Germinoma Originating in the Basal Ganglia and Thalamus: MR and CT Evaluation

Shuichi Higano, Shoki Takahashi, Kiyoshi Ishii, Ko Matsumoto, Hidetoshi Ikeda, and Kiyohiko Sakamoto

PURPOSE: To describe MR and CT features of germinoma originating in the basal ganglia and thalamus and to discuss the roles of each modality for its diagnosis. **METHODS:** MR and CT studies of six cases of germinomas, five of which were histologically proved, were retrospectively reviewed. T1-weighted, T2-weighted, and contrast-enhanced T1-weighted conventional spin-echo images, and unenhanced and contrast-enhanced CT images were evaluated. **RESULTS:** Typically, the tumor consisted of an irregular solid area with contrast enhancement and various-size cysts. Cystic components were found in five cases and calcification in four. Intratumoral hemorrhage was noted in one. Ipsilateral cerebral hemiatrophy and brain stem hemiatrophy were noted in three cases each. MR was superior to CT in evaluating precise tumor extension, cystic components, and intratumoral hemorrhage, although in one case, extension of the tumor was better defined on CT in its early stage. Calcification was difficult to identify by MR alone. The solid components of the tumors generally showed slightly high density on CT, which seemed to be characteristic compared with nonspecific intensity pattern on MR. **CONCLUSION:** The combination of CT and MR findings allows early detection and appropriate diagnosis of the mass in the basal ganglia and/or thalamus.

Index terms: Germinoma; Thalamus; Basal ganglia, neoplasms; Brain neoplasms, computed tomography; Brain neoplasms, magnetic resonance; Brain neoplasms, in infants and children

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The preferential location of intracranial germ-cell tumors is in the midline, such as the pineal and suprasellar regions (1). However, there have been several reports about germinal neoplasms originating in the basal ganglia and/or thalamus, especially in Japanese patients (2–13). Because a germinoma is generally radiosensitive and potentially curable, its early detection and the differentiation from glial tumors are desirable. In addition to reports of computed tomography (CT) of germ-cell tumors in the basal ganglia and thalamus, their magnetic resonance (MR) findings have been recently but only sporadically described (2, 3, 5, 6, 9). We describe CT and MR findings in six cases of germinoma in this special location and discuss its features and the roles of MR and CT in its detection and diagnosis.

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From the Departments of Radiology (S.H., S.T., K.I., K.M., K.S.) and Neurosurgery (H.I.), Tohoku University School of Medicine, Japan.

Address reprint requests to Shuichi Higano, MD, Department of Radiology, Tohoku University School of Medicine, 1-1 Seiryomachi Aobaku Sendai, Tohoku 980, Japan.

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Subjects and Methods

MR and CT findings of six patients with germinoma of the basal ganglia and/or thalamus were retrospectively reviewed. The patients were all boys, ranging in age from 8 to 16 years (mean, 11.3 years). The pathologic diagnosis was made by CT-guided stereotaxic needle biopsy in all patients but one, who underwent total removal of the tumor. In five of six cases, typical two-cell-pattern germinoma (composed of two cell types, large polygonal cells and lymphocytes) was histologically confirmed. In the other case, the specimen included only gliosis, probably because of inappropriate biopsy; we finally diagnosed this tumor as of germ-cell origin because of its high sensitivity to radiotherapy, high serum content of α-fetoprotein, and its characteristic CT image features. Five patients developed slowly progressive hemipareses; the remaining one presented with precocious puberty without any other neurologic symptoms. The latter patient proved to have an increased value of serum human chorionic gonadotropin. In two other cases, the level of serum α-fetoprotein or human chorionic gonadotropin was increased.

Basal ganglia and thalamus germinomas: CT and MR features

Case	Tumor Extention	Cystic and Necrotic Components	Calcification	Contrast Enhancement	Tumor Margin	Perifocal Hyperintensity Area (T2-Weighted)	Hemiatrophy	
							Cerebrum	Brain Stem
1	Right LN	+ (Xanthochromic)	+	+	Sharp	+	−	−
2	Left LN-CH	+ (Hemorrhage)	±	+	Sharp	±	−	+
3	Right LN-IC	+	+	+	Irregular	+	+	+
4	Right LN-IC	−	−→+[a]	−→+[a]	Irregular	−	±→+[b]	±→+[b]
5	Left LN-IC-TH	+ (Necrotic)	+	+	Irregular	+	+	+
6	Right LN-IC-TH-MB-IV	+ (Xanthochomic)	−	+	Irregular	++	−	−

Note.—Contents in cystic and necrotic regions revealed by surgery are in parentheses. LN indicates lentiform nucleus; CH, caudate head; IC, internal capsule; TH, thalamus; MB, midbrain; and IV, intraventricular.

[a] Appeared later on follow-up study.

[b] Remarkable on follow-up study.

MR was performed on a 1.5-T system in all six patients. Using multisection conventional spin-echo sequences, we obtained T1-weighted images (500–550/15–20/2 [repetition time/echo time/excitations]), T2-weighted images (2500/90/1) and T1-weighted images with intravenous injection of gadopentetate demeglumine (0.1 mmol/kg of body weight). We used a field of view of 19 to 25 cm and a matrix of 256 × 256. We obtained images in the axial plane with 5- to 8-mm section thickness and 1- to 2-mm intersection gap for all patients, with additional contrast-enhanced T1-weighted images in coronal planes in three cases. CT study was also performed in all patients with and without intravenous contrast material (2 ml/kg of 300 mg of iodine/ml) with 8-mm section thickness and no intersection gap. CT density and MR intensity of the lesions were evaluated by comparing the lesions with normal gray matter.

Results

The neuroradiologic features obtained from CT and MR studies are summarized in the Table.

MR and CT images of four representative cases are shown in Figure 1–4. The tumors generally consisted of solid areas and various sizes of cystic components. The solid components tended to appear characteristically slightly hyperdense on precontrast CT, whereas they showed isointensity to slight hypointensity on T1-weighted images and isointensity to hyperintensity on T2-weighted images. All the tumors but one demonstrated contrast enhancement; in one case (case 4), the tumor was not enhanced initially on both CT and MR but subsequently enhanced 1½ years later (Fig 2). Although the tumor extension was generally evaluated better on MR than on CT, the tumor in case 4 demonstrated as a more extensive high-density area without contrast enhancement on initial CT; on MR, the lesion appeared only as a less-extensive area of hyperintensity on T2-weighted images and was hardly detectable on T1-weighted images (Fig 2).

Cystic or necrotic components were noted in five patients. In three (cases 1, 2, and 6), the tumors had relatively large cysts that were proved by surgical intervention. In two of them, the cysts showed marked hyperintensity on T2-weighted images and hypointensity on T1-weighted images and demonstrated no contrast enhancement except in their capsules. In the other one (case 2), the cysts showed two kinds of different intensity and density patterns, indicating different phases of intracystic hemorrhage, which was confirmed by stereotaxic surgery (Fig 3).

The tumors invariably involved the lentiform nuclei with frequent extensions to the internal capsules. In one case (case 6), the tumor was huge and extended to the thalamus, midbrain, and even into the third and lateral ventricles (Fig 4).

Intratumoral calcification, presenting as nodular or spotty hyperdensity on CT, was obvious in four cases. In one of them, calcification appeared later on follow-up study (Fig 2). Parts of calcified foci appeared hyperintense on T1-weighted images in three cases.

In three patients, dilatation of cortical sulci, especially the Sylvian fissures, of the cerebral hemispheres was noted on the sides of the tumors, suggesting ipsilateral hemicerebral atrophy (Fig 1). In three cases, the ipsilateral cerebral peduncles were shrunken compared with those of the contralateral sides. In case 4, the hemiatrophy of both brain stem and cerebral hemisphere progressed remarkably during a period of 1½ years (Fig 2).

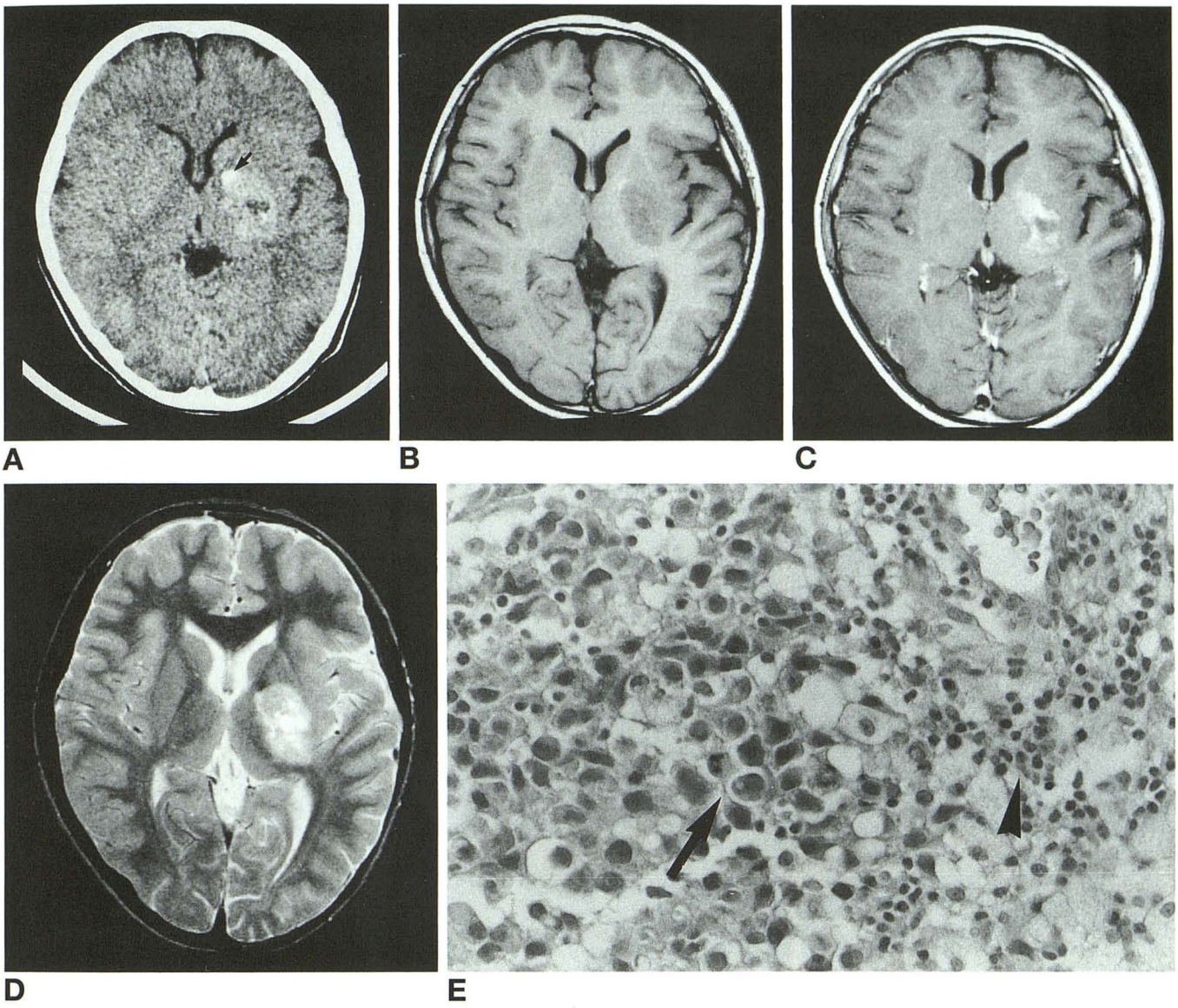

Fig 1. Case 5.

A, Precontrast CT shows an ill-defined, slightly hyperdense area with a small low-density component in the left basal ganglia. Note a nodular calcification in the tumor (*arrow*).

B, T1-weighted, *C,* contrast-enhanced T1-weighted, and *D,* T2-weighted images. The tumor is delineated as an area of slightly low intensity with irregular enhancement on the T1-weighted image and a heterogeneously hyperintense area on the T2-weighted image. The MR evaluates the tumor extension and cystic and necrotic components, whereas CT is superior in detecting calcification. Note mild dilatation of the Sylvian fissure and cortical sulci in the left cerebral hemisphere.

E, Photomicrogram. The tumor is composed of two different types of cells: large spheroidal or polygonal cells (*arrow*) and lymphocytes (*arrowhead*).

Discussion

According to previous CT studies of germinoma in the basal ganglia and thalamus (4–8, 10, 12, 14), the tumor was usually composed of a solid area with irregular margins and various sizes of cystic components. Calcification was frequently associated. Our study revealed features similar to those findings. The MR intensity of the solid areas, which often demonstrated contrast enhancement, was fairly nonspecific; that is, isointense to low on T1-weighted images and isointense to high on T2-weighted images. On the other hand, they showed characteristic hyperdensity on precontrast CT. In the previous CT reports, a similar tendency of high density of the tumor was described (12). Soejima et al

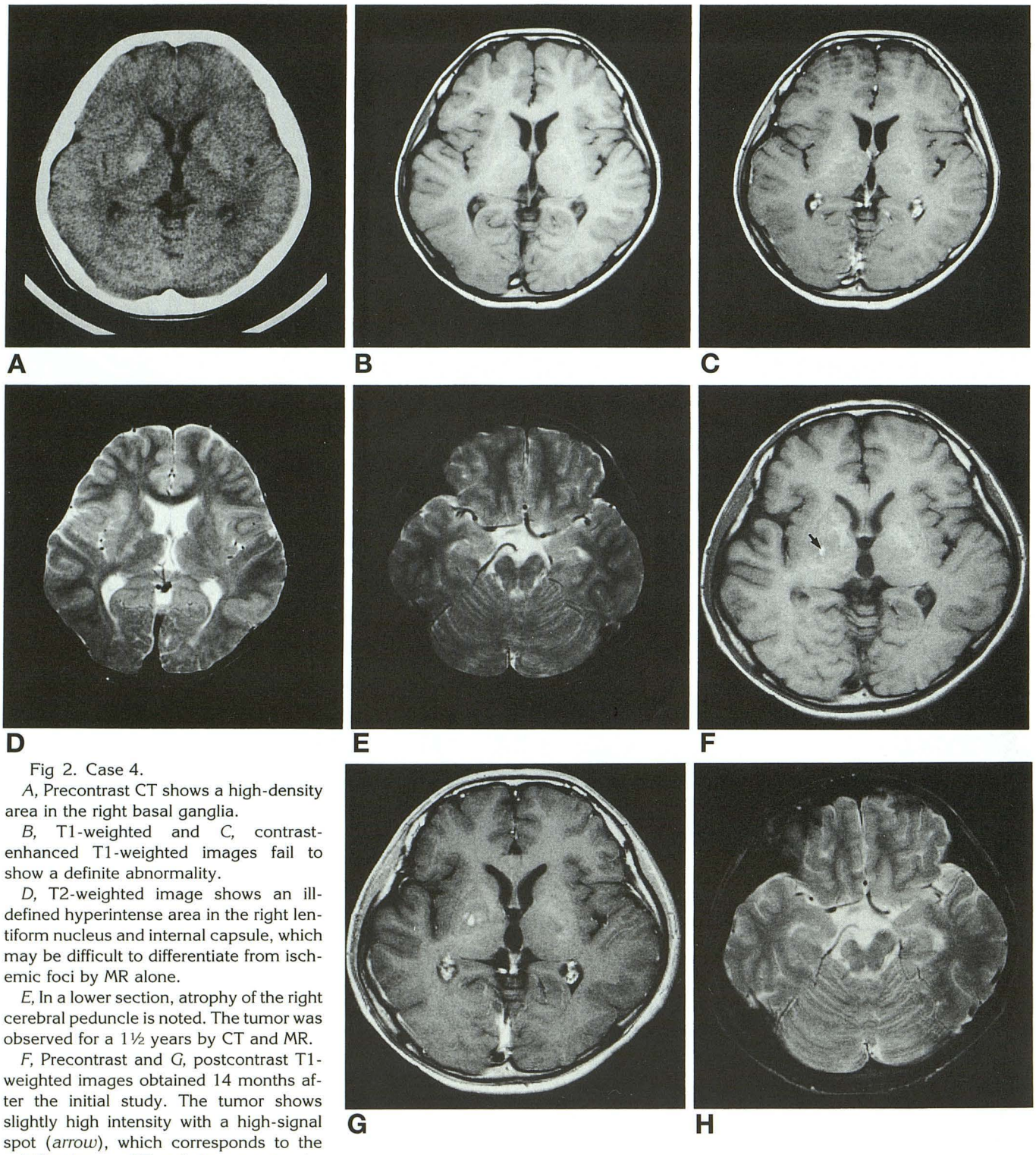

Fig 2. Case 4.

A, Precontrast CT shows a high-density area in the right basal ganglia.

B, T1-weighted and *C,* contrast-enhanced T1-weighted images fail to show a definite abnormality.

D, T2-weighted image shows an ill-defined hyperintense area in the right lentiform nucleus and internal capsule, which may be difficult to differentiate from ischemic foci by MR alone.

E, In a lower section, atrophy of the right cerebral peduncle is noted. The tumor was observed for a 1½ years by CT and MR.

F, Precontrast and *G,* postcontrast T1-weighted images obtained 14 months after the initial study. The tumor shows slightly high intensity with a high-signal spot (*arrow*), which corresponds to the calcification on CT and demonstrates irregular enhancement.

H, The same section as *E* revealed progressive hemiatrophy of the brain stem.

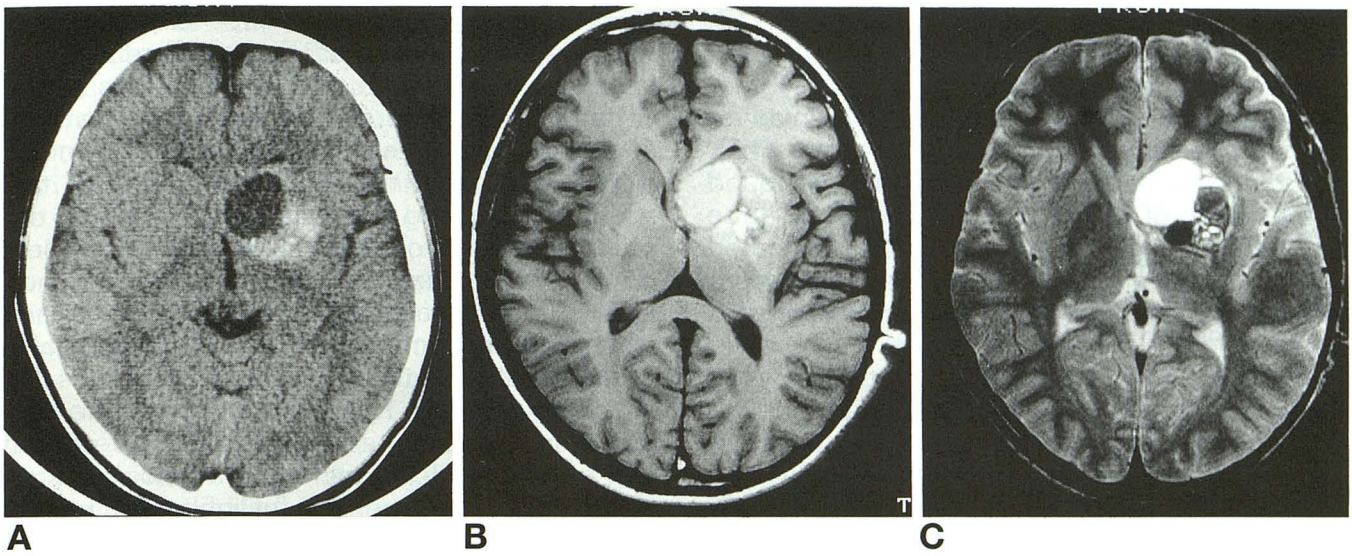

Fig 3. Case 2.
A, Precontrast CT shows a high-density mass with a well-defined low-density cyst in the left basal ganglia.
B, T1-weighted image.
C, T2-weighted image. The hypodense area on CT is depicted as high-signal areas on both T1- and T2-weighted images and the hyperdense component on CT as multiloculated areas with a fluid-fluid level of high and markedly low intensity on the T2-weighted image, which suggests acute to subacute hematoma. On stereotaxic drainage, intracystic hemorrhage was confirmed.

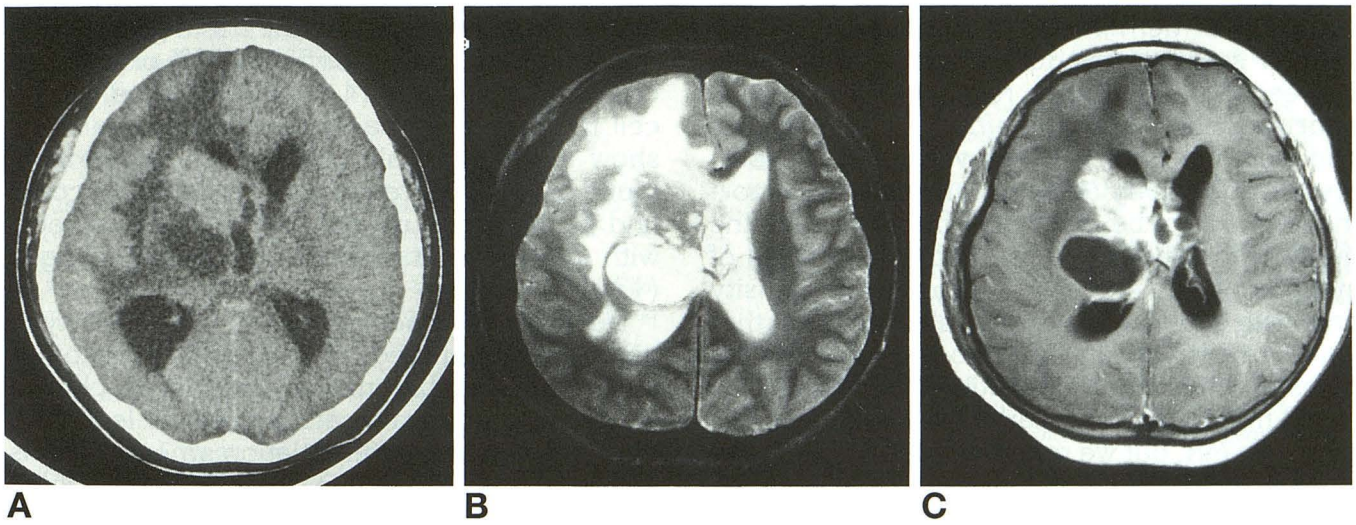

Fig 4. Case 6.
A, Precontrast CT, *B,* T2-weighted image, and *C,* contrast-enhanced T1-weighted image show a large tumor in the right basal ganglia and thalamus with intraventrivular extension. The tumor shows slightly high density on CT. Various size of cysts are associated. A marked perifocal hyperintensity area is noted on the T2-weighted image.

pointed out that this high density on precontrast CT should be one of the diagnostic features differentiating it from most glial tumors, which also may have calcification and cystic areas. In one of our cases, MR showed the characteristic intensity pattern of acute to subacute hemorrhage, which was verified by surgery. Anno et al (3) also reported a case of basal ganglionic germinoma with old hemorrhage with a surrounding hypointense rim on T2-weighted images. As is often the case in most types of tumors, MR was superior to CT in evaluating precise extension of the tumor, cystic components, and intratumoral hemorrhage, but associated calcification recognized on CT was difficult to identify on MR.

Several investigators have noted ipsilateral hemicerebral atrophy in cases with germinoma

of the basal ganglia and thalamus (4, 6, 12, 15–17). Although this hemiatrophy was thought to be a characteristic of germinoma, this feature is now regarded as a result of the tumor involvement of fiber tracks by any kind of tumor (16). In addition to hemicerebral atrophy, we found hemiatrophy of the brain stem on MR in three cases. This hemiatrophy was better delineated on MR because of the lack of artifacts from petrous bones. Such hemiatrophic features tended to be more remarkable in the cases in which the tumors had irregular margins extending to the dense white matter bundles of the internal capsules. In one case (case 4), progression of the hemiatrophy of the brain stem and cerebral hemisphere was observed with enlargement of the tumor involving the internal capsule. To the contrary, there was no definite atrophic change in our case 1, with a relatively well-circumscribed tumor restricted to the basal ganglia. These findings support the belief that hemiatrophy is secondary to tumoral involvement of internal capsule.

Despite the high radiosensitivity and potential curability of germinoma in this region, an advanced stage of the tumor with considerable degree of hemiatrophy results in a clinically poor prognosis (7). Therefore, early diagnosis and treatment are necessary for a better outcome. In the early stage of this disease, abnormality may not be detectable on CT despite the neurologic deficits (4, 12). With progression of symptoms, CT reveals a small high-density area with subtle mass effect, followed by further enlargement of an inhomogeneous density mass and formation of cystic components. We found no report about early detectability of this tumor on MR, but we report a small tumor (case 4) that was not clearly demonstrated on the initial MR in comparison with CT. We believe the combination of CT and MR would enable earlier detection of this lesion.

The CT and MR findings of germinoma in the pineal and suprasellar regions have been well documented (1, 18–24). Germinomas in these familiar locations calcify or contain cystic components less often than those in the basal ganglia. Calcification seen in cases with pineal region germinoma is now believed to be limited to the normal pineal gland possibly engulfed by the tumor, although abnormal intratumoral calcification is more frequently associated with other pineal region tumors such as teratomatous tumors, embryonal cell carcinoma, and tumors of pineal cell origin (19, 23, 24). The reason for such neuroradiologic differences between germinomas in different locations is uncertain. Soejima et al (12) proposed that the anatomic difference might influence the mode of tumor growth; that is, germinomas of the basal ganglia and thalamus are intraaxial tumors, whereas those in the pineal and suprasellar regions are extraaxial. Extraaxial germinomas in the suprasellar and pineal regions are usually well circumscribed but occasionally may infiltrate into the adjacent brain such as the thalamus (pineal), hypothalamus, or optic chiasm (suprasellar), causing perifocal edema, and may spread through subarachnoid spaces (1, 18, 22). The tendency for infiltrative extension was also and frequently found in intraaxial germinoma of the basal ganglia and thalamus, in which they presented with irregular margins and perifocal hyperintensity.

In addition to the neuroradiologic features, some demographic information is helpful in the differential diagnosis. First, there is a high incidence of intracranial germinomas in Japan (18), with germinomas of the basal ganglia and thalamus accounting for 5% to 10% of all intracranial germinomas (4, 7, 25). Second, germ-cell tumors of the basal ganglia and thalamus show a striking male predominance and were found only in children or young adults. We could find in the literature only two female subjects with germ-cell tumors in the basal ganglia (13, 14).

Because the radiosensitivity of mixed-type germ-cell tumors (eg, components of teratomatous tumors, embryonal cell carcinoma, choriocarcinoma, and yolk-sac tumors) is less than pure germinoma, differentiation among them is important for appropriate therapy. There should be no essential difference in CT findings between pure germinoma and the other kind of germ-cell tumors in the basal ganglionic region. The laboratory examinations of tumor markers are, however, useful for this purpose. Generally speaking, the choriocarcinoma releases human chorionic gonadotropin, yolk-sac tumor α-fetoprotein, and embryonal cell carcinoma releases both human chorionic gonadotropin and α-fetoprotein, whereas pure germinoma is known to produce neither α-fetoprotein nor human chorionic gonadotropin (7, 26). This means that there should be some germ-cell components other than pure germinoma mixed in cases with increased tumor markers even if the biopsy

specimens reveal two-cell-pattern histology typical of pure germinoma. In our three cases with elevated values of tumor markers, however, there has been no recurrence of tumors for 1½ to 4 years after radiation therapy.

In summary, germ-cell tumors can involve the basal ganglia and/or the thalamus especially in young male patients. Unlike typical germinomas in pineal or suprasellar regions, they showed a high tendency to cystic formation, calcification, and progressive infiltration into the internal capsule, which in turn may cause progressive cerebral hemiatrophy. Although the MR intensity is not specific to this type of tumor, MR can demonstrate precise extension, associated cysts, and intratumoral hemorrhage. CT disclosed a slightly hyperdense mass in the basal ganglia and the thalamus, which seemed to be characteristic and would be helpful for the differential diagnosis. Consideration of the patient's age and sex and combination of MR and CT studies are important for its early detection and differential diagnosis from other kinds of masses in the basal ganglia and/or the thalamus. When typical findings are present, one can avoid biopsy and proceed with radiotherapy.

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