# Pineal region tumors: A retrospective analysis

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## Abstract
Pineal region tumors are rare comprising 0.4% to 0.1% of all primary tumors of the central nervous system[1,2] and constitute 3% to 11% of childhood brain tumors.[3-5] These tumors are classified into tumors of germ cell origin, which clearly account for the majority of tumors in this region and those originating from pineal parenchymal cells.[1] The latter include pineoblastomas, pineocytomas, and tumors of glial origin. These retain the potential for neuronal or glial differentiation.[1,6] Approximately three-fourths of tumors in this area are malignant with the propensity for seeding(3,7,8,9,10). Retrospectively we have analyzed 47 cases of pineal region tumors and have discussed the clinical features, histopathology, management and outcome.

**Keywords**: Pineal tumors, Central nervous system, Tumors of glial origin.

## Introduction
The clinical syndromes associated with posterior third ventricular region tumors relate directly to normal anatomy as well as tumor histology. Headache, nausea, vomiting and alteration of mental status are the usual presenting features. These symptoms are due to obstructive hydrocephalus caused by compression of the aqueduct of sylvius. Compression of superior colliculi either directly or due to tumor invasion results in the syndrome of vertical gaze palsy or Parinaud'st syndrome. In pineal germ cell tumors-precocious puberty, diabetes insipid us or hypogonadism may be the presenting features. In some of these tumors surgery offers cure, while others need adjuvant therapy. Adequate tissue sample for histological diagnosis is important for treatment planning. Before the development of contemporary microsurgical techniques, surgical therapy was associated with an operative mortality of 30% to 70% and morbidity of up to 65%.[11-16] Most neurosurgeons performed only ventricular shunting for obstructive hydrocephalus followed by fractionated radiation therapy, which allowed an overall mortality of less then 5% and a five year survival rate of 60 to 75%.[17-19,29] Recent advances in Neuroradiology [computed tomography (CT), magnetic resonance imaging (MRI)], micro neurosurgical techniques, modern neuroanaesthesia and postoperative intensive care have led to more encouraging surgical results. The mortality of direct surgery has been reduced to less than 5% and morbidity to a minimal level.[16,21-26] Presently surgical extirpation of pineal tumors is the main approach for pineal region tumors. Chemotherapy coupled with irradiation is needed to treat malignant pineal tumors.

Remissions have been reported in many cases in which mostly cisplatin based chemotherapy in conjunction with radiation therapy was delivered.[27-32] Retrospectively we have analyzed 47 cases of pineal region tumors and have discussed the clinical features, histopathology, management and outcome.

## Materials and Methods
This is a retrospective study carried out in the department of surgery, Career institute of medical sciences and hospital, I.I.M road Lucknow, (U.P).

Data was obtained from departmental records, patient files, operation notes and follow up files. From these records patient's demographic profile, pre and post-operative neurological status, management, complications, hospital course and follow up was analyzed. Appropriate statistical methods were used to analyse the data.

## Result

### Observation
Forty seven cases of posterior third ventricular tumors were reviewed. There were 35 males and 22 females between the age group of 1-87 years. Majority of cases were in their second and third decade. Male to female ratio was 2.9:1.

**Table 1:** Study of the symptomatology

| S. No. | Symptom | Numbers | % |
|---|---|---|---|
| 1 | Headache | 42 | 89.3 |
| 2 | Vomiting | 22 | 46.8 |
| 3 | Visual deterioration | 16 | 34 |
| 4 | Diplopia | 8 | 17 |
| 5 | Generalized seizures | 6 | 12.7 |
| 6 | Memory and behavioral changes | 7 | 14.8 |
| 7 | Altered sensorium | 8 | 12.7 |

**Table 2:** Neurological deficits

| S. No. | Symptom | Number | % |
|---|---|---|---|
| 1 | Hemiparesis | 5 | 10.6 |
| 2 | 6th paresis | 6 | 12.6 |
| 3 | Perinaud's syndrome | 27 | 57.4 |
| 4 | 7th nerve paresis | 3 | 6.3 |
| 5 | 3rd nerve paresis | 2 | 4.2 |
| 6 | Altered sensorium | 6 | 12.6 |
| 7 | Gait ataxia | 11 | 23.4 |

**Table 3:** Radiological findings

| S. No. | Diagnosis | Total | MRI | | | CT Scan |
|---|---|---|---|---|---|---|
| | | | T1W | T2W | Others | |
| 1 | Epidermoid | 12 | Hypointense | Hyper intene | Non contrast enhancing ADC* similar to brain | Hypodense, non enhancing |
| 2 | Cavernoma | 2 | Mixed signal surrounded by hemosiderin ring | Low signal more prominent | Homogenous enhancement | Isodense, contrast enhancing |
| 3 | Arachnoid cyst | 2 | Hypo intense | Hyper intense | Non contrast enhancing, ADC* similar to water | Resemble to CSF, nonenhancing |
| 4 | Pinealocytoma | 4 | Hypo to iso intense | Hyper intense Occasional area of hypo intense on T2W | Contrast enhancing | Isodense enhancing |
| 5 | Pinealoblastoma | 5 | Hypo to iso intense | Hyper intense | Contrast enhancing | Isodense enhancing |
| 6 | Astrocytoma | 1 | iso to hypointense | Heterogeneous | Irregular enhancement | Mixed density |
| 7 | Glioblastoma | 1 | Heterogenous ment | Heterogeneous | Inhomogenous contrast enhance | Mixed density |
| 8 | Immature teratoma | 3 | Mixed signal | Mixed signal | Mixed contrast enhancing | Mixed density |
| 9 | Germinoma | 2 | Isointense | Isointense | Contrast enhancing | Mild hyper dense and homogenously contrast |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | enhancing |
| 10 | Papillary pineal tumor | 1 | Hypo intense | Hyper intense | Mild contrast enhancin | |
| 11 | Acellular biopsy | 2 | Isointense | Isointense | Contrast enhancing | Mild hyperdence and homogenously Contrast enhancing |

ADA: *Apparent Diffusion Coefficient

Surgery was performed in 35 cases (74.4%). Out of these 35 cases, 24 cases required ventriculoperitoneal shunting prior to surgical excision. In 30 cases infratentorial supracerebellar approach was used and in 4 cases transcortical transventricular approach was used (Table 4). One patient was operated endoscopically and ETV and cystoventriculostomy was performed.

Gross total excision was achieved in 17 cases. Near total excision in 6 cases and subtotal excision was performed in 12 cases.

**Table 4**

| S. No. | Surgical Route | Numbers and Percentage |
|---|---|---|
| 1 | Infratentorial supracerebellar approach | 30(8s.7%) |
| 2 | Transcortical transventricular approach | 4(11.4%) |
| 3 | ETV and cystoventriculostomy | 1(2.8%) |

Treatment modalities in non operative cases (12) cases

**Table 5**

| S. No. | Diagnosis | ETV and bx* | VP shunt | Total |
|---|---|---|---|---|
| 1 | Pinealoblastoma | 1(bx) | - | 1 |
| 2 | Astrocytoma | 1(bx) | - | 1 |
| 3 | Acellular biopsy | 1(bx) | - | 1 |
| 4 | Presumptive Radiological diagnosis of germinoma | - | 9 | 9 |

*bx-biopsy

**Complications**

Postoperative complications were observed in 9 cases (18.3%). CSF leak and pseudomeningocele were present in 2 and 1 case respectively. They were managed by lumbar CSF drainage. Transient up gaze palsy was seen in 3 cases and bilateral 6th and up gaze palsy was seen in one case. These cases improved subsequently on steroid therapy. Operative site extradural hematoma and seizure were noted in one case each and were treated successfully.

## Discussion

Pineal region tumors are uncommon deep seated tumors of brain and comprise I% or less of all intracranial neoplasms.[1,2] These tumors are approximately ten times more common in children as compared to adults and constitute 3% to 11% of childhood brain tumors[3,5] and commonly seen in 2nd decade of life.[33,34] In our series 61.7 % cases were present in 2'd and 3'd decade. Approximately three-fourths (75%) of Pineal tumors are malignant in nature with the tendency for seeding.[3,7-10] A higher incidence of pineal region tumors in Asian countries compared to Western countries has been reported. In the Brain Tumor Registry of Japan (BTRJ), there were 38,273 primary brain tumors except those of unknown histology (1123 cases) registered in the period between 1984 and 1993. There were 807 pineal region tumors (with 104 unknown histology) who were registered in BTRI. Of these pineal region tumors, germ cell tumors had highest frequency (70.3%), followed by pineal parenchymal tumors (12.%), pineocytoma 7.8% and pineoblastoma 4.2%. Limited to germ cell tumors germinoma had highest incidence (68.0%), followed by teratoma (including malignant teratoma) with frequency of 14.7% in pineal region.[35] In Ojemann et al, Regis et al and Alexander N. Konovalov et al series, germ cell tumor were commonest pineal region tumor.[33,34,36] Gliomas were second commonest tumors in the series of Regis et al[36] and Alexander N. Konovalov et al[34] but pineal: parenchymal tumors were second most common in Ojemann

et al series.[33] In a study from India, Pragati Kumar et al found highest incidence of pineal parenchymal tumors 33.8% followed by gliomas in 37%. They found germ cell tumors in only 7.4% and miscellaneous tumors in 16.6%.[37] In the present series, benign lesions were present in 16 cases (34%) and malignant lesions were present in 31 (65.9%) cases. In benign lesions, epidermoids were commonest (12 cases). In malignant lesions, Germ cell tumors were most common (16 cases), followed by pineal parenchymal tumors (8 cases) and gliomas (7 cases). Majority of pineal region tumors present with symptoms of intracranial hypertension because of obstructive hydrocephalus due to compression or direct infiltration of the aqueduct of sylvius. Approximately 90% of patients with pineal region tumors have symptoms of intracranial hypertension at the time of presentation.3a In our series 89.3% cases had symptoms of raised intracranial features. Headache was present in 42 cases (89.3%) and it was associated with vomiting in22 cases (46.5%). Perinaud's syndrome was seen in 27 (57.4%) cases. In a study carried out by Alexander N. Konovalov et al found eye movement disorders in 76% cases 30. Magnetic resonance imaging and Computed tomography are important diagnostic tools in the detection of these tumors. CT scan easily detects tumor calcification. MRI is the investigation of choice for pineal region tumors. It gives accurate information about size, extent of tumor, anatomical relations to surrounding neurovascular structures. Establishing histological nature of the tumor and extent of tumor resection are important prognostic factors. These two factors appear dominant in predicting outcome.[25,38-40] Before the development of microsurgical techniques, treatment strategy usually involved ventricular drainage followed by fractionated radiation therapy because of high operative mortality of 30% to 70%o and morbidity of up to 65% after surgery.[11-16] Ventricular drainage followed by fractionated radiation therapy had overall mortality of less then 5oh and a S-year survival rate of 60 to 75year.[17,18] Nowadays with the introduction of modern microsurgical techniques 24 Y and technology, development of neuroanesthesiology and neuro-radiological techniques, surgical treatment of pineal region tumors can be carried out. The mortality of direct surgery has been reduced to under 5% and morbidity to a minimal level.[16,21-26]

In the present series, ventriculoperitoneal shunting was performed 33 cases (70.2%). In 9 cases, only VP shunt was done and in 24 cases definite surgery was done after VP shunt. Nowadays the endoscopic third ventriculostomy is good alternative to normalize CSF circulation for hydrocephalus in pineal region tumors. In patients with malignant germ cell tumors or pineoblastomas, there is risk of peritoneal metastasis following shunting.[42,43,49] Infection, malfunction or peritoneal metastasis associated with ventriculoperitoneal shunts are eliminated by third ventriculostomy. In the present series ETV and biopsy was done in 3 cases. ETV itself can potentially facilitate dissemination of the neoplasm.[44,45] Haw and Steinbok[47] reported metastatic deposit of the pineal germinoma at the ventriculoscope tract. There was no dissemination in ETV group in the present series.

Presently, surgical excision remains the treatment of choice for pineal region tumors and a wide variety of lesions can be safely excised.[7,23-26,48,49] Many approaches for removal of pineal region tumors cafi be adopted. Supracerebellar-infratentorial and occipital-transtentorial approaches are corpmonly used surgical approaches for this location3a. In lg7l, Stein popularized the infratentorial supracerebellar approach, originally described by Krause.

Germinomas are highly radiosensitive and radiation is the primary treatment modality. There is no significant difference between the outcome of patients irradiated after direct surgery and those receiving radiotherapy alone.[8,17,50] The patients with definite radiologic features do not require direct surgery or stereotactic biopsy for pathologic confirmation of diagnosis and can be irradiated directly. In the present series direct radiotherapy was given to 11 cases on the basis of radiological diagnosis of germinoma and these patients responded very well. Three cases were lost to follow up. The tumor disappeared in other with no recturence in available follow up.

Aggressive tumors like malignant germ-cell tumors, pineal parenchymalcell tumors tend to invade surrounding structures and have a risk of CSF disseminationz.[27,29-32,51] There is controversy about the extent of radiation. At present craniospinal ircadiation is indicated only in patients with cliniial or radiologic evidences of dissemination of tumor because myelopathy is a serious late complication of craniospinal irradiation.[38,52-54] In the present series, one case of pinealocytoma had leptomeningeal seeding. Platinum-based multiagent chemotherapy has improved the outcome in patients with nongerminmatous germ cell tumors and anaplastic pinealocytornas.[30,31,43,55,56] The benefits of this approach are still debated,[29,51] although patients with pineoblastomas are often treated with adjuvant systemic chemotherapy after craniospinal irradiation. The incidence of pineal region epidermoid tumors is approximately 3% to 4% of all intracranial epidermoids.[57] The incidence of epidermoid tumors in the 26 pineal region varies from 3.4% to 10 % in different series.[57,58] In present series, epidermoid was present in 12 cases (255%) out of 47 cases. Exact pathogenesis of epidermoids in general is still under discussion. Defect in the cleavage of the neural tissue from

the cutaneous ectoderm, embryonic inclusions, differentiation from multipotential cell rests, and epithelial remnants are the various other mechanisms implicated in the origin of epidermoid tumor. The seedling of the subarachnoid space by the irritant component of the epidermoid cyst results in aseptic chemical meningitis. The incidence of recurrence after radical excision is uncommon.[57-60]

Pineal region cavernomas and arachnoid cysts are rare and only case reports are available in the literature.[61-63] In present series 2 cases of arachnoid cysts and 2 cases of cavernomas were noted. There was no recuffence in available follow up.

## Conclusion

Pineal tumors are a heterogeneous group of mass lesions originating in and around the pineal gland and represent a spectrum of neoplasms" Direct surgical excision remains the treatment of choice for pineal region tumors with minimum mortality and morbidity. Complete excision should be the goal for majority of these lesions. For germinomas, radiation therapy good long term recurrences free survival and outcome. Endoscopic biopsy and ETV offers histological diagnosis and CSF diversion in many of such lesions and further treatment can be planned accordingly.

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## Conflict of Interest

None.

## References

1. Russell DS, Rubenstein LJ. Pathology of tumors of the nervous system. 5th ed. Baltimore: William &Wilkins, 1989:83-350.
2. Benjamin JC, Furneaux CE, Scholtz CL. Pineal astrocytoma. Surg Neurol. 1985;23:139-41.
3. Abay EO II, Laws ER, Grand GL. Pineal tumors in children and adolescents. *J Neurosurg*. 1981;55:889-95.
4. Fuller BG, Kapp DS, Cox R. Radiation therapy of pineal region tumors: 25 new cases and a review of 208 previously reported cases. *Int Radiat Oncol Biol Phys.* 1994;28:229-45.
5. Hart MN, Earle KM. Primitive neuroectodermal tumors of the brain in children. *Cancer*. I973;32:890-7.
6. Burger PC, Scheithauer BW, Vogel FS. Surgical pathology of the nervous system and its coverings. 3rd ed. New York: Churchill Livingstone, I99l; 234-6t.
7. Bruce JN, Stein BM. Supracerebellar approaches in the pineal region. In: Apuzzo MLJ, ed. Brain surgery: complication, avoidance and management. New York: Churchill-Livingstone; 1993:51:1-36.
8. Jooma R, Kendall B. Diagnosis and management of pineal tumors. *J Neurosurg.* 1983;58:654-65.
9. Neuwelt EA, Glasberg M, Frenkel E, Clark K. Malignant pineal region tumors. A clinico-pathological study. *J Neurosurg.* 1979;51:597-607.
10. Neuwelt EA. An update on the surgical treatment of malignant pineal region tumors. In: Clinical neurosurgery: proceedings of the congress of neurological surgeons, Volume 32. Baltimore: Williams & Wilkins, 1985:397-428.
11. Cumins FM, Taveras JM, Schlesinger EB. Treatment of gliomas of the third ventricle and pinealomas. With special reference to the value of radiotherapy. *Neurol.* 1960;10:103:1-6.
12. Dandy WE. Operative experience in cases of pineal tumor. *Arch Surg.* 1936;33:19-46.
13. Davidoff LM. Some considerations in the therapy of pineal tumors. *Bull N Y Acad Med*. 1967;43:537-61.
14. Horrax G. Treatment of tumors of the pineal body. Experience in a series of twenty-two cases. *Arch Neurol Psychiatry*. 1950;64:227-42.
15. Poppen JL, Marino R Jr. Pinealomas and tumors of the posterior portion of the third ventricle. *J Neurosurg*. 1968;28(3):57-64.
16. Suzuki J, Iwabuchi T. Surgical removal of pineal tumors (pinealomas and teratomas). Experience in a series of 19 cases. *J Neurosurg.* 1965;23:565-11.
17. Jenkin RDT, Simpson WJK, Keen CW" Pineal and suprasellar germinomas. t. Results of radiation treatment. J Neurosurg 1978;48:99-107.
18. Obrador S, Soto M, Gutierrez-Diaz JA. Surgical management of tumors of the pineal region. *Acta Neurochir.* 1976;34(1-4):59-71.
19. Torkildsen A. Should extirpation be attempted in cases of neoplasm in or near the third ventricle of the brain? Experience with a palliative method. *J Neurosurg.* 1948,5:249-75.
20. Wara WM, Fellows CF, Sheline GE, Wilson SB, Townsend JJ. Radiation therapy for pineal tumors and suprasellar germinomas. *Radiol.* 1977;124-221.
21. Edwards MSB, Hudgins RI, Wilson CB, Levin VA, Wara WM. Pineal region tumors in children. *J Neurosurg.* l988;68:689-97.
22. Hoffman HJ, Yoshida M, Becker LPE. Pineal region tumors in childhood: experience at the Hospital for Sick Children. In: Humphreys RP, ed. Concepts in pediatric neurosur gery 4.Basel: Karger, 1983:360-86.
23. Lapras C, Patet JD. Controversies, techniques, and strategies for pineal tumor surgery. In: Apuzzo MLJ, ed. Surgery of the third ventricle. Baltimore: Williams& Wilkins, 1987:649-62.
24. Luo S, Deze L, Zhang M, Zhong CW. Occipital transtentorial approach for removal of pineal region tumors: report of 64 consecutive cases. *Surg Neurol.* 1989;32:36-9.
25. Sano K. Pineal and posterior third ventricular tumors: a surgical overview. In: Apuzzo MLJ, ed. Surgery of the third ventricle. Baltimore: Williams & Wilkins, 1998:801-19.
26. Stein BM. The infratentorial supracerebellar approach to pineal lesions. *J Neurosurg.* 1971;35:197-202.
27. Allen JC, Bruce J, Kun LE, Langford LA. Pineal region tumors. In: Cancer in the nervous system. New York: Churchill-Livingstone, Levin, VA, ed. 1996:171-85.
28. Chan HS, Humpreys RP, Hendrick EB, Chuang SH, Fitz CR, Becker LE. Primary intracranial choriocarcinoma. A report of

two cases and review of the literature. *Neurosurg.* 1984;15:540-5.
29. Ghim TT, Davis P, Seo JJ, Crocker I, O'Brien M, Krawiecki N. Response to neoadjuvant chemotherapy in children with pineoblastoma. *Cancer*. 1993;72:1795-800.
30. Herrmann HD, Westphal M, Winkler K, Laas RW, Schulte FJ. Treatment of nongerminomatous germcell tumors of the pineal region. *Neurosurg.* 1994;34:524-9.
31. Matsutani M, Sano K, Takakura K. Primari intracranial germ cell tumors: A clinical analysis of l53histologically verified cases. *J Neurosurg.* 1997;86 446-55.
32. Patil AA, Good R, Bashir R, Etemadrezaie H. Nonresective treatment of pineoblastoma: A case report. *Surg Neurol.* 1995;44:386-9l.
33. Ojemann SG, Chang S, Berger MS. Surgery for pineal region tumors: Results, complications, and outcomes in 55 patients. *Neurosurg.* 1998;43(3):688.
34. Alexander N. Konovalov, David I. Pitskhelauri. Principles of treatment of the pineal region tumors. *Surg Neurol.* 2003;59:250-68.
35. Kazuhiro N. Epidemiology of germ cell tumors in Asia of pineal region tumor. *J Neuro-oncol.* 2001;54(3):211-7.
36. Regis J, Bouillot P, Rouby-Volot F, Branger DF, Dufour H, Jean C, et al. Pineal region tumors and the role of stereotactic biopsy: Review of the mortality, morbidity, and diagnostic rates in 370 cases. *Neurosurg*. 1996;39(5):907-14.
37. Kumar P, Tatke M, Sharma A, Singh D. Histological analysis of lesions of the pineal region: A retrospective study of 12 years. *Pathol Res Pract.* 2006;202(2):85-92.
38. Chang SM, Lillis-Hearne PK, Larson DA, Wara WM, Bollon AW, Prados MD. Pineoblastoma in adults. *Neurosurg.* 1995;37(3):383-90.
39. Jennings MT, Gelman R, Hochberg F. Rntraqanial germ-cell tumors: natural history and pathogenesis. *J Neurosurg*. 1985;63:155-67
40. Satoh H, Uozumi T, Kiya K, Kurisu K, Arita K, Sumida M, Ikawa F. MRI of pineal region tumors: relationship between tumors and adjacent structures. *Neuroradiol.* 1995;37:624-30.
41. Robinson S, Cohen AR. The role of neuroendoscopy in the treatment of pineal region tumors. *Surg Neurol.*1997;48:360-7.
42. Duffner PK, Cohen M, Sanford RA, Horowitz ME, Krischer JP, Burger PC, et al. Lack of efficacy of postoperative chemotherapy and delayed radiation in very young children with pineoblastoma. *Med Pediatr Oncol.* l995;25(1):38-44.
43. Schild SE, Scheithauer BW, Schomberg PJ, Hook CC, Kelly PJ, Frick L, et al.. Pineal parenchymal tumors. Clinical, pathologic and therapeutic aspects. *Cancer*. 1993;72:870-80.
44. Ung AO, Triscott JA, Leditschke JF, Smith JA. Metastasis of pineal germinoma via ventriculoperitoneal shunt. *Aust NZ J Surg*. 1993;63:409-12.
45. Fuller BG, Kapp DS, Cox R. Radiation therapy of pineal region tumors: 25 new cases and a review of 208 previously reported cases. *Int J Radiat Oncol Biol Phys*. 1994;28(1):229-45.
46. Gangemi M, Maiuri F, Donati P, Sigona L, Iaconetta G, De Divitiis E. Neuroendoscopy: Personal experience, indications and limits. *J Neurosurg Sci.* 1998;42:1-10.
47. Haw C, Steinbok P. Ventriculoscope tract recurrence after endoscopic biopsy of pineal germinoma. *Pediatr Neurosurg*. 2001;34:215-7.
48. Konovalov AN, Spallone A, Pitskhelauri DI. Meningioma of the pineal region: a surgical series of 10 cases. *J Neurosurg*. 1996;85:586-90.
49. Konovalov AN, Spallone A, Pitskhelauri DI. Pineal epidermoid cysts: diagnosis and management. *J Neurosur*. 1999;91:370-4.
50. Sawamura Y, Tribolet N, Ishu N, Abe H. Management of primary intracranial germinomas: diagnostic surgery or radical resection? *J Neurosurg.* 1997;87:262-6.
51. Schild SE, Scheithauer BW, Haddock MG. Histologically confirmed pineal tumors and other germ cell tumors of the brain. *Cancer*. 1996;78:2564-71.
52. Disclafani A, Hudgins RI, Edwards MSB, Wara W, Wilson CB, Levin VA. Pineocytomas. *Cancer*. 1989;63:3024.
53. Packer RJ, Sutton LN, Atkins TE. A prospective study of cognitive function in children receiving whole-brain radiotherapy and chemotherapy: 2-year results. *J Neurosurg.* 1989;70:707-13.
54. Sutton LN, Radcliffe J, Goldwein JW. Quality of life of adult survivors of germinomas treated with craniospinal irradiation. *Neurosurg.* 1999;45:1292-8.
55. Bosl GJ, Yagoda A, Whitmore WF. VP-16-213 and cisplatin in the treatment of patients with refractory germ-cell tumours. *Am J Clin Oncol*. 1984;7:327-30.
56. Einhorn LH, Donohue J. Cis-diamminedichloroplatinum vinblastine, and bleomycin combination chemotherapy in disseminated testicular cancer. *Ann Intern Med*. 1977;87:293-8.
57. Konovalov AN, Spallone A, Pitzkhelauri DL. Pineal epidermoid cysts: diagnosis and management. *J Neurosurg.* 1999;91:370-4.
58. Ketan I. Desai, Trimurti D. Nadkarni, Sudhir C. Fattepurkar, Atul H. Goel, Pineal epidermoid cysts: a study of 24 cases. *Surg Neurol*. 2006;65:124-29.
59. Cantu RC, Ojemann RG. Glucocorticoid treatment of keratin meningitis following removal of a fourth ventricle epidermoid tumor. *J Neurol Neurosurg Psychiatry*. 1968;31:7:3-5.
60. Altschuler EM, Jungreis CA, Sekhar LN, Janetta PJ, Shepak PE. Operative treatment of intracranial epidermoid cysts and cholesterol granulomas. Report of 21 cases. *Neurosurg.* 1990;26:606-14.
61. Vaquero, J, Carrillo R, Cabezudo J, Leunda G, Villoria F, Bravo G. Cavernous angiomas of the pineal region. Report of two cases. *J Neurosurg.* 1980;53:833-5.
62. Behrens, P, Ostertag CB. Stereotactic management of congenital midline cysts. *Acta Neurochir (Wien).* 1993;123:14l-6.
63. Raimondi, AJ, Tomita T. Pineal tumours in childhood. Epidemiology, pathophysiology, and surgical approaches. *Childs Brain.* 1982;9:239-66.

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