PINEALOMA WITH METASTASES IN THE CENTRAL NERVOUS SYSTEM

A RATIONALE OF TREATMENT*

FRED D. FOWLER, M.D.,† EBEN ALEXANDER, JR., M.D., AND COURTLAND H. DAVIS, JR., M.D.

Section of Neurosurgery, Department of Surgery, Bowman Gray School of Medicine, Winston-Salem, North Carolina

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The metastatic potentiality of pineal tumors has been demonstrated by a number of isolated case reports. In 1911, Bailey and Jelliffe summarized the literature pertaining to pineal tumors since the first report by Blane in 1800. In none of these cases was the occurrence of metastatic spread mentioned. In 1925 Horrax and Bailey reported 2 cases in which there were metastases and it has been shown subsequently that tumors arising from the pineal body may extend beyond their site of origin by direct continuity, by seeding through the cerebrospinal fluid pathways, and, occasionally, through the blood stream. These reports have been summarized in Table 1.

There are 3 reported cases of pineal tumors with extracranial metastases. Stowell et al. described a patient with soft, nodular metastases in his lung. This patient had been subjected to a transcallosal exploration in an attempt to remove his tumor. It is of interest to note that this neoplasm was histologically identified as a choriocarcinoma, and the chorionic gonadotropin was elevated both in the urine and cerebrospinal fluid. Tompkins et al. found metastases to the lung in 2 out of 13 cases of pineal tumors in which autopsy was performed. In 1 of their cases direct invasion of the straight sinus by the tumor was demonstrated. This patient had been explored through the right parieto-occipital cortex with incomplete removal of his lesion. He died 4 months postoperatively and pathologically this tumor was classified as a teratocarcinoma. In their second case the tumor was partially removed at surgery and was histologically identified as a pinealoma. This patient was given roentgen therapy to the posterior portion of the third ventricle. Ten months later a spastic paraplegia developed, and the cerebrospinal fluid at this time contained "fragments of necrotic tissue in which neoplastic cells were identified." Radiation was then given to the vertebral column, but the condition of the patient deteriorated and he died 6 months later. At autopsy tumor could not be identified at the site of the pineal body,

† Now at Children's Medical Center, Boston, Massachusetts.
and the structures in this region were replaced by arenaceous bodies and dense fibrous connective tissue. However, tumor was found in the lung and tracheobronchial lymph nodes. Examination of the spinal cord was not done. As will be noted, all reported patients with extracranial spread of their tumor had been subjected to direct surgical exploration. It is probable that this has played some part in allowing the malignant cells access to the blood stream.

Spread by means of the cerebrospinal fluid pathways has been mentioned by Cushing who pointed out the similarity between the pinealoblastoma and the medulloblastoma stating that they are "akin . . . both in their microscopic appearance and behaviour (e.g., in their tendency to seed themselves in the floor of the third ventricle)." Horrax and Bailey noted in their series of 12 cases that there was spread to the anterior part of the third ventricle or posterior fossa in 2. Russell and Sachs reported that in 7 of 15 cases at autopsy there were metastases to either the ventricles or the subarachnoid space. Baggenstoss and Love reported a patient from whom a tumor, which was identified pathologically as a pinealoma, was removed from the suprachiasmatic region. Roentgen therapy was given to the head and the patient did well for 18 months at which time he began to have pain in his left leg. At laminectomy multiple tumor nodules, having the same histologic appearance as his cranial lesion, were found to be implanted about the cauda equina.

The occurrence of spread of pineal body tumors is likely to be more frequent than may be inferred from the number of reported cases because of the lack of pathologic examinations of the spinal cord. It has been shown that examination for these metastases must be done histologically, as, on occasion, diffuse meningeal involvement that is not grossly obvious may occur. It is also possible that before the use of palliative roentgen therapy, many of these patients died quite promptly with increased intracranial pressure as a result of their primary tumor, and thus metastases did not have time to occur or were not clinically significant prior to death. As the longevity of the patient is increased by decompression combined with roentgen treatment directed toward the primary lesion, an increased incidence of metastases may become apparent. The following cases are presented in the hope that a more general cognizance of this problem may lead to a more efficacious manner of therapy.

CASE REPORTS

Case 1. NCBH #185634. L.L., a 10-year-old white male, was admitted to the North Carolina Baptist Hospital on May 17, 1954. He had been in good health until 10 months previously, when his appetite became poor, he began to lose weight, and he seemed to tire more easily. He then began to have polydipsia and polyuria. Seven months before admission he started having frontal headaches and aching pains in his legs and was admitted to another hospital for metabolic investigation without any definite conclusions being reached. The patient became continually weaker, and began to have vomiting associated with his headaches. Studies done 3 months prior
to admission showed the cerebrospinal fluid to contain 65 leukocytes (72 per cent mononuclear cells); protein 21 mg. per cent, sugar 48 mg. per cent. During the next 2 months the patient became increasingly ataxic, and the vision in his right eye diminished. Because of his increasing neurologic deficit he was referred for further study.

**Examination.** The patient was cachectic and appeared chronically ill and malnourished. He had intermittent periods of drowsiness, and it was difficult to sustain his attention for more than a few minutes at a time. The head was 21½ inches in circumference and there was prominence of the frontal bosses. He had bitemporal baldness. There was no Macowen’s sign. There was moderate bilateral optic atrophy with a complete left temporal visual field loss and an incomplete right lower temporal field defect. Vision—O.D. 20/200; O.S. 20/50. Extraocular movements were normal. There was no ataxia of the extremities, but there was slight truncal ataxia. The genitalia were small and left testis was undescended. There were no palpable testicular masses.

**Laboratory Findings.** Urinalysis and blood counts were normal. Blood test for syphilis was negative. Tuberculin test was negative. Spinal fluid: pressure 160 mm.; 134 leukocytes (98 per cent mononuclear cells); protein 85 mg. per cent; sugar 39 mg. per cent. Roentgenograms of the chest were negative, and skull films showed no evidence of calcification above the sella turcica or in the pineal region.

**Hospital Course.** The patient was prepared for 2 days with ACTH and cortisone because of the possibility of his having a suprasellar lesion, and on May 24, 1954 ventriculography was performed. This showed dilatation of the lateral ventricles and the anterior portion of the third ventricle. Air passed readily between the two lateral ventricles. In the brow-down position a mass was demonstrated in the posterior part of the third ventricle, and air did not pass beyond this point (Fig. 1).

**Operation.** The posterior fossa was explored with the intent of performing a ventriculocisternostomy. When the dura mater was opened, a pink-white fleshy
nodule was found adherent to the left cerebellar hemisphere. The fourth ventricle appeared to be completely normal. The lower end of the aqueduct of Sylvius was seen, and from it protruded a small tuft of tissue similar in appearance to that found on the cerebellum. The cerebellar nodule was quite superficial and easily removed. A soft #8 red rubber catheter was placed subcutaneously as a shunt between the right lateral ventricle and the cervical subarachnoid space and the wound was closed.

Postoperative course was uneventful, and the patient was continued on gradually decreasing doses of ACTH and cortisone for 7 days. He was discharged on his 11th postoperative day, and was referred to the Charlotte Memorial Hospital for roentgen therapy with a recommendation for total cerebrospinal axis irradiation. Treatment was given with 220 kV.; 0.5 Cu, 1.0 Al filter. The patient received an air dose of 1800 r through each of 2 lateral ports directed to the region of the pineal body over a 12-day period. He also received an air dose of 1700 r through each of 4 ports covering the entire spinal column over a period of 18 days.

The patient has now been studied for a period of 12 months and has shown gradual improvement. He has gained 15 pounds, but is still drinking up to 1 gallon of fluids a day. His appetite is good and he is free from headache. He is no longer ataxic, and there are no other cerebellar signs. At present his vision is 20/70 in both eyes, but there is still a temporal defect in the visual field of his left eye.
Pathology. NCB No. 54-2086 (Fig. 2). Biopsy from cerebellar hemisphere. The tumor is composed of cells showing a gradation in nuclear size. The smaller cells are about the size of a lymphocyte and have scanty cytoplasmic processes. These are some intermediate-sized cells and numerous cells with large, heavily staining nuclei. In some of these a nucleolus is visible. Mitotic figures are not seen. There is a finely reticulated background produced by the cytoplasmic processes of these cells. There is an occasional multinucleated giant cell. The vessels appear normal except for occasional perivascular clusters of the small cells. Diagnosis: Pinealoma.

Comment. This patient exemplifies the spread of pineal tumors by means of the cerebrospinal fluid to other parts of the central nervous system. The presence of cells in the spinal fluid is of interest as it seems likely that a certain number of these may have been derived from the tumor itself. There is a morphologic similarity between the small cells of pineal tumors and the mononuclear cells of hematogenous origin, and it is probable that on routine examination of the spinal fluid the significance of this pleocytosis may pass unrecognized. Dorothy Russell39 considers the small cells as immature forms of the larger parenchymal cells, and hence the production of tumor implants from these cells seems quite plausible.

This patient also had evidence of injury to the structures in the suprasellar region. The early onset of diabetes insipidus in cases of pineal tumors has been noted by other authors.16,33 This is occasionally caused by actual tumor implants in the anterior portion of the third ventricle, but it was felt that the ventriculogram adequately ruled out any significant mass in this location. It is more probable that these symptoms were secondary to the obstructive hydrocephalus with ballooning of the lamina terminalis into the suprasellar region. It was because of the possibility of a lesion in this area that the child was given supportive therapy with ACTH and cortisone, as has been recommended by Ingraham et al.21 This may have been helpful in this debilitated child as he withstood air studies and operation remarkably well.

Case 2. NCBH #139872. B.S., a 19-year-old boy, was first admitted to the North Carolina Baptist Hospital on Oct. 5, 1951. He complained at that time of headaches, nausea, vomiting, and diplopia of 8 weeks' duration. He had difficulty reading fine print, and about 3 weeks prior to admission had noted numbness of the right side of his face.

Examination. His pupils were dilated and reacted poorly to light. There was no ptosis of the eyelids and extraocular movements were normal. The blind spots were enlarged, but there were no visual field defects. There were severe bilateral papilledema. He had a slightly decreased sensibility to pin prick over the right side of his face. Reflexes and coordination were normal. There were no palpable masses in the testes. Genitalia were normally developed.

Roentgenograms of the skull showed midline calcification in the region of the pineal body. On Dec. 7, 1951 the patient underwent ventriculography which demonstrated dilatation of the lateral ventricles and the anterior part of the third ventricle with a rounded mass present in the posterior portion (Fig. 3). There was no air seen in the fourth ventricle. Fluid removed from the lateral ventricles at this time contained 10 "mononuclear cells" per c.mm.
Operation. The posterior fossa was explored and the cerebellar tonsils were found to be herniated into the foramen magnum. There was no evidence of tumor in the cerebellum or fourth ventricle, but a catheter passed into the aqueduct of Sylvius met with an obstruction. A ventriculocisternostomy was done.

Postoperative course was uneventful and the patient was discharged from the hospital asymptomatic to receive roentgen therapy on an outpatient basis. He was treated with 200 kV.; 50 cm. target distance; 58 r per min.; 1 mm. Cu filter; through 4 seven-cm. ports, directed toward the posterior third ventricle, receiving 1000 r through each.

2nd Admission, Feb. 3, 1952. The patient had done well since his discharge from the hospital except for occasional dull headache and some vomiting associated with roentgen therapy. He was admitted for re-evaluation and to have ventriculography repeated. On Feb. 4, 1952 a ventricular tap was done and the pressure in the lateral ventricle was about 30 mm. of cerebrospinal fluid. Three to 4 cc. of air were injected before the procedure was discontinued, but subsequent roentgenograms failed to demonstrate the ventricular system. The patient was discharged, his condition essentially unchanged.

3rd Admission, Oct. 20, 1953. Starting about 4 months prior to this admission, the patient noticed numbness of the backs of his legs. This gradually progressed until several days before admission when he sustained a severe burn of his buttocks while leaning against a steam radiator.

Examination. The area of the posterior fossa decompression was flat. There was anesthesia over the L4 through S5 segments on the left, and hypesthesia over S2 through S5 segments on the right. The left ankle jerk was absent. He had very poor anal sphincter tone.

The spinal fluid contained 1,000 cells per c.mm. (98 per cent mononuclear cells); protein was 298 mg. per cent. A myelogram demonstrated a mass extending from L1 through L3 (Fig. 4).

Fig. 3. Case 2. Ventriculogram, lateral view. The lateral ventricles are enlarged and there is a mass in the posterior portion of the third ventricle. Note also calcification in region of the pineal body.
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Operation. An upper lumbar laminectomy was performed, disclosing a pink-grey tumor about 8 cm. in length surrounding the roots of the cauda equina. Some of this was removed and the dura mater was left open.

Course. Following surgery, the patient was on catheter drainage for 2 weeks, after which he was able to void satisfactorily. The sensory loss and reflex changes in his legs persisted. He was given a course of roentgen therapy, receiving 2970 r to the lower dorsal and lumbar spinal column.

Following this therapy he returned to college and got along well.

4th Admission, Aug. 10, 1954. Three weeks before this admission the patient began to have aching and stiffness in the muscles of his neck and shoulders, and tingling in his hands. For the last 5 days he had noted increasing weakness in his legs.

Examination. He had hypesthesia up to the C4 level with hyperactive reflexes in his arms and right leg. There was generalized weakness of all muscle groups, especially those of the shoulder girdle and right arm. The bladder was distended to the umbilicus.
Lumbar puncture revealed a complete manometric block. The fluid was xanthochromic with protein of 725 mg. per cent and 107 cells per c.mm. These cells for the most part resembled mononuclear cells, but occasional larger cells very similar to the pineal parenchymal cells were seen. A myelogram was done which showed a complete block at the C5-C6 level (Fig. 5). The oil passed freely over the T12-L4 area in which, prior to roentgen therapy, there had been a complete block.

Operation. Cervical laminectomy was done on Aug. 11, 1954. The dura mater was full and bulging at the C4-C5 level and on opening it the leptomeninges were cloudy in several areas. The dentate ligaments were cut, and on moving the cord to the left a grey tumor was found anterior and lateral to the cord on the right. Biopsies of this were taken as well as a biopsy of the leptomeninges, and the dura mater was left open.

Course. The patient regained strength slowly. He was started on roentgen therapy on his 7th postoperative day, beginning over the cervical region. He was given 2100 r to the cervical spine over a 6-day period, and an additional course through 2 oblique ports of 1800 r each after an interval of 1 month. The complete spinal axis was treated during this series, giving 2400 r to the thoracic spine and 2100 r to the previously treated lumbar area.

He responded well and left the hospital 6 weeks after operation. He was able to use his arms well and was able to walk for moderate distances unassisted.
The patient gradually regained strength in both arms and legs over a 7-month period. About this time he began to notice polydipsia and polyuria and within 3 to 4 weeks he had an intake of approximately 10,000 cc. per day. Because of these symptoms he has been started on another course of radiation to the anterior portion of the third ventricle, and is also being treated symptomatically with pitressin tannate in oil intramuscularly. He has shown no evidence of any further difficulty from his spinal lesions. His shoulder girdle muscles are moderately weak, but the reflexes are normal and his sensory level is no longer present.

Pathology. NCB No. 53-3863. Cauda equina tumor (Fig. 6). There are large cells with vesicular nuclei, some of which show one or two nucleoli. These cells have a moderate amount of cytoplasm. There are also smaller cells with hyperchromatic nuclei and scant cytoplasm. Strands of collagenous connective tissue extend about the blood vessels and around the more cellular areas of the neoplasm. Diagnosis: Pinealoma.

NCB No. 54-3161. Biopsy of cervical tumor and cervical leptomeninges. The tumor resembles the original biopsy, but the large cells have more hyperchromatic nuclei and the lymphocytic elements are more abundant. The arachnoid membrane is infiltrated with numerous cells of both large and small types morphologically similar to those in the main tumor (Fig. 7).
Comment. On this patient's first hospital admission a lumbar puncture was not performed because of the presence of increased intracranial pressure. It is interesting to note, however, that the ventricular fluid contained 10 "monocytes." On his 4th admission the cell count in the spinal fluid was elevated, and large cells similar to those seen in the pineal parenchyma as well as the small lymphoid cells were observed on smear. At operation, the biopsy of opaque areas in the cervical leptomeninges showed definite microscopic tumor implants. There is a substantial amount of evidence, therefore, that the medium of spread of the neoplastic cells was the cerebrospinal fluid.

On each occasion when this patient's tumor has been treated locally by roentgen therapy there has been definite clinical evidence of improvement. Further indication of the efficacy of this treatment is given by the fact that the myelographic defect in the upper lumbar region noted in October 1953 had completely resolved by the time myelography was repeated in August 1954.

Case 3. NCBH #181817. B.B., a 20-year-old girl, came to the North Carolina Baptist Hospital on March 4, 1954, complaining of headache, nausea and vomiting, blurred vision and staggering gait. She first noted trouble with her vision 1 year prior to admission, and 6 months later this became associated with generalized headache. As her headaches grew progressively worse she had nausea and vomiting. Her vision became steadily poorer, especially in the left homonymous field. For 2 months she had noticed a numb feeling over the right side of her face and about this time her gait became ataxic with a tendency to stagger to the right. For 5 weeks she had been bedridden because of the severity of these symptoms.

Examination. The patient was a young girl, fairly well nourished, but appearing chronically ill. Visual acuity was poor, and there appeared to be a left homonymous field defect. The fundi showed 4 D. of papilledema bilaterally with hemorrhages on and about the nerve head. The pupils were moderately dilated and did not react well to light or in convergence. Extraocular movements were normal. There was ataxia of the extremities, worse on the right than on the left. The reflexes were equal and active. Sensation was normal over the entire body. There was no evidence of a mass in the nasopharynx.

Laboratory Findings. Urinalysis and blood counts were normal. Serologic examination for syphilis was negative. Roentgenograms of the chest were normal. Skull films showed slight widening of the suture lines and erosion of the posterior clinoid processes. There were some stippled areas of calcification 3.5 cm. posterior to, and slightly above the sella turcica.

Operation. On March 5, 1954, the patient underwent ventriculography. The intraventricular pressure was elevated, and roentgenogram demonstrated a mass in the posterior part of the third ventricle (Fig. 8). After this, a posterior fossa exploration was carried out. In exploring the fourth ventricle fluid was not observed to pass through the aqueduct of Sylvius. The vermis of the cerebellum showed two small pinkish areas of discoloration on its inferior aspect which were removed for pathologic examination. A rubber catheter was placed beneath the scalp, shunting the cerebrospinal fluid from the left ventricle to the cisterna magna.

Course. The patient did well following surgery except for slight persistent nausea.
She was discharged on her 10th postoperative day and was referred to a radiologist near her home for therapy. She was given 3,000 r (in air) through each of 3 ports to the region of the posterior third ventricle and 2,500 r (in air) to each area of the spinal column.

2nd Admission, March 29, 1955. The patient was getting along well except for occasional nausea which was well controlled with medication until 3 weeks prior to readmission, when she began to notice numbness over the right side of her face and body. She also had occasional spells of weakness of the right arm and leg.

Examination. She had horizontal nystagmus on right lateral gaze and weakness of the left lateral rectus muscle. There was hypalgesia over the right side of the face with right peripheral facial weakness. There was hypalgesia over the right side of the body which faded out at about the T2 level. Deep tendon reflexes were increased in the right arm and leg. Roentgenograms of the skull showed a marked increase in the calcification in the region of the pineal and midbrain.

A myelogram was done to check on the possibility of a cervical metastasis as a cause for the peripheral neurologic findings. This was normal to the upper cervical region. It was therefore concluded that the patient probably had extension of her tumor locally into the thalamic region and possibly into the posterior fossa. She was then discharged to receive further roentgen therapy to these regions.

3rd Admission, May 3, 1955. The patient returned to the Outpatient Department on the day of admission for a follow-up visit after 11 roentgen treatments. She was feeling better except for slight headache and occasional “weak spells.” She had not noted much change in the numbness of her extremities, but her facial weakness was definitely improved. Before leaving for home she said she had a headache and felt quite faint, and because of this she was readmitted to the hospital.

Examination. She showed moderate right facial weakness as well as some loss of hearing in the right ear. There was no evidence of papilledema. She still had a left
lateral rectus weakness. There were ataxia and weakness of the right hand. Deep tendon reflexes were increased on the right. There was still a suggestion of a sensory level in the upper thoracic region on the right, but this was not as well demarcated as on the previous examination.

Course. The patient was given a high protein diet and bed rest for several days. During this time she appeared to be much improved and she was discharged to continue her roentgen treatment. Further roentgen therapy was given to the posterior fossa during June 1955, but because of the patient’s continued downhill course and the difficulties associated with her being taken to the radiotherapist, this could not be consistently followed. A right facial weakness of peripheral type developed, associated with subjective hypalgesia of the right side of the face. It was considered clinically that she showed evidence of a progressive lesion in the right cerebello-pontine angle.

She died at home on Aug. 12, 1955. An autopsy was performed by Dr. S. S. Hindman of Waynesville, N.C. The brain was removed and delivered to Dr. Martin Netsky. The spinal cord was not removed. The general postmortem examination showed no evidence of primary or metastatic tumor.

Dr. Netsky reviewed the original specimen of tumor taken from the cerebellum at operation and concurred in the diagnosis of pinealoma. On examining the brain he remarked that there was very little neoplasm remaining in the specimen. A small

Fig. 9. Case 3. Photomicrograph of cerebellar biopsy. Hematoxylin and eosin stain, ×570.
portion of this was seen just behind the collicular plate, where it extended as a finger-like projection into the leptomeninges. There were extensive areas of destruction of the cerebellum and brain stem, presumably secondary to the radiation therapy.

Pathology. NCB No. 54-883. Biopsy of a nodule from the surface of the cerebellum (Fig. 9). There are masses of large cells showing some variation in size. The nuclei of these cells are vesicular and nucleoli are present. There are some areas of smaller, hyperchromatic cells which are not intermingled with the large cells. Special stains showed no evidence of reticulin being laid down by the tumor. Diagnosis: Pinealoma.

Comment. Admittedly the histologic picture of the tumor could have suggested other types of neoplasm such as nasopharyngeal lymphepithelioma or dysgerminoma. There was neither clinical nor postmortem evidence of primary tumor elsewhere. The increasing calcification in the pineal region in more recent roentgenograms gives further positive evidence of the nature of this tumor. It is unfortunate that the postmortem examination performed elsewhere did not include the spinal cord. The very striking changes in the cerebellum, apparently secondary to roentgen therapy administered at our request, and the small residual tumor present in the pineal region bear adequate evidence both to the effectiveness of such therapy to this pinealoma and to the possible destructive effects on normal nervous tissue. Since there was no evidence of increased intracranial pressure clinically before her death or at postmortem examination, it is possible that the effect of roentgen radiation on the brain stem and midbrain may have contributed to her terminal course.

DISCUSSION

From the cases reported in the literature was well as the 3 cases summarized in this paper, it has been shown that tumors of the pineal body have a definite ability to metastasize within, and occasionally outside of the central nervous system. It has not been determined whether certain types of tumor have a greater propensity in this regard than others. This is attributable in part to the variations encountered in the pathologic classification of these lesions, and in part to the fact that many of them are treated by irradiation without a pathologic specimen being obtained.

Pathologically, tumors arising in the pineal region show much variation in their histologic structure. Some observers feel that in spite of this, these lesions fall into one neoplastic group, reflecting in their cellular constituents some stage in the embryologic development of the pineal body. Russell, however, believes that although neoplastic transformation of pineal cells may rarely occur, the majority of tumors arising in this region are actually teratomas or teratoid growths. She stated that there are morphologic differences between the normal pineal cells and those of the pineal tumors. She also found that serial sections of most "pinealomas" show cellular elements that would more properly classify them as teratomas, and that most teratomas arising in the pineal region have areas showing typical pineal structure. Walton gave further support to this theory in his report of a case of a
typical teratoma of the pineal body which seeded into the hypothalamic region and in this location took the form of a teratoid growth with pinealomatous areas. Occasionally these lesions are immature enough to warrant classifying them as chorionepitheliomas.\textsuperscript{32} McGovern\textsuperscript{22} has grouped pineal tumors under five headings: pinealoblastoma, pinealocytoma, ganglioneuroma, glioma, and teratoma (which he considers to be the most common tumor of the pineal region). Several cases have also been reported of diffuse involvement of the ependymal surface without the presence of a primary tumor in the region of the pineal body.\textsuperscript{18,23,28} Russell explained this by stating that because most pineal body tumors are teratomas they may closely resemble teratomas arising from other sites within the brain. It is the feeling of some,\textsuperscript{26,24} however, that true ectopic pinealomas may occur. Despite the variance in these opinions it is known that teratomas, chorionepitheliomas, pinealoblastomas, and pinealocytomas may metastasize by means of the cerebrospinal fluid. These represent the majority of tumors arising in the region of the pineal body.

Attempts at surgical extirpation have been carried out in the past but, in general, the results of such operations have been quite disappointing.\textsuperscript{10,25} Because of the high mortality associated with direct surgical attack, the more generally accepted method of management at present is to relieve the increased intracranial pressure by ventriculocisternostomy,\textsuperscript{35} subtemporal decompression,\textsuperscript{18} or third ventriculostomy,\textsuperscript{31} followed by roentgen therapy to the posterior portion of the third ventricle. When these methods of treatment are used, the exact histology of the neoplasm usually is not known. This is in opposition to the well-founded rule of not giving radiation to a lesion of undetermined pathology, but even biopsy of a tumor in this region may have fatal consequences, and from the patient’s standpoint a more conservative, albeit blind, approach is frequently more satisfactory.

The potent effect of radiation on these tumors is well exemplified by our Cases 2 and 3, as well as Case 2 of Tompkins et al.\textsuperscript{34} in which a tumor incompletely removed at surgery was irradiated postoperatively and at postmortem examination was found to have been completely destroyed. Horrax\textsuperscript{17} reported a series of 32 pineal tumors, 14 of which had been verified by operation or autopsy. The other 8 were diagnosed on the basis of neurologic and ventriculographic findings. Of 10 patients who had gross operative removal, 3 were living 10, 5 and 3 years after operation. These 3 patients had also been given postoperative irradiation to the pineal body (a fact that may have some bearing on their survival). Of the 12 patients who received only decompression or biopsy and radiation therapy, 7 were alive 2 to 15 years later, and one other patient was living 3 months after therapy. Four of these conservatively treated patients died within a few days to 1 year following operation. Horrax feels on the basis of his experience with these tumors that the results obtained with decompression and irradiation are superior to those with radical surgery.

Because a variety of tumors of the pineal region may spread \textit{via} the cerebrospinal fluid pathways, it suggested that even though a definite micro-
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PINEALOMA WITH METASTASES IN THE NERVOUS SYSTEM can rarely be made prior to treatment, total irradiation of the central nervous system might be advisable in those patients showing a mass lesion in the posterior third ventricle. This would seem to be a more rational approach than awaiting the clinical appearance of metastases (as in Case 2) and then treating each of these recurrences individually. It is entirely possible that cells may shed from an untreated and clinically undetected metastasis, and thus diffuse spread of the tumor will occur back into areas previously treated by X-ray.

Various methods have been suggested for the complete irradiation of the central nervous system. The most generally used is the multiple port technique. More recently, the use of a single spade-shaped field covering the entire cerebrospinal axis has been suggested for the treatment of medulloblastomas. This could be used in conjunction with supplementary ports to the head to very good advantage in the therapy of pineal tumors. Work has also been done on the use of intrathecal radioactive colloidal gold, but this has not been investigated sufficiently to justify its clinical use at present. From the cases tabulated in Table 1 it would seem especially important to

**TABLE 1**

*Previously reported pineal tumors with metastases*

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Site of Metastasis</th>
<th>Pathology</th>
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<tbody>
<tr>
<td>Horrax and Bailey</td>
<td>1925</td>
<td>Meninges over surface of cerebellum, and about brain stem</td>
<td>Spongioblastoma</td>
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<tr>
<td>Case 2</td>
<td></td>
<td>Floor of 3rd ventricle</td>
<td>Pinealoma</td>
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<td>Case 4</td>
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<tr>
<td>Berblinger</td>
<td>1925</td>
<td>Cauda equina</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Fulton and Bailey</td>
<td>1929</td>
<td>Hypophysial stalk and optic nerves</td>
<td>Pinealoma</td>
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<td>Case 5</td>
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<tr>
<td>Cairns and Russell</td>
<td>1931</td>
<td>Spinal metastases</td>
<td>Unclassified glioma</td>
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<td>Case 1</td>
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<tr>
<td>Alajouanine et al.</td>
<td>1934</td>
<td>Third ventricle and implants along cord with areas of intramedullary invasion</td>
<td>Neurospongionoma (medulloblastoma) originating in pineal region</td>
</tr>
<tr>
<td>Stringer</td>
<td>1934</td>
<td>Tuber cinereum</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Friedman and Plaut</td>
<td>1935</td>
<td>Cauda equina and diffuse spread over cranial nerve roots</td>
<td>Pinealocytoma (a primary tumor was not found in region of epiphysis)</td>
</tr>
<tr>
<td>Alajouanine et al.</td>
<td>1937</td>
<td>Posterior 3rd ventricle and 4th ventricle; seeding over surface of 3rd and lateral ventricles, olfactory bulb; spinal cord and nerve roots diffusely involved</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Van Gehuchten and Callewaert</td>
<td>1937</td>
<td>Third and lateral ventricles</td>
<td>Pinealoma</td>
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<tr>
<td>Author</td>
<td>Year</td>
<td>Site of Metastasis</td>
<td>Pathology</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------</td>
<td>--------------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Baggenstoss and Love²³</td>
<td>1939</td>
<td>Suprachiasmatic region and lumbar spinal canal</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Mackay²³</td>
<td>1939</td>
<td>Diffuse ependymal involvement</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Werner²⁴</td>
<td>1939</td>
<td>Diffuse meningeal and ependymal involvement</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Russell and Sachs³⁰</td>
<td>1943</td>
<td>Seven out of 18 cases showed spread into subarachnoid spaces or ventricles</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Dublin¹⁴</td>
<td>1945</td>
<td>Microscopic dissemination over surfaces of cerebrum, cerebellum, and spinal cord</td>
<td>Pineal ependymoma</td>
</tr>
<tr>
<td>Stowell et al.²³</td>
<td>1945</td>
<td>Third ventricle and lung</td>
<td>Chorionepithelioma</td>
</tr>
<tr>
<td>Horrax and Wyatt³⁰</td>
<td>1947</td>
<td>Microscopic invasion of posterior lobe of pituitary and ependyma</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Case 1</td>
<td></td>
<td>Suprachiasmatic region</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Case 2</td>
<td></td>
<td>Suprachiasmatic region</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Case 3</td>
<td></td>
<td>Suprachiasmatic region</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>McGovern²⁵</td>
<td>1949</td>
<td>Third ventricle</td>
<td>Pinealoblastoma</td>
</tr>
<tr>
<td>Case 2</td>
<td></td>
<td>Third ventricle</td>
<td>Pinealoblastoma</td>
</tr>
<tr>
<td>Case 4</td>
<td></td>
<td>Third ventricle</td>
<td>Pinealoblastoma</td>
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<tr>
<td>Walton³⁷</td>
<td>1949</td>
<td>Hypothalamic region</td>
<td>Primary: teratoma; metastasis: atypical teratoma with pinealomatous regions</td>
</tr>
<tr>
<td>Baker and Rucker⁵⁰</td>
<td>1950</td>
<td>Optic chiasm (found at operation); spinal cord (progressive paraplegia developed later, presumably caused by same tumor). No autopsy reported</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Tompkins et al.³⁴</td>
<td>1950</td>
<td>Centrum ovale, straight sinus, and lung</td>
<td>Teratocarcinoma</td>
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<tr>
<td>Case 1</td>
<td></td>
<td>Spastic paraplegia developed 6 months before death, Lung and tracheobronchial lymph nodes (spinal cord not examined at autopsy)</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Case 2</td>
<td></td>
<td>Spinal cord involvement indicated by radicular symptoms and signs</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Case 3</td>
<td></td>
<td>Region of optic chiasm</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>3 cases</td>
<td></td>
<td>Optic nerves and septum pellucidum</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Rand and Lemmen²³</td>
<td>1953</td>
<td>Region of optic chiasm</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Case 2</td>
<td></td>
<td>Optic nerves and septum pellucidum</td>
<td>Pinealoma</td>
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<tr>
<td>3 cases</td>
<td></td>
<td>Spinal cord involvement indicated by radicular symptoms and signs</td>
<td>Pinealoma</td>
</tr>
<tr>
<td>Ray⁵⁸</td>
<td>1953</td>
<td>Ependymal lining of ventricles, right internal capsule, posterior pituitary and infundibular stalk</td>
<td>Pinealoma (pineal body not present at autopsy)</td>
</tr>
</tbody>
</table>
give adequate treatment to the region of the third ventricle, the suprachiasmatic structures, and the cauda equina as these appear to be the most frequent sites of metastasis.

SUMMARY

Three cases have been presented illustrating the potentiality of tumors originating in the pineal region to metastasize via the cerebrospinal fluid. Literature pertaining to the spread of pineal tumors by various routes has been reviewed, and the implications relating to the therapy of these neoplasms have been outlined. It is suggested that these tumors be treated by operative decompression followed by irradiation of the complete cerebrospinal axis.

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REFERENCES

4. BAILEY, P., and JELIFFE, S. E. Tumors of the pineal body. With an account of the pineal syndrome, the report of a case of teratoma of the pineal and abstracts of all previously recorded cases of pineal tumors. Arch. intern. Med., 1911, 8: 851–880.
6. BERHLENGER, W. Cited by Friedman and Plant.12