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Pineal Region Tumors: Computed Tomographic-Pathologic Spectrum

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While several computed tomographic (CT) studies of posterior third ventricular neoplasms have included descriptions of pineal tumors, few reports have concentrated on these uncommon lesions. Some authors have asserted that the CT appearance of many pineal tumors is virtually pathognomonic. A series of nine biopsy-proved pineal gland and eight other presumed tumors is presented that illustrates their remarkable heterogeneity in both histopathologic and CT appearance. These tumors included germinomas, teratocarcinomas, hamartomas, and other varieties. They had variable margination, attenuation, calcification, and suprasellar extension. Germinomas have the best response to radiation therapy. Biopsy of pineal region tumors is now feasible and is recommended for treatment planning.

Tumors of the pineal region account for less than 2% of all intracranial neoplasms [1]. While several reports of computed tomography (CT) of third ventricular neoplasms have included an occasional pineal tumor [2, 3], few have focused on the radiographic spectrum of these uncommon lesions [4]. Some authors have asserted that the CT appearance of many pineal tumors is virtually pathognomonic [5]. We studied a series of nine biopsy-proven pineal gland tumors that demonstrated remarkable heterogeneity in both histopathologic and CT appearance.

Materials and Methods

A total of 17 pineal gland tumors were detected in 15,000 consecutive CT scans. Four patients were female and 13 were male. Mean age for the females was 27 years; for the males, 15 years. Initial symptoms ranged from headache, nausea, and vomiting, to Parinaud syndrome, visual field defects, diabetes insipidus, and hypopituitarism (table 1). Plain and contrast-enhanced CT scans were obtained in all cases.

Nine of the 17 cases were proven by biopsy or autopsy. Two were germinomas (atypical teratomas), two were teratocarcinomas, and one each was pineal hamartoma, benign teratoma, astrocytoma, and neurilemmoma. One other case was designated as a "malignant pineal tumor" by cerebrospinal fluid cytology. One case had insufficient tissue for pathologic diagnosis. One case was diagnosed as a pineal lipoma from characteristic CT findings. The dramatic response of five other cases to radiation therapy led to the presumptive clinical diagnosis of germinoma (table 1); these had no evidence of residual or recurrent disease for a minimum of 3 years. One patient was lost to follow-up.

Results

Germinoma (Atypical Teratoma)

The two documented and five presumed germinomas were either isodense or slightly hyperdense on plain CT scan (fig. 1A) and showed marked, uniform increase in attenuation after contrast enhancement (fig. 1B). Several were well

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TABLE 1: Pineal Gland Tumors: Case Summaries

Case No.	Age, Gender	Presenting Symptoms	CT Appearance	Biopsy	Treatment/Results
1	6, M	Diplopia, headache, nausea, vomiting, CN III, IV palsies	Isodense noncalcified posterior third ventricular mass, irregular margins, inhomogeneous contrast enhancement	Germinoma	Complete resolution following ventricular shunting, surgery, and radiation therapy
2	17, M	Anorexia, diabetes insipidus, panhypopituitarism	Well marginated, hyperdense mass left basal ganglia with strong contrast enhancement, edema, obstructive hydrocephalus secondary to aqueduct stenosis; subtle ependymal enhancement, third ventricle	Atypical teratoma with prominent germinomatous elements (autopsy)	Died 2 years after initial presentation; atypical teratoma with suprasellar, pineal, basal ganglia, ependymal involvement diagnosed at postmortem
3	18, M	Vomiting, diabetes insipidus, Parinaud syndrome, panhypopituitarism	Well delineated hyperdense suprasellar, posterior third ventricular masses; Ca ⁺⁺ in pineal region. Strong contrast enhancement of masses and ventricular ependyma; obstructive hydrocephalus	...	Complete resolution after ventricular shunt and radiation therapy; no recurrence after 4 years; presumptive diagnosis: germinoma
4	14, F	Headache, diplopia, papilledema, seizures	Well delineated slightly hyperdense posterior third ventricular mass without Ca ⁺⁺ ; strong, uniform contrast enhancement; moderate obstructive hydrocephalus	...	Ventricular shunt, radiation therapy with tumor resolution; 1 year follow-up; presumptive diagnosis: germinoma
5	26, M	Headache, vomiting, anorexia	Calcified isodense posterior third ventricular mass with moderate contrast enhancement, obstructive hydrocephalus	...	Complete resolution after ventricular shunting and radiation therapy; no recurrence after 5 years; presumptive diagnosis: germinoma
6	17, M	Headache, Parinaud syndrome, papilledema	Isodense third ventricular mass with strong contrast enhancement	...	Complete resolution after ventricular shunting and radiation therapy; 3 year follow-up without recurrence; presumptive diagnosis: germinoma
7	14, M	?Headache, Parinaud syndrome	Well marginated hyperdense pineal region tumor with focal calcification, strong contrast enhancement, moderate obstructive hydrocephalus	...	Complete resolution after ventricular shunting and radiation therapy; no recurrence after 5 years; presumed germinoma
8	14, M	Headache, nausea, vomiting, diabetes insipidus, Parinaud syndrome	Well delineated isodense, calcified posterior third ventricular mass with strong contrast enhancement, moderate obstructive hydrocephalus	Teratocarcinoma	Died from widespread metastatic disease 1 year after diagnosis
9	18, M	Diabetes insipidus, panhypopituitarism	Lobulated, hyperdense suprasellar, posterior third ventricular masses with foci of calcification in the pineal tumor; strong but slightly inhomogeneous contrast enhancement	Teratocarcinoma	Apparent resolution of both masses following shunt and radiation therapy; recurrence of suprasellar component after 6 months; alpha-fetoprotein in CSF

Case No.	Age, Gender	Presenting Symptoms	CT Appearance	Biopsy	Treatment/Results
10	6, M	Anisocoria, Parinaud syndrome discovered after head trauma	Well margined posterior third ventricular mass with densely calcified rim, contrast-enhancing center; moderate hydrocephalus	Pineal hamatoma	Shunted with surgical removal; in coma 4 months postop with major residual neurologic deficits 2¼ years later
11	8, M	Decreased coordination	Multicystic lobulated, irregular third ventricular tumor with foci of calcification, patchy peripheral contrast enhancement	Benign teratoma (with abundant neuroglial elements)	Residual mass and neurologic deficit following surgery (3 year follow-up)
12	63, M	Memory loss, imbalance	Well margined isodense partially calcified posterior third ventricular mass with moderate obstructive hydrocephalus; uniform contrast enhancement	Neurilemmoma or pineocytoma with predominately neural elements	Complete surgical removal
13	33, M	Dizziness, headache	Slight irregular hyperdense posterior third ventricular mass with focal calcification, patchy contrast enhancement	Midbrain astrocytoma	Unsuccessful radiation therapy; died 1 year following biopsy
14	42, F	Headache, vomiting	Well delineated low attenuation (-15 H) mass with peripheral calcification; no contrast enhancement; no hydrocephalus	...	Presumed lipoma because of CT characteristics
15	14, M	Anorexia, nausea, vomiting, diabetes insipidus	Slightly irregular enhancing, partially calcified posterior third ventricular mass; subtle suprasellar mass identified on multiple thin, overlapping axial scans; moderate obstructive hydrocephalus	"Small malignant cells" on CSF cytology	Complete resolution following ventricular shunting, radiation therapy (16 month follow-up)
16	20, M	Diplopia, Parinaud syndrome	Well demarcated hyperdense posterior third ventricular mass, small focus of Ca ⁺⁺ ; strong contrast enhancement	Insufficient tissue	Resolving after radiation therapy (2 month follow-up only)
17	22, M	Diplopia, Parinaud syndrome	Irregular mixed density posterior third ventricular mass with foci of calcification, patchy contrast enhancement	...	Lost to follow-up

Note.—CN = cranial nerve, CSF = cerebrospinal fluid, postop = postoperative.

margined while others appeared less well circumscribed. Four cases had definite suprasellar involvement (fig. 2A). The suprasellar mass was quite subtle in two cases and required several overlapping thin sections for detection. One case demonstrated striking subependymal enhancement (fig. 2B). When present, calcification appeared limited to the pineal gland, which was itself engulfed by the tumor.

An atypical teratoma with prominent germinomatous elements was seen as a hyperdense mass in the basal ganglia with strong contrast enhancement and ependymal spread along the third ventricle (fig. 3). To our knowledge, only one

similar case of documented "ectopic pinealoma" in the basal ganglia has been reported [6]. The present case was diagnosed at autopsy.

Teratocarcinoma

One case had a well demarcated, partly calcified, solitary posterior third ventricular mass that was slightly hyperdense on unenhanced CT scans. The lesion showed striking homogeneous increase in attenuation with contrast infusion (fig. 4). Although the CT appearance initially suggested

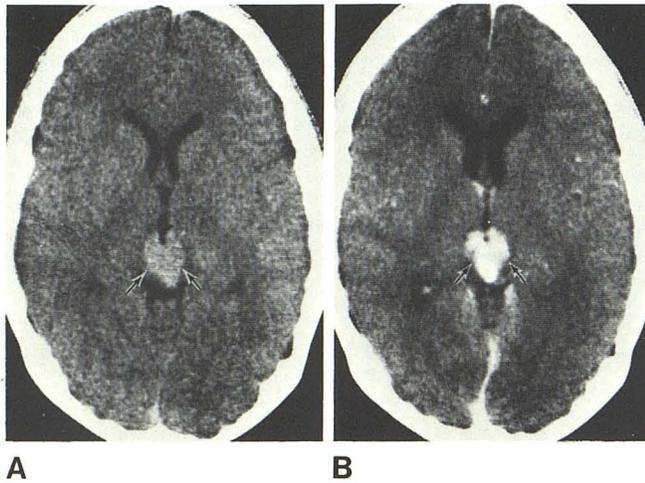


Fig. 1.—Case 4, presumed pineal germinoma. **A**, Plain scan. Slightly hyperdense, posterior third ventricular mass (arrows). **B**, After intravenous contrast infusion. Marked increase in attenuation of mass (arrows).

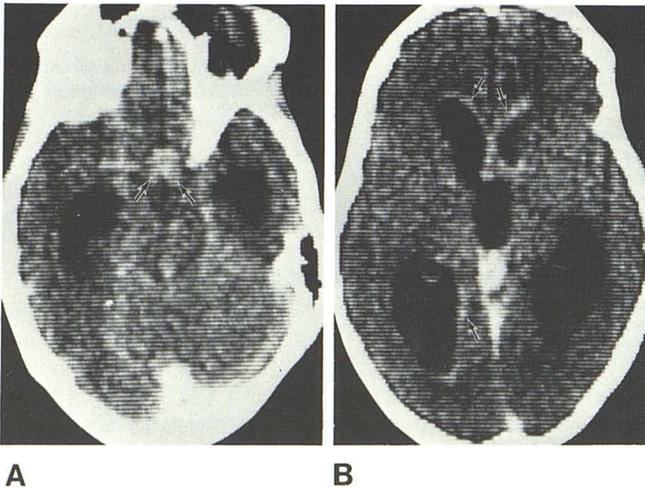


Fig. 2.—Case 3, presumed pineal germinoma. Contrast-enhanced scans with suprasellar (**A**, arrows) and diffuse ependymal (**B**, arrows) involvement.

pineal germinoma, teratocarcinoma was found at surgery. A second case had lobulated hyperdense suprasellar and posterior third ventricular masses with scattered calcific foci. Strong but slightly inhomogeneous contrast enhancement was present (fig. 5). Complete resolution of these lesions after radiation therapy led to the presumptive diagnosis of germinoma. The suprasellar component recurred after 6 months. Biopsy disclosed a teratocarcinoma.

Pineal Hamartoma

The single pineal hamartoma had a striking peripheral calcified rim with a hyperdense center that enhanced after intravenous contrast administration (fig. 6).

Benign Teratoma

A large irregular, locally invasive lesion with mixed low and normal attenuation regions showed patchy contrast

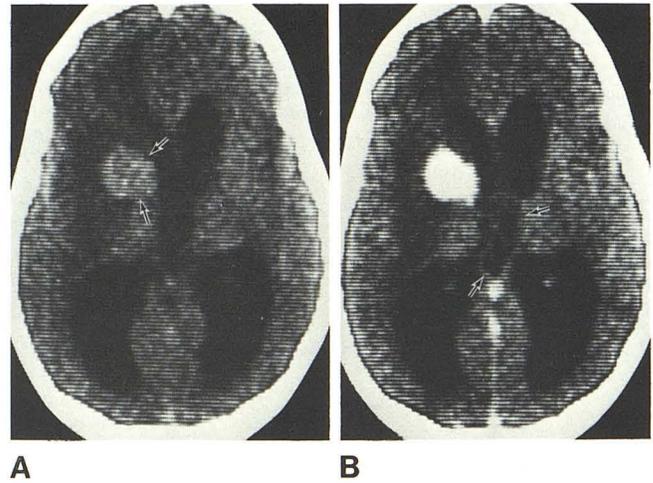


Fig. 3.—Case 2, atypical teratoma with germinomatous elements. **A**, Without contrast. Hyperdense mass with peripheral edema in basal ganglia (arrows). **B**, Marked increase in attenuation of lesion after contrast enhancement. Subtle ependymal involvement (arrows). At autopsy, pineal gland and ventricular ependyma were diffusely involved.

enhancement; one small focus of calcification was present (fig. 7).

Pineal Parenchymal Neoplasms

One hyperdense posterior third ventricular mass with strong contrast enhancement was either a neurilemmoma or pineocytoma with predominant neural elements (fig. 8).

Astrocytoma

One lobulated contrast-enhancing pineal region mass was found to be an astrocytoma at autopsy (fig. 9). It probably originated in the midbrain.

Lipoma

One homogeneous (–15 Hounsfield units [H]) noncontrast-enhancing lesion with a thin peripheral rim was identified in the pineal region. The CT characteristics were typical for lipoma.

Discussion

The term "pinealoma" has been loosely applied to all tumors arising from the pineal gland and posterior third ventricle. This practice has resulted in significant confusion in classifying the several varieties of tumors that arise from the pineal body.

Tumors arising from pineal parenchymal cells ("true pinealomas") are much less common than germ cell neoplasms (germinomas, teratomas, endodermal sinus tumors, or the rare primary intracranial choriocarcinoma) [7–9]. Parenchymal tumors have been subdivided into a more undifferentiated type composed primarily of immature cells (the so-called "pineoblastoma" is histologically similar to medulloblastoma) and pineocytoma with more mature com-

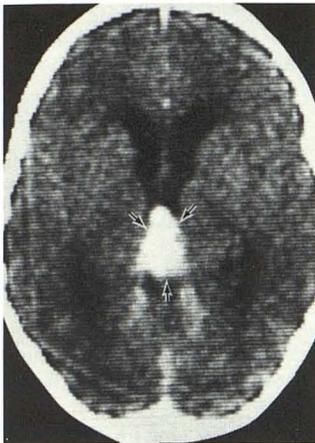


Fig. 4.—Case 8, teratocarcinoma. Contrast-enhanced scan. Well delineated enhancing mass in third ventricle (arrows). Plain scans (not shown) demonstrated an isodense, partly calcified pineal region mass.



A

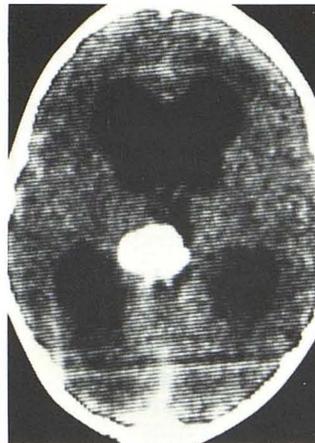


B

Fig. 5.—Teratocarcinoma. **A**, Case 9, before contrast enhancement. Lobulated hyperdense lesions in suprasellar region and posterior third ventricle (arrows). Punctate calcifications within pineal mass. Subarachnoid air from previous pneumoencephalography attempted elsewhere. **B**, Case 11, contrast-enhanced CT angiogram. Computer-registered stereoscopic pair can be focused with either mechanical viewer or cross-eyed stereo techniques.



A



B

Fig. 6.—Case 10, pineal hamartoma (arrows). Plain (A) and contrast-enhanced (B) scans. Peripheral rim of calcification along with central enhancement of hyperdense mass. There is moderate obstructive hydrocephalus.



A



B

Fig. 7.—Case 11, benign teratoma. Plain (A) and contrast-enhanced (B) scans. Locally invasive, lobulated, mixed attenuation mass with irregular areas of contrast enhancement. Solitary focus of calcification (arrow).

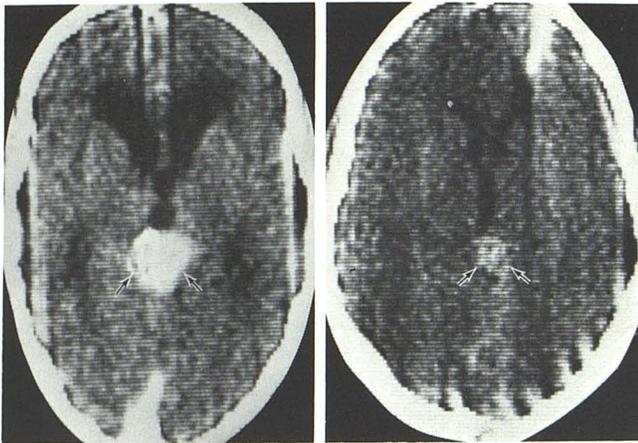
ponents. The latter can have either predominant astrocytic or neuroepithelial differentiation [10].

The remarkably divergent differentiating potential of pineal parenchymal tumors plus the considerable heterogeneity of germ cell neoplasms is reflected in their variable CT appearance. While calcification in pineal neoplasms suggests teratoma, it can also occasionally occur in pineal parenchymal tumors [4, 11]. Although ependymal or suprasellar involvement has been considered diagnostic of germinoma [5], teratocarcinoma can be radiographically indistinguishable (fig. 5). We found that a presumptive histologic diagnosis on the basis of CT alone was not possible. Uniformity or intensity of contrast enhancement, size, tumor margination, multiplicity, and location also were not helpful in distinguishing benign from malignant neoplasms. One

well delineated, uniformly enhancing lesion was a teratocarcinoma (fig. 4), while a mixed density, locally invasive mass was histologically benign (fig. 7). Therefore, we found no definite correlation between CT appearance and tumor type.

While some authors have regarded periventricular contrast enhancement as virtually pathognomonic of germinoma [5], diffuse ventricular spread or invasion of the midbrain or basal ganglia can also occur with pineoblastoma or malignant teratoma [10]. One atypical teratoma with numerous germinomatous components was eccentrically located in the basal ganglia and at autopsy had marked ependymal and suprasellar involvement (fig. 3).

The term "ectopic pinealoma" has been used inaccurately to designate suprasellar germinoma [12]; embryonic nests of true pineal tissue have not been demonstrated in



8
9
Fig. 8.—Case 12, neurilemmoma or pineocytoma. Contrast-enhanced scan. Enhancing posterior third ventricular mass.

Fig. 9.—Case 13, astrocytoma. Contrast-enhanced scan of pineal tumor (arrows).

this region [13]. These tumors may occur either as isolated suprasellar masses or in association with a similar pineal region tumor (fig. 3) [14]. Four of five patients with presumed pineal germinoma also had a suprasellar lesion; all five were seen initially with diabetes insipidus. One pineal teratocarcinoma also was associated with a suprasellar mass. From this experience, we believe exhaustive search for a suprasellar mass is imperative in all pineal region tumors. Multiplanar CT with thin, overlapping cuts or metrizamide CT cisternography is helpful since the suprasellar component may be quite small.

Other posterior third ventricular or parapineal masses can be virtually indistinguishable from pineal tumors on CT. Exophytic brainstem glioma, neurilemmoma, incisural meningioma, intraventricular craniopharyngioma, and metastasis should be included in the differential diagnosis of enhancing masses in or adjacent to the posterior third ventricle or quadrigeminal plate. Since histology cannot be inferred from the CT appearance alone, diagnostic efforts should be focused on accurately delineating the tumor itself, detecting suprasellar or ependymal involvement, and excluding primary vascular lesions that can mimic pineal region neoplasms.

Before 1970, histologic verification of pineal tumors was seldom possible due to their deep midline location [13]. Mortality was unacceptably high, approaching 60% for surgical removal and 33% for biopsy alone [15]. Ventricular shunting and radiation therapy without pathologic diagnosis were common since an estimated 70% of pineal region tumors are radiosensitive [16]. With more sophisticated microsurgical techniques [15], operative morbidity and mortality have declined [17, 18]. Accurate CT-guided stereotaxic biopsy procedures also may enhance treatment planning [19, 20]. An increasing number of investigators believe that tissue diagnosis is now both practical and necessary for determining the most appropriate therapeutic regimen

[9, 15, 18, 21]. The great variations in histology and clinical behavior of our 17 pineal region neoplasms persuade us also that the traditional approach of treatment without a tissue diagnosis is no longer warranted.

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