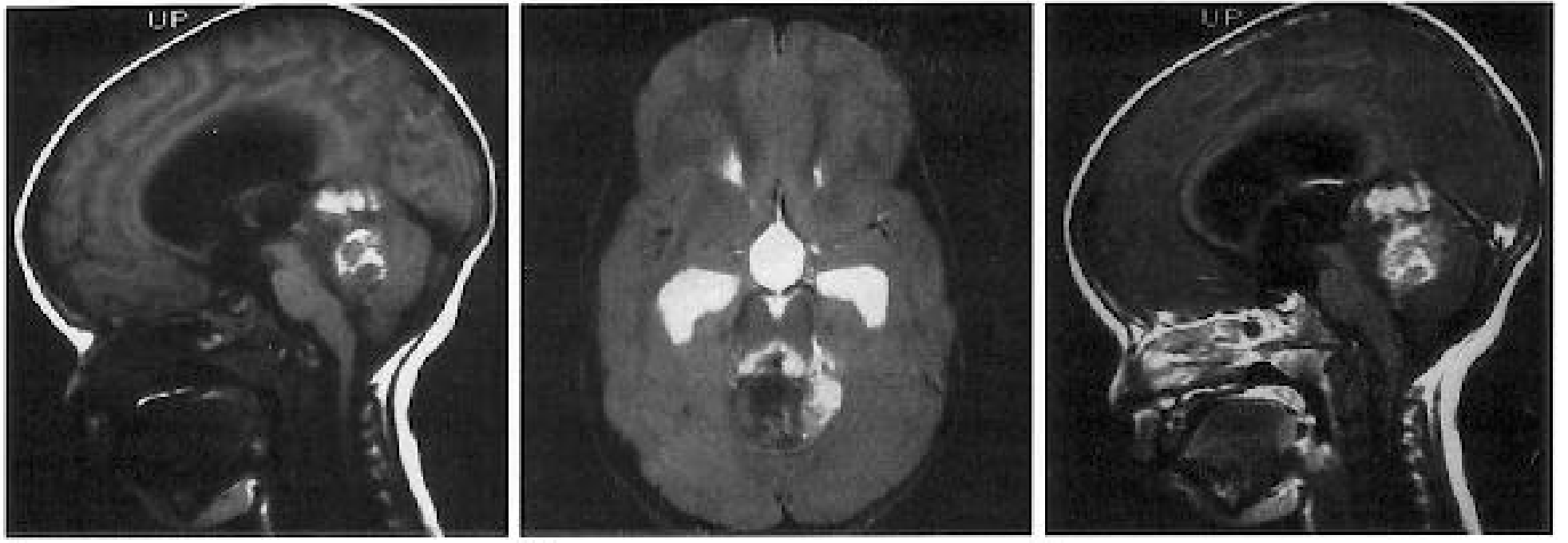
mon, but calcification or cystic change is rarely seen (25).

Other posterior fossa tumors that show similar contrast enhancement include primitive neuroectodermal tumor of the posterior fossa or medulloblastoma, ependymoma, pilocytic astrocytoma, or hemangioblastoma. Primitive neuroectodermal tumor most often occurs in the midline within the posterior fossa and frequently causes marked hydrocephalus and peritumoral edema (17, 26). They often enhance homogeneously but may also have cystic changes and heterogeneous enhancement. Medulloblastoma can be seen in the cerebellar hemisphere, especially in older patients (27). Ependymoma is usually seen in close relation to the fourth ventricle but can extend inferiorly and laterally via the foramina of Magendie and Luschka, respectively (17). Peritumoral edema is minimal. Pilocytic astrocytoma, often seen in children, shows cystic components with mural nodules with little or no surrounding edema. Extensive contrast enhancement is sometimes seen; however, ring enhancement is uncommon (17). Hemangioblastoma may be sometimes multicentric and may have cystic change with mural nodule but usually also shows vascular flow voids in and around the mass (28).

In conclusion, glioblastoma multiforme rarely occurs in the posterior fossa. The MR findings are nonspecific and differentiation from metastases, which are much more commonly found in the posterior fossa, may be difficult. However, features such as median location, heterogeneous signal intensity (presence of hemorrhage), prominent heterogeneous and ringlike enhancement (necrosis) with poorly defined margins, and multicentricity or extraaxial metastases associated with a disproportionally large tumor may be useful clues for the prospective diagnosis of glioblastoma multiforme in this location.

References

1. Russell DS, Rubinstein LJ. *Pathology of Tumor of the Nervous System*. 5th ed. Baltimore: Williams & Wilkins; 1989:219–247
2. Taveras JM, Thompson HG Jr, Porel JL. Should we treat glioblastoma multiforme? A study of survival in 425 cases. *AJR Am J Roentgenol* 1962;87:473–479
3. Zülch KJ. *Brain Tumors: Their Biology and Pathology*. 3rd ed. New York: Springer-Verlag; 1986:307–324
4. Dohrmann GJ, Dunsmore RH. Glioblastoma multiforme of the cerebellum. *Surg Neurol* 1975;3:219–223
5. Tibbs PA, Mortara RH. Primary glioblastoma multiforme of the cerebellum: a case report. *Acta Neurochirurgica* 1980;52: 13–18
6. Bhimani S, Virapongse C, Spencer D, Kim J. CT appearance of cerebellar glioblastoma multiforme. *J Comput Assist Tomogr* 1983;7:889–891
7. Zito JL, Siva A, Smith TW, Leeds M, Davidson R. Glioblastoma of the cerebellum: computed tomographic and pathologic considerations. *Surg Neurol* 1983;19:373–378
8. Kopelson G. Cerebellar glioblastoma. *Cancer* 1982;50: 308–311
9. Hegedus K, Molnar P. Primary cerebellar glioblastoma multiforme with an unusually long survival. *J Neurosurg* 1983;58: 589–592
10. Chamberlain MC, Silver P, Levin VA. Poorly differentiated gliomas of the cerebellum: a study of 18 patients. *Cancer* 1990;65: 337–340
11. Berger MS, Edwards MSB, LaMasters D, Davis RL, Wilson CB. Pediatric brain stem tumors: radiographic, pathological, and clinical correlations. *Neurosurgery* 1983;12:298–302
12. Nishio S, Fukui M, Tateishi J. Brain stem gliomas: a clinicopathological analysis of 23 histologically proven cases. *J Neurooncol* 1988;6:245–250
13. Smith RR. Brain stem tumors. *Semin Roentgenol* 1990;25: 249–262
14. Burger PC, Vogel FS, Green SB, Strike TA. Glioblastoma multiforme and anaplastic astrocytoma: pathologic criteria and prognostic implications. *Cancer* 1985;56:1106–1111
15. Svien HJ, Mabon RF, Kernohan JW. Astrocytomas. *Proc Staff Mayo Clinic* 1949;24:54–64
16. Bilaniuk LT. Adult infratentorial tumors. *Semin Roentgenol* 1990; 25:155–173
17. Gusnard DA. Cerebellar neoplasms in children. *Semin Roentgenol* 1990;25:263–278
18. Atlas SW, Grossman RI, Gomori JM, et al. Hemorrhagic intracranial malignant neoplasms: spin-echo MR imaging. *Radiology* 1987;164:71–77
19. Atlas SW. Adult supratentorial tumors. *Semin Roentgenol* 1990; 25:130–154
20. Onda K, Tanaka R, Takahashi H, Takeda N, Ikuta F. Symptomatic cerebrospinal fluid dissemination of cerebral glioblastoma. *Neuroradiology* 1990;32:146–150
21. Mishra HB, Haran RP, Singh JP, Joseph T. Multicentric gliomas: two case reports and a review of the literature. *Br J Neurosurg* 1990;4:535–539
22. Tassel PV, Lee YY, Bruner JM. Synchronous and metachronous malignant gliomas: CT findings. *AJNR Am J Neuroradiol* 1988;9: 725–732
23. Pang D, Ashmead JW. Extraneural metastasis of cerebellar glioblastoma multiforme. *Neurosurgery* 1982;10:252–257
24. Egelhoff JC, Ross JS, Modic MT, Masaryk TJ, Estes M. MR imaging of metastatic GI adenocarcinoma in Brain. *AJNR Am J Neuroradiol* 1992;13:1221–1224
25. Leeds NE, Elkin CM, Zimmerman RD. Gliomas of the brain. *Semin Roentgenol* 1984;19:27–43
26. Buetow PC, Smirniotopoulos JG, Done S. Congenital brain tumors: a review of 45 cases. *AJNR Am J Neuroradiol* 1990;11: 793–799
27. Koci TM, Chiang F, Mehringer CM, et al. Adult cerebellar medulloblastoma: imaging features with emphasis on MR findings. *AJNR Am J Neuroradiol* 1993;14:929–939
28. Lee SR, Sanches J, Mark AS, Dillon WP, Norman D, Newton TH. Posterior fossa hemangioblastomas: MR imaging. *Radiology* 1989;171:463–468



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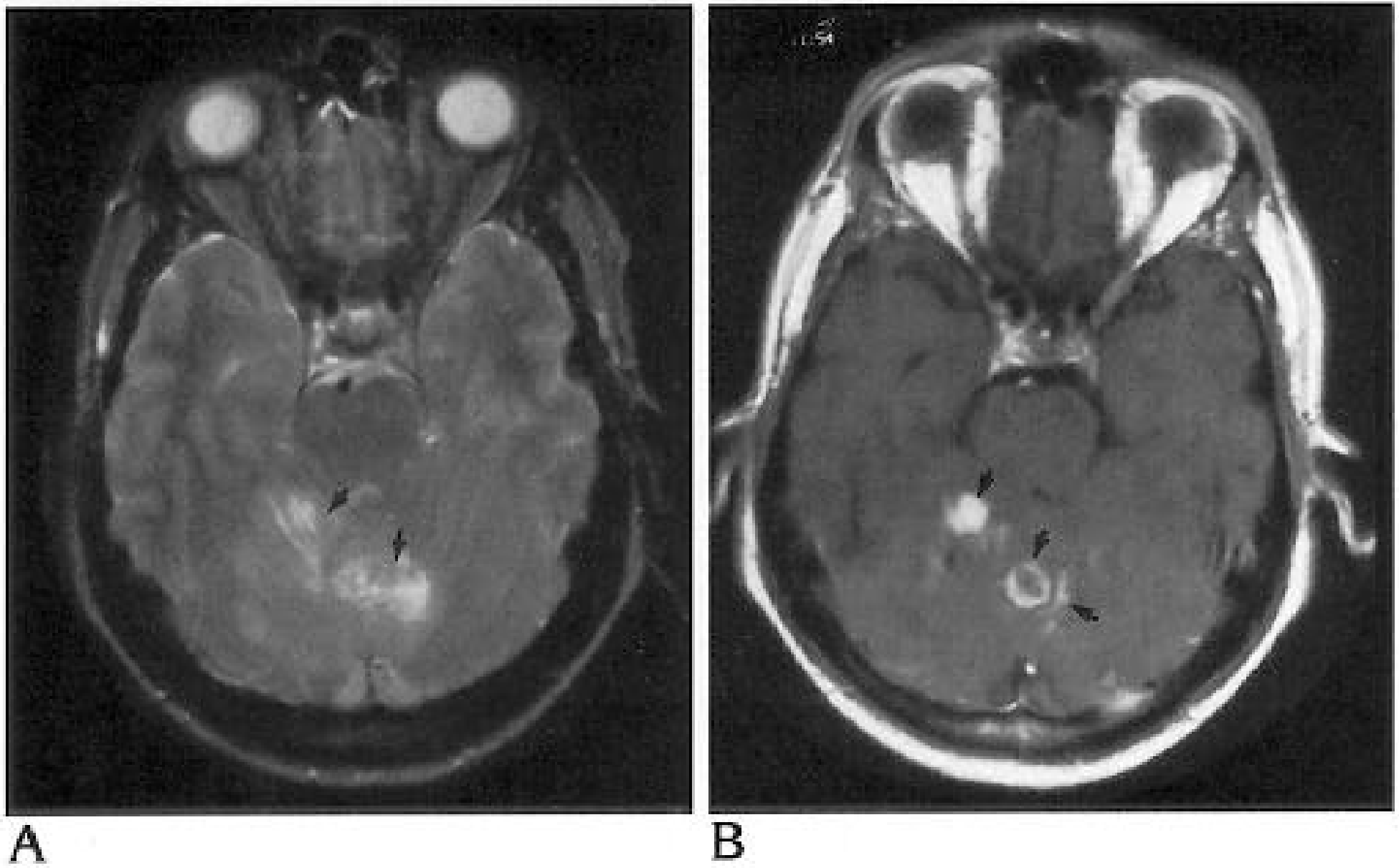
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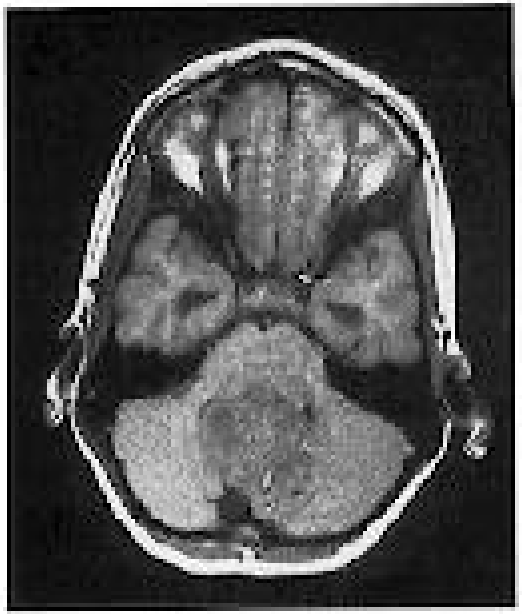

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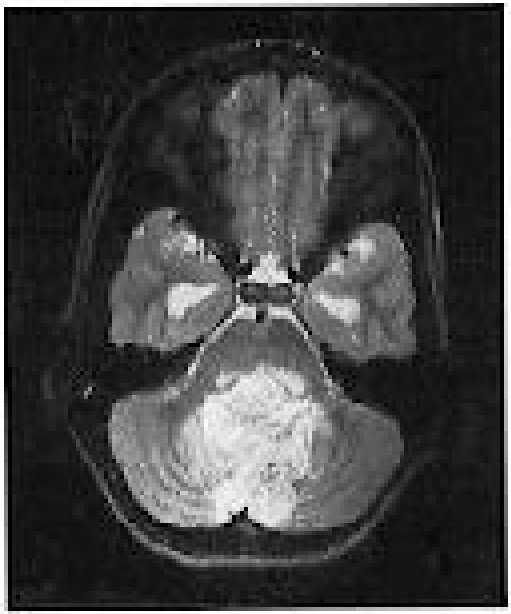

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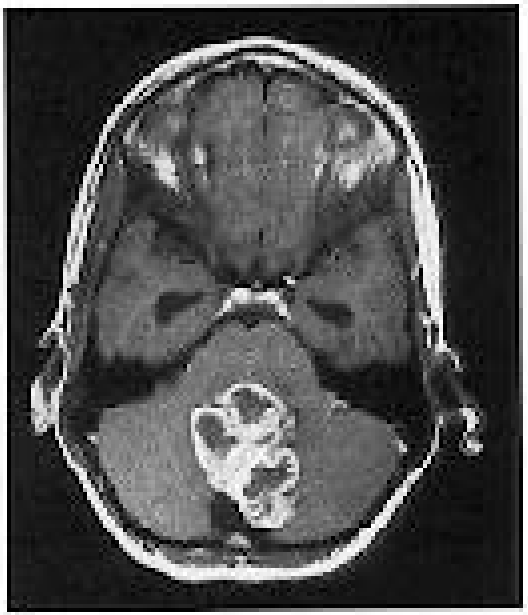

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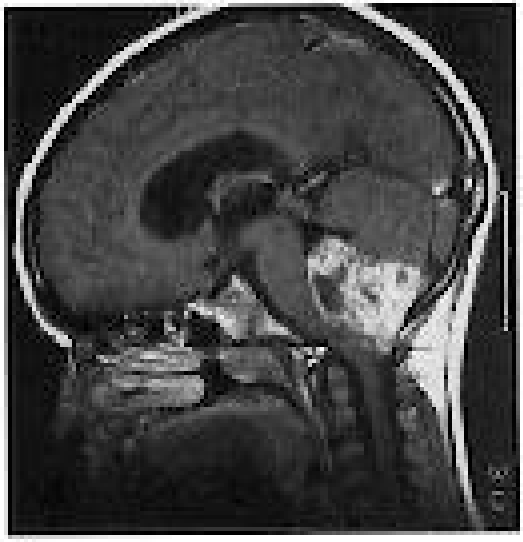

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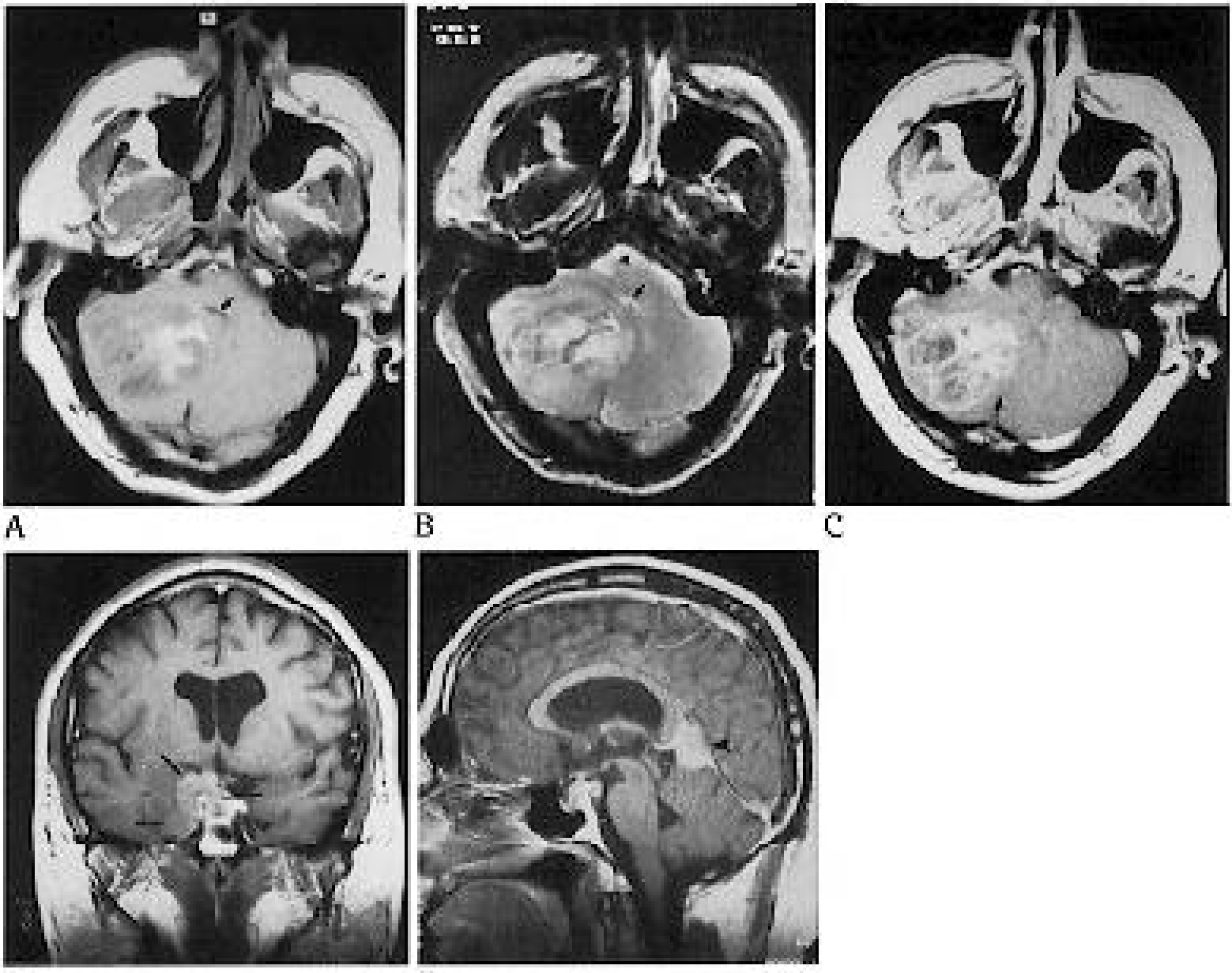
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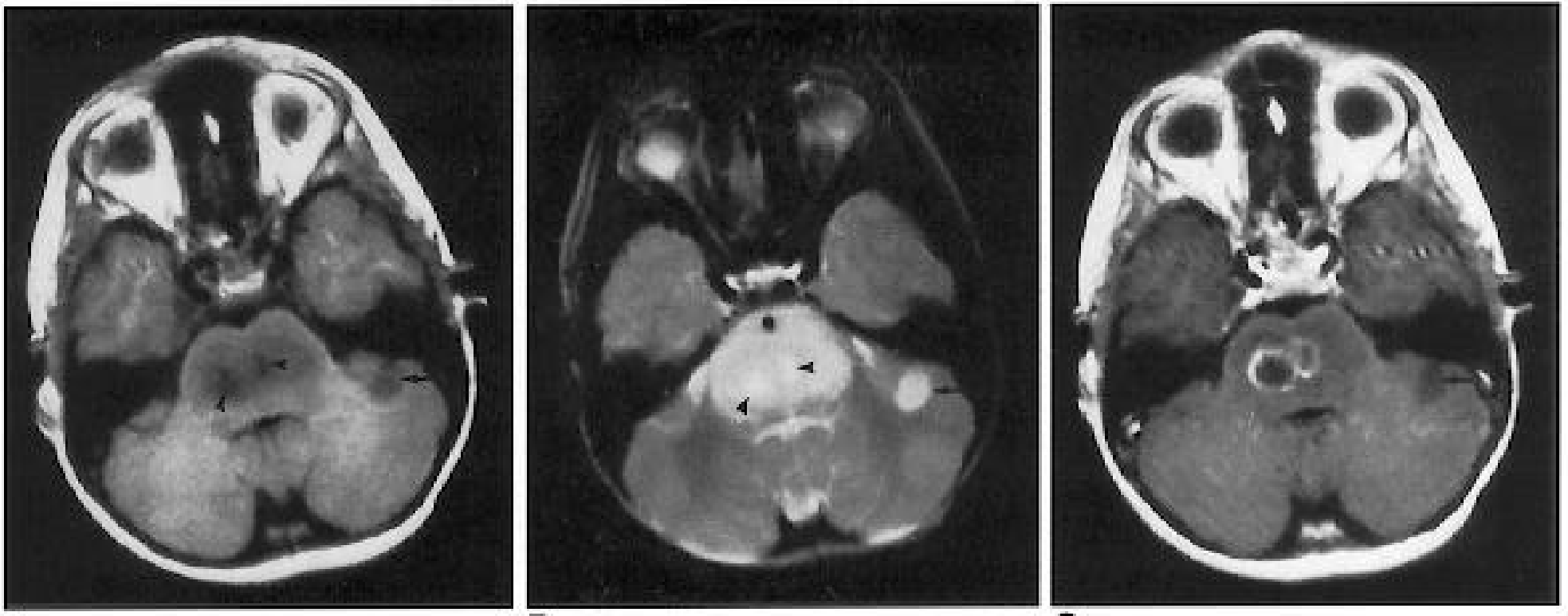
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