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Surgical Management of Pineal Region Tumors

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Summary

The authors advocate an aggressive surgical approach to pineal region tumors to provide a definitive histological diagnosis and to facilitate extensive tumor removal. This strategy is based on their surgical experience in 160 operations for pineal region tumors in which operative mortality was 4% with 3% permanent major morbidity. One-third of pineal tumors were benign for which surgery alone was usually curative. A gross total removal was possible in 31 of 107 malignant tumors. The supracerebellar infratentorial approach was preferred in 86% of patients.

The tumors displayed considerable histological diversity with germ cell tumors most common (37%), followd by glial cell tumors (28%) and pineal cell tumors (23%). Mixed tumors occurred 15% of the time. Spinal metastases were rare, occurring in less than 10% of patients with malignant tumors.

These results with a large series of pineal region tumors demonstrate the safety and efficacy of aggressive pineal tumor surgery.

Keywords: Pineal tumor; surgery; brain tumor; results.

Introduction

Clinical management of pineal region tumors is complicated by the diversity of histological subtypes which can occur and their anatomical location deep within the brain. The deep location thwarted early efforts to surgically approach the pineal region resulting in significant operative morbidity and mortality [8, 27]. These unsatisfactory results promped a conservative approach consisting of control of hydrocephalus followed by "blind" radiation without histologic confirmation [7, 12].

This conservative approach became obsolete as refinements in microsurgical techniques eventually enabled pineal region surgery to evolve safely and propitiously [6, 10, 16, 21]. Current management strategies for pineal region tumors are dependent upon accurate diagnosis of individual tumors, which can best be accomplished with surgically obtained tissue [2]. In addition to establishing a histological diagnosis, aggressive surgical removal can result in cure of most benign tumors and improved response to adjuvant therapy for malignant tumors [14, 19, 22]. Our surgical results with a large series of patients with pineal tumors demonstrates that aggressive surgical approaches can be accomplished safely, with improved outcome.

Methods and Materials

The authors performed 160 operations for pineal region tumors at the New York Neurological Institute. This included 6 patients who underwent reoperation for recurrent tumors. Patient age ranged from 4 to 69 years with an average age of 29 (Table 1). There were twice as many men as women (102 versus 52), mostly due to an overwhelming male predominance among tumors of germ cell origin (51 versus 6). Gender predilection was roughly equal among pineal cell and glial cell tumors.

Preoperatively all patients underwent diagnostic imaging with either CT scan, MRI or both. Currently MRI with and without gadolinium is the procedure of choice (Fig. 1). All patients underwent serum and CSF tumor marker analysis for β-HCG and alphafetoprotein. Postoperatively all patients with malignant tumors underwent CT scan with myelography or spinal MRI to screen for spinal metastases.

A histological diagnosis was made in all instances. Due to the diversity of histologic subtypes and frequent heterogeneity of the tumor types, an attempt was made to send as much tumor tissue as possible for histopathological examination. Germ cell tumors were the most common (57 patients) followed by glial cell tumors (43 patients) and pineal cell tumors (35 patients). Among individual subtypes, germinomas were the most common tumor (26 patients) followed by astrocytomas (23 patients) and pineocytomas (19 patients). Overall, one third of all tumors were benign. Tumors were of a mixed cell type in 15% of patients.

90% of patients presented with symptoms of increased intracranial pressure and required preoperative shunting procedures. Approximately 33% had symptoms of dorsal midbrain compres-

Table 1. *Summary of Pathology in 154 Patients Undergoing Surgery for Pineal Region Tumors at the New York Neurological Institute*

Tumor pathology	Number	Male/Female	Average age
Germ cell	57 (37%)	51/6	20.3
Germinoma	26		
Teratoma	9		
Lipoma	2		
Epidermoid	2		
Mixed malignant germ cell	14		
Immature teratoma	2		
Embryonal cell carcinoma	2		
Pineal cell	35 (23%)	19/16	33.7
Pineocytoma	19		
Pineoblastoma	7		
Mixed pineal cell	9		
Glial cell	43 (28%)	21/22	28.9
Astrocytoma	23		
Anaplastic astrocytoma			
Glioblastoma	4		
Ependymoma	10		
Oligodendroglioma	2		
Choroid plexus papilloma	1		
Miscellaneous	19 (12%)	11/8	45.7
Pineal cysts	4		
Meningioma	9		
Other malignant	3		
Other benign	3		
Total	154 (100%)	102/52	28.9

sion. On exam, 75% of patients had some degree of Parinaud's syndrome.

The infratentorial supracerebellar approach was used in 86% of patients (Fig. 1). A sitting position was used in nearly all instances. A supratentorial approach was used in 14% of patients, with the transcallosal interhemispheric approach generally preferred over the occipital transtentorial approach. The supratentorial approaches were preferred for patients whose tumors were large and had significant supratentorial or lateral extension.

Results

Of the 160 pineal region operations, the overall operative mortality was 4% (6 patients), with permanent major morbidity in 3% (4 patients) (Table 2). Over 90% of patients had an excellent outcome and a gross total resection was accomplished in 45% of patients. In all cases a histological diagnosis was obtained. Benign tumors accounted for approximately 33% of all pineal region tumors and surgery was generally curative for these patients. A gross total resection was possible in 46 out of 53 patients with benign tumors. Among 107 patients with malignant tumors, a gross total resection was possible in 31.

Of the six patients with operative-related deaths, all but one had complications directly resulting from hemorrhage into a tumor bed (Table 3). Two out of five patients with hemorrhage were recovering well following surgery when they hemorrhaged. Hemorrhage occurred on anywhere from postoperative day 2 to postoperative day 16.

Seventeen patients had significant postoperative morbidity with all but five eventually making a complete recovery. Major morbidity was most commonly associated with malignant tumors, prior radiation

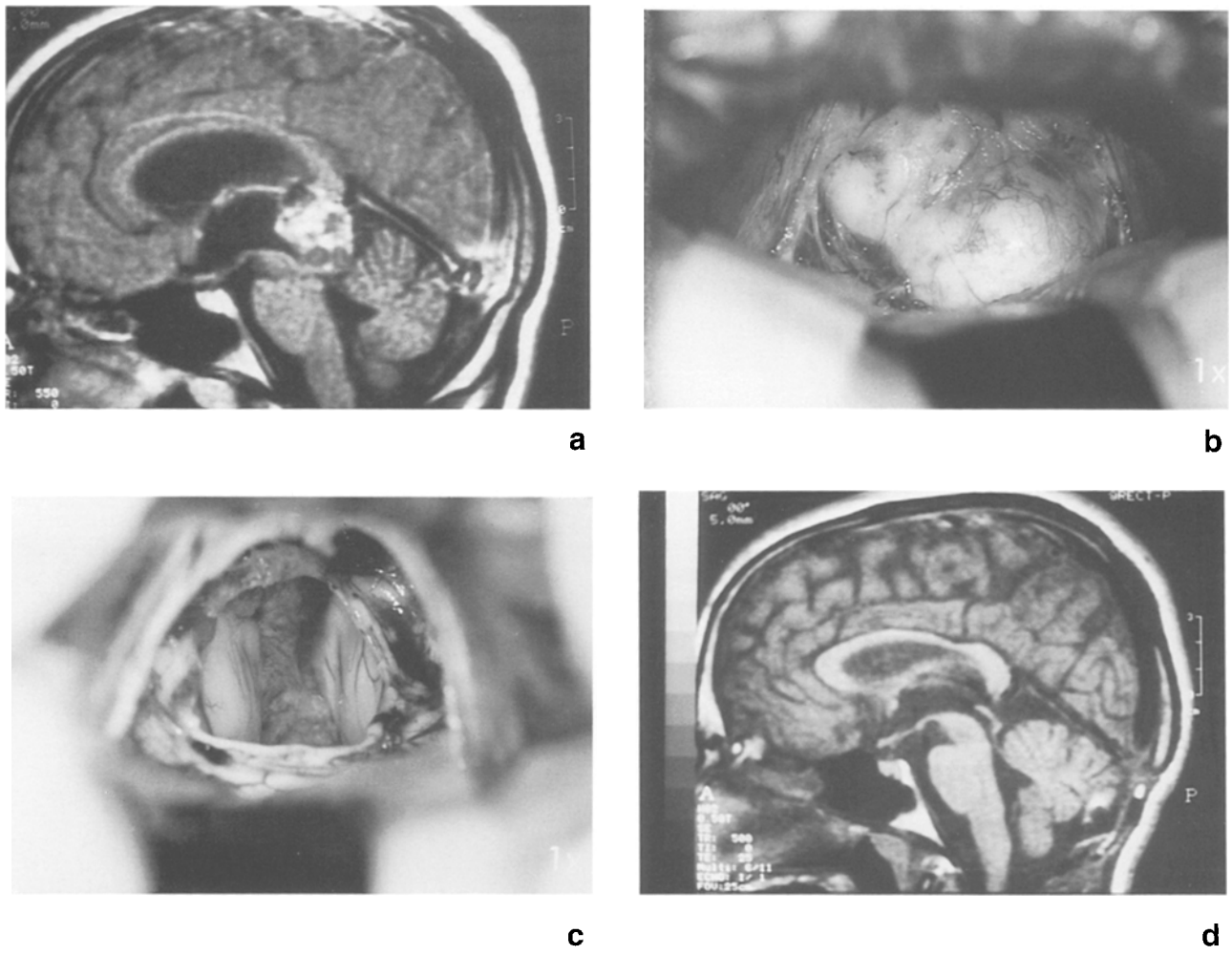

Fig. 1. (a) MRI with gadolinium of an 18 year old man who presented with symptoms of increased intracranial pressure and Parinaud's syndrome. There is a heterogeneously enhancing pineal mass causing obstructive hydrocephalus. This clinical presentation is typical of many patients with pineal region tumors. (b) Intraoperative photograph of dorsal surface of the tumor which was exposed through an infratentorial supracerebellar approach. (c) The tumor has been completely resected and the third ventricle is visualized with the choroid plexus at the center of the picture. Histopathological analysis revealed a mixed germinoma/dermoid tumor. (d) Postoperative MRI showing complete resection of tumor and relief of aqueductal obstruction

therapy or the presence of significant preoperative neurological impairment. Patients undergoing supratentorial approaches had a higher incidence of complications, however, this may partly be explained by a bias towards the use uf supratentorial approaches for larger tumors.

New or worsening disturbances in extraocular movements occurred in about one-third of patients with most gradually improving over time (Table 3). The next most common complications were ataxia and cognitive dysfunction, although, as with other complications of pineal surgery, these were generally transient. Other common complications included shunt malfunction and aseptic meningitis. Seizures, hemiparesis, and hemianopsia were rare complications that only occurred with supratentorial approaches.

As the authors' experience with pineal surgery increased, the operative complications were reduced. In the first 120 patients the combined mortality and permanent major morbidity rate was 8%. In the most recent 40 patients this complication rate was reduced to 2.5%.

All 84 patients with malignant tumors of germ cell, pineal cell, and ependymal cell origin underwent postoperative staging by either myelography or MRI. In this group of patients, the overall incidence of spinal metastases was 8%. Spinal metastases occurred in one patient with germinoma, one with non-germi-

Table 2. *Surgical Results in 160 Operations (154 Patients) for Pineal Region Tumors*

Histology	Biopsy	Subtotal resection	Total resection	Transient/ minor/no morbidity	Permanent major morbidity	Death	Total
Benign	0	7	46	52	0	1	53
Malignant	6	70	31	97	5	5	107
Total	6	77	76	149	5	6	160

Table 3. *Number of Patients with Significant Complications Following Pineal Region Surgery (160 Operations Performed)*

	Transient morbidity	Permanent morbidity
Surgical complications		
EOM dysfunction	54	16
Altered mental status	29	5
Ataxia	28	3
Aseptic meningitis	8	
Symptomatic hemorrhage	4	6
Extrapyramidal syndrome	5	
Hemiparesis	5	
Seizures	4	
Hemianopsia	2	1
Wound infection	1	
Bacterial meningitis	1	
Facial weakness	1	
CSF collection in wound	1	
Complications Related to Operative Positioning		
Subdural hematoma/hygroma	1	
Paraparesis/quadriparesis	1	1
Pin site fracture with CSF leak	1	
Sciatic nerve palsy	1	
Shunt complications		
Shunt malfunction	30	
Shunt infection	1	
Medical and iatrogenic complications		
Respiratory infection/insuff	5	
Steroid psychosis	3	
Erythema multiforme	1	
Pulmonary embolus	2	1
Deep vein thrombosis	2	
Pleural empyema	1	
Hepatitis		1
Ruptured gastric ulcer	1	
Multisystem failure	0	1

nomatous malignant germ cell tumor, one with pineocytoma, one with mixed pineal cell tumor, and three with pineoblastomas.

Discussion

A wide variety of histological subtypes can occur in the pineal region, making histologic diagnosis mandatory for optimal patient management [3]. Management decisions including choice of adjuvant therapy, estimation of long-term prognosis, and necessity for metastatic workup depend on the histological subtype present. CSF cytology, presence of tumor markers and radiographic characteristics can provide possible predictions as to the type of tumor present, however, a definitive diagnosis can only be obtained through surgically derived tissue specimens [2, 11, 23, 26].

Tumor specimens for diagnosis may be obtained through a variety of direct operative approaches, or alternatively, by stereotactic biopsy [2, 9]. Stereotactic biopsy is generally reserved for patients with disseminated or invasive tumors, or in patients whose medical conditions contraindicate a lengthy operation. Stereotactic biopsy increases the risk of diagnostic error since only a small specimen is provided for analysis [3, 5, 10]. Furthermore, many cell types are rare and difficult for even experienced neuropathologists to interpret. Additionally, in our series, 15% of patients had mixed cell types which could have easily been misdiagnosed with a small biopsy.

An open operation provides the opportunity to resect a large portion of tumor. For the one-third of pineal region tumors which are benign, surgery is usually curative [22]. Most malignant tumors may also be radically resected, improving the potential response to adjuvant therapy [14, 19, 22]. Pineal region tumors may be approached either supratentorially or infratentorially. The most popular approaches are the infratentorial-supracerebellar, occipital-transtentorial, and interhemispheric-transcallosal [2]. We generally prefer the infratentorial-supracerebellar approach because of its midline trajectory and because, in the sitting position, gravity is a useful adjunct in tumor dissection. The supratentorial approaches are especially useful for large tumors with extensive supratentorial or lateral components. The surgeon's degree of comfort with a given approach should also be considered in choosing the approach.

The most common complications of surgery include impairment of extraocular movements, altered mental status and ataxia. Complications are more frequent in patients with prior radiation therapy, tumors having a high degree of malignancy and invasion, and severe or prolonged preoperative symptoms [1]. Most problems are transient and improve spontaneously with time. Shunt malfunction occurs with surprising frequency and is probably related to increased protein content and cellular debris accumulating during surgery. Supratentorial approaches, which require brain retraction and sacrifice of bridging veins, can occasionally cause seizures, hemianopsia or hemiparesis. The most serious complications are related to postoperative hemorrhage in a subtotally resected tumor. This phenomenon is most common in pineal cell tumors and may occur up to several days after surgery. Hemorrhage can occur preoperatively as pineal apoplexy and has been reported with stereotactic biopsies [4, 18, 24].

Although surgery is generally curative for benign tumors, adjuvant therapy is generally indicated postoperatively for malignant tumors. Patients with malignant tumors should receive radiation therapy [2, 20, 25]. The only exceptions are occasional ependymomas or low grade pineocytomas that are encapsulated and have been completely resected. The indications for prophylactic spinal irradiation are controversial [2, 10, 15], however, we reserve spinal irradiation only for patients with radiographically documented metastases. Chemotherapy is given along with radiation for patients with malignant nongerminomatous germ cell tumors [2, 13, 17, 20].

This operative series demonstrates that tumors of the pineal region can be approached safely and effectively, using current microsurgical techniques. The approaches to the pineal region permit sufficient exposure for aggressive surgical resection. Although there are many potential complications of pineal region surgery, operative experience and judgement can minimize these risks. The benefits of surgery extend beyond that of establishing histological diagnosis particularly for the one-third of pineal tumors that are benign and treatable with surgery alone. Even malignant tumors may benefit from aggressive surgery as complete resection or at least radical debulking may be achieved to improve the response to adjuvant radiation or chemotherapy.

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